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BIOCHEMISTRY

01

INSULIN-LIKE GROWTH FACTORS AND IGF-BINDING PROTEINS AS DIAGNOSTIC, PROGNOSTIC AND PREDICTIVE TUMOR MARKERS

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Background: Insulin-like growth factors (IGFs) signaling system – a complicated regulatory network enclosing IGF-I and II, their cellular transmembrane receptors and serum binding proteins (IGFBPs) – plays a key role in development and progression of various malignant tumors. Hence, these proteins are actively evaluated as potential markers for diagnostic, monitoring and prognosis, as well as objects for molecular-targeted therapy.

Aim of the study: evaluation of clinical prospects of IGF-I, II, IGFBPs 1, 2 3 and IGF receptors measurement in blood serum and tumors of various oncologic patients for diagnostics, monitoring and prognosis.

Materials and methods: 104 ovarian tumor (74 malignant, 14 borderline and 16 benign), 95 colorectal cancer (CRC), 79 – breast cancer, 64 – cervical cancer and intraepithelial neoplasia (CIN), and 113 – bone tumor patients were enclosed in the study. Control group comprised 77 practically healthy women and 17 men. The markers' levels were measured in tumor extracts and/or blood serum with standard direct ELISA kits («Mediagnost», Germany).

Results: Important disturbances in IGFs/IGBPs balance indicating to an increase of IGF bioavailability for tumor cells were demonstrated. The direction and degree of these changes depended on tumor type, expansion and some other clinical and pathologic characteristics. Thus, IGF-I level was decreased in serum of female reproductive tract tumor patients, but increased in CRC and bone tumor patients' sera. IGFBP-2 was shown to be a potential serological marker for ovarian cancer differential diagnostics: its diagnostic sensitivity at 80% specificity comprised more than 85% even at the earliest stages of the diseases. IGFBP-2 is also a valuable CRC diagnostic marker with diagnostic sensitivity comparable to that for ovarian cancer, but application of a complex of tests – IGFBP-2, IGFBP-1 and IGF-I – allows to perform preliminary differential diagnostics between CRC and ovarian cancer in female patients. Marked decrease of serum IGF-I, II and IGFBP-3 and increase of IGFBP-1 were revealed in cervical cancer patients, indicating to involvement of these proteins in cervical carcinogenesis and making them prospective markers of latent invasion in severe forms of CIN. And in bone sarcoma patients significant differences in 3-years survival were found depending on pre-treatment serum IGF/IGFBPs levels.

Conclusion: Measurement of serum IGFs and IGFBPs levels might be useful for differential diagnostics, treatment monitoring and disease prognosis of various human tumors. In future, these markers can also be used for prediction of the sensitivity to specific molecular-targeted agents.

DOES GAMMA-IRRADIATION AFFECT THE QUALITY OF FRESH-CUT WATERCRESS?

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Watercress (*Nasturtium officinale* R. Br.) is a nutrient rich perennial plant of the Brassicaceae family highly appreciated in the Mediterranean cuisine. It is eaten raw in salads, soups and other recipes and used in folk medicine due to its medicinal and therapeutic properties [1,2]. However, it has a reduced shelf-life of approximately 7 days [3]. Since most conventional preservation treatments can't extend the shelf-life without compromising the quality and consumers are more aware about the limitations and side effects of the commonly used sanitizing treatments [4], irradiation emerged as a potential and safe alternative against these conventional postharvest treatments. In this study, the effect of different doses of gamma-irradiation on fresh-cut watercress quality was evaluated. Samples were collected in Bragança region (Northeast of Portugal), rinsed in tap water and packaged in sterilized bags. Packaged samples were exposed to 0 (control), 1, 2 and 5 kGy of γ-rays in a ^{60}Co chamber and stored at 4 ºC for 7 days. Among the evaluated parameters, color was measured with a colorimeter, total soluble solids using a digital refractometer, and pH with a digital pH-meter. Macronutrients were determined using standard procedures, and hydrophilic (sugars, organic acids, phenolics and flavonoids) and lipophilic (fatty acids and tocopherols) compounds by chromatographic or spectrophotometric techniques. Furthermore, the bioactivity was evaluated in hydroalcoholic extracts through DPPH scavenging activity, reducing power, β-carotene bleaching inhibition and TBARS formation inhibition. Data were evaluated through Linear Discriminant Analysis (LDA) to verify if the differences induce by irradiation on the evaluated parameters could act as discriminant variables. Among the 58 studied variables, only 13 (including fructose, glucose, citric acid, some fatty acids such as linoleic and α-linolenic acids, β- and γ-tocopherols and β-carotene bleaching inhibition) were selected in the application of LDA, which is a strong indication of the similarity between the results obtained for the remaining 45 variables. Furthermore, some of the observed differences proved to be advantageous for the irradiated samples. Thus, this study demonstrated that, up to 5 kGy, gamma-irradiation did not affect the main quality parameters of fresh-cut watercress.

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EFFECTS OF GAMMA IRRADIATION ON THE PHENOLIC COMPOUNDS OF *GINKGO BILOBA L.*

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Irradiation has been increasingly recognized as an effective decontamination technique that ensures the chemical and organoleptic quality of medicinal and aromatic plants |1,2|. One of those plants that has been highly studied is *Ginkgo biloba* L., due to its use in traditional medicine, but also by professionals in the medical field in order to treat problems typically associated with aging, such as intermittent claudication, decreased mental vitality in old age (mental confusion, memory loss, dementia praecox, concentration problems), poor circulation and tinnitus |3|.

The aim of the present study was to evaluate the effects of gamma irradiation in the bioactive compounds of *G. biloba* (infusion and methanol/water extract), widely used in traditional medicine and in dietary supplements. Twenty-five compounds were detected, eighteen of which were flavonoids, one phenolic acid, five terpene lactones and one unknown compound. Among the quantified phenolic compounds, flavonoids were the main group present, being two kaempferol derivatives the major compounds found: kaempferol-3-*O*-dirhamnosylglucoside and kaempferol-3-*O*-rutinoside. Kaempferol-3-*O*-dirhamnosylglucoside was the most abundant compound in all the infusion preparations and in the methanol/water extract irradiated at 1 kGy, whereas kaempferol-3-*O*-rutinoside was the most abundant one in the control and irradiated at 10 kGy methanol/water extracts. Protocatechuic acid was the only phenolic acid identified and the quantities present were in the same range as the major flavonoids. The irradiation with the highest dose (10 kGy) is sufficient to guarantee the product disinfestation and microbial decontamination, also contributing to an increase in the extractability of phenolic compounds, both in methanol/water and infusion preparations.

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THE PECULIARITIES OF EVALUATION OF OXIDATIVE METABOLISM IN CELLS CAPABLE TO PRODUCE FREE RADICALS

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Objectives: Cytotoxicity testing is a common procedure for studying exposure to damaging agents at the cell (in vitro) or whole organism (ex vivo) level. The conventional and most frequently used method for evaluation of cell metabolic activity is MTT-test. Nevertheless, due to its low specificity thiazolyl blue tetrazolium bromide could react with free radicals and thus demonstrate overestimated or deceptive results under certain conditions. It has been demonstrated before (Petrenyov, RAD2014) that exposure to ionizing (IR) and non-ionizing radiation could enhance the spontaneous production of reactive oxygen (ROS) and nitrogen (RNS) species in a variety of cell types. These data raise the issue about adequacy of evaluating metabolic activity with MTT-test in cells exposed to IR or isolated from exposed animals. The aim of this work is to study how enhanced ROS production could affects data of cell metabolic activity obtained through MTT and resazurin reduction.

Methods: The rat resident peritoneal cells (RPMs) were collected by lavage with 12 ml of HBBS supplemented with 10 mM HEPES, 1% antibiotic/antimicotic cocktail and heparin 10 U/ml. The bone marrow cells (BMCs) were isolated from thighbone with 7 ml of complete media (DMEM, 1% antibiotic/antimicotic cocktail, 5 % FBS, heparin 10 U/ml). Common metabolic activity of cells was evaluated by 2 hr incubation (37°C and 5% CO_2) with 0.5 mg/ml MTT (M5655, Sigma) or 1 hr incubation with 44 uM Resazurin (R7017, Sigma) immediately and 24 hr after stimulation with PMA (P1585, Sigma) and Zymosan A (Z4250, Sigma). The XTT (X4251, Fluka) reduction was used for monitoring level of ROS production.

Results: The PMA (100 nM) and Zymosan (0.78 mg/ml) increased production of ROS in RPMs and BMCs. This effect was accompanied by elevated levels of MTT reduction in RPMs (130 and 101 % of control) and in BMCs (180 and 136 % o.c.) but depressed levels of resazurin conversion to resorufin in RPMs (88 and 64 % o.c.) and in BMCs (89 and 69 % o.c.), as was estimated immediately after stimulation. The MTT-test repeated 24 hr after stimulation shown dose-dependent decrease in viability of RPMs and BMCs. Thus oxidative burst after PMA-stimulation accounted for cytotoxicity (i.e. corresponds to data of resazurin test immediately a.s.) and for increased levels of MTT reduction. The median lethal dose in BMCs was 67.6 nM for PMA and 21.8 ug/ml for Zymosan, as estimated by MTT-test 24 hr after stimulation. The DMSO addition in media partially protected cells from toxic effects of ROS.

Conclusions: The result of resazurin reduction gave more realistic data than MTT-test during estimation of metabolic activity in cells capable to produce ROS. The XTT also should be used with care during testing of metabolic activity of the cells. Strong attention should be given to selection of correct viability estimation method under conditions where free radical production could be stimulated.

EFFECTS OF FLUOXETINE ON THYROID HORMONE METABOLISM

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Thyroid hormones (TH) are supposed to control the activity of some neurotransmitters (e.g., serotonin), which are hypothetically involved in the pathogenesis of depressive illness. Inadequate activities of brain deiodinating enzymes iodothyronine deiodinases (IDs) could lead to local insufficient concentration of 3,3 ´, 5-triiodo-L-thyronine (T_3) and might be, therefore, one of the pathogenic factors of depression. Hence, we studied recently [Pavelka S., Physiol. Res. 63 (Suppl. 1) (2014) S133-S140] the interaction of the most frequently used non-tricyclic antidepressant drug fluoxetine (Fluox) with the metabolism of TH in the rat.

Here, with the aid of our newly developed radiometric assays for IDs of types 1, 2 and 3 (D1, D2 and D3) [Pavelka S., J. Radioanal. Nucl. Chem. 286 (2010) 861-865], as well as the adapted radiometric assays for conjugating enzymes iodothyronine sulfotransferases (ST) and uridine 5'-diphospho-glucuronyltransferase (UDP-GT), we followed in more details the effects of subchronic administration (for 25 days) to adult Wistar rats of Fluox alone or in combination with T_3 on triiodothyronine production and degradation in the CNS and in different peripheral rat tissues.

We found about two-fold higher UDP-GT enzyme activities in samples of liver microsomes of rats treated with Fluox, in comparison with control rats. On the contrary, the enzyme activities of ST in the liver and kidney cytosolic fractions of the control and treated animals were found to be negligible and not influenced by the treatments. However, profound changes in enzyme activities were determined in case of IDs, especially in the pituitary and cerebellum of treated rats.

In conclusion, the elaborated radiometric assays for IDs, UDP-GT and ST were found to be usable for the assessment of changes in the enzyme activities caused by the administration of the studied drugs to the rats.

LEPTIN AFFECTS THYROID HORMONE METABOLISM IN WAT

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Leptin is the major adipokine, which is secreted in enhanced rate from hypertrophic white adipose tissue (WAT) and controls food intake and energy expenditure. Adipose tissue is also one of the most important targets for thyroid hormones (TH). We have shown recently some relations between leptin and TH metabolism in murine WAT [Macek Jilkova Z., Pavelka S. et al., Physiol. Res. 59 (2010) 561-569].

Here, we followed, with the aid of several radioanalytical methods, possible changes in activities of the key enzymes of TH metabolism in murine WAT under the conditions that promoted either tissue hypertrophy (i.e., under obesogenic treatment) or involution (i.e., under mild caloric restriction), and in response to the administration of hormone leptin. Genetically modified, high-fat (HF) diet-induced obesity prone, adult male C57BL/6J mice were subjected to these three different treatment protocols. Enzyme activities of iodothyronine deiodinases of types 1, 2 and 3 (D1, D2 and D3, respectively) in WAT, brown adipose tissue (BAT), and in the liver (which served as a control material) were measured with the aid of our newly developed [Pavelka S., Physiol. Res. 63 (Suppl. 1) (2014) S133-S140] radiometric enzyme assays.

We found that D1 activity in WAT was stimulated by a HF-diet feeding; this treatment also increased plasma levels of leptin. However, D1 or D2 activities in BAT did not change. In return, caloric restriction decreased D1 activity in WAT, but not in the liver, and reduced leptin levels.

In conclusion, our results suggest a functional role for deiodinase D1 in WAT, with D1 possibly being involved in the control of adipose tissue metabolism and/or accumulation of the tissue.

COMPARISON OF ^{14}C RADIATION- AND SPECTROPHOTO-METRIC METHODS IN MEASUREMENTS OF DIFFERENT PARAMETERS IN SENESCING SUGAR BEET LEAVES

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Ion $H^{14}CO^{-}_{3}$ is activator and at the same time substrate source for ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco), the first enzyme of the well-known reducing pentose phosphate cycle of carbon assimilation. ^{14}C-PGA is the only labelled product of the reaction. Two indices of leaves senescence: soluble protein content (mg) and potential Rubisco activity (μmoles/min), both calculated per 1 g leaf fresh mass. Both of these values depend on proteolysis of relevant enzymes and we took them as the most important ones for studies of normal senescence of sugar beet leaves. These changes are based at enzyme proteins biosynthesis and accompanied with progressive changes sink for source leaf functions. Our measurements of soluble protein content and Rubisco activity changes during complete senescence showed significant difference at its last stage. Plurality of sum of different possible products of proteolysis could be reflected while use of Lowry' method. These products could have different further fates and functions, including regulatory ones. On opposite to it radiometric method registered the proteolysis for only one protein – Rubisco. This is rear, if not the first, demonstration of special features for late leaf senescence using individual native extremely important soluble protein.

STUDIES OF MECHANISMS INVOLVED IN BLEOMYCIN-INDUCED BYSTANDER EFFECTS AND STRESS RESPONSE ON MOUSE EMBRIONARY FIBROBLASTS

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Radiation exposure induces molecular damages leading to detrimental effects on cells, including DNA lesions, chromosomal aberrations, increased mutation frequency, decreased clonogenic survival. The "bystander effect" represents an indirect effect of radiation and genotoxic agents such as bleomycin, that produces similar damages in cells that have not been directly exposed to toxic factors, but have received signals from affected cells either from molecules released in the medium or by gap junctions. Recent studies suggest that bystander effects are ATP-dependent processes, fully functional mitochondria being essential for this type of damage signaling. PINK1 is a mitochondrial serine/threonine kinase involved in essential cellular processes such as ATP production, calcium homeostasis, stress response. Loss of function mutation of PINK1 are associated with mitochondrial defects leading to development of Parkinson's disease, while increased expression of the protein was found in different cancers. In these cases PINK1 promotes cell survival, protects against cell stressors (including chemoterapeutic agents), and inceases the metastatic potential of the cell system.

Hence knowing that PINK1 is involved in cell survival, and in ATP production, we investigated the role of the kinase in response to cellular stress and in bystander effect induction on mouse embrionary fibroblasts (MEF). For induction of bystander effects our study used bleomycin (BLM) treatment, a radiomimetic frequently used in cancer therapy, followed by medium transfer at 24 hours post-treatment.

Our experiments show that MEF PINK1 knock-out (KO) are more vulnerable to stress factors as compared to MEFs wild type (WT). Thus, in PINK1-KO, BLM induced increased genotoxic and cytotoxic effects as detected in increased number of micronuclei and decreased viability. In the study of bystander effect induction, medium from MEF WT treated cells increased the micronuclei frequency in acceptor MEFs, but medium transferred from PINK1 KO MEFs was not able to induce this type of damage in WT acceptor cells. We evaluated ATP levels in these cells, showing that MEF PINK1 KO cells presented a reduced ATP basal level. In WT cells, but not in PINK1 KO MEFs, BLM treatment induced an increase in ATP level, which can be correlated with their capacity of transmitting bystander signals. Studies of expression of compartmental stress markers proved an increase in mARN levels for several markers in directly treated cells, as opposed to a slightly decreased expression in bystander cells. This suggests different mechanisms of damage induction in direct versus bystander cells.

Therefore, our study proved that PINK1 is required for bystander effects signaling, the protein being a kinase involved in ATP production, and sustain recent data suggesting that induction of bystander effects is an ATP dependent process.

IMPLICATION OF ERK KINASE SIGNALING IN INTEGRIN ALPHA-2/BETA-1 DEPENDENT ANOIKIS PROTECTION

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Implication of Erk kinase signaling in integrin alpa-2/beta-1 dependent anoikis protection. Silencing of alpha2/beta-1 integrin expression significantly promoted anchorage-dependent apoptosis, anoikis, and drastically reduced clonal activity of the MCF-7 human breast carcinoma cells, Bcl-2, and multifunctional potei c-Myc. Blocking the expression of alpha-2/beta-1had no effect on citity of protein kinase Akt, but sharply increased the kinase activity of Erk1/2. Pharmacological inhibition of Erk1/2 had a minor effect on anoikis of control cells, while reduced that of cells with down-regulated alpha-2/beta-1 to the level of control cells. The data showed for the first time that integrin alpha-2/beta-1 is implicated in protection of tumor cells from anoikis through a mechanism based on the inhibition of protein kinase Erk

INTEGRIN ALPHA-2/BETA-1 RESCUES HUMAN MELANOMA CELLS FROM SENESCENE

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Involvement of integrin alpha-2/beta-1 in senescence of tumor cells was investigated in SKMel-147 human melanoma cells. Down-regulation of alpha-2/beta-1 expression which was achieved by cell transduction with the alpha-2 specific shRNA caused a 2-4 fold increase in the number of cells demonstrating a characteristic sign of senescence. In addition, knock-down of alpha-2/beta-1 expression was accompanied by a strongly reduced expession of the phosphokinases FAK, Erk and EGFR and a markedly increased activation of kinases Akt and mTOR. Pharmacological inhibition of EGFR and Erk repressed the growth of the cells but demonstrated no visible effect on their senescence. Blocking the expression of p53 and p21 and inhibition of the Akt and mTOR activities markedly attenuated the impact of reduced alpha-2/beta-1 expression cell senescence. This study demonstrates for the first time a protective function of alpha-2/beta-1 integrin against cell senescence and shows that the integrin impact on senescence is p53-and p21-dependent and is realized via Akt-mTOR signal pathway.

INTEGRIN ALPHA-5/BETA-1 AS A SIGNAL SWITCH TO THE HUMAN BREAST CARCINOMA CELL INVASION

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Down-regulation of integrin alpha-5/beta-1 in MCF-7Dox human breast carcinoma cells accomplished by transfecting the cells with alpha-2-cpecific siRNA, sharply decreased MMP-2 collagenase expression and inhibited the cell invasion in vitro. Similar reduction of invasion was observed upon silencing of the MMP-2 gene caused by treatment of the cells with MMP-2 specific siRNA. Down-regulation of alpha-5/beta-1 was accompanied by a substantial depletion of the active (phosphorylated) aorms of Act and Erk1/2 kinases and c-Jun oncoprotein. Blocking the activities of above kinases by specific inhibitors strongly reduced the expression of MMP- and c-Jun and suppressed invasion of the cells *in vitro*. The same result was observed upon silencing of c-Jun expression by transfecting the cells with c-Jun specific siRNA. IP-Western blotting experiments have shown that alpha-5/beta-1 forms associates with MMP-2 collagenase on the surface of MCF-7Dox breast carcinoma and SKMe-147 human melanoma cells. The data obtained provide evidence that alpha-5/beta-1 controls invasion of the studied cells by regulation of MMP-2 collagenese expression through signaling pathways including Akt and Erk protein kinases and c-Jun transactivator. An alternative mechanism might operate in a way that alpha-5/beta-1 recruits MMP-2 to the cell surface thereby enhancing destruction of matrix proteins and facilitating cell invasion

ANTIOXIDANT ACTIVITY ULTRASONIC EXTRACT AND MACERATE COLORED VEGETABLES

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Beet (cv. Palanacka crvena) was cultivated under controlled plastic-covered greenhouse conditions using standard production methods. During harvest maturity, beethead sampling was performed for chemical analysis. The objective of this study was to investigate the correlation between total phenolic content and antioxidant activity of ethanol extracts of beet. Total phenols were evaluated by the Folin-Ciocalteu spectrophotometric method. Antioxidant activity, defined as the DPPH radical neutralizing ability, was also determined by spectrophotometry. Results show that the total phenolic content was higher in beet-ultrasonic extract E_1 (0.0811±0.0001 g GAE/100g sample) than in macerate E_2 (0.0577±0.0001 g GAE/100g sample). High values of antioxidant activity were identified (92.67 % for E1 and 91.69% for E2), suggesting a favourable correlation with the total phenolic content (r^2 = 0.832 and r^2 =0.998).

Key words: beet, correlation, phenolic compounds, antioxidant, macerate, ultrasonic extract.

IN VITRO ANTIOXIDATIVE ACTIVITY OF ONIONS GROWING IN SERBIA

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The aim of this study was to examine onions from Serbia for their potential antioxidant activity. Therefore, antioxidant activity as says were carried out, including: total antioxidant capacity, DPPH free radical scavenging, the inhibitory activity toward lipid peroxidation, Fe^{3+}-reducing power, Fe^{2+}-chelating ability and hydroxyl radical scavenging activity. The highest proportion of flavonoids was found in the Jasenicki rouge ethanol extract (105.10 mg RU/g). Jasenicki jaune and Nid dore ethanol extracts showed the highest total antioxidant capacity (312.7 and 231.03 mg AA/g dry extract), DPPH free radical scavenging (IC_{50}=9.23 and 99.05 µg/mL), as well as inhibitory activity toward lipid peroxidation (IC_{50}=2.72 and 17.32 µg/mL)and reducing power. Whereas, the greatest hydroxyl radical scavenging activity, as well as ferrous ion chelating ability showed all three types onions, Jasenicki rouge, Jasenicki jaune and Nid dore.

Key words: antioxidant, flavonoids, phenolics.

THE INFLUENCE OF DIAZINON AND ITS METABOLITES ON ACETYLCHOLINESTERASE, NA^+/K^+-ATPASE AND ANTIOXIDANT ENZYMES IN RAT BRAIN SYNAPTOSOMES

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The aim of this study was to investigate neurotoxic potential and oxidative stress responses of diazinon and its metabolites, diazoxon and 2-isopropyl-6-methyl-4-pyrimidinol using synaptosomes as a model system. Synaptosomes were isolated from the brain of Wistar albino rats and incubated at 37°C for 1 hour in the presence of selected concentrations of the investigated compounds. Acetylcholinesterase, Na^+/K^+-ATPase and antioxidant enzymes activities were determined by standard spectrophotometric methods. Diazinon induced concentration-dependent acetylcholinesterase and Na^+/K^+-ATPase inhibition, while the activity of catalase, superoxide dismutase and glutathione peroxidase was not significantly affected. Increasing concentrations of diazoxon, oxo analog of diazinon, caused almost complete acetylcholinesterase and Na^+/K^+-ATPase inhibition, and activated antioxidant enzymes: catalase (up to 25%), superoxide dismutase (up to 55%) and glutathione peroxidase (up to 30%). Unlike diazoxon, diazinon hydrolysis product, 2-isopropyl-6-methyl-4-pyrimidinol did not remarkably change the activities of the investigated enzymes, except superoxide dismutase that was stimulated up to 25%. The obtained results suggest that neurotoxic and prooxidative potential of diazinon, thioorganophoshate used as a commercial insecticide preparation, significantly reinforces mostly due to its transformation to diazoxon in the metabolic pathways.

BIOMATERIALS

02

MAGNETITE NANOPARTICLES AS MONOFACTOR OF ANTITUMOR TREATMENT IN EXPERIMENTS

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Background. Known data about the diverse and pronounced effects of iron compounds on cell development and cell death point to the need to deepen the study of the effects of these compounds on tumor and organisms without the use of special antitumor agents. Herewith ferrimagnetic nanoparticles (NPs) are of particular interest in relation to their high biological activity, and their use in targeted therapy and in controlled hyperthermia of tumors. The aim of the research was to reveal the conditions for effective antitumor influence of ferrimagnetic NPs on experimental animals with transplanted tumors.

Methods. In experiments on 165 white outbred rats bearded sarcoma 45 or Pliss lymphosarcoma magnetite NPs in form of water-based ferrofluid were applied (size of magnetite NPs was 10 ± 2 nm, stearic acid as a surfactant). Original ferrofluid was diluted with saline and used in different doses (55-220 mg/kg). Injections of the substances were carried in peritumoral zone along the perimeter of the tumor twice a week during 3 week. In the cases of large tumors (more than 5 sm^3) single dose of ferrofluid could be increased up to 400 mg/kg. In some experiments weak infra low-frequency electromagnetic radiation was applied (20 mT, 7.8 Hz, 15 min) on tumor zone five times a week during cure. During the experiments the dynamics of tumor size and of structure of adaptation reactions of animal organism were monitored. Tumor histological preparations were studied after hematoxylin-eosin, Brachet and Van Gison staining, and also transmission electron microscope and flow cytometry were performed for analyzing of the changes in tumors and peritumoral zone. To clarify the degree of oxidation of iron in dilute ferrofluid the X-ray absorption spectroscopy analysis was used.

Results. Introduction of magnetite NPs promoted tumor growth inhibition and tumor regression until complete regression of sarcoma 45 in 70 % of cases and lymphosarcoma Plissa - in 40% of the animals. The effect depended on the dose of the substance, sex of the animal and the conditions of preparation of dilute magnetic fluid. In animals with pronounced effect increase lymphoproliferative activity in thymus and spleen (more than 10 times) was noted. Moreover in these cases numerous signs of cell-cell interactions involving tumor cells, lymphocytes, macrophages, neutrophils and mast cells were observed.

Conclusion. Magnetite nanoparticles under certain conditions of their application can activate the immune mechanisms of antitumor resistance in experiments in vivo without special antitumor agents.

The reported study was supported by RScF research project No 14-35-00051

INVESTIGATION OF ADSORPTIVE REMOVAL OF Sr(II) IONS FROM AQUEOUS SOLUTIONS BY CALCIUM AND HYDROXYAPATITE (HAP) BASED SEA SHELL SORBENTS

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Radioactive wastes are produced inevitably during the production of nuclear energy, preparation and application of the radionuclides. In the nuclear industry, radioactive waste contains a variety of radionuclides, which will severely pollute the environment if the pollutants are not treated well and can pose serious chemical and radiological toxicity threats to lower and higher living organism. Strontium, especially radioactive ^{90}Sr, is one of the most frequently found radionuclides in the soil and groundwater at nuclear test sites. Strontium-90 ($T_{1/2}$ = 28.7 years), β-emitter with 0.546 MeV energy, is considered as one of the main fission products. Strontium-90 is a kind of carcinogen and hazardous pollutant. The chemical properties of strontium-90 are similar to calcium, so when entering into the human body. Therefore, it is very important to concentrate and separate the Sr(II) ions from the waste solutions. Hydroxyapatite, $(Ca_{10}(PO_4)_6(OH)_2$ is chemically similar to the mineral component of bones and teeth and, HAp can be produced from biogenic materials like coral, seashell, eggshell, body fluids and by some chemical synthetic methods.

In this study, sorption potentiality of Ca based sea shell (Donax trunculus) and sea sell (with hydroxyapatite) for strontium ions has been investigated in diluted aqueous solutions. The ability of Ca based sea shell to adsorb strontium (II) from aqueous solution has been studied at different experimental conditions of pH, biomass dosage (V/m), concentration of Sr(II), contact time and temperature. The percent adsorption (%) for uranium ions from aqueous solution was determined as 59% for calcium based seashell and 74% sea sell (with hydroxyapatite) under the optimized experimental conditions. The sorption results have been subjected to different sorption isotherms, namely Freundlich, Langmuir and Dubinin-Radushkevich. Biosorption equilibrium better fits Dubinin-Radushkevich and Freundlich equation than Langmuir model. The thermodynamic parameters were calculated. Furthermore, structural characterization of the adsorbent was realized by FT-IR, XRD, SEM and SEM-EDX analyses. The results showed that Ca based sea shell (Donax trunculus) and seashell with hydroxyapatite could be used as an economic, efficient and natural sorbent for strontium removal from aqueous solutions.

Keywords: Strontium, biosorption, hydroxyapatite, natural adsorbent.

INTEGRAL AND DIFFERENTIAL DISPERSION OF CLAY PORES IN GOSHICA, KOSOVO

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The goal of this study is to analyze the dispersion of pores in temperatures ranging between 40°C, 80°C, 120°C and 830°C, as well as the clay treated with the organic reagent tetraethylammonium chloride and tetramethylammonium chloride.

The graph of the differential dispersion of untreated clay pores shows that the dispersion of pores range in the interval between 1-3 nm and they make for 75% of the pore volume, which are shown in the integral dispersion graph; it can be inferred that the pores with a radius between 1.2 and 2.5 nm are clearly dominant.

The differential dispersion of pores in the clay treated with tetraethylammonium chloride range between 0.9 to 3 nm. These pores make for 85% of their overall volume shown in the integral dispersion graph; the pores with radiuses varying between 1, 1.5 or 2 nm are dominant.

The differential dispersion of pores in the clay treated with tetramethylammonium chloride range between 0.7 to 3 nm. These pores represent about 65% of their total volume shown in the integral dispersion graph; the pores with radiuses varying between 1.1 and 1.5 nm are dominant.

The differential dispersion of pores in the clay treated with a thermal method G.(80)-(70) range between 0.6 to 3 nm. These pores make for about 80% of their total volume shown in the integral dispersion graph; the pores with radiuses varying between 1, 1.6 and 2 nm are dominant.

The differential dispersion of pores in the clay treated with a thermal method G.(120)-(70) range between 0.6 to 2.1 nm. These pores represent about 65% of their total volume shown in the integral dispersion graph; the pores with radiuses varying between 1.7 and 2.1 nm are noticeably dominant.

The differential dispersion of pores in the clay treated with a thermal method G.(830)-(70) range between 0.8 to 6 nm. These pores represent about 90% of their total volume shown in the integral dispersion graph; the pores with radiuses varying between 1.6, 2.2, 3.6 and 6.3 nm are largely dominant.

* This definition does not prejudge the position of status in accordance with UNSC Resolution 1244 and the International Court of Justice on Kosovo's Declaration of Independence

THE ANTINEOPLASTIC EFFECT OF NANOPARTICLES OF SOME BIOGENIC METALS IN TUMOR-BEARING RATS

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Much attention in the development of new anticancer agents is given to the study of agents based on transition metals, many of which are essential ones. Since metals in nanoform possess higher biological activity, we investigated the influence of copper nanoparticles (Cu NPs), iron nanoparticles (Fe NPs) and zinc nanoparticles (Zn NPs) on the growth of transplanted tumors in rats - of sarcoma 45 (S-45) and Pliss's lymphosarcoma (Pliss). Nanoparticles with size about 20-80 nm were obtained by using plasma technology. The elemental composition, morphology and homogeneity of NPs were investigated by X-ray absorption near edge spectroscopy, scanning electron microscopy and measuring zeta potential. Fe NPs were presented in the metal form, Cu NPs - metal and oxides forms (Cu_2O and CuO), Zn NPs as ZnO. Nanoparticles suspended in physiological saline immediately before administration and the animals were injected four times a week during two weeks with a week's break intratumorally or intraperitoneally. A single dose was 1.25 mg/kg, course dose - 10 mg/kg. In control groups' rats with S-45 or Pliss received intraperitoneally 0.3 ml of saline only. Effect of NPs on tumor growth was determined by tumor size and mass, percentage inhibition of tumor growth (by volume - Tv%), index of effectiveness (IE - tumor weight of control/ tumor weight of test) and morphological changes in the tumor tissue. Introduction of Cu NPs to rats with S-45 produced a significant decrease in tumor volume and weight in the majority of experimental animals (68%) regardless of the mode of administration: in 41.0% of cases showed complete resorption of the tumor, in 27% - partial tumor regression, Tv % was 65.5%, IE - 3.31. In animals with Pliss antitumor effect was obtained in 53.0% of cases, of which almost complete resorption observed in 2/3 rats. On average, the group Tv% was 60%, IE - 2.17. In this cytostatic effect was more pronounced in the group of animals treated intratumorally: IE - 5.79, while with intraperitoneal administration - only 1.8. Introduction of Fe NPs also promoted antitumor effect: at C-45 Tv% - 49.3%, IE - 2.15; at Pliss Tv% - 66.3%, IE - 2.79 and the effect was more pronounced in intratumoral injection, Tv% reached 86.6-96.0%. Introduction of Zn NPs, on the contrary, led to 2 times increase in tumor mass in 60% of animals with C-45 and only other 40.0% showed partial tumor regression. Anti-blastic effect of nanoparticles was confirmed by morphological changes in tumor tissue - extensive tumor necrosis, low mitotic activity of cancer cells and intense infiltration of tumor by lymphocytic cells.

Thus, different models of neoplastic process demonstrated significant antitumor effect of introducing to tumor-bearing animals nanoparticles of copper or iron, which allows considering them as potential anticancer agents.

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CORE-SHELL MODELS OF NANOSTRUCTURED MATERIALS FOR MEDICAL APPLICATIONS

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In this paper we will analyze application of nanomaterials in biomedicine, that is to say we will present the recent accomplishments in basic and clinical nanomedicine. Achieving full potential of nanomedicine may be years of even decades away, however, potential advances in drug delivery, diagnosis, and development of nanotechnology-related drugs start to change the landscape of medicine. Site-specific targeted drug delivery (made possible by the availability of unique delivery platforms, such as dendrimers, nanoparticles and nanoliposomes) and personalized medicine (result of the advance in pharmacogenetics) is just a few concepts on the horizon of research. In this paper, especially, we have analyzed the changes in basic physical properties of spherical-shaped nanoparticles that can be made in several (nano)layers and have, at the same time, multiple applications in medicine.

Based on our research in ultrathin crystal structures performed so far, superlattices, Q-wires and Q-dots, we will consider the materials that can act as carriers for medicines and tagged substances. For this purpose we established a shell-model of ultrathin molecular crystals and investigated their dielectric, particularly optic characteristics. We conducted this research with the help of two-time dependent Green's function method, adjusted to ultrathin crystalline structure analysis. It is shown that specific resonant absorption lines appear in these structures, the number of which depends on crystal layers position and on values of parameters on shell-structure boundary surfaces. The absorption of electromagnetic radiation declines in infrared part and its detection is a relatively easy process.

The subject of the research in this paper includes modeling of nanomaterials in the field of pharmaceutical technology for biomedical application. This includes very precise encapsulated drug delivery, on exactly defined place in the human tissue or organ and disintegration of capsule – drug carrier, so that the medicament can start producing its effect. The goal of multidisciplinary researches with biocompatible molecular nanomaterials is to find the parameters and the possibilities to construct boundary surfaces that will, in interaction with biological environment, create such properties of nanolayers that are convenient for use for layers of drug carrier capsules, biochips and biomarkers. These layers should demonstrate controlled disintegration of structure, better dielectric properties, discrete luminescence and appropriate bioporosity as all these are the requirements of contemporary nanomedicine.

EXPERIMENTAL MODEL FOR THE STUDY OF TISSUE TOLERANCE TO RADIATIONS IN THE PRESENCE OF IMPLANTED BIOMATERIALS

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Background. Experimental studies on the radiation effects on tissue flaps and on biocompatible materials are justified by the serious problems that occur in reconstructive surgery performed in areas affected by radiotherapy. Biocompatibility improvement of the implantable products is a cutting edge research subject at an international level. A synthetic product with perfect biocompatibility has not been invented yet. Experimental research regarding the biocompatibility of synthetic materials is trying to create the possibility of using high quality materials produced locally.

Aim. The aim of our research was to establish an experimental model for the irradiation of tissular flaps in small animals, which could be appropriate for the study of tissue reactions and tolerance to radiations in the presence or absence of implanted materials.

Materials and method. A number of 31 Wistar-Bratislava rats were utilized. Commercially available surgical titan clips, pieces of silicone and modified polypropylene mesh (obtained by a new method in the Department of Materials Science and Technology, Technical University Cluj-Napoca) were used. The right *rectus abdominis* muscle sheet was opened and 2 normal titanium clips were inserted into the muscle. A piece of silicone or a piece of polypropylene mesh was placed in a subcutaneous pocket at the level of the right iliac fossa. A group of 5 rats was kept as control until the end of the experiment, whilst the other animals received postoperative radiotherapy. Irradiation was delivered using 6MeV energy electrons produced by a Siemens Primus Clinac linear accelerator, in a total dose of 25Gy/5fractions/5days. The tissular reaction to radiation in the presence of implanted materials was studied by histological evaluation.

Results. Macroscopically, the local appearance was variable, from the complete integration of the flap into the tissular defect to the complete necrosis of the fasciocutaneous and muscular flap. In most animals an intermediary aspect was found, consisting on the partial dehiscence of sutures and some degree of marginal necrosis in the transferred flaps. Microscopically, a mild inflammatory reaction with cutaneous and subcutaneous necrotic areas was noted 7 days postoperatively. At 20 days after surgery, an important proliferation of the connective tissue was noted. The muscular tissue containing the two metallic implants appears more fibrotic.

Conclusions. The tissular changes, macro- and microscopically evaluated, were variable and depended on the type of biomaterial used. We conclude that our experimental model is appropriate and can be used for the study of tissue reactions and tolerance to radiations in the presence or absence of implanted materials.

VACUUM ARC DEPOSITION OF BIOINERT COATING AND ITS PROPERTIES

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Materials used in technology and biomedical applications must comply with stringent requirements; in particular, these should possess high mechanical, chemical and biological compatibility. Operating experience suggests that stainless Cr-Ni steel has high mechanical and satisfactory chemical compatibility. However, its biological compatibility is impaired significantly due to the presence of toxic nickel. Therefore, vacuum arc deposition of bioinert coating widens the scope of applicability of the stainless Cr-Ni steel for implant manufacture. Thus TiN coating provides for biological compatibility as well as significant enhancement in surface hardness and wear resistance of implants manufactured from the stainless Cr-Ni steel. Vacuum arc deposition of TiN coatings is widely used for improving the service properties of metals. In practice, however, we have to deal with the problems of coating adhesion and continuity as well as its chemical and mechanical uniformity. The latter problems are pursued herein.

The test samples were prepared from the stainless Cr-Ni steel which had been subjected to annealing. These had 'dog-bone' shape and gauge dimensions 40×6×1 mm. The deposition of technically pure titanium coating was performed at low pressure of ionized nitrogen, using a two-step process: first the sample surface was cleaned in gas discharge argon plasma for 40 min at a pressure of $5 \cdot 10^{-4}$ Torr and at the temperature of 575 K; then argon was replaced by nitrogen and the pressure was increased to $6 \cdot 10^{-4}$ Torr. The plasma generator and the metal arc evaporator were operating simultaneously and the samples were rotated in the plasma stream at a rate of 4 rpm. Under ion bombardment the process of TiN film deposition takes up 90 min in the temperature interval 625...675 K. The deposition process over, the plasma sources are de-energized, the nitrogen is shut off, the working chamber is pumped out up to a limiting residual pressure of 10^{-5} Torr and the samples are allowed to cool down for 2 h.

Using the deposition method described above, continuous uniform coating about 2 μm thick was formed on the entire sample gauge. The coating hardness was 22...25 GPa. The coated samples were tested in uniaxial tension.

The properties of the original and coated samples were determined. The results obtained are as follows: conventional yield strength of 195±6 MPa and 193±6 MPa; ultimate strength of 593±8 MPa and 578±8 MPa and elongation at rupture of 61±1.5 % and 63±1.55 %, respectively. Within the limits of experimental error, the above values suggest that the mechanical characteristics of coated material are determined by the properties of the substrate. The coating was also found to exhibit significant elasticity. The first symptoms of imminent rupture or flaking of the coating were observed at the total deformation > 8 %. Using the methods of atomic force microscopy and double-exposure speckle photography, the processes involved in the fracture of coating by the deformation were examined in detail.

Thus, the results presented herein suggest that the vacuum arc method holds much promise, in particular, for the deposition of high-quality bioinert coatings on the stainless Cr-Ni steel.

ANTIBIOTIC-LOADED HYDROXYAPATITE AND CALCIUM SULPHATE COMPOSITE IS A POTENT BIOMATERIAL FOR ONE STAGE TREATMENT OF THE EXTENSIVE INFECTED BONE DEFECT

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In the chronic osteomyelitis local vascularisation is compromised and it is very difficult to obtain the effective local antibiotic concentration by parenteral administration. The direct delivery of an active antimicrobial agent to the site of infection represents a viable alternative treatment, particularly if the bone sequesters and defects are in case. Antibiotic-loaded hydroxyapatite and calcium sulphate (PerOssal, aap Biomaterials GmbH, Dieburg, Germany) compound is completely absorbable biomaterial able to deliver high concentration of an active antimicrobial agent directly to the site of infection. Usually infected bone defects with sequesters are treated in several stages.

The aim of this paper is to present one stage operative treatment of the extensive infected bone defect with PerOssal pallets loaded with high concentration of the specific antibiotic.

Patient is 25 years old man with 2 years old history of chronic tibia osteomyelitis and several attempts of conservative and surgical treatments. In the clinical picture skin defect exposing bone of proximal third of tibia was most striking feature. Plain x-ray revealed that the exposed bone is long bone sequester of the medial half of almost whole tibial diaphysis. In the wound swab Methicyline resistant Staphylococcus aureus (MRSA) was found.

In one stage, surgery excision of the sequester and debridement and curettage of the bone defect were done. The defect was filled with 100 pellets of PerOssal loaded with 8ml of Vancomycine (250mg/ml). The skin defect was covered with local graft. Parenteral antibiotics were administrated in the following month. The remnant bone continuity was secured with unilateral external fixator.

Two weeks after the surgery there were no local signs of infection. High values of the infection tests were significantly reduced in the same period. After 6 months new bone formation was good enough to permit removal of the fixator. Walking boot was used in next 5 months and full weight bearing was allowed. PerOssal pellets were visible on the plain x-ray even 3 months after the operation, but after 6 months they were completely resorbed.

This patient is a good example of the efficient way to treat extensive septic bone defect with local administration of very high concentration of specific antibiotic. High concentration is achieved due to the technological characteristics of PerOssal pellets. This and the fact that the PerOssal is completely absorbable made this biomaterial a very potent weapon against the most resistant infections and even in one stage surgery. The osteoinductive and osteoconductive effects of PerOssal are additional contribution when the extensive bone defect is in case.

INFLUENCE OF GAMMA RADIATION ON PHYSICAL AND CHEMICAL PROPERTIES OF RADIATION SEWED ON THE ION-EXCHANGE POLYMER HYDROGELS

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The paper is devoted to the analysis of the total absorbed dose of radiation on the content of the gel-fraction in the ion-exchange polymer hydrogels in order to achieve high degrees of conversion of monomers that provide biological inertness of materials. Ion-exchange polymer hydrogels in the form of a contact lens are designed for the use in ophthalmology for the treatment of chemical burns and infectious diseases of the eye.

The content of the gel-fraction in the ion-exchange polymer hydrogels synthesized under the influence of different absorbed doses (25, 30, 35, 40 kGy) of ionizing radiation had been analysed.

The effect of the total absorbed dose of the radiation to water content and strength characteristics of ion-exchange polymer hydrogels were analysed.

The study determined the absorbed dose of γ-radiation in the radiation polymerization of ion-exchange hydrogel in which the maximum reached value of the content of gel fraction did not affect its exploitation properties. The comparison of all results allows us to consider the optimal absorbed dose of γ-radiation 35 kGy with radiation synthesis of polymeric ion-exchange hydrogels.

THE BI-SUBSTITUTED HYDROXYAPATITE AS RADIO-OPAQUE MATERIAL

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In dental and orthopedic applications, radio-opaque materials may be used as fillers in the composition of the biocement paste in order to enhance absorption of X-rays, and therefore for improving the visibility of the cement under X-ray examination. Radio-opacity is important for the uses of cements in dental filling and dental sealing.

This study relates to a new apatite material which is biocompatible and exhibits radio-opacity enhancing its utility in the dental and medical fields. In this work, we present the preparation of bismuth-substituted hydroxyapatite by means of wet chemical method, respectively by co-precipitation reactions. The effects of the bismuth substitution for calcium on the morphology and optical proprieties of the resulting powders were investigated and discussed.

BIOMEDICAL ENGINEERING

03

TREATMENT OF BULLOUS KERATOPATHY USING TRACK MEMBRANES - EXPERIMENTAL STUDY

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The bullous keratopathy of eye is a disease of the cornea associated with the violation of the integrity of the endothelial cell layer.

The problem of treating bullous keratopathy is a serious problem in the Russian Federation.

The purpose of the research is the study the possibility of using the track membrane in the surgical treatment of bullous keratopathy.

Technique of producing porous track structures based on high-energy irradiation of different polymers by heavy ions, which induce latent narrow tracks through the entire thickness of the polymer material. Characteristics of the original membranes were determined using a number of complementary methods. The density and pore sizes were controlled with an electron microscope Hitachi TM – 1000. A pore diameter was 0.4 μm. A density was $5 \cdot 10^6$ pores / cm^2.

A contact angle of the surface wettability of Θ track membrane was measured.

Series of experiments were carried out on 8 Chinchilla's rabbits. The implantation of the track membrane with a diameter of 10.0 mm was done 3 weeks after corneal damage. Eyes of rabbits were enucleated 5 weeks after implantation of the track membranes. The resulting material was fixed for light microscopy. In experimental studies, it was found that the implantation of track membranes occurs without implant rejection and contributes to the stabilization of the pathological process in the cornea. This method of surgical treatment of bullous keratopathy can be recommended for testing in a clinical practice.

RED BLOOD CELLS SHAPES AND DYNAMICS IN THE MICROVASCULATURE

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Red blood cells (RBCs) carry oxygen from the lungs and deliver it through the microvasculature. The shape adopted by RBCs in the microvasculature can affect blood flow and influence oxygen delivery. The mechanism determining the shape, and therefore the hydrodynamics, of RBCs from among many possibilities is a long-standing puzzle in blood microcirculation research. A powerful numerical simulation, combined with general physical concepts, provides here a solution to this unique yet basic question. The reported results reveal unexpected complexity. In sufficiently large vessels (arterioles), a slipper-like (asymmetric) shape prevails. A parachute-like (symmetric) shape is adopted in smaller vessels (venules), but this shape loses stability and again changes to a pronounced slipper-like morphology in capillaries. The stable slipper shape moves faster than the parachute shape, offering more efficient blood flow. The slipper is shown to favor internal fluid mixing, resulting in oxygen and ATP availability at the membrane, enabling their rapid release. Stiff red RBCs, such as those infected with malaria, adopt snake-like locomotion instead, the only alternative to efficiently flow within the microvasculature, but at a certain price: the internal fluid mixing is low. A general scenario of how and why do healthy and pathological cells adopt their morphologies and dynamics among several distinct possibilities is provided and explained. This finding offers new insight into blood cell dynamics, and the present results may be used to guide ongoing research of physiological flows to identify the relationships between cell shape and dynamics, cell diseases, blood flow, and oxygen supply.

THE SPECIFIC DECISION SUPPORT SYSTEMS IN RADIOLOGY

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A set of activities which improve the health system in one country, at the macro and micro level is determined by a number of factors, with the main objective to promote, restore and maintain the health of each individual. One of the factors is to monitor trends and new technological developments in medicine, which is reconciled with the needs and real possibilities. Today it is considered that the number of systems for magnetic resonance imaging (MRI), in relation to the number of population indicates the development of the health system in one country. According to this parameter, Serbia is lagging behind developed countries. Financial capacities are not sufficient and not primarily directed towards solving this problem. Partial improvement of such situation can be found in the effective engagement of existing systems. This could have a positive effect in terms of greater availability of existing diagnostic methods and fulfil the users growing needs. Starting from this position, in this case study, it is analyzed the work of the Centre for MRI within the Railway Health Institute in Belgrade from 2005 to 2012. The starting point is the possibility of improving the work, increasing the number of services provided and innovation modes using decision support systems. Decision support system (DSS) is an additional tool for medical specialists, ensuring optimal use of the MRI and the shorter time for right diagnosis. This case study shows multidisciplinary approach for solving different problems, with emphasis on the achievements and possibilities of modern bioengineering.

Objectives and hypotheses

General objectives

1) Analysis of decision support systems in radiology
2) Introduction and development of the new tool (DSS) for achieving optimal results and effectiveness

Special goals

1) Analysis of the current possibilities of DSS;
2) Practical implementation of DSS in the MRI.

General hypothesis

1) The development and implementation of DSS presupposes an analysis of existing DSS, identify the optimal system for the selected MRI and define the way for the implementation of the optimal system.

Special hypothesis

1) DSS have an increasing impact in medicine, particularly in the diagnostic branches;
2) Successful modelling and implementation of a new DSS assumes a multidisciplinary approach and a good knowledge of user's needs.

Methodology

· Analysis of existing systems for decision-making support and achievements in different areas of medicine;
· The main principles of magnetic resonance imaging in clinical conditions;
· Analysis of services provided from 2005 until 2012 comparing to optimal use of the MRI (according to one referral diagnosis-cephalea);
· Proposal for overcoming the existing problems through modeling DSS for the selection of precise diagnosis methods.

Keywords: decision support system, magnetic resonance imaging

COMPARISON OF ECL AND ELISA EUROIMMUN FOR DETECTION OF CYTOMEGALOVIRUS IGM ANTIBODIES

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Cytomegalovirus is a herpes virus transmitted by close human contact. No symptoms of infection are apparent in majority of cases. However, congenital Cytomegalovirus (CMV) infection is the most common intrauterine viral infection. The majority of fetus infection cases are asymptomatic, but a few may develop late sequelae, such as sensorineuronal hearing loss or chorioretinitis. The purpose of the present study was to compare ECl and ELISA EUROIMMUN immunoassays for detection of anti-Cytomegalovirus IgM antibodies in pregnant women and to evaluate the sensitivity and specificity of each technique. 200 pregnant women were involved in this study and serum samples were analyzed with both techniques including 150 negative and 50 positive samples for anti-cytomegalovirus IgM antibodies. The ECL immunoassay resulted with higher sensitivity and lower specificity of 98% and 98.7%, respectively, while ELISA immunoassay resulted with lower sensitivity and higher specificity of 93.9% and 99.3%, respectively. The evaluation of the results (ANOVA; $F_{0.05[1.398]} = 0.432$,$p = 0.512$) showed a very good concordance between the two immunoassays ($r=0.873$) for early diagnosis of cytomegalovirus infections in pregnant women.

CHALLENGES IN THE APPLICATION OF BIOMEDICAL ENGINEERING TECHNIQUES INTO THE LOCAL MEDICAL FACILITIES

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The biomedical engineering is a young scientific discipline gaining tremendous expansion in the recent years thanks to appearing of the innovative instruments which combine: data defined by the international standards, procedures of testing, precision measuring instruments and the information data exchange tools. The use of these devices has opened a field of infinite possibilities for optimization in maintenance and operation of the equipment in medicine. In this paper it is shown where are the hidden opportunities for better and cost effective routines in health care institutions in our environment and where the challenges are inherent to the introduction of these innovative techniques. The two illustrative practical examples in this paper, points out the space for the introduction of optimization methods and the difficulties encountered in this mission. The electrical safety testing of vital signs monitors and the preventative maintenance of defibrillators in accordance to international standards are examples which bring us to the conclusion that the use of biomedical techniques in local medical facilities still suffers in its infancy and that serious steps in this direction we have to expect only in the future.

ESSAY ON THE FUTURE OF PHYSICS AND SCANNING TECHNOLOGIES: LIMITS BY FOUR FUNDAMENTAL FORCES AND QUANTUM MECHANICS

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The success of first generation of brain scans has been fantastic and spectacular. Just a small number of regions were known before. Now NMR machine opening up new frontiers for brain science. To understand the reasons why this radical new technology which offered window into the brain helped to decode thinking brain we have to turn our attention to basic principle of physics and that is the subject of the introduction of this article. Another question is what the future of physics is, or in another words, what the technology limits set down by the law of physics are; the scientific quest to enhance and empower the mind and technology. With so many new scanning technologies being introduced from physics just within the last fifteen years, one might wonder: are there any more? The answer is, yes, but they will be variations and refinements of the previous one, a new way of looking at something that brings to light an entirely new perspective, but not radically new technologies. This is because there are only four fundamental forces in nature: gravitational, electromagnetic, weak nuclear and strong nuclear. Furthermore, the quantum mechanics which rule the transistors set another limits to electronic power and computation. At present, the electromagnetic force is the source of almost all scanning technology except PET scan which is governed by the weak nuclear force. However, NMR size and access to people raises intriguing questions: will MRI machine fit soon into cell phone? What is the future of “hyper modal" imaging technologies that merging the results of multiple modalities (computed tomography (CT) scanning, positron emission tomography (PET) scanning, photoacoustic imaging, upconversion imaging and Cerenkov luminescence imaging)? How close we are to the artificial mind and silicon consciousness? Designing and fabricating miniaturized (lab-on-a-chip) devices is extremely challenging, but physicists and engineers are beginning to construct highly integrated and compact labs on chips with exciting functionality. Another question, which is highlighted these days, is the future of reverse engineering the brain. This article shows that no matter how spectacular the success of the past twenty years, they were just taste of the future.

BIOMEDICINE

04

STUDY OF RESPIRATION, ION TRANSPORT AND OXIDATIVE PROCESSES OF RAT BRAIN AND LIVER MITOCHONDRIA IN EXPERIMENTAL EPILEPSY

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Epilepsy is characterized by a decrease in the membrane potential of the cell and an increase in the extracellular concentration of potassium ions. The mechanism of epileptic seizures appearance is not yet clear, and investigation of the energy and ion, especially K^+, exchange in the tissues in epilepsy is very actual. In our research three groups of animals was used: 1 - rat Krushinsky Molodkina (KM), which is highly susceptible to convulsive seizures in response to sound; 2 - KM rats that 2 days before the experiment were subjected to acoustic stress; 3 - control rat. These animals were studied in order to examine the following parameters, which are important for the function of rat brain and liver mitochondria: respiratory rate and intensity of oxidative phosphorylation, the rate of transport of K^+ ions, potassium capacity, and the amount of hydrogen peroxide. It was found that the respiratory rate of rat brain mitochondria from KM rats was 20-25% less than control. The changes were found in the 2nd and 3rd regions of the respiratory chain, and only in KM animal exposed to acoustic stress prior to measurements. In liver mitochondria changes in respiration were observed in all parts of the respiratory chain of both groups KM rats. The rates of potassium ion uptake in the mitochondria of both brain and liver of all KM rat groups were decreased compared with control animals (average 20-30%). The amount of potassium in brain mitochondria was slightly reduced and statistically increased in brain mitochondria. The amount of hydrogen peroxide, estimated by malonic dialdehyde, was higher in brain and liver mitochondria of KM rats exposed to acoustic stress than in KM and control rats. The mitochondrial Ca^{2+} capacity, defined as amount of accumulated calcium ions, is reduced in brain and liver mitochondria of KM rats after preliminary sound exposure, indicating an increase of the probability of opening of Ca^{2+}-dependent cyclosporin A (CsA)-sensitive pore (mitochondrial permeability transition pore, MPT) in mitochondria of these animals compared to intact ones. At the same time, the differences in the parameters of functioning of the CsA-insensitive palmitate/Ca^{2+} -induced pore in brain and liver mitochondria of the animals before and after sound exposure have not been revealed. Based on the data obtained, the role of mitochondrial potassium channels and pores in disturbance of cell potassium and calcium homeostasis under autogenic epilepsy is discussed.

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A COMPARATIVE ASSESSMENT OF THE EFFECTS OF DMSA, MONENSIN AND SALINOMYCIN ON LEAD-INDUCED HEPATOTOXICITY IN MICE, SUBJECTED TO SUBACUTE LEAD INTOXICATION

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Lead (Pb) is one of the most toxic environmental pollutants. Its ion accumulates primarily in the liver, kidneys, bones, spleen, brain. Exposure to Pb induces liver damage by altering the activity of hepatic enzymes and enhancing lipid peroxidation. The present study is focused on the effects of DMSA (2,3 dimercaptosuccinic acid) and the polyether ionophorous antibiotics monensin and salinomycin as possible chelating agents for the treatment of Pb intoxication. Mature ICR male mice were divided into five groups of eight animals in each as follows: control group (no treatment); Pb-treated group (subjected to treatment with 80 mg/kg b.w. Pb nitrate from the 1st to 14th days of the experimental protocol); Pb+DMSA group - treated with 20 mg/kg b.w. DMSA; Pb+Mon - received 20 mg/kg b.w. monensin salt; Pb+Sal - administrated 20 mg/kg b.w. salinomycin salt. All compounds were applied orally, dissolved in the drinking (distilled) water. The chelating agents were administrated from the 15th to 28th days of the experimental protocol after the Pb-intoxication. On the 29th day of the experimental protocol all animals were sacrificed under light ether anesthesia and the liver samples were excised and prepared for hystopathological analysis. The data demonstrated that subacute intoxication of mature male mice with Pb nitrate increased significantly liver index (LI) compared to the untreated controls. Treatment with DMSA, monensin and/or salinomycin reduced LI although it remained higher than in the control group. The index decreased after detoxification in the order: DMSA>salinomycin>monensin. The lowest LI was observed in the group treated with monensin following the intoxication. Exposure to Pb induced anisokaryosis and binucleation in the hepatocytes, Kuppfer cell hyperplasia and abundant number of apoptotic bodies. Treatment with monensin improved significantly liver morphology as well. Surprisingly the effect of DMSA was less beneficial. The results suggest that the ionophorous antibiotics monensin and salinomycin could be potential chelating agents for the treatment of subacute Pb intoxication.

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BIOALLERGENS AND BLEEDING IN PREGNANCY

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Background. Biological agents in indoor air are known to cause three types of human diseases: infections, hypersensitivity diseases and toxics. During pregnancy, the mother and her body appeared many pollutants from the environment, including the biological agents. The effect of biological agents should be viewed through negative pregnancy outcomes such as spontaneous abortion, premature birth, and anomalies in the newborn.

Aim. The aim of our paper was to investigate the association between exposure to bioallergens from pets and bleeding in pregnancy.

Method. The subjects were 356 non-smoker pregnant women, without atopic constitution, divided into two groups (exposed and control) on the basis of the exposure to pet allergens. Women were not professionally exposed to harmful materials and influence of combustion products (wood and coal heating) in their home. Assessment of exposure to pet allergens was done by using the original questionnaire. Training physicians have filled out a questionnaire in directly interview with women. Investigation was done during the six months (since January to June 2011). In addition to questions about demographic characteristics, the second part of questionnaire consisted of the questions about the pets. For this analysis the following questions from the initial questionnaire were used: “Have you got any pets in home?”," Which of the pets do you keep in your home and how many? ",“How long do you got pets in home?”. Data on pregnancy were collected on the basis of physical examinations, fetal ultrasounds and hospital registrations. All the collected data were taken in and done in software system. All women were divided in a group of exposed to pet allergens and a group of non-exposed. In both of them, prevalence of bleeding in pregnancy was analysed. Interview data were analysed using programmes Epiinfo 6 and Microsoft excel. Statistical significance of difference is established by χ^2 – test.

Results. In a sample of this investigation, the exposed group comprised 184 pregnant women, average age 31.25 ± 5.07 and the control group included 172 pregnant women, average age 27.73± 4.76. Out of the total number of studied women exposed to pet allergens, 46.19% kept cats.152 (82.61%) subjects kept only one pet. The period of keeping pets for most of women (71.19%) was longer than one year. About 52.72% women kept their pets in bedroom. Chi-square test (χ^2=4.62,p<0.05) confirmed that there was a significant difference in the frequency of bleeding in pregnant women exposed to pets allergens, when compared to those who were not exposed to same allergens. The values of relative risk were more than 1 (RR =1.64; 95% CI:1.12-3.85).

Conclusion. There is a risk of bleeding in pregnancy with exposure to pets allergens which statistically insignificant. However, further study is needed to disentangle this interaction and the underlying mechanisms.

Key words: women, pets, pregnancy, bleeding, indoor air pollution.

NUTRITIVE PROTECTION OF OCULAR PHOTOTOXICITY

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Besides well-known positive effects of light on numerous processes in nature, exposure to light can also degrade human health. Human eye is one of the organs that is constantly exposed to natural and artificial light with the ability to transform light sensation to well-defined visual picture. Since light exerts certain phototoxic potential, ocular tissue evolved various defensive mechanisms as a protection from phototoxic injuries. The major defensive mechanisms in the eye include antioxidant enzymes and antioxidants that have role in protection from the oxidative and inflammatory processes. Since most of the protective substances are of the dietary origin new research is focused on the nutritive strategies in the eye health protection. Since the eye is a major sensory organ it requires special nutritive care for healthy and optimal functioning. Nutrients that are found in common food, like oranges, green leafy vegetables or salmon, can have a significant positive effect on eye health. Vitamins, minerals and antioxidants are the key food ingredients which are structural elements of the eye cells, and maintain normal eye function and improve eyesight. Among them the most important are omega-3 fatty acids, particularly docosahexaenoic acid and carotenoids vitamin A and its provitamins, and xanthophylls (lutein and zeaxanthin). Vitamin A is a structural component of visual pigments of rods and cones in retina, docosahexaenoic acid is the major structural lipid of retinal photoreceptor outer segment membranes, and lutein and zeaxanthin are found in the yellow spot of the human retina and they are also known as the macular pigments. Advances in nutritional supplementation and recent positive effects that the intake of these nutrients showed in several studies of cataract and age-related macular degeneration may help in reducing the phototoxic effects of light to the ocular tissues.

THE IMPORTANCE OF NUTRITION IN CANCER PATIENTS UNDERGOING RADIOTHERAPY

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Ionizing radiation is commonly used to treat a number of malignancies, but many patients suffer side effects. Radiation enteritis continues to be a major health concern in recipients of radiation therapy and can present as either an acute or chronic symptoms which affect quality of life due to permanent changes in the small and large intestine. Also the changes that result from cancer radiotherapy led to reductions in dietary intake and negatively affected body composition measures. Nutrition intervention is an attractive option for the prevention and management of symptoms in patients undergoing radiotherapy. The purpose of this review is to provide an opinion on the nutritional intervention in cancer patients undergoing radiotherapy based on the most recent available evidence.

Methods: A critical literature review of relevant original studies was performed using a specific set of mesh terms in MEDLINE and EMBASE databases in September 2014. Full texts of all relevant articles were collected and reference lists were checked.

Results: In patients with cancer undergoing radiotherapy, there is strong evidence that nutrition counseling increases dietary intake, body weight, nutritional status and quality of life with some suggestion that dietary counseling may improve nutrition impact symptoms, treatment response and survival. The use of n-3 polyunsaturated fatty acids may have some positive effects in patients with cancer; however, clinical judgment and care need to be taken in its application. Preliminary results of studies in the use of L-carnitine in improving fatigue are promising; however, the largest trial in 'healthy' cancer patients showed no benefit. There have been benefits demonstrated with dietary modification during pelvic radiotherapy to reduce diarrhoea. Those diets included single interventions or combinations of modified fat, lactose-restriction, fat-restriction and fiber supplementation. Evidence for probiotics as prophylactic interventions was more promising, but dose, strains and methodologies varied. For some patients, tube feeding is required to minimize weight loss during treatment.

Conclusion: This review shows beneficial effects of individualized dietary counseling on nutritional status and quality of life, compared to no counseling or standard nutritional advice. Effects of tube feeding were inconsistent. Early and intensive nutritional intervention appears beneficial in terms of minimizing weight loss, deterioration in nutritional status, global quality of life and physical function in oncology outpatients receiving radiotherapy.

ON THE APPLICATION OF PHOTOACOUSTIC METHODS FOR *IN-VIVO* EVALUATION OF THE PROPERTIES OF BIOLOGICAL TISSUES

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The application of photoacoustic methods in studying physical properties of biological tissues and their relation to physiology and morphology parameters have been reviewed. The advantages and limitations of the photoacoustic techniques, compared to conventional biomedical techniques, have been discussed. The improvement of inverse theoretical evaluation of tissue properties, based on our generalized theoretical models of photoacoustic effect, has been presented.

HUMAN GPI-LINKED GLYCOPROTEIN *ACA* AND ITS ROLE IN PROMOTING SELF-RENEWAL AND EXPANSION OF PRIMITIVE HUMAN HAEMATOPOIETIC STEM CELLS

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Haematopoiesis and development of human haematopoietic stem cells (HSC) are the key role to improve efficient expansion for the transplantations. Successful immune reconstitution with HSC is highly dependent on the number of $CD34^+$ cells transplanted/kg body weight. However, BM and especially single UCB extraction provide insufficient numbers of $CD34^+$ cells for adult transplantation, often requiring the pooling of multiple cord samples to obtain the optimal cell dose for full reconstitution. Complications related to the use of pooled samples include the possibility of graft-versus-graft or multiple graft-versus-host reactions and unpredictable reconstitution of each sample.

We report here that activation of human GPI-linked glycoprotein ACA at the surface of human peripheral blood (PB) progenitor cells via PLCγ /IPI3K/Akt promotes self-renewal and generation of primitive HSCs.

Pre-clinical studies reveal, that starting with as little as 40 ml PB, averagely 2-6 $x10^6$ progenitor / HSCs ($CD34^+$) cells could be generated, resulting in 63,6 -192 fold increase of these cells compared with the number of these cells that circulate in PB. Evidently, a larger volume of PB, as used in a clinical routine, would give a far greater yield of HSCs. Using xeno-transplantation assay in immunocompromised (NSG) mice, ACA-generated self-renewing cells show long-term multi-lineage repopulation activity in primary and secondary recipients, including T-and natural killer cells.

Unmanipulated, steady-state peripheral blood as the strictly autologous source for generation and expansion of early primitive HSCs with long-term functional capacity is an easily accessible and practically infinite source of cells which could circumvent the most confiding limitations of HSCs transplantation, insufficient number of CD34 (CB) or availability of appropriate donor (BM). Accessibility of PB as well as generation and amplification of $CD34^+$ cells by ACA method warrants the major problem in transplantation medicine to be solved.

Biography: Dr. Becker-Kojić has Bachelor in Chemistry at University of Belgrade, earned Ph.D. at University of Heidelberg, Germany. During her carrier Dr. Becker-Kojić had held a senior research positions at the University of Heidelberg, University of New York, USA, Centro de Investigacion Principe Felipe, Valencia Spain, as well as teaching position at Mannheim University of Applied Science, Germany. She holds various international Patents related to Novel Human GPI-linked Protein ACA and its role in the regulation of self-renewal from adult to embryonic human stem cells. Currently, she is Co-founder and the leading scientists at R&D Centre for Autologous Adult Stem Cell Therapies Heidelberg Germany.

ANTIOXIDANT ENZYMES IN WOMEN WITH HYPERPLASIA COMPLEX: RELATION WITH SEX HORMONES

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Hyperplasia complex is a non-physiological process comprising endometrium, an inner layer of human uterus. According to WHO (World Health Organization) classification, hyperplasia complex could be with atypical cytology or without atypia. The main features of this condition are morphological irregularities in endometrium caused by changes in the glands shape and size. There is a strong relationship between endometrial hyperplasia and endometrial carcinoma. Endometrial tissue is under a strong influence of sexual hormones and its exposure to an excessive amount of estrogen unopposed by progesterone leads to abnormal proliferation.

Reactive oxygen species (ROS) are produced during cell physiological activity. When ROS production overcomes the antioxidant (AO) capacity of the cell, the result is oxidative stress, which may lead to different pathological conditions such as cancer. AO enzymes superoxide dismutase (SOD), catalase (CAT) glutathione peroxidase (GPx) and glutathione reductase (GR) have an essential role in preventing oxidative damage in cell caused by ROS. The AO status and hormone influence were previously studied during the menstrual cycle and postmenopause in healthy women and in those with certain gynaecological disorders. In this study, we examined the AO status in menstrual cycle and postmenopause of women with endometrial hyperplasia complex as well as the relationship between sex hormones and AO parameters. The material consisted of endometrial tissue specimens. Hormonal status (FSH, LH, estradiol and progesterone) was determined and assays for AO enzymes and lipid hydroperoxides level (LOOH) were performed.

The examined menstrual phase-related parameters in hyperplastic tissue showed significant changes of GPx and GR activity, with similar activity pattern, which was different than in healthy women. Their activity was higher in follicular phase compared to luteal phase and postmenopause. The phase-related activity of SOD and CAT as well as the LOOH level did not show any statistical difference. The linear regression analysis of individual hormonal variables against antioxidant parameters showed a significant negative correlation between FSH/LH concentrations and GPx activity. The exact role of gonadotropins under pathological conditions is still not clarified and it may be very important in the etiology of various gynecologic disorders, including hyperplastic changes and endometrial cancer.

Endometrial hyperplasias are generally considered as precancerous lesions and are commonly treated by various forms of non-surgical therapy-primarily hormonal, but in many cases, by radiation therapy. Since the effects of these therapies are associated with antioxidant and hormonal changes in target tissue, we believe that the presented results can contribute to the prediction of potential therapeutic efficacy and to selection the most effective treatment for the hyperplasia complex.

INVESTIGATION OF BROCCOLI EXTRACT AS A NEW PROTECTIVE STRATEGY AGAINST TOXIC EFFECT OF STANNOUS DICHLORIDE ($SNCL_2$)

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In nuclear medicine, the most widely used radionuclide is Technetium-99m (^{99m}Tc) because of its favorable physical and chemical characteristics. When preparing ^{99m}Tc radiopharmaceuticals, the presence of a reducing agent is needed. For this purpose, the most commonly used reducing agent is stannous dichloride ($SnCl_2$). Unfortunately, $SnCl_2$ have genotoxic and cytotoxic effects on biological systems. In the literature it is reported that there are some herbal extracts which would reduce genotoxic and cytotoxic effects of $SnCl_2$.

Broccoli (*Brassica oleracea Italica*) from the *Brassicaceae* family is a nutrient source which contains many bioactive components including glucosinolates, flavonoids, minerals and antioxidants. Broccoli is grown in Mediterranean region, South-Western Europe and Southern England and also in Turkey and is consumed in almost every region of the world.

In the present study, broccoli extract was investigated as a new protective strategy against the toxic effect of stannous dichloride. With this purpose, we have evaluated the effect of the broccoli extract on the survival of E. coli ATCC 25922 strain against to toxic effect of $SnCl_2$. In line with our goal, E.coli was treated with three stock solutions [i. $SnCl_2$, ii. Extract + $SnCl_2$ and iii. Extract (as control group)]. According to our results, broccoli extract has significant protective effect against toxicity of $SnCl_2$ on the E. coli.

The consumption of broccoli may alter the stannous dichloride toxicity. Broccoli extract should be used as a new protective strategy against toxic effect of $SnCl_2$ on patients who taken ^{99m}Tc radiopharmaceuticals.

ANALYSIS OF THE INTRACELLULAR MOLECULES EXPRESSION AS COMPARED TO CONVENTIONAL CHROMIUM RELEASE ASSAY FOR EVALUATION OF NK CYTOTOXICITY

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Human natural killer (NK) cells are an important subpopulation of the innate immune system. Functionally, NK cells are able to lyse transformed, infected, and allogeneic cells without prior sensitization or MHC restriction, and play an important role in antitumor immune defense. NK cells have the ability to kill target cells by two molecular mechanisms of cellular cytotoxicity; secretory and non-secretory. For estimation effectors' function of NK cells, many assays where used in last decade. Commonly used assay is based on determination of ^{51}Cr release from target cells. It is based upon the passive internalization and binding of ^{51}Cr from sodium chromate by target cells and release during target death. This assay is proposed to be a golden standard for many years. In our research we compared classical chromium release assay with newer assays based on analysis of the intracellular molecules expression by Flow cytometry. Here we also discussed advantage and disadvantage usage of the other assays in estimation of NK cell function. Non- radioactive, non- toxic assay is based on release intracellular LDH enzyme trough damaged cell membrane of target cells and this assay in frequently used in last period. The most popular approaches are also based on detection of caspase activation; annexin V binding to the apoptotic cells or uptake of propidium iodine (PI) by dead target cells. Flow cytometry assay is based on principle usage of monoclonal antibodies that labeled several molecules involved during death process in target cells. Flow cytometry for NK cell has been successfully used for measured: a) binding of NK cells to targets and b) NK cell-mediated cytotoxicity. Using anti-CD107 antibodies that binding any effectors cell that is expressing CD107 due to degranulation is also appropriated assay for estimation NK cell function and we report results using this assay. So, using different assays and newer visualization techniques, we can better understanding complex molecular mechanism involved in cytotoxic activity of NK cells, since this cell subpopultion have an important role in innate immune system.

THE USAGE OF RADIOPHARMACEUTICALS IN CANCER BIOMARKERS

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Clinical Pharmacology tends to find the best way to efficient personalized therapy. Biomarkers are the future of medical science to detect disease and find the most efficient therapy option, in personalized medicine way.

The cancers incidence is continuing to rise and reach an estimated 9.2 million deaths in 2015 globally. In Serbia separately, the rising trend is more drastically.

Cancer biomarkers significance is in cancer diagnosis, following clinical disease status, therapy option and health status in general. Biomarkers can be detected in all human mediums - blood, saliva, urine, tissue samples, etc. RIA methods have advantage because of their precision, sensitivity, specific features and reproduction.

In this paper authors present 3 biomarkers case reports - RIA compared with other biochemical methods. Because of patients co-morbidity, eating habits, drugs used, some results could be wrong interpreted and clinical treatment done by mistake. Authors discuss the advantages and disadvantages of different laboratory biomarkers methods, and suggest the interpretation of the results in connection of further medical action.

Authors suggest RIA methods for cancer biomarkers, for clinical practice and research as well. The special chance is in personalized clinical pharmacology.

RADIOMETRIC DETERMINATION OF THYROTOXIC EFFECTS OF SOME XENOBIOTICS

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In contrast to iodine, which forms an irreplaceable part of thyroid hormones (TH) and is one of the essential substances inevitable for the proper development of young mammals, in case of similar halogen bromine, there is not enough information available on its biological function. Recently, we have shown [Pavelka S., *J. Radioanal. Nucl. Chem.* 291 (2012) 405-408] in the isolated rat thyroids marked effects of excessive exogenous bromide and perchlorate ions on the activity of the key enzyme in TH metabolism, on thyroid peroxidase (TPO).

Here, we studied in more details, with the aid of several radioanalytical methods, effects of an enhanced bromide and/or perchlorate intake on various aspects of iodine metabolism and, consequently, on TH metabolism in the rat. Presumed goitrogenic and thyrotoxic effects of excessive bromide and perchlorate ions were followed in adult male rats, as well as in lactating rat dams (and their breast-fed pups), maintained on diets with various iodine content, ensuring either sufficient iodine supply or mild to severe iodine deficiency. The animals were administered subchronically (for 7 to 56 days, in drinking water) with bromide alone or in combination with perchlorate.

In rats administered with these xenobiotics we measured a consistent increase in relative weight of the thyroids with increasing time and concentration of applied bromide, and a sharp reduction of the 24-h uptake of [^{131}I]-iodide by their thyroids. In these animals, we also determined a steady decline in serum total thyroxine concentration. Moreover, excessive bromide in the mothers substantially depressed the extent of [^{131}I]-iodine transfer from the dams through mother's milk to the suckling. As a consequence, a marked decline in the body weight increments of afflicted pups, in comparison with the young from mothers kept on a low bromide intake was observed. We have also confirmed the earlier observation that bromide toxicity is dependent on the state of iodine supply into the organism. Hypothyroidism in experimental animals caused by excessive bromide intake was more pronounced under the conditions of iodine deficiency.

At the molecular level, we found, unexpectedly, that the influence of exogenous bromide on the TPO enzyme activity in the rat thyroids was not simply inhibitory. It was more complex, biphasic with regard to the extent of bromide intake in the animals. Interestingly, perchlorate administered chronically in even higher amounts than bromide caused in all cases elevation of the TPO activity.

In conclusion, the presumed thyrotoxic effects of xenobiotics bromide and perchlorate ions have been confirmed and quantified.

RELATION OF ELEMENTS IN HUMAN HAIR WITH HEALTH STATUS

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It is commonly known that the elemental status of human body changes with changes of physiological status e.g. in some diseases. There are many studies which detected specific changes of elemental composition of human tissues and liquids. In this respect human hair is very significant tissue beside other ones. The last decade studies discovered specific and statistically significant changes of hair elemental composition in some diseases (especially if multielemental relations are considered). It was shown that these changes could be detected in some cases 1 - 1.5 years earlier then the classical diagnostic indications. Comparing the data for groups with various diagnoses with hair composition and comparing medical statistic data with hair composition on population level we tried to elaborate criteria for detection of samples belonging to the groups of risk. In order to justify assumptions made on the base of hair composition we collected 150 samples from inhabitants of two different cities. These samples were analyzed for 24 elements using instrumental neutron activation analysis. The data obtained were grouped according to previously elaborated criteria for detection of certain groups of risk. Then, we have compared our assumptions with medical record for each person and results of personal interview. In most cases the reliability of elaborated procedure was very high (93% for kidney diseases, close to 100% for thyroid gland and nervous system diseases, diabetes, malignant neoplasm, 90% for anemia). In gastro-intestinal diseases the reliability was low (less than 50%), probably because the selenium (which is one of the elements used in this case) is elevated in all population. The preliminary data evidence once again that the hair elemental composition can be used in medical (diagnostic) purposes. Because of simplicity and productivity of the proposed procedure this approach could be very fruitful in routine screening of human health on the level of populations.

CYTOTOXIC EFFECT OF PHOTOEXCITED FULLERENE C_{60} NANOSTRUCTURE IN LEUKEMIC CELLS

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Nowadays searching for a new nanoscale chemically inert compounds that would selectively impair tumor and would not affect normal cells is a very important task in biology. Recent progress in nanobiotechnology has a raised interest in biomedical application of a new class of nanostructures made exclusively of carbon atoms - fullerenes C_{60}, spherically-shaped molecules (0.72 nm in diameter), which are nontoxic and demonstrate unique physicochemical properties. Small size of lipophilic C_{60} molecule account for steric compatibility with biological molecules and promote accommodation inside hydrophobic regions of membranes. Due to extended π-conjugated system of molecular orbitals fullerene C_{60} absorb UV/Vis light efficiently, its unique property is the ability to shift to long-lived triplet state under light irradiation and to generate cytotoxic reactive oxygen species (ROS) with almost 100% quantum yield. The most apparently predominant mechanism of ROS generation after C_{60} illumination in biological systems is electron transfer from reduced fullerene triplet or radical anion to molecular oxygen forming superoxide anion radical ($^3C_{60}^* \rightarrow C_{60}^{\cdot-} \rightarrow C_{60} + O_2^{\cdot-}$). This pathway of ROS generation is more effective for $O_2^{\cdot-}$ dismutation to hydrogen peroxide and further formation of hydroxyl radical, the most reactive and cytotoxic of all ROS. The ability of a photoexcited molecule to produce ROS opens the perspective to use fullerene C_{60} for mediating cytotoxic effect on cancer cells. The aim of the study was to estimate the effect of fullerene C_{60} after UV/Vis irradiation on viability of normal (Wistar rats thymocytes) and oncotransformed (murine leukemia L1210 and human lymphoma Jurkat cell lines) lymphoid cells, intracellular ROS production and concentration of free cytosolic Ca^{2+}. Fullerenes C_{60} were synthesized in Technical University of Ilmenau (Germany). A stable water colloid solution of 10^{-4}M fullerene C_{60} (purity >99.5%), prepared by C_{60} transfer from toluene to water using ultrasound sonication, contains C_{60} clusters with size 12- 50 nm. Cells were incubated for 1 h with or without fullerene C_{60}(10^{-5}M). Fullerene C_{60} photoactivation was done by UV/Vis irradiation of probes with mercury-vapor lamp (320-600 nm light, irradiance 200mW/cm², distance 2cm). By confocal microscopy with using of fluorescently-labeled fullerene C_{60} (C_{60}-RITC), it was demonstrated that fullerene C_{60} are efficiently accumulated inside oncotransformed cells. Cell viability was assessed by the MTT [3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide] reduction assay. It was shown that viability of leukemic cells after photoexcitation of accumulated fullerene C_{60} was substantially decreased while no cytotoxic effect on normal lymphoid cells was observed. ROS production was measured by using fluorescent probe 2′,7′-dichlorodihydrofluorescein diacetate (DCF-DA). Irradiation per se was shown to be followed by slight increase of ROS production. Leukemic cells respond to combined action of C_{60} and light irradiation by pronounced intensification of ROS production and prooxidant-antioxidant imbalance leading to oxidative stress. The concentration of free cytosolic calcium ($[Ca^{2+}]_i$) in cells was measured with using of fluorescent probe Indo-1. Photoactivation of C_{60} causes remodulation of calcium homeostasis and sustained increase of $[Ca^{2+}]_i$ in L1210 and Jurkat cells. A long-term ROS production and $[Ca^{2+}]_i$ elevation are the markers of apoptotic mechanisms induced by photoexcited fullerene C_{60} in leukemic cells. The data obtained show that C_{60} fullerene could be used as a photosensitizer for elaborating the strategies of targeted oxidative injury of leukemic cells.

A BRIEF HISTORY AND CLASSIFICATION OF VITAMINS

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The formation of free radicals is a kind of a natural process accelerated by various factors, such as ionizing radiation, for example.

Antioxidants are located in modern medicines and they fight free radicals. They are vitamins or substances which are capable of delivering the missing electron fragile molecules, to prevent the damage that free radicals cause to the body.

Objective

This paper presents short historical notes on the main antioxidant vitamins and their classification.

The research method

1. Systematic approach and critical analysis of the available scientific periodical

2. Sociological methods:

a) documentary method

b) own research on the issue

Discussion

Vitamins can be classified according to:

- Their action

- Chemical structure

- Physicochemical their references- according to their ability to dissolve in water or fat.

This paper presents physiological daily rate of vitamins, consistent with age, sex, physiological status, profession, working conditions. Under consideration are the increased daily needs in pregnancy, lactation, intensive physical and mental labor, active sports, after diseases.

A careful reading of the available scientific periodicals and exhibitions above allows us to conclude:

Antioxidant vitamins work together in harmony, for it can not be argued, an antioxidant which is the most important or the most powerful.

Keywords: vitamins, free radicals

RADIOMETRIC ENZYME ASSAYS

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For our recent studies [Pavelka S., Physiol. Res. 63 (Suppl. 1) (2014) S133-S140] of the influence of the administration to the rats of several xenobiotics - excessive bromide and perchlorate ions on the one hand, or an antidepressant drug fluoxetine (Fluox) on the other hand - on the key enzymes in the metabolism of thyroid hormones (TH), we developed and adapted various radiometric enzyme assays.

Thyroid peroxidase (TPO) is the key enzyme in the biosynthesis of TH in the thyroid gland, while conjugating enzymes iodothyronine sulfotransferases (ST) and uridine 5'-diphospho-glucuronyltransferase (UDP-GT) in the liver and kidneys play an important role in excretion of TH. And iodothyronine deiodinases (IDs), in different proportions, are the most important players in biotransformation of TH in many peripheral tissues. Here, we describe in more details our newly developed radiometric methods for extremely sensitive determination of enzyme activities of IDs of types 1, 2 and 3 (D1, D2, and D3) in microsomal fractions of various rat and human tissues, as well as in homogenates of cultured mammalian cells.

All these radiometric enzyme assays were based on the use of high-specific-radioactivity ^{125}I-labeled iodothyronines as substrates; TLC separation of radioactive products from the unconsumed substrates; film-less autoradiography of radiochromatograms using storage phosphor screens; and quantification of the separated compounds with a BAS-5000 laser scanner (Fujifilm Life Science) equipped with an evaluating software AIDA (Raytest). This methodology enabled us to determine IDs enzyme activities as low as 10 exp -18 katals.

We demonstrate applicability of our advanced assays by following the alterations of IDs activities induced in cultured astroglial cells by a series of purinergic agonists, by retinoic acid, and/or combination of these drugs. The elaborated radiometric assays proved to be very sensitive and rapid and, at the same time, reliable and robust.

HEAVY METAL CONCENTRATIONS IN VEGETABLES WITH GROWTH STAGE AND PLANT SPECIES VARIATIONS

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Vegetables constitute an important part of the human diet since there contain carbohydrates, proteins, as well as vitamins, minerals and heavy metals. Heavy metals are one of a range of important types of contaminants that can be found on the surface and in the tissue of fresh vegetables (Bigdeli and Seilsepour, 2008). Anumber of elements, such as lead (Pb), cadmium (Cd), nickel (Ni), cobalt (Co),chromium (Cr), Copper (Cu) and Selenium (Se) (IV) can be harmful to plants and humans even at quite low concentrations. Soil pollution is caused by misuse of the soil, such as poor agricultural practices, disposal of industrial and urban wastes, etc.

The research was conducted in order to see the concentration of heavy metals in leafy vegetables spinach –Spinacia oleracea, garlic - Allium sativum and onion - Allium cepa. Spinach, garlic and onion seeds were sown on 23rd November 2011; samples for analysis of these plants were taken at different stages - 20, 30, 40 and 50 days after sowing.

The results showed that the concentration of lead, zinc, cadmium, nickel, and cobalt increased with increasing age of the plant. The percentage of increase of heavy metals was higher from 20th to 30th day, compared to that between 30th and 40th day.

The result indicated that there was significant difference ($P < 0.01$) in mean heavy metal content in the three vegetable species. The result showed significantly higher level of Pb concentration in amaranth compared to spinach and red amaranth. Spinach exhibited significantly higher levels of Cd and Cr than the other vegetables.

Heavy metal content in different leafy vegetables varies significantly. The content varies with time of harvesting and stage of maturity of crops. The Cd and Cr contents in leafy vegetables in this study were detected higher while Pb and Ni were within the permissible limits as per the WHO standard but all the metals were within the maximum allowable level. The magnitude of time dependence of plant metal concentration variations differed among crop species and metals. Further research is needed to obtain more specific information about the effect of age of the plants on accumulation and distribution of the heavy metal in the different plant parts, variations in uptake between different plant species, cropping history and fertilization.

THE ROLE OF LONG-TERM EXPOSURE TO LOW DOSES OF IONIZING RADIATION ON THE ACTIVITY OF TRYPSINOSIMILAR OF PROTEINASIS (TpA) AND THEIR INHIBITORS (α-1 IP) AND (α-2 MG) IN PLASMA OF BLOOD IN PATIENTS WITH COPD

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Beam and reperfusion injury is accompanied by the activation of proteolysis that promotes the release of leukocyte proteases (Sizov IP, 1996). With long-term exposure to low doses of ionizing radiation in the respiratory system of patients with COPD morphological changes are developed underlying the functional disorders of the central and peripheral airways, lung parenchyma and vasculature [Bednarzhevskii, T., 2005].The inflammatory response in the lungs is further amplified by the oxidative stress and an excess of proteinases (W. MacNee, 2007).

The aim of this study was to evaluate the activity of trypsinosimilar of proteinasis (TpA) and their inhibitors (α-1 IP) and (α-2 MG) in the plasma of blood of healthy donors and patients with different stages of COPD.

The complex clinical functional research included 60 patients, 30 of which had COPD (the basic group) and 30 healthy donors from 31 to 62 years of age (53,6±1,1). The activity of trypsinosimilar of proteinasis and their inhibitors has been defined with the complex method of Karyaginae I. U., 1990.

4 groups of supervision have been generated: I – with mild COPD (TpA -199,25±26,46*; α-1 IP 1,5±0,58*, α-2 MG 1,78±0,19 **), II – with moderate COPD (TpA -202,07±20,36 *; α-1 IP -0,8±0,18 **, α-2 MG 1,48 ±0,18 *), III – with severe COPD (TpA -284,09±24,12 * α-1 IP 0,67±0,44 **, α-2 MG 1,50 ±0,16 *) IY – and with very severe COPD (TpA -341,13±10,99 * α-1 IP 0,28±0,1 *, α-2 MG 1,61±0,04*), (*-p <0,001; **-p <0,05 compared to Controls).

We concluded, that significant increasing of activity TpA and decreasing of activity their inhibitors α-1 IP, α-2 MG in plasma of blood is the important mechanism for developing oxidative stress and the progression of chronic respiratory failure in patients with COPD via long-term exposure to low doses of ionizing radiation.

EFFECTS OF CRANIAL ELECTROTHERAPY STIMULATION ON DIFFERENT STRESS-RELATED DISORDERS (A PILOT STUDY)

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Cranial electrotherapy stimulation (CES) is a noninvasive procedure that has been used mainly to treat anxiety, depression, and insomnia in the general population.

The aim of this article is to present own obtained results in a pilot study performed with the use of CES by Alpha-Stim modality.

The evaluated sample comprised several groups of patients with a) anxiety and depression, b) cystic fibrosis, c) moderate hypertension, as well as d) ADHD children. Each group is containing of 10 patients. All problems were diagnosed according DSM-IV criteria.

For measuring behavioral issues Child Depression Inventory (CDI), Scale for Anxiety for Adolescents (SCAN) and Beck Depression Inventory (BDI) were applied.

Quantitative electroencephalography (qEEG), using Mizar 19 electrode placement equipment, is performed for evaluation the brain spectra before and after treatment. Spectrum weighted frequency was calculated in Cz to measure general mental arousal.

Obtained results suggest that this pilot study confirms the efficacy of CES treatment in different psycho physiological disorders such as general anxiety, moderate depression and hypertension but in nonlinear dependences. No significant results are obtained for ADHD children. However, for ADHD children, the neurofeedback is more effective.

CES is cost-effective compared with drugs, but neurofeedback as another non-invasive tool in psychiatry is also available.

Key words: cranial electrostimulation therapy, medicine, biophysics, depression, anxiety, moderate hypertension.

URIDINE AS A POTENTIAL MEDICINE FOR OXIDATIVE STRESS PREVENTION

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It is well-known that uridine is a pyrimidine nucleoside which increases the concentration of UTP and glycogen in tissues. In this paper we have shown that the administration of uridine to animals can increase UDP concentration in tissues, which, as we found earlier, is a metabolic activator of the mitochondrial ATP-dependent potassium channel (mitoKATP). From the literature it is known that pharmacological activators of mitoKATP have a pronounced cardioprotecive effect against hypoxia. We have suggested that uridine can be used as an effective defense against oxidative stress. In the work we studied the effect of uridine on the morphological, electrophysiological and biochemical changes in animals under oxidative stress. 3 experimental models were used: 1 - acute myocardial ischemia of the rat left ventricle (namely, 60 min occlusion of the left coronary artery (LCA) without reperfusion); 2 - animal endurance under physical load, which was measured by recording the time during which the male Wistar rats swam with a load of 20% of body weight in water at 32^{o}C to exhaustion; 3- acute inflammation in mice induced by toxins from Gram-negative bacteria (E.coli) lipopolysaccharides (LPS). We found that uridine prevented the pathological disturbances in tissues of the all studied animals. In case of experimental acute myocardial infarction, uridine possesses the anti-ischemic and anti-arrhythmic actions and normalizes the energy and oxidizes metabolisms in myocardium. In animals with endurance under physical load, uridine increased the time of the rats swelling in 2 fold. In case of using the endotoxin injection, uridine increased the concentrations of several pro-inflammatory cytokines in blood and significantly enhanced the expression level of Hsp72 and NF-κB signaling pathway (phNF-kB and IKK) proteins in spleen lymphocytes. The mechanism of uridine action is attributed to the formation in tissues of UDP, which is an activator of mitoKATP and UTP which can activate glycogen synthesis. In models when the effects of uridine, according to our data, are eliminated by specific inhibitors of the mitoKATP channel (myocardial infarction and enhanced physical exercise) we assumed that the channel is a significant and perhaps the defining element in the defense against oxidative stress which was observed in these pathological states. In the case of bacterial intoxication, when the inhibitor of mitoKATP does not remove the positive effect of uridine, we can suggest that the effect of uridine is associated with improvement in energy metabolism. The perspectives for development of new uridine-based drugs, which would be able to reduce the level of toxic stress, is discussed.

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DIAGNOSIS AND MORE EFFECTIVE CANCER THERAPY

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Cancer is an intersystem disease. A multifaceted approach is necessary for effective prevention and treatment. This discussion is a topical introduction to the clinic prevention and rehabilitation methods that prevent the occurrence of cancer, hinder the development of this disease, and reduce the negative consequences of specialized treatment on the patient. At the center, “INDIVID,” work is being carried out in 3 main areas: 1. Diagnosis of disorders affecting metabolic processes in patients with cancer, reflected by shifts in the primary metabolism of the cell. 2. Identification of a "pathogenic link” in the chain of metabolic reactions and the mechanisms of change in the correction of the disorder. 3. Early diagnosis of cancer and precancerous conditions, or "precancer”, using new a highly specific and sensitive universal method, known as the “RO-Test.”

Diagnostics of metabolic processes: energy and oxidization processes in mitochondria, immunity, system metabolism peroxidation and free radicals, hormonal metabolism, in particular, thyroid hormones. Identification of the causes leading to disorders of metabolic processes allowed us to develop methods of rapid recovery of disturbed functions by providing a biochemically informed choice of adequate therapy in each case. Correction of disturbances affecting primary metabolic processes has lead to a significant improvement of patients’ health.

The “RO-Test” is easy to implement, and rapidly provides results (results within 2 hours), which allows for perform early diagnosis of cancer, monitor effectiveness of anti-cancer therapy, identify the quality of operations, the presence of recurrence, and metastasis. Specificity 86 - 95%, sensitivity 85 - 94%, which exceeds the numbers of other known oncologic markers. Over the last 15 years, this method has been successfully used in the diagnosis of cancer in our center “INDIVID”

Malignant transformation is followed by a significant restructuring of the energy systems of the body; increased glycolysis - the main source of energy for malignancy, and the weakening of oxidative energy formation localized in the mitochondria of cells. Gulidova GP developed a method for diagnosing the state of oxidative processes and energy formation in humans, as well as ways to normalize this important metabolic system of the body, which is significantly reduced in cancer along with the disturbance of other metabolic systems, such as the immune system, hormonal exchange, peroxidation, antioxidant activity, etc. Treatment at the “precancer” stage of the disease results in a normalization of metabolic systems and contributes to the restoration of reparative processes in the cells of the body, leading to a reduction in the number of transformed cells and a normalization of the “RO-Test” ($K < 1.5$). In other words, the patient is no longer afflicted with cancer. When the oncology coefficient of the “RO-Test” is not normal and a declining trend is observed in the patient. Thus, the diagnosis of cancer by the "RO-Test" and normalization of metabolic processes allows separating the “precancer” from cancer.

SYNCHROTRON RADIATION STUDY ON DISTRIBUTION OF TRACE ELEMENTS AND STRUCTURAL CHANGE IN GLIOMA CELLS IN SITU

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Gliomas are the most common primary human brain tumors which comprise a heterogeneous group of benign and malignant neoplasms that are histologically classified according to the World Health Organization in four groups. Late stage Glioma (WHO IV) are characterized by a short median survival and an almost 100% tumor related mortality. Despite development of new chemotherapies in recent years, the overall survival of gliomas has improved only marginally. Moreover, it is still not known which exact cell type initiates the development of gliomas

Molecular neuroscience is in need of new techniques that would widen the set of tools available for investigation of disease features that may have not yet been revealed. Recent advances in X-ray imaging technologies, and the establishment of dedicated facilities, have made X-ray microscopy an important new tool for cellular imaging. The novel bio-imaging station at the synchrotrons provides the ideal sample environment and handling capabilities for X-ray imaging in biomedical applications.

We investigate the structural and elemental changes in the fourth stadium of gliomas in order to determine elemental map in glioma samples by X-ray fluorescence and full-field tomography. Moreover, gliomas cells were imaged on the subcellular level to assess the trace element profiles and structural changes in frozen hydrated cells that originate from different brain tumour tissues. Here we fortify hard X-ray imaging and combine it with soft-X-ray tomography in order to gain a deeper cellular and molecular insight into elemental and structural features of different stages of gliomas and glioma cells. This platform allows us to draw conclusions about the patho-physiological role of trace metals and other chemical elements in glioma. This approach was to show different elemental requirements of glioma cells vs. other glioma cell types, new approaches for treatment could be devised to target the glioma more specifically. Ideally, future therapies could turn from the elimination of the rapidly dividing, but differentiated tumor cells, to specifically targeting the minority of tumor cells that repopulate the tumor.

The final goal of this study is to unify the efforts in X-ray microscopes to elucidate a biomedical problem like glioma.

BIOPHYSICS

05

RADIATION-INDUCED EFFECTS ON LIPOSOMES - A TOOL FOR STUDYING THE MECHANISM UNDER RADIATION ACTION ON THE ORGANISM

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Earlier aqueous dispersions of liposomes are predominantly considered as a convenient model system for studying the mechanism of radiation - induced damage of biological membranes. However, in our work the functioning similarity of the physicochemical regulatory system of the lipid peroxidation on the membrane and organ levels was revealed. It allows us to suppose a possibility of using liposomes as a tool for studying the mechanism under radiation action on organism.

The aim of this work is to study the parameters of the Physicochemical lipid peroxidation regulatory system of liposomes formed from the liver and brain lipids of mice and the native and soybean lecithin-standard under the radiation action.

Physicochemical characteristics of the liver and brain lipids are modified by carrying out experiments in different seasons. y-Irradiation was performed at the dose rate of 27.6; 26.4 and 29.9 Gy/min for liposomes from lecithin and the murine liver and brain lipids correspondingly. The range of doses is from 0 to 7 kGy.

Data obtained are discussed in a point of view the community and distinctions the radiation - induced effects on liposomes and tissues of organism.

THE EFFECT OF A PHOSPHODIESTERASE INHIBITOR ON THE UPTAKE OF THE CELL ELECTROPERMEABILIZATION MARKER 2-NBDG IN TUMOR CELLS

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Molecules spontaneously transported inside the cells, like glucose derivatives, can also be used as electropermeabilization markers. In a previous study, we evaluate the uptake of a fluorescent deoxyglucose derivative (2-NBDG) by normal and electropermeabilized Chinese hamster cells. The study was aimed to extend our previous study to two murine tumor model cells and to investigate the effect of rolipram, a selective PDDE4 inhibitor, on 2-NBDG uptake by tumor cells, with or without electric pulses. 2-NBDG was added to the tumor cell suspensions and cells, exposed or not to eight square-wave electric pulses of 100-µs duration and of appropriate field amplitude at a repetition frequency of 1 Hz or 5 kHz, were incubated at 37°C. In rolipram experiments, after a 15 min pre-incubation with rolipram, 2-NBDG was added to the cells for 20 minutes and uptake measured by flow cytometry.

In spite of significant uptake of 2-NBDG mediated by GLUT transporters into the non permeabilized cells, the electric pulses significantly increased the 2-NBDG uptake into the murine tumor cells. Under our experimental conditions, the fluorescence intensity of permeabilized cells within the population of the cells exposed to the electric pulses showed the reduced effectiveness of pulses delivered at a repetition frequency of 5 kHz in comparison to the typical 1 Hz repetition frequency. Pretreatment with rolipram did not attenuated the uptake of 2-NBDG in permeabilized tumor cells while at high concentration it actually reduced 2-NBDG uptake in non-electropermeabilized cells.

Glucose derivatives can also be used to detect electropermeabilized cells exposed to the electric pulses. Moreover, rolipram can be used as a probably useful tool for improve the visualization of tumor using glucose derivatives by affecting the uptake in normal tissue.

THE INFLUENCES OF THE ELECTROMAGNET RADIATION ON THE TEAR FILM

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Introduction: High frequency microwave electromagnetic radiation from mobile phones and other modern devices has the potential to damage eye tissues, but its effect on the tear film and ocular surface is insufficiently unknown at present. A healthy and stable preocular tear film play a vital role in maintaining both the optical quality of the eye and the health of the ocular surface.

The aim of this study was to investigate the effects of high frequency microwave electromagnetic radiation (1.1GHz, 2.22 mW) on the tear film and ocular surface.

Research included 35 subjects(70 eyes), all subjects were between 18 and 25 years old, healthy persons with no known diseases, allergies and without use of medication. Fluorescein Tear's break-up time test (TFBUT), tear ferning test (TFT) and tear pH was done to all subjects prior to phone cell use and after 15 min of cell phone use.

Results show that after 15 min. of cell phone use, TFBUT was significantly shorter; TFT type III and IV was present and tear pH was > 8.

Conclusion: Electromagnetic fields generated from high frequency microwave radiation leads to damaging effect on the tear film and ocular surface. It has also been recognized that a particularly vulnerable group might be children, as they are likely to have the highest cumulative exposure to radiowaves from mobile devices.

It is recommended to use cell phones from a distance to minimize exposure, thus reducing any potential harmful effects of cell phone use on the tear film and ocular surface.

DEVELOPMENT OF A SYSTEM FOR MEASURING WALL SHEAR STRESS IN BLOOD VESSELS USING INTRAVITAL MICROSCOPY AND COMPUTATIONAL FLUID DYNAMICS

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We developed a system for measuring the wall shear stress (WSS) in blood vessels using intravital microscopy (IVM) and computational fluid dynamics (CFD). The time-dependent velocity at the center of the blood vessel was measured by phase-contrast algorithm based on Origin pro-software (Origin Lab Inc.) and was approximated by finite Fourier series, which was used for generating the velocity profile at the inlet for the boundary condition to the CFD method. To validate the CFD method, we compared the WSS obtained by the CFD method with the theoretical value in a straight cylinder with various radii for both steady and pulsatile flows. We also investigated the dependence of the WSS on the inlet velocity profile incorporated into the CFD method. For steady flow, there was a good agreement between the WSS obtained by the CFD method and the theoretical value. For pulsatile flow, there was a relatively good agreement between them when the radius of the cylinder was average diameter 80 mkm and the inlet velocity profile was given by the Womersley solution for fully developed pulsatile flow in a straight circular cylinder. When the radius of the cylinder was 80 mkm and/or the inlet velocity profile was assumed to be parabolic, large differences were observed between them, suggesting that the assumption of fully developed flow does not hold true in these cases.

After the recording of vasomotion- rhythmic oscillations in blood vessel diameter measured by IVM we analyzed the nonlinear signal of those oscillations by means wavelet analysis. Vasomotion is caused by local changes in blood vessel smooth muscle constriction and dilation, these processes are observed since the invention of the microscope, but its physiological role and its underlying mechanism remain elusive. At present in many tissues, vasomotion might serve as a protective mechanism under conditions of ischemia. Its generation seems dependent on time synchronization of a multitude of individual cellular oscillators. The concept of calcium release and uptake by the smooth muscle calcium stores, synchronized by sarcolemmal ion channels, and sometimes influenced by endothelial factors, may provide further understanding of this little-understood phenomenon.

Wavelet analysis is an accurate and reliable tool for studying signals with changes of phase and frequency. Arterioles between 45 and 80 mkm in diameter were measured. Spectral range of oscillations with physiological relevance are found, from 0.0095 to 1.2 Hz, and four subintervals are revealed, (0.0095-0.02 Hz), (0.02-0.05 Hz), (0.05-0.14 Hz) and (0.14-1.2 Hz), by wavelet analysis. In this work our group applied wavelet Daubechies analysis. Daubechies wavelets are a family of orthogonal wavelets defining a discrete wavelet transform.

STORAGE METHOD FOR COMET ASSAY SLIDES AT -10 ºC

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Comet Assay is a rapid and sensitive technique for assessing and measuring DNA damage. This method is widely used in radiation, toxicological and environmental studies with application under in vitro and in vivo conditions in different organisms. There is a problem of simultaneous processing of a large number of samples. Cryopreservation is a most common way to store biological material. We propose to store it after the cells lysis step instead of cryopreservation of initial samples. This approach allows further processing of prepared slides at a convenient time. The results of DNA damage measurement in eukaryotic cells stored for a long time are presented. The slides with cell nucleoids embedded in agarose were stored at -10 °C. Slides were prepared according to the standard Comet Assay protocol. Afterwards the lysis of cells embedded in agarose was performed. Thereafter these slides were incubated for 30 min in the solution with glycerol. The solution was removed and slides were placed in a freezer chamber at -10 °C. At the end of storage time slides were taken from the freezer and submersed into lysis solution at 4-8 °C during 1 hour. After that subsequent steps of the Comet Assay protocol were performed.

We determined the basal and induced by ROX (H_2O_2) in vitro levels of DNA damage. The human peripheral blood leukocytes and lymphocytes and mice leukocytes embedded in agarose slides stored in freezing chamber were used. The result showed the level DNA damages after 9-10 month storage was not significantly different from the level of DNA damages in slides without storage.

Our results show that long term storage of agarose slides at low temperature can be used for biomonitoring studies. The possibility of the long term storage of slides at the lysis stage is essential also in clinical trial. The material from the same patient is accumulated for a long time because it is preferred to perform the analysis under identical experimental conditions.

MEDICAL IMAGING

06

THE OPTIMIZATION METHODS OF IMAGE QUALITY DURING THE CHEST SCREENING OF PATIENTS WITH DIFFERENT MASS INDEX

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The overdosage problem solution for patient undergoing the chest screening examination was proposed in way to find the reasonable combined approach of application of software for digital image processing and anti-scatter grid method. The results demonstrate the various possibilities of visual contrast image improvement using for patients with average body mass index, which allow refusing of the anti-scatter grid application or significantly reducing the radiation dose. Also the reasonable technical parameters combination for simultaneous using of both methods for patients with high body index was described.

According to the National Health Standards of Ukraine the normal parameters of average patient undergoing X-ray examination were determined for estimation and calculation of the delivered radiation dose amount. Thereafter an average patient was defined as an adult person 71.1 kg weight, 174 cm high, the thickness of anteroposterior and lateral projection of the chest are equal to 20 and 40 cm correspondingly. Also the chest screening parameters were determined, they include the size of radiation field 35x35 cm, tube-to-patient distance 100 cm, tube potential 80kV, 60mAs, the effective dose 800 μSv. For the two last decades in clinic practice the water phantoms simulated a human chest to test the operation of the X-ray system. As well such phantoms are the suitable simulation object for research. An average patient with chest thickness of 20 cm corresponds to the 10.5 cm water phantom thickness.

The clinic roentgenology problem for chest screening is a finding of the reasonable balance between the image quality with sufficient contrast, brightness, accuracy for the visual detection of the pathology and maximal reduce of the dose delivered to the patient undergoing chest examination. In routine clinical practice the problem of significant dose delivering is usually caused by anti-scatter grid application (typically radiation dose increases in Bucky factor 2...4 times). This is the most urgent for the corpulent patients (chest thickness more than 20 cm), because of scatter radiation caused by body. The scatter radiation makes undesirable effects on image quality, decreasing the signal to noise ratio. Also the optimization of the tube potential selection is sufficient for receiving of digital images with a good quality. If the tube potential is quite low, the low energy quanta would be absorbed by the human body. It leads to unreasonable increase in radiation dose. The high energy quanta posses high transmission and low absorption ability instead, but still the contrast of the received X-ray image can be sufficiently reduced. Therefore the present work is dedicated to the finding of a reasonable approach to effective methods application, including software digital processing, choosing optimal operational parameters and anti-scatter grid using.

IMPROVEMENT OF PEDIATRIC DIAGNOSTIC IMAGING DUE TO APPLICATION OF DIGITAL MICROFOCUS RADIOGRAPHY

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Aim. Pediatric patients differ significantly from each other as by the geometric dimensions as well as by the density of the structures. Bone structures in infants are not totally formed, the geometric dimensions of objects are small what requires high contrast and spatial resolution of the X-ray images. The aim of the work is to evaluate the diagnostic capabilities of a digital microfocus radiography in pediatrics.

Materials and methods. The results of clinical application of digital microfocus X-ray system in a children's emergency hospital are presented. More than 150 children aged from 1 to 17 years were examined. The examinations were performed using the zoom mode from 1.0 to 2.0. The composition of microfocus X-ray system includes an X-ray source (output power up to 50 W, focal spot size less than 50 microns), X-ray universal tripod to perform examinations in the zoom mode, and digital receiver (the size of the working field is 25x30 cm, resolution is 4.0 p.l/ mm).

Results. Various fractures of the upper extremities were identified in 109 (72.6%) examined patients. Damages of physeal zones were detected in 38 (34.8%) patients due to the peculiarities of microfocus radiography. Visualization of the growth zone fracture presents as an enlightenment line on the verge of ossificated & non-neossificated tissues which is not determined by conventional radiography, explains physical and technical characteristics of microfocus X-ray, primarily an increase of the receiver resolution in zoom mode (the effect of increasing the depth of field). It should be noted that this sign determined in different types of physeal zone damages without displacement which is a certain difficulty in diagnostics using conventional or digital radiography, i.e. the use of digital X-ray microfocus allows to objectify damages of physeal zones without displacement. In addition, with the help of digital microfocus radiography additional information was received at the "missed" fractures with damage of single bone trabeculaes, the diagnostics of which also causes difficulties on convention or digital X-ray images.

Conclusions. Using digital X-ray microfocus radiography allows to objectify the damages of physeal zones and improve the detection of "missed" fractures, what avoid hyper- or under-diagnostics of such injuries in a timely manner to establish the diagnosis and to carry out the appropriate treatment of these patients. Consumption of digital X-ray equipment energy is reduced in the ten or more times and radiation load on patients and staff is also reduced.

CLINICAL CASE: MAGNETIC RESONANCE IMAGINING IN DETECTION OF COMBINATION DENDY-WALKER SYNDROME AND DIABETES MELLITUS TYPE 1

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Dandy-Walker syndrome (DWs) can be find by magnetic resonance imagining (MRI) examination and characterized by following features: hypoplasia of the cerebellar vermis (and hemispheres), extension of the IV venticle of the formation of cysts of the posterior vfossa due to its increase associated with the upward shift of the lateral sinus and cerebellar tentorium, internal hydrocephalus. The presence of cognitive dysfunction in patients with DWs in some studies describes as severe impairment, in others not.

Clinical case. We have described a clinical case of combination mellitus type 1 (DM1T) and DWs as a part of research work "Identification markers of cognitive dysfunction in atientith DM1T".

Patient K., male, 16 yeas old, diagnosed with DM1T, disease duration 4 years, HbA1c 9 (N<7,5), fastin glucose 10,1 mmol/l. The contact was difficult. The study of cognitive function using Montreal scale (MoCA test) showed a reduction of points 6 (N>26) on the majority of scales: memory, attention, verbal fluency, abstraction. Brain MRI revealed a broad message of the IV ventricle with expended large tank marrow hypoplasia of the cerebellar vermis. Defined asymmetric (D>S) expansion of the lateral ventrces of the brain. III ventricle has also been expanded to 2,5 cm. The corpus collosum was thinned (hypoplastic). Subarachnoid space locally expanded, mainly in the front and parietal lobes.

Discussion. Cognitive dysfunction, neuropsychological changes are determined not only by the presence of DM1T, greater of DWs. Considering a clinical case it is example of interdisciplinary approach, requiring complex treatment and rehabilitation. The MRI diagnosis was a key method for understanding the causes of cognitive dysfunction and to clarify the diagnosis.

SW-BASED MEASUREMENT FOR THE AREAS OF THE PLANAR FIGURES

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Here conceived the methods of measurement for the areas of the planar figures of arbitrary shape. Both methods use measurement method for the areas of the planar figures via computation of the amount of the pixels with the given brightness. There used the Adobe Photoshop (or ImageJ) and Mathcad 14.0 SW integrated functions for the processing of the graphic files. As an example, there given the measurement of the area of the microorganism colony.

Despite the great information value of the planar figure parameter area, the corresponding measurement tools are scarcely offered at the global software market. With that, the measurements of the figures areas are quite important for the researches of the various types, including biomedical research – for example, in microbiology where there is a need to compute the microorganisms colonies size, biofilm areas etc.

The investigators aware of the existence of the only one SW system that supports the analysis of the various parameters of the planar figures of arbitrary shape, including area – it is the SigmaScan Pro software system manufactured by the SYSTAT company. Considering the high price of the license for this SW, this SW cannot be regarded as easily available for the community of researchers.

Adobe Photoshop is widely available graphic editor software that offers the wide range of tools for analysis of files of the bitmap type. The quantity calculation for the given type of the pixels is the process quite simple for the Adobe Photoshop; this procedure enables the calculation of the planar figure area with exceptional accuracy (with Histogram software tool).

ImageJ is even more accessible program for processing graphic images, which also has a histogram tool and can calculate the area.

Mathcad software mathematical processor includes the tools for reading and displaying of the graphic files: READBMP (File) command. It enables the reading of the image files saved in grayscale giving the output in the form of the array with integers in 0-255 range. Then there will be created the iterations for two directions: width and height. The iterations will sum up only the pixels with brightness lower than the specified threshold value.

MEASUREMENT OF DOSE RECEIVED BY ORGANS IN KNEE JOINT X-RAY EXAMINATION

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This study performed to assess the effective dose (ED) received in lumbosacral radiographic examination and to analyze effective dose distributions among radiological departments under study. The study was performed in Khartoum teaching hospital, covering two x-ray units and a sample of 50 patients. The following parameters were recorded age, weight, height, body mass index (BMI) derived from weight (kg) and (height (m)) and exposure factors. The dose was measured for knee joint x-rays examination. For effective dose calculation, the entrance surface dose (ESD) values were estimated from the x-ray tube output parameters for knee joint AP and lateral examinations. The ED values were then calculated from the obtained ESD values using IAEA calculation methods. Effective doses were then calculated from energy imparted using ED conversion factors proposed by IAEA. The results of ED values calculated showed that patient exposure were within the normal range of exposure. The mean ED values calculated were 2.49 $\pm$0.03 and 5.60 $\pm$ 0.22 for knee joint AP and lateral examinations, respectively.

ORQA - ONLINE RADIOLOGY QUALITY ASSURANCE

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The process of digitalization in diagnostic radiology and the development of the DICOM standard opened the possibility of individual patient dose tracking. Until recently patient doses were usually collected only by sampling and procedure-specific average-patient doses were determined. These were then used for comparison to diagnostic reference levels and as a tool for optimization. With digitalization of radiological modalities a number of different procedure parameters can be followed including dose. Although a commercial dose-tracking software is becoming available, the authors decided to establish a small sized system compatible with smaller medical institutions which are common in Slovenia. System collect patient dose data from different modalities using information stored in DICOM headers. Collected data is stored in a database named ORQA (Online Radiology Quality Assurance) and access to the stored data is possible through a web application. The aim of ORQA is not only to enable patient dose tracking but also to facilitate a quality assurance program by following different system performance indicators. Some of the problems encountered during the set-up of the system will be presented together with examples on how the system can help in optimization of diagnostic procedures in radiology.

IMPROVEMENT OF NUCLEAR MEDICINE IMAGES USING PROCESSING TECHNIQUE

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Nuclear medicine imaging is an incontestable vital tool for diagnosis, it provides in non-invasive manner the internal structure of the body to detect eventually diseases or abnormalities tissues. Unfortunately, the presence of speckle noise in these images affects edges and fine details which limit the contrast resolution and make diagnostic more difficult. The main objective of this study was to enhance of nuclear medicine images using Filtering Technique in order to evaluate contrast enhancement pattern in different nuclear medicine images such as grey color and to evaluate the usage of new nonlinear approach for contrast enhancement of soft tissues in Nuclear Medicine images. The data analyzed by using MatLab program to enhance the contrast within the soft tissues, the gray levels in both enhanced and unenhanced images and noise variance. The main techniques of enhancement used in this study were Top-hat filtering and Deblurring Images Using the Blind Deconvolution Algorithm. The study showed enhancement of nuclear medicine images using filtering techniques that the blind deconvolution algorithm and linear filtering were best technique in reducing the speckle and noise without fully eliminating the image edges.

DATA EXTRACTION IN DENTAL X-RAY IMAGES USING TEXTURE STUDY

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This study presented an appropriate approach for the robust estimation of noise statistic in dental x-rays images. To achieve maximum image quality after denoising, a new, low order, local adaptive Gaussian Scale Mixture model is presented, which accomplishes nonlinearities from scattering. State of art methods use multi scale filtering of images to reduce the irrelevant part of information, based on generic estimation of noise. The usual assumption of a distribution of Gaussian and Poisson statistics only lead to overestimation of the noise variance in regions of low intensity (small photon counts), but to underestimation in regions of high intensity and therefore to non-optional results. The new approach is funded on an attempt to interpret the problem from the view of blind source separation (BSS), thus to see the dental image as a simple mixture of (unwanted) background information, diagnostic information and noise.

BRAIN DISLOCATION MORPHOMETRY AT NEUROLOGY AND NEUROSURGERY

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Research objective – optimization of beam research with a quantitative assessment of a brain dislocation degree at craniocerebral injury (CCI), stroke (ST) and brain tumors (BT).

Materials and methods. Complex examination of 370 patients in an equal gender ratio from severe CCI (140), hemorrhagic, ischemic ST (110) and with primary BT (120) carried out. Inspection included neurological survey with an assessment of violation of consciousness on the Glasgow Coma Scale (GCS), CT and MRI. Intracranial hematomas and the foci of a laceration of a brain at 115 victims operated on. Meningiomas revealed in 20.8% of cases, in other supervision glial tumors of 1-2 degrees of an anaplastic (19.2%) and the low-differentiated tumors of 3-4 degrees of an anaplastic (60.0%) took place. Surgical treatment at all people with BT was undertaken. In all cases of ST conservative therapy was done.

Results and their discussion. When performing CT of a brain standardly used thickness of a cut of 3 mm, giving of a table of 9 mm with further reconstruction on 1.5 mm. It was doing for reduction of a total dose of radiation and artifacts because of x-ray rigidity distribution at visualization of a skull structures, and possibility of performance in the subsequent 3D-reconstruction. Protocol of scanning: kV 120, mA 300, time of rotation of gentry 0.5 with collimation 6×0.75-1.5, an interval of reconstruction of 0.75-3.0 mm. Morphometric beam researches consisted in calculation of a brain cross dislocation index (BCDI), degree of expressiveness temporal-tentorial infringements (TTI) and in a foramen magnum (FM).

For calculation of a BCDI estimated the level of violation of consciousness (G), the volume (V) pathological substratum, the size of shift of median structures (D) and the cross size of both lateral ventricles (L) at the level of the middle of a transparent partition determined. Then calculated a BCDI (I_d) on a formula: $I_d = (V:3+3\times D):(G+L)$. Visualization of TTI at the level of tentorium is most informative in a frontal projection and defined by the relation of a hippocampal and a parahippocampal gyrus to free edge of tentorium. At shift of this gyrus medially under free edge of tentorium degree on 1-2 mm considered TTI of a brainstem of a moderate, on depth of 3-4 mm – expressed and on depth more than 5 mm – considerable. For definition of degree of an axial dislocation, measured square FM (S_1), which at each adult has the invariable individual bone sizes. Then measured the area of cerebellum tonsils displaced in FM from both parties and summarized them (S_2). Calculated coefficient of infringement of a brainstem (Co) in FM on a formula: $Co=S_2:S_1\times 100\%$. At value Co to 20%, degree of infringement considered moderate, from 21 to 30% – expressed and more than 30% – considerable.

Conclusions. Inclusion in the protocol of beam research of morphometric definition of a brain dislocation at neurology and neurosurgery allows allocating three of its degrees: moderate, expressed and considerable. It gives the chance to prove operation terms, to specify expediency and volume of a bone external decompression during surgical intervention, and intensity of necessary antiedematous therapy.

A NEW ALGORITHM FOR METAL ARTIFACT REDUCTION IN PET-CT IMAGES

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PET and CT are widely used to assess the malignant diseases. PET/CT is a device that enables simultaneous imaging from anatomical lesions and its metabolic changes that mainly occur in the malignant cells with rapid growth. The attenuation correction in PET/CT performs enhancement the contrast of images.

Among the various artifacts of the PET-CT device, metal artifact has a great importance since non-removable metals have impacts on the obtained images and there is no solution to avoid this ineffectiveness. It occurs in the presence of metallic materials such as metallic prostheses, dental filling materials and pacemakers in the patient body.

The metal objects prevent radiation to be received into the detector. Since the bones have the highest attenuation rate in body, the CT number “1000” - that belongs to bones - devotes to all voxels which exist on the radiation way through body and by turning the tube around, these lines can be seen like a whole white star around the metal object.

To annihilate this type of artifact, metal objects beside the patient should be taken out and if not possible, metallic materials contained within the patient body should be removed using special processing.

In the innovative approach proposed in this paper, the degraded images are classified due to the destruction rate of metal artifacts in the image. Then, the section containing the pieces of metal objects is extracted for subsequent processing using the Fuzzy Classifier Method (FCM). Afterwards, the original image data is transferred to Sinograms scope so the CT numbers of the metal parts in original image Sinogram can be located for interpolating. This is done by using the Radon Transform. The Radon Transform is applied to the image of metal implants due to extract the Sinogram of metal parts and then the way which metal implants are existed in the obtained Sinogram is segmented using the two-class classification method. With the metal implants directions acquired above, shape of the metal artifact in the image can be released. Finally improved image is obtained from the Sinogram after its modifying.

To evaluate the performance of our algorithm we have used the real PET/CT data sets. These images were acquired by the Nuclear Medicine Center of Masih Daneshvari Hospital in Tehran. The results showed, the proposed algorithm can effectively remove effects and lines caused by artifacts in comparison to the other algorithms. In the proposed method, a simple approach was expressed to modify the artifact effects which do not need any complex changes in the raw data of the image. It is also shown that the proposed algorithm has some specifications such as the appropriate output image quality, less Signal to Noise Ratio (SNR), accurate identification of metal, improved contrast, preserving the edges and basic characteristics for clinical applications and appropriate time of execution.

POSSIBILITIES OF THE BEAM DIAGNOSTIC AT PATHOLOGY OF A VERTEBRAL ARTERY

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Research objective - development of a method for an assessment of the degree of a compression of the vertebral artery in the vertebral canal with CT and color duplex scanning application at cervical degenerative and dystrophic diseases and a spinal injury in respect of surgical treatment.

Clinical and beam examination of 110 patients with cervical degenerative and dystrophic diseases and a spinal injury conducted. Carried out the CT-morphometry with measurement of the area of cross section of the vertebral artery canal at the level of C_3-C_6 on both sides and every segment color duplex-metric with determination of the area of cross section of an artery. Syndrome of irritative influence on vertebral artery met at 9.5% surveyed with degenerative and dystrophic diseases and at 16.7% at a spinal injury. Extravascular influence on vertebral artery without system deficiency of a blood flow took place at 25.2% of patients and 31.6% of victims accordingly. Extravascular compression of vertebral artery with hemodynamic significant local gradients of high-speed indicators and system deficiency of a blood flow observed at 3.8% cases at degenerative and dystrophic diseases and at 11.6% cases at a spinal injury. Indicators of diagnostic efficiency of the using of color duplex scanning are comparable to results of the CT-angiography and MRI (program of an angiography). At an irritation and a moderate compression of vertebral artery applied a course of blockade of an artery (anterior and posterior access) and ganglion stellate (not less than five blockades). At the considerable and expressed degree of a compression of vertebral artery used as usually a miniinvasive anterior decompression of an artery.

Conclusions. The way of definition of a compression of a vertebral artery allows calculating quantitatively character and degree the extravascular of influences on an artery that defines different tactics of further surgical treatment.

VALUE OF THE BEAM DIAGNOSTIC FOR SPINE SURGERY

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Research objective - studying the CT-morphometry, densitometry and color duplex scanning in establishment of indications to surgery of degenerative and dystrophic diseases and osteoporosis of a backbone.

Clinical and beam examination of 330 patients with the degenerative and dystrophic diseases and osteoporosis of a backbone conducted. The intervertebral foramens, cross section of the canal of vertebral arteries on both sides at the level of C_3-C_6, volume the intervertebral of canals, width the facet of joints and the bone mineral density carried out the CT-morphometry with area measurement. Strategy of treatment the principle of «accruing radicalism» with five-step staging (first of all, conservative therapy, than blockade, miniinvasive surgery, decompressive and decompressive-stabilizing operations, and at last reconstructive interventions) was. Moderate degree of a stenosis of parameters of vertebral segment (34% cases), expressed (31% cases) and considerable (35% cases) revealed. It appeared that at moderate and expressed degree of a stenosis the miniinvasive interventions which main targets were an intervertebral disc, a vertebral artery and facet joints are more effective. The osteoporosis of a backbone found in 37% of patients with degenerative and dystrophic diseases. It is established, that at the bone mineral density lower than -2.5 by criterion of T (S.D.) use of rigidly fixing of a backbone (transpeducular fixation) is inexpedient in connection with arising complications. Operation of a choice at osteoporosis of a backbone is miniinvasive transcutaneous vertebroplasty. For elimination of instability, it should be supplemented with miniinvasive back dynamic fixing of a backbone by means of nitinol (NiTi) designs with a self-regulating compression. Efficiency miniinvasive intervention at degenerative and dystrophic diseases and osteoporosis of a backbone in terms up to 16 months after operation made 83%.

Conclusions. Use of the color duplex scanning, CT-morphometry of parameters of a vertebral segment and densitometry is weighty justification of use different methods of actions surgery, including miniinvasive one.

MDCT RADIATION DOSE OPTIMIZATION: HOW TO REDUCE RADIATION EXPOSURE?

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Background: Computed tomography for diagnostic evaluation has increased dramatically over the past 15 years and it has led to concerns regarding the increase of cancer risk due to cumulative exposure to ionizing radiation. According to a study published in the Journal of American Medical Association regarding the use of diagnostic imaging studies and radiation, the CT scan exposure rate has increased from 52 per 1000 patient, to 149 per 1000 patient in 15 years. American College of Radiology has addressed concern regarding the dose of radiation and the recent media reports of unnecessary exposure from MDCT have garnered national attention. Even though yearly quantitative measures of radiation exposure have never been performed in Macedonia, in our last yearly report (unpublished data) we have noted an increase of 22% for CT. Regarding the biological effects of elevated radiation dose exposure and the potential risks of cancer development, we consider the appropriate use of radiation in medical purpose as a matter of concern of public health care and a priority in our health institution with optimization of the MDCT radiation dose.

Aim: The aim of this study is to provide a general overview of radiation dose in MDCT investigations in our patient with optimization and reduction of the radiation dose and evaluate the adequacy and performance of our current Low-Dose approach in medical imaging against the ALARA principles.

Method and Materials: We will review the radiation exposure reduction by using low dose approach and individual protocols for the patient and systematically detect their insufficiencies against the ALARA principles. We will use our internal records and reports of performed examinations.

Results: Our current Low-Dose approach as we assessed it, has proven to be insufficient in monitoring and recording patients' radiation exposure during their treatment in our hospital. We need to monitor cumulative radiation doses. Simultaneously, an individual radiation exposure report for each patient will be issued in order to record their cumulative radiation dose. Individual dose reports are a very useful tool but still a partial solution if they are not integrated together in a cumulative dose report. We need to create a register of overall radiation exposure induced by our multidisciplinary diagnostic and therapeutic practices for some medical conditions that are most commonly treated in our hospital. Beyond optimizing current MDCT protocols and evaluate the overall radiation exposure per patient we need to create teams of physicians when treating one pathology as a resultant of their multidisciplinary approach. We lack insight in the appropriateness of certain imaging investigations involving radiation exposure induced by our multidisciplinary clinical practice.

Discussion: It is very important to present the scope of MDCT activities and measures that we have undertaken in our MDCT daily practice in order to implement ALARA principles. Our radiology department is using the basic principles for reducing radiation exposure by: lowering radiation exposure during CT examinations with optimization the dose, performing standardized individual protocols and using post processing software that offer multitude of opportunities for low dose scanning and high definition reconstructions and reformats. Our daily practice regarding lowering radiation exposure to MDCT examination implies: reducing the number of phases by choosing optimal scanning parameters to obtain the most relevant information at the lowest dose possible (mAs, KV, pitch and collimation); standardizing CT scanning protocols by radiation follow up in the Dose report displayed by the CT scanner. We are continuously working on standardization of the CT Dose Index. We need to implement a Continuous Quality Improvement Approach. Namely, the cumulative dose report, per patient as well as per treated medical condition, is a key quality indicator that allows us to assess the pertinence of our clinical practices.

Conclusion: Dose saving strategies are continuously evolving in terms of imaging techniques as well as dose management. This article will provide an update on how we can optimize MDCT dose in order to maximize the benefit-to-risk ration of the clinically useful diagnostic imaging methods. Our study clearly demonstrated that, in order to completely implement a Low-Dose approach according ALARA principles, we need to undertake the following next steps: raising awareness among all physicians to radiation exposure; standardize key CT protocols in our daily practice; recording cumulative radiation dose per patient and create a performance evaluation tool, allowing review and assessment of daily clinical practices as key steps in a Continuous Quality Improvement Approach.

DAT-SCAN IN DIAGNOSIS OF IDIOPATHIC PARKINSON DISEASE IN OUR HOSPITAL

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Purpose: Idiopathic Parkinson's disease (IPD) is a movement disorder with a mean prevalence of 100~150 per 100,000 people in Japan. Our hospital is state-of-the-art on Neurology, especially, Parkinson's disease. The diagnosis of IPD is made clinically by expert neurologists in our hospital. In Jan 2014, DAT- scan was approved for diagnosis of Parkinsonism and Lewy body dementia (LBD) in Japan. We evaluated the ability of diagnosis on IPD patients by DAT scan in our hospital.

Materials and Methods: We evaluated 125 patients who were suspected IPD. They consisted of 68 females and 57 males, with ages ranging from 35 to 87 (mean 72.7) years. Following the intravenous injection of 167MBq of ^{123}I-Ioflupan, images were acquired using a two-head gamma camera equipped with low-energy high-resolution collimators. Reconstruction was performed by ADAC FORTE workstation and soft ware. We evaluated the image with visual assessment as follows : (a) Normal (b) Abnormal grade 1 (c) Abnormal grade 2 (d) Abnormal grade 3, according to Benamer's classification. Benamer's classification includes (a) Tracer uptake bilaterally in putamen and caudate and largely symmetric. (b) Asymmetric uptake with normal or almost normal putamen activity in one hemisphere, and with a more marked reduction in the contralateral putamen. (c) Significant bilateral reduction in putamen uptake with activity confined to the caudate nuclei. (d) Virtually absent uptake bilaterally affecting both putamen and caudate nuclei.

Results: Reduced accumulation of the radiopharmaceutical was mentioned at the level of putamen and caudate nucleus in IPD patients. However, these findings were also partly seen in the patients with Parkinson's syndrome, Progressive Supranuclear Palsy (PSP), Multiple System Atrohy (MSA), Corticobasal Degeneration (CBD) and so on. The Sensitivity, specificity and accuracy of DAT-scan in diagnosis of IPD patients was 93%, 58%, 82%, respectively.

Conclusion: Low specificity and accuracy on diagnosis of IPD by DAT scan might be due to quite a few number of false positive and evaluating images by visual assessment without quantitative assessment.

COMBINED POSITRON-EMISSION AND COMPUTED TOMOGRAPHY WITH ^{18}F-FDG IN DIAGNOSIS AND STAGING OF PATIENTS WITH INDOLENT NON-HODGKIN'S LYMPHOMA

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Purpose: The aim was to investigate the role of positron-emission and computed tomography (PET/CT) with ^{18}F-FDG in the diagnosis and staging of patients with indolent non-Hodgkin's lymphoma, to compare PET/CT findings with the results of computed tomography (CT) and proliferative activity of tumor cells.

Material and methods: 49 consecutive patients with untreated indolent non-Hodgkin's lymphoma were evaluated in our study. Conventional staging methods including CT as well as PET/CT with ^{18}F-FDG were performed for investigating lymph node and extranodal manifestation of the disease.

Results: The sensitivities, specificities and diagnostic accuracies in diagnosis for lymphomatous involvement of nodal regions were 75,7%, 98,4% and 86,8% for PET/CT and 51%, 98,4% and 74,4% for CT. The accuracy in detecting extranodal manifestation for PET/CT was 84,6% compared to 71,8% for CT. Disease staging by PET/CT and conventional diagnostic methods was identical in 75,5% of patients, 24,5% showed discordant results. PET/CT correctly resulted in a higher stage than CT in more than 18% (n=9) of the patients. No significant difference was found between the SUV_{max} of the various types of indolent lymphoma (p=0,065). The correlation of SUV_{max} and Ki-67 index was not statistically significant (r=0,1, p=0,7).

Conclusion: PET/CT provides significantly more accurate information compared to CT for diagnosis and staging of patients with indolent non-Hodgkin's lymphoma.

LOW - DOSE CORONARY COMPUTED TOMOGRAPHY IN THE EVALUATION OF SPOTTY CALCIFICATIONS IN ARTERIAL PLAQUE

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Computed Tomography (CT) has developed considerably in recent years and coronary CT is known to be a useful tool to determine the degree of stenosis and diagnosis of plaque. Charactarization of the plaque is essential, because Acute Coronary Syndrome (ACS) almost always occurs in individuals with precarious plaque. Motoyama *et al.* defined precarious plaque as that featuring positive remodeling soft plaque, and spotty calcification, and used multi-slice Computed Tomography (MSCT) to demonstrate that these characteristics were significantly more frequent in angina with precarious plaque than in stable angina pectoris. However, it has also been reported that exposure dose is in a high propensity as a disadvantage.

We focused on the spotty calcification that is one of the features of unstable plaque, and evaluated the minimal-dose radiation with CT Cardiac Phantom.

IMPACT IONIZATION PHENOMENA IN DISORDERED SYSTEMS RELATED TO THE AVALANCHE MULTIPLICATION AND SWITCHING EFFECT

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Applications of chalcogenide materials in medical imaging and in phase-change memories have caused a renascence in the basic research on the photo- and voltage-induced properties of chalcogenides. While the avalanche multiplication and the electrical current switching are already used commercially, for instance, a-Se - in high-gain avalanche rushing photoconductor video tubes and $Ge_2Sb_2Te_5$ (GST) - in phase-change memories governed by electrical currents, the physical nature of these phenomena in chalcogenides still looks intriguing.

The impact ionization process has been revealed experimentally as the precursor of the current avalanche [1] and of the switching effect [2]. The question arises then how is it possible that in amorphous chalcogenides with very small mean free path of charge carriers the latter can gain enough energy from the electric field to cause the impact ionization. We show how the "lucky-drift model" suggested recently [3] can successfully account for the impact ionization in a-Se and in GST. We show also why this effect takes place in a-Se and not in the prototype amorphous semiconductor: hydrogenated amorphous silicon (a-Si:H) although the carrier mobility in a-Si:H is much larger than that in a-Se.

The main difference of the suggested lucky drift model from the "conventional" (Shockley's) model based on the ballistic motion of photo-excited carriers is that it allows for carriers to undergo scattering while drifting in electric field and acquiring energy. This results in a much higher probability to build up sufficient energy to initiate impact ionization. For the particular cases of a-Se and GST it is shown that the lucky drift model is capable to explain experimental results on the impact ionization.

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INDIVIDUAL ANATOMIC LANDMARKS IN IMAGING OF TEMPOROMANDIBULAR JOINT BY METHOD OF LINEAR TOMOGRAPHY

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Defining the optimal depth of tomography slice during imaging of temporomandibular joint (TMJ) by method of linear tomography is a necessary condition for obtaining an image of high quality. Development of methodic protocol for determination of the depth of the tomographic slice and the distance between the centers of TMJ heads by an individual anatomic landmark allows its implication in standard research diagnostic criteria of classification by Dworkin S.F., LeResche L. (1992).

Objective. The aim of the research is to develop and justify the method of determining individual anatomic landmark in imaging of temporomandibular joint by linear tomography.

Methods and materials. Craniometry of 20 human skulls from museum collection of the Chair of Normal Anatomy was performed. It was discovered that sagittal plane of the center of glenoid cavity in 92.2% cases coincides with sagittal plane of frontal process of zygomatic bone, which forms the frontal part of the lateral wall of the eye-socket (lateral orbital border).

The patient's head was positioned in lateral projection: its medial sagittal plane being exactly parallel, and physiological horizontal plane being perpendicular to the plane of the table. The depth of the slice was set according to the palpable lateral orbital bone. The angle of the tube shifting was 30 °. Thickness of the slice was 5.3 cm. Central ray was targeted 1.0 cm above and anteriad from the external auditory canal. Focal distance of the tube was 100 cm. Cassette 13x18 cm was positioned in transverse direction. On the same film two images were taken consequently - in central occlusion and in maximal abduction of the lower jaw downwards. The depth of the examined layer was fixed according to the index of tomography scale. Technical conditions of imaging: 60 kV, 100 mA, 2 sec.

Results and discussion. Our work resulted in obtaining patent №– 2177722 (Bulletin of inventions №– 0201, dated 10.01.02). For eight years till the present time TMJ imaging has been performed by the described method. 604 tomograms were studied. Images of high quality were obtained in 94.2% cases. In 86.7% cases the depth of the slice was from 2.0 to 3.0 cm (in 42.2% cases - 2.5 cm, in 21.6% cases - 2.0 cm, in 22.9% cases - 3.0 cm accordingly).

Conclusion. It is eligible to use the lateral orbital border as an individual anatomic landmark during linear tomography of temporomandibular joint, which helps to optimize technical conditions of imaging and considerably decrease the necessity to carry out additional searching images.

PREGNANCY AND DELIVERY DECURS IN WOMEN WITH HOMOZYGOUS HEMOGLOBINOPATHIES

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Purpose of this study: The aim of this research paper is to highlight pregnancy and delivery decurs in both these major pathologies.

Material and methods: To realise this study, 24 clinical files of pregnant women were investigated. 22 of these women suffered from homozygous sickle cell, and 2 others form major thalassemies. We considered the patients' age, their parity, delivery way, babies' average weight at birth, etc. These women gave birth during the period of time from 1992-2013.

Results: In the 2 last years, at Obstetrics-Gynecology University Hospital "Queen Geraldine" , for the first time, gave birth 2 women suffering from major thalassemie. During their pregnancy, 2 patients had hemotransfusion every 3 weeks. Their delivery was done through S/C for fetal soference. The other 22 patients had an average of 4.5 times hemotransfusion during pregnancy and at delivery. 10 of these women had a vaginal delivery, while the other 12 by S/C. 15 pregnant women out of the 24 were primipare ones (62.5%), 6 secondipare (25%) and only 1 tercipare case (4.2%), while the 2 patients suffering from thalassemie were primipare (8.3%). The average babies' weight at birth was compared in women with hemoglobinopathie (24) x^{-}2425.32 ± 59.74 with the average babies' weight delivered by normal mothers (46 women) x = 3309.78 ± 78.69 which resulted an obvious statistically difference P < 0.01

Conclusion: Pregnant women suffering from homozygous hemoglobinopathies following multi-disciplinary and contemporary therapy can give birth considering the multiple complications of the mother and the baby.

Keywords: sickle cell anaemia, major thalassemia, pregnancy and delivery.

UNIFIED ANALYSIS OF TEMPOROMANDIBULAR JOINT TOMOGRAMS BY CRANIOMETRIC POINTS

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Craniometry data of temporomandibular joint (TMJ) tomograms in different researches by different authors can hardly be compared. There is no agreed unified method to determine craniometric points and to analyze the obtained results.

Objective. The aim of our research work is to develop and justify the method of analyzing temporomandibular joint tomograms by craniometric points.

Material and methods. TMJ elements imaging was performed by method of targeted linear tomography in lateral projection. The depth of the slice was determined according to the palpable lateral orbital border. The central ray was targeted 1 cm above and anteriad from the external auditory canal. Focal distance of the tube was 100 cm. Cassette 13x18 cm was positioned in transverse direction. Physical and technological conditions of imaging: tube voltage 57-63 kV; current intensity 60-100 mA; focal distance 110-120 cm; exposure 2 s; angle of tube shifting during tomography 30â °. Two images were taken on 13x18 film positioned in transverse direction: in “mouth closed” and “mouth opened” positions. 56 tomographic images of joints from 28 women aged 36-45 with TMJ dysfunction were studied. Evaluation of all tomographic images was performed simultaneously with the use of Ryabukhina’s method (1966) as well as by craniometric points.

On scanned tomographic images craniometric points on TMJ bone elements were defined with the help of «PARAGONE » software and Adobe Photoshop (Slesarev O.V., 2013; 2014). It was determined that while analyzing temporomandibular joint tomograms it is necessary to use not the projection of the contour of anatomic structure, but the center of its tomographic section. The center of the section was measured by the circle described within the roentgenologic contours of the structure. The circle lies in the maximum contact with the contours of the bone anatomic structure, covering the surface of its tomographic slice to the fullest extent. The center of the circle is relatively constant and it was taken as a craniometric point. Using craniometrical points, cephalometric planes and angles are constructed and the character of geometric correlation of TMJ elements is determined.

Results and conclusion. While analyzing TMJ tomograms, it is more preferable to use as a craniometric point not the projection of cranial bones contour, but the centers of their tomographic section. Angular rates, as opposed to the linear ones, are the most credible for the characteristics of joint function. Metric analysis of the width of the X-ray articular cavity based on craniometry by external contours does not characterize intra-articular correlations. Determination of craniometric points in TMJ imaging is a way for unified analysis of TMJ imaging by agreed craniometric points in standard research diagnostic criteria of classification by Dworkin S.F., LeResche L. (1992).

SYNTHESIS AND PROPERTIES RADIOLABELED GLYCYLGLYCINE WITH $^{99M}Tc(Co)_3^+$ CORE

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The aim of this study is to radiolabel glycylglycine with $^{99m}Tc(CO)_3^+$core and to investigate the biological behavior in vivo. Radiolabeled peptides have become important radiopharmaceuticals of molecular imaging and nuclear medicine for the treatment of tumors.

In this study we radiolabeled glycylglycine with $^{99m}Tc(CO)_3^+$core. Thin layer radio chromatography (TLRC) and high performance liquid radio chromatography (HPLRC) were used to perform the quality control study of radiolabeled glycylglycine. Radiolabeled yield was found as 94.69 % ± 2.0 by TLRC. In addition biological behavior of $^{99m}Tc(CO)_3$-Gly-Gly complex was examined by biodistribution and imaging studies on male Albino Wistar rats in vivo. Dynamic images for both radiolabeled complex was increased in the kidneys and bladder were observed and excretion from body that way was both hepatobiliary and renal. The biodistribution results for$^{99m}Tc(CO)_3$-Gly-Gly were similar with SPECT imaging's results. For SPECT imaging, peptides labeled with Tc-99m are widely used in many target organs for imaging. In conclusion $^{99m}Tc(CO)_3$–Gly-Gly could be beneficial as a peptide radiopharmaceutical.

THE ROLE OF SOMATOSTATIN RECEPTOR SCINTIGRAPHY AND F-18 FDG PET SCAN IN SELECTING THYROID CANCER PATIENTS WITH NEGATIVE I-131 SCANS AND RISING TYREOGLOBULIN FOR PEPTIDE RADIO-RECEPTOR THERAPY

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Precise localization of thyroid cancer lesions is essential to deciding upon the therapeutic strategy, especially in patients who cannot benefit from radioiodine therapy. The aim of this study is to present the role of somatostatin receptor scintigraphy (SRS) using Tc-99m- HYNIC-[D-Phe[1],Tyr[3]-Octreotide] and positron emission tomography using F-18 FDG as a potential tool for the detection of recurrences in patients with non-iodine avid DTC, as well as to potentially indicate which patients could benefit from peptide radio-receptor therapy (PRRT).

The study enrolled 5 patients with radioiodine-negative DTC and elevated Tg values (3 women and 2 men; mean 59.4±17.1 years, range:33–77 years). Patients were followed for 4-11 years (mean 6.8 ±3.0 years) after their surgery and successive radioiodine ablation. Elevated Tg was detected 1-5 years following the surgery (3.2±1.6 years). All the patients were treated using I-131, four weeks after levothyroxin withdrawal and a 14-day low-iodine diet, but no visible pathological iodine accumulation on post-therapy whole body scan were observed. Tc-99m- HYNIC-[D-Phe[1],Tyr[3]-Octreotide] and F-18 FDG PET/CT scans were performed on the patients in less than one month. Patients were selected for PRRT if focal accumulation on SRS matched 18-F-FDG-PET/CT or if more lesions were visualized by means of SRS than by 18F-FDG PET/CT scan in the same region. Somatostatin receptor scan was found positive in 4 and F-18 FDG in all patients. Three out of 5 patients have met the inclusion criteria for PRRT and were treated using Y90-DOTA-TOC (one). Two patients were treated with a dual isotope using Y90-DOTA-TOC/Lu177-DOTA-TATE. Two out of five patients were excluded as candidates for PRRT. In one of those patients F-18-FDG PET/CT detected more lesions than SRS, while in the other patient SRS and F-18-FDG were found positive but in different anatomical regions.

Our results demonstrated that SRS using Tc-99m- HYNIC-[D-Phe[1],Tyr[3]-Octreotide] cannot safely be used as a single marker for assessing residual and recurrent disease in patients with TENIS syndrome. The results presented suggest that F-18-FDG PET/CT should be included in the diagnostic work up and the decision making process when managing patients with TENIS syndrome.

DIFFERENTIAL RADIODIAGNOSIS OF SALIVARY GLAND MASSES

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The aim of the investigation was to evaluate the possibilities of radiological methods in differential diagnostics of salivary gland masses.

Materials and Methods. 76 patients with tumors and tumor-like salivary gland masses were examined. We analyzed the findings of their physical examination, and performed operative interventions compared to the data of histological verification, multiplanar reconstruction sialography and ultrasound investigation.

Results. At clinical examination the complaints were non-specific. 97.5% of patients complained of a constant mass in the affected salivary gland. A mass expanded in 14.5% of patients over the last 3–4 months; and in 2.5% of patients it was an incidental finding and had no manifestations. There were predominantly (96% of cases) involved parotid and submaxillary salivary glands. Tumor-like masses were recorded in 16 patients (21%), benign tumors — in 57 (75.0%), malignancies and locally destructive tumors — in 3 (4.0%).

Conclusion. High resolution ultrasound is the primary diagnostic technique of neoplastic processes of major salivary glands, and enables to evaluate reliably the mass localization, form, size, structure, its contour, and blood supply level. Multiplanar reconstruction sialography enables to assess more precisely topographo-anatomical relations of tumors and tumor-like masses of salivary glands with duct system, adjacent osseous and soft tissue structures.

LUNG CANCER - DEMOGRAPHIC CHARACTERISTICS IN MACEDONIA

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Background: Lung cancer worldwide is the most common malignancy in men, while in women this is on a second place. At the same time the lung cancer is the leading cause of cancer-related death. Today, smoking is considered as a major cause of lung cancer. About 90% of lung cancers in men and 78 % of lung cancers in women may be associated with long-term smoking.

Methods: A total of 173 patients with histologically confirmed NSCLC and SCLC were included in this prospective - retrospective study. In the interest of the study, and to facilitate statistical analysis, all patients were divided into two groups: operable (117) and inoperable (56). To quantify the association of certain risk factors and the incidence of lung cancer an odds ratio - Odds ratio (OR) 95 % CI was calculated. To determine the level of significance i.e. importance the value of $p < 0.05$ is taken, and the value of $p < 0.01$ for highly significant.

Results: The mean age of the group was 60.2 ± 8.7 years, with the youngest patient in the study group aged 31 and the oldest 75 years. Pensioners were 80 accounting for 46.25%, in the structure of the socio - economic status and active - the working age patients were 59 or 34.1 %. In regard to smoking status, the majority were smokers, the period of smoking was over 20 years and longer, and in regard to intensity of smoking they were divided into three groups: smokers with more than 20 years of smoking and more than one pack of cigarettes per day - 49.13%, smokers with more than 20 years of smoking and one pack of cigarettes per day - 5.78%, and smokers who smoke more than 20 years but not continuously - 15.61%. Occupational exposure was present in 16.18% of study population, while positive family history was present in 20.81% of patients. Regarding heredity, applying the Chi-square test, we have shown that heredity has a highly significant correlation with the type of cancer that occurs in both groups.

Conclusion: The demographic characteristics of the test are shown to be statistically significant in relation to lung cancer.

Key words: age, smoking, socioeconomic status, occupational exposure, heredity

DEVELOPMENT OF A HIGH RATE PROTON COMPUTED TOMOGRAPHY DETECTOR SYSTEM

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Proton computed tomography (pCT) offers an alternative to x-ray imaging with potential for three dimensional imaging, reduced radiation exposure, and in-situ imaging. The second generation pCT system being developed at Northern Illinois University in collaboration with Fermilab and Delhi University is comprised of a tracking system, a calorimeter or the range detector, data acquisition system, a computing farm, and software algorithms for image reconstruction. The proton beam encounters the upstream tracking detectors, the patient or phantom, the downstream tracking detectors, and a calorimeter. The tracking detectors are scintillating fibers and the calorimeter is made up of stacked scintillator plates. The data acquisition sends the proton scattering information to an offline computing farm. The pCT detector design allows for an increased data acquisition rate (up to 5 million proton tracks per second) and an improved imaging algorithm, which significantly reduced reconstruction times of three dimensional images.

In this presentation, we will present the current status of the pCT detector system, development of the complete detector simulation and reconstruction tools and their validation, and preliminary test beam data analysis with the full pCT detector system.

CELLULAR UPTAKE OF RADIOLABELED NANOSTRUCTURED LIPID CARRIERS

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Biodegradable drug delivery systems are promising to make chemotherapy agents tumor-specific and to avoid their side effects. Nanostructured lipid carriers(NLCs) are new generation of solid lipid drug delivery systems. Their suitability as contrast agents for gamma scintigraphy is attracting major attention. Paclitaxel we used as a model chemotherapy agent is insoluble in water and it has serious side effects. In this study, paclitaxel loaded nanostructured lipid carriers modified with a folate derivative (folate-PEG-cholesteryl hemisuccinate) and radiolabeled with technetium-99m tricarbonyl complex $[^{99m}Tc(OH_2)_3(CO)_3]^+$ to develop a drug delivery system with imaging and active targeting functions. In vitro bioaffinities and incorporation ratios of radiolabeled nanoparticles were investigated on three cell lines, human breast carcinoma (MCF7), adenocarcinoma human alveolar epithelial cell line (A549) and human epithelial cervix adenocarcinoma cell line (HeLa). Incorporation studies were carried out comparing of cellular uptakes at different time points as 30, 60, 120, 240 minutes. The data obtained from this study could be useful in the design of biodegradable drug carriers of paclitaxel and folate receptor based tumor imaging.

Keywords: Solid lipid nanoparticle, technetium-99m, active targeting, paclitaxel, folate receptor

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THE ROLE OF STEM CELL TRANSPLANTATION FOR PATIENTS WITH CHRONIC MYELOID LEUKEMIA (CML) RESISTANT TO TYROSINE KINASE INHIBITORS WITH BCR-ABL KINASE DOMAIN MUTATION T315I

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Abstract. Treatment of CML based on the use of tyrosine kinase inhibitors (TKIs). Resistance to TKIs therapy is associated with the development of kinase domain mutations. The threonine-to-isoleucine mutation at codon 315 of the breakpoint cluster region/v-abl Abelson murine leukemia viral oncogene protein fusion Bcr-Abl (T315I) is insensitive to currently available TKIs. In 2012, ponatinib (Iclusig®) was approved for treatment patients who have failed first-line therapy, have the T315I mutation, or have progressed, and became an alternative to SCT.

Aim. Evaluate the role of Stem Cell Transplantation (SCT) in the treatment of patients CML with T315I mutation.

Objectives and Methods. 14 patients with TKI-resistant CML who had T315I mutations underwent 16 transplantations. At the time of SCT, 5 patients were in chronic phase, 4 patients were in accelerated phase, 1 patient was in blast crisis phase; and 4 patients were in second chronic phase. All patients had received TKI and had become resistant: 4 patients received imatinib, 6 - nilotinib, 4 - dasatinib. The median time from CML diagnosis to SCT was 39 months (range, 14-119 months), and the median time from fist detection of T315I to SCT was 10 months (range, 4-72 months). In 6 cases, donors were HLA - identical siblings, 8 - unrelated donors. 12 patients were male, 2 - female, age was 17-55 years (median 33.5 years).Conditioning regimen: in 4 cases was myeloablative, 12 - reduced-intensity conditioning. Source graft in 5 cases was bone marrow (BM), 9 - peripheral stem cells (PBSC), 2 BM + PBSC.

Results. Survived 5 patients of 14. The best responses after SCT were a complete molecular response (CMR) in 6 patients, and complete cytogenetic response (CCyR) in 1 patient, The best outcome was for patients who underwent transplantation in chronic phase, and all of those patients remained alive and in complete molecular remission: 3 patients in the 1 st and 1 - in the 2nd reached after abolition of the basic immunosuppression and resumption of TKIs. In 1 patient reported relapse after SCT and achieving CMR - progress in blast crisis phase, currently under chemotherapy in combination with TKIs. Duration of observation for living patients to date 1- 66 months, median 7 months. Overall survival of patients who underwent SCT was 43.8% with a median-up follow 7 months.

Conclusions. The current results indicated that SCT is an effective strategy for patients with CML who have the T315I mutation, particularly in earlier stages.

ASSESSMENT THE EFFECT OF X-RAY CROSSTALK ON SPATIAL RESOLUTION IN CT SCANNERS DUE TO LACK OF HIGH VOLTAGE CALIBRATION

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The crosstalk is a leakage of X-Ray or produced light in a radiation detector or photodiode in one element to the other elements. Therefore the crosstalk is one of the most important parameters affecting the output of the detector and impacts on the spatial resolution of the image. The purpose of this research is to investigate the effect of X-Ray crosstalk on spatial resolution in CT scanners due to lack of high voltage calibration. For this purpose, the most important components of the 64-slice GE Light Speed VCT scanner such as X-Ray tube, filters, detectors and grid were simulated using the MCNPX code. The detector module consists of 16×64 array of pixels with dimensions of 1×3×1 (mm^3) and made of $Y_2Gd_2O_3$: Eu. On the detector module a one dimensional tungsten grid, with grid ratio of 10 and septa thickness of 0.2 mm was considered. The detector module was considered in distance of 95 cm of X-Ray source with adjustable energy spectrum of 140, 120, 100 and 80 kVp. For MTF's of 0.98 the spatial resolution was calculated 4.2, 4.5, 5 and 6 cys/mm for energy spectrum of 140, 120, 100 and 80 kVp, respectively. Also for each lack of 5 kVp calibration in CT voltage from 80 kVp to 100 kVp, the spatial resolution reduced by 0.25 cys/mm. So for example in brain's perfusion that 100 kVp is used; not being adjusted could reduce the chance of diagnosis of disease. Considering the simulation results, it's advised in order to reduce the amount of X-Ray crosstalk lowest possible energies should be used and pay enough attention to calibrate CT High Voltage.

DESIGN AND EXECUTION OF A METHOD TO IMPROVE THE DIAGNOSIS OF MULTIPLE SCLEROSIS(MS) DISEASE IN BRAIN MRI IMAGES

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One of the most common diseases of this century, causes of disability in young adults, especially women is multiple sclerosis (MS). In MS, the immune system attacks the central nervous system and the myelin sheath, which is a protective membrane that wraps around the axon of a nerve cell, is destroyed. Multiple areas of scar tissue called lesions (plaques). Early detection of MS and estimation of its progression are critical for optimal treatment of the disease. MRI is a powerful tool for diagnosis of MS and monitoring the disease activity and progression. However, due to the large amount of MRI data to be analyzed, manual segmentation of the lesions by clinical experts translates into a cumbersome and time consuming task.

Hence the automatic segmentation of MS lesions in brain MR images can be path finding. In this paper we applied gaussian mixture model (GMM) to segment MS in MR images including T1-W, T2-W and T2-FLAIR. In order to reach the optimal results, two pre-processing step are necessary. First of all the intensity inhomogeneity should be corrected and in second step the non-brain objects, like skull, are removed. We used Low-pass filtering (LPF) to correct the intensity inhomogeneity and Otsu thresholding method combining with some morphological operation to remove skull from the images.

Usually, GMM is optimized using expectation-maximization (EM) algorithm. One of the drawbacks of this optimization method is that, it does not convergence to optimal maximum or minimum. Starting from different initial points and saving best result, is a strategy which is used to reach the near optimal. This approach is time consuming and we proposed another way to initiate the EM algorithm. GMM is applied to segment only T1-W image with 100 different starting points with the maximum iteration of 50. Segmentation results are used to calculate the parameters of other two images. Since we limited the maximum iteration and only used T1-W image, simulation time decreased considerably and also the initial points are reasonable and not random.

Most of the time, there are some voxels which do not fit the GMM model and have to be rejected. The rejected voxels have no contribution on computing the GMM parameters and as a result better estimation of GMM parameters will be available. In this paper, FAST- Trimmed Likelihood Estimator (FAST-TLE) algorithm is applied to determine which voxels should be rejected. The result of segmentation is three classes (white matter, gray matter, cerebrospinal fluid) and some rejected voxels which prone to be MS. In the next phase, MS lesions are detected using some heuristic rules.

We used MR image of 25 patients from two different hospitals to evaluate the proposed algorithm. The automatically segmentation outputs were scored by two specialists and the results show that our method has capability to segment the MS lesions with dice similarity coefficient (DSC) score of 0.78.

THE NECESSITY OF HIGHER VOLTAGES FOR SPECIAL RADIOGRAPHS IN MEDICAL RADIOLOGY

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The paper sustains the necessity of higher voltages for special radiographs, and low doses. It is the case of lombo–spine, lateral and large persons radiographs. In general, the absorption of X-beams in patient body is huge. Calculations are made concerning the absorption of radiation in the body, in different situations. Only a few percentages of photons escape from the body. The higher part of spectrum is favored, but it is a small part of the spectra. The low and inefficient energies must be attenuated by filtration, to reduce the patient–dose. In the film–radiographs, the higher energies are less recorded, but in modern systems, with silicon and NaI detectors, this problem is not important. The radiographs for arms, legs and small children need no filtration. There are situations where good image is primordial. In the radiology there is a contradiction between good image and low dose. The physician, based on his own experience, may choose the right compromise. Filtration attenuates all energies but, if necessary, for good image, the parameter (mAs) may be increased. Attenuation by filtration for higher voltages must be smaller than for a spectrum obtained with 90 kV. The high energies are absorbed less, but even so for equal number of photons the absorbed dose is greater than for low energies. For a given good image, obtained with given number of escape photons, the spectrum obtained with 125 kV, 150 kV high voltage produce a lower dose than the spectrum obtained with 90 kV. This valid for patients with both 20 cm and 30 cm.

INVESTIGATION OF NOISE SOURCES FOR DIGITAL RADIOGRAPHY SYSTEMS

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The image signal-to-noise ratio (SNR), and hence the image quality in digital radiography detectors is limited by the number of the x-ray quanta used to create the digital image. The noise in a digital radiographic image can be divided to three components. These are quantum-statistical (Poisson) noise source, dose related (multiplicative) noise source and dose independent (additive) noise source. To determine the system noise, both noise power spectra (NPS) and relative standard deviation (RSD) analysis were carried out. The effect of grid variations as well as gain and offset correction on the noise components have been investigated for different digital radiography systems. We also evaluated the quantum noise limited condition for each detector for the different exposure levels.

AORTIC DISSECTION AND HOCM-CASE REPORT

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Introduction: Acute aortic dissection(AD) is a relatively rare, but potentially deadly medical emergency that requires accurate diagnostic confirmation and treatment. The causes are hereditary, inflammatory and traumatic etiology, in the elderly atherosclerosis, and the main risk factors as hypertension, dyslipidemia and smoking. In people under age 40, the risk factors are Marfan syndrome, bicuspid aortic valve and cocaine addiction .As far as we know, there is no connection between AD and obstructive hypertrophic cardiomyopathy (HOCM) in literature.

CASE: Male, 37 years, admitted in hospital because of severe pain in the chest that arose back an hour and a half. Similar problems had before, but not this intensity. Auscultation of the heart sound is rough systolic murmur over the chest, blood pressure 90/60 mmHg. The electrocardiogram showed sinus rhythm, heart rate 50 per minute, a negative T wave in DI, AVL. Cardio markers were negative. Transthoracic echocardiography presented primary HOCM, dilation of the ascending aorta 48mm, LVOT obstruction velocity 4.2 m / sec, SAM effect. The patient was followed up in the coronary care unit because of suspected acute coronary syndrome. The symptoms were worsening during few hours . The first patient refused CT scanning of the aorta due to fears of radiation, because he did the same examination 6 months ago, but due to further progression of symptoms the CT aorta was performed. Examination showed intima-media splitting, with visible intimal flap that began in the final part of the ascending aorta before origins of the left subclavian artery and extended the entire length of the descending thoracic aorta, abdominal aorta and both iliac arteries. Fake lumen was large and took up two-thirds of its circumference. The patient was transported to cardiovascular surgery department. Persistent hypertension resistant to therapy and persistent pain without hemodynamic changes and organ damage indicated forthcoming rupture of aorta. According to the registry, such clinical presentation is associated with higher hospital mortality and represents an absolute indication for invasive therapy which can improve outcome. Despite the modern therapeutic strategies, still it is not determined what is the optimal treatment for AD type B. The primary disease of our patient was idiopathic HOCM, autosomal-dominant inherited disease that is characterized solely to changes in the cardiac muscle and for now there is no research that it could connect HOCM with aortic aneurysm and its complications.

ANTIBACTERIAL ACTIVITY AND CELL MIGRATION STUDIES OF RADIOIODINATED ZINC OXIDE NANOPARTICLES

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Green Fluorescent Protein (GFP) was observed Aquaria victoria named jellyfish which is promising biomolecules for the cell imaging studies. Whole-body external imaging makes use of GFP-expressing tumors in intact animals. Stable GFP expression in cancer cells is an extremely effective marker. With the aid of GFP; the development of nerve cells in the brain, such as the spread of cancer cells or non-process monitoring of earlier observations that provide the ability to have developed ways. Using DNA technology, researchers tied the proteins that are usually invisible, with GFP. With this glowing marker proteins movements, positions and interactions could be monitored.

Zinc oxide (ZnO) belongs to a group of metal oxide, which is characterized by photocatalytic ability and photo-oxidizing capacity against chemical and biological species. Moreover, ZnO utilizes a multifunctional nanoplatform that bombards malignant cells from the outside. On the other hand, ZnO nanoparticles propose new opportunities including the improvement of the specific drug delivery and also manipulating cell membranes. No cytotoxic effects of ZnO nanoparticles were found in human glioma cells. ZnO nanoparticles are known to be one of the multifunctional inorganic nanoparticles with effective antibacterial activity.

In this study, ZnO/GFP was synthesized and used in cell imaging studies for targeting and labeling platform. In the synthesis procedure, initially ZnO/GFP was conjugated through crosslinker. The sizes of ZnO were change by the incubation time. The bonding of GFP to the ZnO nanoparticles yield was detected by High Performance Liquid Radio Chromatography. The complex was labeled with ^{131}I via iodogen method. The yield of radiolabeling of ZnO/GFP was determined by Thin Layer Radio Chromatography. Radiolabeling yield of ^{131}I/ZnO/GFP was 98.42 ± 0.90 % . Lipophilicity of the bioconjugate was actualized using n-octanol: phosphate buffer solution (pH:7.0) and radiolabeling stability studies were performed. ^{131}I labeled ZnO/GFP (^{131}I/ZnO/GFP) was added to the glioma cells in order to investigate its optical signals. All data were compared to each other. Human glioblastoma cells (U87-MG) were used to determinate the time dependent incorporation of ^{131}I, ^{131}I/ZnO and ^{131}I/ZnO/GFP. Due to investigation time dependent incorporation of ^{131}I 0.037 MBq (1.0 μCi/mL) labeled components, the cells were incubated for 1, 2, 4 and 24 hour at 37 áμ'C. Two hour was found as the maximum uptake time. The healing properties of the promising bioconjugate were studied with U87-MG. Finally the antimicrobial activity and bacterial adhesion tests were carried out at E.coli, S. aureus and C.albicans for this bioconjugate.

All experimental results suggest that ^{131}I labeled GFP/ZnO compound can be used in the applications of Nuclear Medicine as a radiolabeled agent for imaging both optical and radioisotopical.

RADIOIODINATED GREEN FLUORESCENCE PROTEIN LINKED MAGNETIC NANOPARTICLES IN DUAL IMAGING OF CANCER CELLS

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Green Fluorescent Proteins (GFP) are promising biomolecules for the cell imaging studies. On the other hand, magnetic nanoparticles (MNP) propose new opportunities including the improvement of the specific drug delivery and also manipulating cell membranes. The biological application of these nanomaterials to have high magnetization values, small size, and narrow particle size distribution and has special surface coating for both prevent toxicity and allowing the coupling of biomolecules.

In this study, MNP/GFP/Anti-HER and MNP/GFP/Anti-MTDH bioconjugates were synthesized and used for imaging of cancer cells using both fluorescence and nuclear imaging methods. In the synthesis procedure firstly GFP/MNP was conjugated by interaction of His-6-tag with MNP, and then antibody was added to structure. Finally complex was labeled with ^{125}I or ^{131}I using iodogen method. ^{125}I or ^{131}I labeled protein were used on MCF7 (human breast adenocarcinoma cell) in order to investigate its biological affinities on cells. Optimization studies were carried out to increase fluorescence intensity. For this aim influence of some parameters such as immobilization time, immobilization amount of magnetic nanoparticles and pH were investigated. Radioiodine/GFP/MNP/antibody incorporated with cancer cells. Radionuclide/GFP/MNP/antibody was applied to mice in order to detect organ distribution and *in vivo* imaging both nuclear and optical imaging methods.

Finally, the radiolabeling yield was detected as 95%, suitable stability time of radioidination and high ratio of incorporation of MCF7 showed that ^{131}I/MNP/GFP/Anti-HER has high binding in 240 minutes. Fluorescent microscopy images were carried out at 460 nm. On the other hand selectivity of localization can be controlled via magnetic field.

^{99m}TC-MELPHALAN AND *IN VITRO* EVALUATION

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The purpose of this study is to study of in vitro biological behavior of ^{99m}Tc radiolabel melphalan (^{99m}Tc-L-PAM) complex. Melphalan is known as a significant analog of nitrogen mustards which belongs to a category of bifunctional alkylating agents.

In order to prepare ^{99m}Tc-L-PAM, primarily melphalan commercially named as ALKERAN (2mg), has been purified from its tablet form, and quality control was checked with HPLC method. After purification process, L-PAM has been reduced in the presence of $SnCl_2$ and labeled with Tc-99m in an acidic environment. The quality control of the radiolabeling procedure has been checked with TLRC method, and the yield has been calculated as % 99.0 ± 1.19. It is observed that the stability of the ^{99m}Tc-L-PAM in serum was preserved as % 95.3 ± 3.10 at the end of 24 hours and the experimental logP value was calculated as -0.35 ±0.03.

The biological activity of the resulting complex of ^{99m}Tc-L-PAM was conducted *in vitro* using four different cell lines as MCF-7 (breast adenocarcinoma cell line), HeLa (ovarian adenocarcinoma cell line), HEP-3B (human hepatoma cell line) and HMEC (mammary epithelial cell). Concerning MCF-7 cell line, binding yields were determined depending on the time vs ligand amount and activity. Binding activities to the other cell lines HeLa, HEP-3B and HMEC, were examined according to percentage binding yields of ^{99m}TC-L-PAM to MCF-7. Activity counts of the cells is obtained through Cd(Te) semiconductor solid detector. It's observed that the binding yield of the radiolabeled complex has been increased in the process of time.

In conclusion, it was thought that melphalan radiolabeled with Tc-99m (^{99m}Tc-L-PAM) would contribute improvement for effective radiochemotherapy.

Keyword: Nitrogen mustard, melphalan, L-PAM, ^{99m}Tc, cell culture, alkylation of DNA.

DUAL-PHASE 18F-FDG PET/CT IN PATIENTS WITH SUSPECTED LUNG CANCER

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Background: Last years growing number of oncology pathologies has been observed in Ukraine, as well as in the majority of European countries. At the same time growth of tuberculosis is registered in Ukraine. Taking into account this fact authors have an objective to determine the efficiency of dual-phase 18F-FDG PET/CT in patients with suspected lung cancer in order to differentiate malignancy from potential infective lesions.

Materials and Methods: Twenty-seven patients with suspected lung cancer underwent dual-phase FDG PET/CT using a hybrid PET/CT scanner before histopathological study. Total number of patients investigated: 27 (22 males, 5 females; age: 35-69 y.o.). Images were taken 60 minutes and 180 minutes after injection of the tracer. Radiopharmaceutical activity administrated to the patient was 4 MBk/kg. The intensity of 18F-FDG uptake by pulmonary lesions was assessed visually and scored using four-point scale (without metabolic activity, low intensity, middle intensity, high intensity). The maximum standardized uptake value (SUV max) in 60 minutes and 180 minutes was labeled as SUVf and SUVs. PET/CT results were compared to final histological diagnoses.

Results:

Histological diagnoses	NSLC : adenocarcinoma	Lung tuberculosis	Tuberculoma	Local fibrosis
Mean SUV_f (max)	9.0 (range from 4.0 to 13.5)	3.0 (range from 1.7 to 5.0)	2.4 (range from 2.1 to 3.0)	ametabolic
Mean SUV_s (max)	12.5 (range from 4.9 to 18.5)	3.9 (range from 1.7 to 6.5)	2.5 (range from 1.5 to 3.6)	ametabolic
Mean SUV(max)= SUV_s (max)- SUV_f(max)	3.5	0.9	0.1	; -
Number of patients male/ female	18 (16/2)	2 (2/-)	2 (-/2)	5 (3/2)

Conclusions: Based on the result of the study dual-phase PET/CT seems to be an efficient tool to initially differentiate malignancy and infective/non-malignancy lesions that allow to further select specific treatment strategy. In order to validate these results with a statistic accuracy further studies are required.

MONTE CARLO MODELING OF A NOVEL DEPTH-ENCODING PET DETECTOR WITH DETECT2000

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We designed a depth-encoding PET detector using wavelength-shifting (WLS) fibers for low cost and high resolution PET. In order to characterize the theoretical performance of a newly designed PET detector, we performed the DETECT2000 simulation of the optical photon transport in crystal array and WLS fibers.

The detector module is made of an array of individual crystals, WLS fibers and silicon photo-multipliers (SiPMs). The LSO crystal array consists of 15 x 15 crystals with 2 mm x 2 mm surface size and three different heights: 18, 20 and 22 mm. On the every other line, scintillator having 2 mm shorter height area arranged to x-direction on the top and y-direction on the bottom of the array to make grooves for WLS fiber insertion. The total size of detector module is 30 mm x 30 mm x 22 mm. One end of each WLS fiber is coupled to SiPM to measure scintillating lights trapped in the fiber. Depth-of-interaction (DOI) resolution and the pixel identification capability are determined by DETECT2000 simulation.

All pixels of the 15 x 15 LSO array are well decoded and DOI resolution ranges from 1.43 mm to 2.44 mm with an average of 2.02 mm FWHM.

The results indicate that the proposed detector performs respectably for hig resolution PET.

FAST COMPRESSED SENSING BASED PROTON CBCT RECONSTRUCTION ALGORITHM

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Purpose: The purpose of this study is to develop a fast compressed sensing (CS) based proton CBCT (pCBCT) reconstruction framework that allows reconstruction of high quality pCBCT images with no more that the imaging dose as well as projections used in the current physical setup of pCBCT scan.

Methods: In this study, we proposed new pCBCT scanner using the GEANT4.9.6 simulation toolkit. GEANT4 simulation was performed to optimize the system geometry based on pCBCT application. The geometric optimization factor was achieved in terms of the detector thickness and distance between entry detectors and exit detectors, respectively. The system was composed of 4 Silicon strip detectors (SSDs) for particle tracking and an energy detector calorimeter to measure residual energy of individual protons. This systematic model of pCBCT system was then casted into CS based convex optimization problem such that it ensures the solution converges into desired pCBCT images after sufficient number of iterative correction steps. In particular, we have used total variation (TV) based formulation that has been useful in exploiting prior knowledge of minimal variation in the proton attenuation characteristics across the human body. To enhance the convergence and computational efficiency, we have used gradient projection algorithm based on the Barzilai-Borwein (GPBB) that can handle TV based CS type of CBCT formulation in an extremely efficient manner.

Results: Examinations of our CS algorithm showed that high quality pCBCT images with sets of 72 projections could be reconstructed within 20 iterations. Moreover, in comparison with other reconstruction algorithms, the image quality of the CS algorithm is shown to be superior.

Conclusions: This work demonstrates the potential for providing high-quality pCBCT during on-line image-guided proton therapy, without increasing the imaging dose. The result show that high quality pCBCT images could be reconstructed with 72 evenly sampled proton projections without any streak or noise that are caused by under-sampling and proton starvation. This makes our CS based proton CBCT reconstruction algorithm potentially useful in an on-line proton therapy environment.

COMPARISON OF CANCER RISKS FOR TWO DIFFERENT CHEST CT PROTOCOLS

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The use of computed tomography (CT) is increasing rapidly and doses are not negligible especially when medical procedures require more than one CT scan. The objectives of the present study were to measure doses in/on an anthropomorphic Rando phantom during standard and low dose CT protocol of thorax and to estimate radiation risks for adult patients that undergo multiple CT scans of thorax. Thermoluminescent (TL) and radiophotoluminescent (RPL) dosimeters were used for dose measurements. Radiation risks of cancer incidence, in the form of lifetime attributable risk (LAR), were estimated using BEIR VII model. For five exposures with standard protocol mean organ doses were 94 mGy (breast), 85 mGy (stomach), 85 mGy (thyroid), 78 mGy (lung), 52 mGy (liver) and 16 mGy (colon). For standard CT protocol associated LARs were found to be up to 0.401% (breast cancer) and 0.116% (lung cancer) for women and men respectively. Low dose protocol reduces doses and risks by the average factor of 5 and therefore the use of low dose protocol is recommended whenever it is medically justified.

Key words: CT, dose reduction, organ doses, cancer risk

NEUTRON RADIATION

07

THE COMPARISON OF TEST RESULTS OF SRAM TO ATMOSPHERIC RADIATION EFFECT HARDNESS AND HIGH-ENERGY PROTONS OF SPACE

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The Roscosmos test facility IS OP was created on the base of FM cyclotron CS-1000 in PNPI with proton energy equaled 1GeV. This test facility was made for space proton influence modeling. This test facility has following proton beam parameters:

- energy: 1GeV;
- energy uniformity: 1%;
- beam intensity in chamber: not more then 3 uA;
- beam intensity outside chamber: 1 uA;
- efficiency: 30%;
- macropulse repetition rate: from 40 to 60 cycles per second (Hertz);
- width of macropulse: from 300 us to 10 ms;
- width of micropulse: from 6 to 10 ns.

In the future, the IS NP testing aid with neutron energy spectrum, which is simile to neutron radiation in the atmosphere, is created on the base of existing Roscosmos test facilities in PNPI. The facility is intended for testing the neutron radiation hardness of chips and electronics and meets the requirements of the JEDEC international standard. The parameters of the neutron beam are as follows:

- energy range: 1-900 MeV;
- width of the fast neutron pulse: 10 ns;
- intensity: $5 \cdot 10^5$ neutron/cm^2/sec (at the 36 m flight path);
- beam diameter: 50-100 mm (at the 36 m flight path);
- beam monitor: fission ionization chamber (FIC);
- beam profilometer: multiwire proportional counter (MWPC).

The development of the neutron beam and the test facility extends considerably the experimental potential of radiation research at the PNPI and can act as a basis for establishing a unique center for neutron radiation tests of aviation and space electronics relatively.

The tests were carried out on following part type SRAM under checking test facility working capacity center and getting the neutron beam characteristics. According to the test results (Table 1) and the usage of the regulatory and procedural guidelines, the order of the experimental index determination was created. This procedure shows the impact of atmospheric neutron radiation on electronic components which is formalized as a fundamental document about the standardization and approved by Central Design Bureau «TsNIIMASH».

Table 1 – Part type SRAM tested on neutron radiation hardness and high energy space protons

Part type	Protons		Neutrons	
	Fluence proton./cm2	σSEU, cm2/bit	1) Fluence neutron/cm2	σSEU, cm2/bit
CY7C1021BN-15ZSXE	3,17·109	5,73·10-14	1,61·109	9,60·10-15
1667 014	5,33·1010	3,10·10-14	1,86·109	SEU is not registered
1) the represented data of integral neutron fluence with the energy rage from 1 to 1000 MeV				

LONG TIME OBSERVATIONS OF THE EMISSION CHANGE OF AN OLD CALIFORNIUM SOURCE

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Many years of careful measurements carried out in the Radiation Protection Measurements Laboratory (LPD) at the National Centre for Nuclear Research (NCBJ) led to adopt an efficient method describing the effective decay scheme for the ^{252}Cf spontaneous fission neutron sources.

Owing to long time periodic measurements of a neutron fluence with the 2202 D neutron monitor in a settled geometry, a curve with a neutron emission decline has been experimentally determined. The radioactive neutron source of bare ^{252}Cf, installed 1m above the ground in the centre of the room dedicated for the neutron irradiation, which is $4 \times 4 \times 16$ m^3 in size. The detector has been situated in the reference point in distance 1 meter, facing to the neutron source. Measured data are showing slower decline in the neutron fluence of the source, which does not follow the decay curve of ^{252}Cf isotope.

The explanation of the phenomenon is based on the assumption of occurring isotope impurities. The source contains the neutron emitting isotope ^{250}Cf, which has longer half-life time than ^{252}Cf. With time this becomes a more significant fraction. To extrapolate emission forward in time we fit a function to the data.

ROOM TEMPERATURE NEUTRON DIFFRACTION STUDY OF THE PROTON CONDUCTING $BaCe_{0.85}Y_{0.15}O_{3-\delta}$ (BCY15)

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A solid oxide fuel cell (SOFC) is made up of four layers, three of which are ceramics (hence the name). The advancement of highly efficient ion conducting materials is essential to the development of SOFC and other electrochemical devices. The quest is on solid oxide materials with high ionic conductivity while preserving structural stability at high temperatures. The oxides with perovskite structure ABO_3 are recognized among the most efficient ion conducting materials used in electrode structures in solid oxide fuel cells operated in the intermediate temperature range. In this regard Barium cerate with Y-substitution at the B-site (Ce site) is well known for excellent conduction capabilities in the temperature range 400–800 °C as a result from the proton motion in the crystal lattice. Doping with Y^{3+} is very effective and the proton conductivity in $BaCe_{1-x}Y_xO_{3-\delta}$ increases with the increasing of the dopant concentration up to x =0.2. However, the phase behaviour of the composition BCY20 (x=0.20) is very complicated. Even at room temperature the crystalline structure remains contradictory because various structures of monoclinic, rhombohedral and orthorhombic symmetry are reported.

We report on the powder neutron diffraction study of $BaCe_{0.8}Y_{0.2}O_{3-\delta}$ (BCY15) prepared by solid-state reaction and used recently in a new design of SOFC [1]. The method has proven advantages over other diffraction (electron, x-ray) methods in the determination of the position of the oxygen and it was used to find additional information about the crystal structure of the electrodes. The structural details in dependence on preparation of powder, dense and porous samples of BCY15 were investigated using Rietveld full profile analysis of diffraction patterns collected with the PSD diffractometer of the Budapest Neutron Center.

[1] G. Raikova, M. Krapchanska, I. Genov, G. Caboche, L. Combemale, A. Thorel, A. Chesnaud, D. Vladikova, Z. Stoynov, “Impedance Investigation of $BaCe_{0.8}Y_{0.2}O_{3-\delta}$ Properties for Hydrogen Conductor in Fuel Cells”, Bulgarian Chemical Communications, 44(4) (2012) 389-394.

CALIBRATION OF A NE230 SCINTILLATOR UP TO 64 MeV AT THE ITHEMBA LABS TIME-OF-FLIGHT FACILITY FOR IN WATER NEUTRON SPECTROMETRY

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Knowledge of how neutrons transfer energy into body tissue as they progress through the body is required in neutron radiotherapy. This knowledge is important to calculate the fluence energy distributions of secondary charged particles, to characterize the radiation quality and absorbed dose both inside and near to the area under treatment. For this purpose, there is a need to know, how the neutron fluence energy distribution will vary as a function of position in a body that is irradiated by a neutron therapy beam. Experimental measurement and Monte Carlo transport codes can be used to determine neutron fluence energy distributions.

This paper reports on a neutron spectrometer base on an NE230 deuterated organic liquid scintillator that has been developed for measuring neutron fluence energy distributions in a water phantom (simulating body tissue). This NE230 scintillator offers advantages over the NE213 which had be widely used for this purpose, in particular its ability to discriminate against backgrounds that can arise from n-p scattering in the water. This paper focuses on the tests done to check the validity of the procedures used to determine neutron fluence energy distributions from pulse height distributions measured with the NE230 scintillator.

The NE230 spectrometer was tested by recording pulse height spectra in air irradiated by neutrons of energy up to ~ 64 MeV at the iThemba LABS time-of-flight facility. Neutron energy spectra were obtained from the pulse height spectra by Bayesian unfolding with the code MAXED using a response matrix that was determined experimentally. The efficiency of the NE230 detector was determined experimentally relative to an NE213 detector of known efficiency. A series of tests were carried out, in particular this paper will focus on the results obtained of comparisons between neutron fluence energy distributions from pulse height distributions measured with the NE230 scintillator with a NE213 scintillator using the time-of-flight method at the iThemba LABS time-of-flight facility will be presented and discuss.

ACCELERATOR-DRIVEN NEUTRON SOURCES AND THEIR RECENT APPLICATIONS IN JAPAN

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Accelerator driven neutron sources are used for various fields. High power accelerators have been used for neutron scattering experiments such as ISIS in UK, SNS in USA and JSNS in Japan. On the other hand neutron sources driven by compact accelerators have been constructed in the world. Two of major applications are the scattering and the boron neutron capture therapy (BNCT).

The compact accelerators with a power of about 1 kW around 10 MeV or less have been constructed in Japan, and neutron imaging, neutron device development and so on are performed. The neutron imaging is one of very useful methods and can be used for industrial application. Traditional neutron transmission imaging is feasible at the compact neutron sources. They are used for various fields due to its easy access. At a pulsed neutron source we can obtain a transmission datum depending on the neutron wavelength at each pixel of a 2-dimensional position sensitive detector. We can deduce various information from the wavelength dependent spectrum since it includes crystallographic information and element information. The characteristics have opened a new field of the neutron imaging and enable us to mapping the quantitative physical values of such information.

On the other hand, the neutron sources for the BNCT are being planned and under construction. The neutron intensity is about one order higher than that for the scattering experiment. The proton energy proposed ranges from about 3 to 30 MeV at around several 10 kW power. The reactions used for the neutron production are p-Li for low proton energy and p-Be for higher energy. At low energy, the produced neutron energy is also low. Therefore, the neutron moderator system becomes compact and the activation become low. On other hand, at higher energy the moderator system becomes larger and the activity higher. However, in general, the target fabrication is now considered to be easier for Be than for Li since Li is active element and has low meting temperature. Therefore, two methods are being developed in parallel and it gives information on feasibility and performance of both neutron generation systems.

In both neutron applications to make the activity lower is important since the compact accelerator neutron facility is not operated by a big organization and there is not enough disposal place. We have studied the activation depending on the proton energy and materials. In this presentation we report design and its recent applications of the neutron sources driven by compact accelerators in Japan.

STUDY OF FAST NEUTRON INTERACTIONS IN SILICON BY TIMEPIX DETECTORS

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Timepix detectors with silicon sensor layers of thicknesses 300 μm and 1 mm were exposed to neutrons at the Flight Path 30R (FP30R) in the Weapons Neutron Research facility of the Los Alamos Neutron Science Center. An 800 MeV pulsed proton beam is directed onto a tungsten target, where neutrons with a broad energy spectrum from less than hundreds of keV up to ~600 MeV are produced in a spallation process. The detectors were placed ~20 m away from the interaction point. The silicon sensor layers are flip chip bump-bonded to the Timepix ASIC, which divides the active area into pixels. These pixels are arranged in a square matrix of 256 columns and 256 rows with a pixel pitch of 55 μm. This pixelation allows the characterization of different track shapes, indicating different types of interactions and energy depositions in the silicon sensor layer. By measuring the Time-of-Flight the recorded tracks were assigned to the incident neutron energy. For the first time also a Timepix3 detector was used, which measured the time and the deposited energy simultaneously.

In this work special attention is paid to the energy range between 100 keV and 1 MeV, where peaks in the TOF spectrum, resembling the resonances of elastic scattering of neutrons on the silicon nucleus, were seen. The signatures of these events are clusters with up to four pixels due to ionization by the recoil silicon nucleus, whose displacement may already induce radiation damage. By studying the spectra of the deposited energy of neutron events in the resonance peaks the border of the energy depositions by ionizing energy losses (IEL) and non-ionizing energy losses (NIEL) may be identified.

Events with a high energy transfer to the silicon pixel sensor are seen as huge tracks with round or elliptical shapes, sometimes even accompanied by long outgoing tracks. An edge in the TOF spectrum is pronounced for these events at neutron energies around ~3MeV, where the threshold for Si(n,X)-reactions is reached. These events are likely to cause single event upsets (SEU) in electronic devices.

THE SPECIAL TRANS FUNCTION THEORY TO THE DEGREE OF NUCLEAR FUEL BURN-UP ESTIMATIONS

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The problem of finding an exact analytical closed form solution to the Lambert transcendental equation, which describes phenomenon of the degree of nuclear fuel burn-up, is studied in some detail, by using the Special trans function theory (STFT).

The STF Theory for all magnitudes of the initial fuel enrichment in 235U, and, for all laying down times after finishing of irradiation, just as the structure of the theoretical derivations are presented, while proofs and numerical results confirm the validity and base principle of the STFT.

In addition, the obtained results are compared with the calculated values of other methods for alternative proving its significance. Undoubtedly, the proposed novel STFT exact analytical approach implies qualitative improvement of the conventional analytical and numerical methods.

CYSP AND SP^2: NOVEL INSTRUMENTS FOR CONTINUOUS SPECTROMETRIC MONITORING OF NEUTRON PRODUCING FACILITIES

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Novel neutron spectrometers called CYSP (CYlindrical SPectrometer) and SP^2 (SPherical Spectrometer) were developed within NESCOFI@BTF and NEURAPID collaborations (INFN - Scientific Commission 5). The devices, composed by multiple active thermal neutron detectors arranged in optimized geometrical patterns within a single moderator, were designed to simultaneously respond from the thermal domain up to hundreds of MeV neutrons. These spectrometers condense the performance and functionality of the Bonner Sphere Spectrometer in a single moderator, thus requiring only one exposure to determine the whole spectrum. Whilst CYSP has directional response and is suited for studying angle-dependent neutron emissions (such as from targets), SP^2 has isotropic response and is suited for radiation protection purposes. The new active spectrometers represent innovative options for wide energy, continuous, spectrometric monitoring of neutron fields in a variety of facilities.

STUDIES OF NEUTRON ACTIVATION PROFILES IN CARBON, IRON AND COPPER TARGETS

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The study of the ESS (Energy System Selection) activation in a protontherapy centre is a very important topic for industry. This activation is mostly due to the secondary neutrons created by the interactions between the protons and the degrador (carbon, aluminum or beryllium). Due to the huge cost of the treatment of nuclear waste, the whole activated materials are preferentially stocked until they reach a convenient level of radioactivity and pass under the exemption level. The main question which must be considered is the time to wait until reaching this level. In order to answer to this question, we have made Monte Carlo Simulation using FLUKA and PHITS codes. The simulations also allow to study the activation profile inside a material and more particularly to know if there is hot spots in the material, near the surface or deep in the solid. This is an important information in the purpose of more pertinent measurements or in the analysis of these measurements. Moreover, we check that the simulated average isotope production concentration for neutron activation can be extrapolated to a given volume.

We have considered neutrons beams of kinetic energies from few keV to 230 MeV incident on Carbon, Iron and Copper parallelepiped targets. The length of these targets is 1 meter and is subdivided into 100 parts. We have collected the isotopes concentration part by part for particular isotopes (as Mn54, Co60, etc.) and we have observed that the activation profile is highly influenced by the neutron kinetic energy. For neutron energies smaller than a threshold characteristic of the isotope, we observe that the concentration of isotopes is maximal near the surface and exponentially decreases as a function of the depth. For energies larger of this threshold, the maximum of the concentration moves deeper inside the target for increasing energy. This phenomenon is due to the characteristic shape of the capture cross section.

WORKER'S HEALTH AWARENESS PROGRAM IN BELO HORIZONTE, BRAZIL: SUPPORT BY NEUTRON ACTIVATION ANALYSIS

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Nuclear techniques have been applied on prevention, diagnosis and treatment of diseases. This paper is about a support that, in practice, it is not usual: application of neutron activation analysis in galvanising industry. An assessment of several elements was carried out in three galvanising factories analysing hair and toenail samples as biomonitors and airborne particulate filters. The goal was to give support to the Worker's Health Awareness Program of the Municipal Department of Health of Belo Horizonte, capital of the Brazilian State of Minas Gerais.

Studies concerning galvanising industrial process have usually been developed broaching many aspects including chromium contamination consequences, but usually they have not pointed out the detection and measurement of arsenic, therefore, this paper focuses on the arsenic determination in the galvanising studied.

The high concentration results surprised the health surveillance professionals, and alerted for the need of assessing the influence of a long-term exposure. The k_0-Instrumental Neutron Activation method was applied on elemental concentration using the TRIGA MARK I IPR-R1 research reactor located at Belo Horizonte, Brazil. The nuclear analytical technique confirmed to be a suitable method on determination of arsenic in biological and air filter matrices.

NON-IONIZING RADIATION

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THE ANALYSIS OF AMBIENT TEMPERATURE INFLUENCE ON DIGITAL ICs ELECTRICAL OVERSTRESS PULSE HARDNESS

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The results of the experimental studies of CMOS IC's electrical overstress (EOS) pulse hardness at two ambient temperatures (+25 °C and +125 °C) are given. The value and behavior of the EOS hardness can be described by the p–n junction thermal damage model.

Introduction: The EOS pulse hardness of chips refers to the maximal amplitude of a single voltage pulse with specified duration and shape at which the device is no damaged. In real operation the electronic equipment ambient temperature values can differ from the room temperature. Therefore the problem of studying the temperature influence on the EOS value of the chips arises.

The Experimental Results: CD4001BCN_NL CMOS chips manufactured in one production lot were selected for this investigation. To study the temperature impact on the EOS level in more detail, one group of leads (inputs) was selected, to which critical polarity (positive) and middle duration (1 μs) pulses were applied to determine a scatter of the pulse amplitude threshold values in the available chip sample at ambient temperatures of +25 °C and +125 °C.

The obtained results distinctly show the presence of the influence of the ambient temperature on the threshold pulse amplitude. When the ambient temperature was increased by 100 degrees, the threshold pulse amplitudes decreased for about 20% under the EOS pulses applied to input IC's leads.

The obtained results are in good agreement with the known Arrhenius formula for the lifetime reduction of the product with an increase in the temperature, underlying the accelerated tests: $v=Aexp(Ea/kT)$ (1), where v is the acceleration of the process time; A is the coefficient; k is the Boltzmann constant; T is the temperature; and Ea is the activation energy. However, instead of a constant temperature, the periodic thermal loads related to the EOS pulses affect it.

In accordance with the expression (1) for CD4001BCN_NL CMOS chips the EOS pulse threshold voltage at an ambient temperature of +25 °C was 480 V and at an ambient temperature of +125 °C it was 420 V. The coefficient b corresponding to Ea was defined as $2.27 \times 10{-}4\ V{-}2$.

Conclusion: The obtained results showed that the ambient temperature affects the digital IC's EOS pulse hardness. The temperature dependence of the EOS hardness confirms the thermal nature of the IC damage under the action of the external electrical pulses.

FRACTALITY OF OBSERVED SOLAR RADIATION DATA

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To describe complex behavior of solar radiation in terms of multifractional Brownian motion, two methods are used: central Detrended Moving Average (cDMA) and its version, the-so-called time dependent Detrended Moving Average (tdDMA).

The methods are applied to solar radiation time series (SRTS) consisting of 696 daily solar irradiation measurements for Belgrade (44.810 °N, 20.460 °E), Serbia (data obtained from www.soda-is.com on 15 November 2014). The measurements are taken with a 15-minute temporal resolution, and they cover approximately two full years of measurements, 2004 and 2005.

The time dependent Detrended Moving Average method gives a distribution of the local Hurst exponents for the whole data series. Long range correlations are characterized by the Hurst exponent H. In particular, the exponents $0.0 < H < 0.5$ and $0.5 < H < 1.0$ correspond to negative (anti-persistence) and positive (persistence) correlation, respectively. The Hurst exponent equal to 0.5 corresponds to an uncorrelated Brownian process. In accordance with an estimated magnitude of Hurst exponents, the results with persistent characteristics are obtained. This finding implies some underlying trends.

Further investigation focuses on the effects of potential periodic-like influences on the analyzed SRTS data. For example, daily and three-month periodicities that correspond to a diurnal and seasonal variability of solar radiation, respectively, are found. We propose that an existence of a number of periodic-like influences on SRTS data may partially explain the observed difference in types of correlated behavior of corresponding scaling functions.

EVALUATION OF SMF EXPOSURE FIELD LEVELS AND GRADIENTS OBTAINABLE USING THE 2D MAGNETIC ARRAYS

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Effects of electromagnetic (EM) fields on biological systems can be either beneficial or adversarial. Whereas, for many of the parts of the electromagnetic spectrum under investigation research data is still mainly inconclusive, empirical and collected research data suggest that the low intensity static magnetic fields (SMF) have mainly beneficial effects. Observed therapeutic effects include those related to treating arthritis, healing bone fractures, and improving microcirculation.

Some types of two-dimensional (2D) magnetic arrays can be used as exposure setups for studying the effects of both applied magnetic induction and its vertical gradient to biological systems. Except for the possible utilization of small current coils, which can act to produce fields less than about 0.1 mT, these arrays can be formed from permanent magnets. The latter is not only superior in terms of larger fields available, but also more convenient to use.

Different SMF field levels as well as field gradients can be attained from these exposure setups by means of varying the geometrical parameters of an array and the type of magnetic material employed. We present and use exact analytical expressions for the magnetic induction of such an array, and the software based on these expressions, to conduct detailed theoretical evaluation of the obtainable ranges of field levels and gradients. Several magnetic materials most commonly used for permanent magnets are compared as well as various exposure setup geometries.

Considering such design criteria as the desired mean field level, height of the experimental volume, and magnetic field quality, we outline the guidelines that can serve to accomplish the design process of 2D magnetic array setup in a relatively straightforward manner. The collection of data and results presented here can be used themselves for preliminary design.

A LABORATORY INVESTIGATION OF THE ALLEGED ASSOCIATION BETWEEN EXTREMELY LOW FREQUENCY MAGNETIC FIELD EXPOSURES AND AN INCREASED RISK OF ALZHEIMER'S DISEASE

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There are a few publications in scientific journals suggesting that persons who are exposed to ELF-magnetic fields (occupational-, but also residential exposures) may be at risk for contracting Alzheimer's disease. It should be noted that these reports are only pointing to a possible association but do not at present provide any proof of association. We have performed a number of preliminary in vitro laboratory investigations to explore the plausibility of such an association. Our investigations were based on similarities found in cells from Alzheimer disease patients and in cells exposed to extreme low frequency magnetic fields. We especially investigated genetic damage in C3A and SH-SY5Y cells exposed in vitro to 50 Hz magnetic fields (0-500 μT) using the cytome assay. We found an increased frequency of large micronuclei (suggesting a possible aneugenic effect) and increased frequency of nuclear buds (suggesting gene amplification). In this our results may show some similarities with observed micronuclei in blood and buccal cells of Alzheimer disease patients. The effects were found in both cell lines and were already observed for exposure levels as low as 10 μT. This is however in contrast with earlier results obtained in human lymphocytes where no induction of micronuclei was found using the same exposure unit. The results thus need to be confirmed and further analyses need to be done. We here present our results, including those from a repeat study.

CROSSLINKING OF HISTONE H1 WITH NON-HISTONE PROTEINS IN INTERPHASE NUCLEI UNDER UV-IRRADIATION

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UV irradiation at λ = 254 nm (a mercury quartz lamps low pressure BUF-15) of nuclei with condensed chromatin (in the presence of 5 mM Mg ++) resulted in a dose-dependent decrease of histone H1 yield by extraction with $HClO_4$ reaching its plateau of around 50% of the total content of H1 in the nucleus. Mild acid hydrolysis of DNA during extraction has virtually no effect on the output of H1. Immunoblotting of proteins from nuclei pellets after acid extraction with antibodies to histone H1 shows staining of bands in 45-80 kD region. We can assume that, along with the known effects of UV exposure with λ = 254 nm of chromatin (base modification, DNA-protein crosslinks, DNA strand breaks) in the nuclei appears a new type of adducts - H1-protein crosslinks. Apparently, in our conditions of the irradiation output of H1- DNA crosslinks is unessential. H1-linked proteins are not found in the pellets of irradiated nuclei with decondensed chromatin and do not appear at the refolding of chromatin by the transfer of nuclei into medium with 5 mM Mg ++. Apparently, in these manipulations the histone H1 spatial proximity to other proteins is lost or their steric interposition is broken. Sensitivity to sulfhydryl agents in the medium during irradiation suggests a radical mechanism for the formation of H1-protein crosslinks. The formation of H1-protein crosslinks upon UV irradiation of nuclei in the presence of the antibiotic distamycin (DM), a competitor of H1 for matrix DNA depended on its concentration. DM at saturating concentrations (DM / DNA = 0.1) prevents the formation of crosslinks. At the same time, a low concentration of DM (DM / DNA = 0.01), which interacts mainly with the AT-rich sites in DNA, does not reduce the proportion of crosslinked histone H1. Perhaps H1 located on the AT-rich nucleosome linkers does not cross-link with non-histone proteins. Further information was obtained by comparing the quantitative data of polyglutamic acid (PG) extraction of H1 from UV-irradiated nuclei in the absence and presence of low concentrations of DM. At a ratio PG/DNA = 6 the H1 extraction was 30% in the control experiments, but after UV irradiation PG extract only 3% from total H1 and histone H1 output in pellet decreases to about 50% (according to data of SDS-electrophoresis). DM in low concentration increases PG-extraction of H1 from control and irradiated nuclei on 25% but only from H1 remaining in the pellet without affecting 50% crosslinked H1. This fact confirms our suggestion that histone H1 localized on AT-rich nucleosome linkers, is apparently not involved in the H1-protein crosslinks. Perhaps this fraction of H1 is not extracted by PG (without DM) since it is in the "locked" state within a condensed chromatin and is not available for macromolecular polyanion. Since it is known that non-histone proteins are located on the surface of the chromatin, it can be assumed that in crosslinkings take part mainly the molecules of histone H1 located on GC-rich linkers.

HIGH PRESSURE PLASMA CLEANING OF GLASS SURFACES AND MICROCHANNEL PLATES

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Plasma cleaning involves the removal of impurities and contaminants from surfaces using the plasma created by the high frequency alternating voltages (typically from few kHz to few Mhz) to ionize the gas. High pressure plasma cleaning of glass surfaces and microchannel plates (MCPs) is presented in this paper. Microchannel plates are current-multiplying optical devices frequently used in image intensifier tubes for the intensification of the photoelectron image. Other applications include high-speed photomultiplier tubes, cathode ray tubes, camera tubes, and electron, ion, X-ray, and ultraviolet radiation detectors and imaging. Results shows advantages and a few disadvantages of this kind of cleaning comparing to standard chemical treatment. In summary this kind of plasma cleaning gives much better results, than standard procedures in final electro-optical properties of MCPs.

THE INFLUENCE OF RF FIELD ON THE LOW PRESSURE ELECTRIC DISCHARGE IN THE GAS DIODE FILLED WITH NEON

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The results of RF field influence on electrical discharge in gas diode are presented in this paper. Thereby, low pressure gas diode filled with Neon, with electrodes in the spike-globe geometry, was used. A comparative analysis of electrical discharge in a tube has been done in two cases: with and without influence of RF field. The analysis has shown difference in breakdown voltage, time delay of electrical breakdown, current, and the continually redistribution of light, inside gas diode, with variable frequency depending on field's strength.

SENSITIVITY OF MICROORGANISMS TO PHOTOINACTIVATION IN THE PRESENCE OF ENDOGENOUS AND EXOGENOUS TETRAPYRROLES

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Light can induce direct (UVC and UVB) or sensitized (UVA and visible radiation) destructive processes in microorganisms. Photodynamic inactivation of microorganisms is based on their destruction with reactive oxygen species produced by the combination of chemical compound photosensitizer (PS) and corresponding irradiation with harmless light of the spectral region corresponding to the PS absorption bands. Normally, in the absence of exogenous PSs, the effectiveness of the damaging effects of UVA and visible radiation is small. However, there are a number of metabolic disorders, resulting in excessive accumulation of potential endogenous PSs and increased photosensitivity. In particular, endogenous porphyrin accumulation under inhibition of heme biosynthesis results in five- to six-fold yeast sensitization to visible light. Accumulation of protoporphyrin IX in yeast mitochondria and plasma membranes is accompanied by photoinhibition of cell respiration and destruction of cells permeability barrier. The rad 52 mutant cells, which are deficient in the postreplicative recombination DNA repair system, are considerably more sensitive to the inactivating action of visible light than wild type cells and the rad 3 mutant cells, deficient in the excision DNA repair. Exogenous tetrapyrrolic PSs, such as chlorines and phthalocyanines, strongly enhance yeast sensitivity to visible light causing oxygen dependent damage of external cell structures. Yeast photosensitization in the presence of chlorines is associated with plasma membrane blebbing and can be prevented by protein or heme biosynthesis inhibition that is indicating possibility of apoptosis. Cationic phthalocyanines induce the loss in cell wall rigidity. Among bacteria, gram-negative species are the most resistant to photodynamic inactivation. This is due to low permeability of the cellular outer membrane for dyes. The important primary stage of PS transmembrane self-facilitated transport is its binding to cell surface. The negative charge of external surface of viable bacterial cells determines active binding and, accordingly, expressed antibacterial activity of cationic metallophthalocyanines and chlorines. The increase in the total positive charge of PS molecules results in the enhanced bacterial inactivation. The electrostatic interactions between cationic dyes and lipopolysaccharides contribute essentially to the binding of PSs to cell surface of gram-negative bacteria. During the past two decades, interest to photodynamic inactivation of microorganisms was renewed mostly due to emergence of antibiotic resistant pathogens. The antimicrobial potential of PSs is thought to be useful both for therapeutic and non-therapeutic purposes in the treatment of localized infections, sterilization of blood products and water disinfection.

NON-IONIZING ELECTROMAGNETIC RADIATION EFFECT ON THE MOTILITY OF *SACCHAROMYCES CEREVISIAE* VACUOLAR GRANULES

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The volutin granules are intracellular structures containing inorganic polyphosphates. They are widely distributed among various microorganisms including yeasts Saccharomyces cerevisiae. Due to their ability to move actively within internal space of the vacuoles they are called “dancing bodies” . The chaotic displacement of granules led to suggestion of Brownian character of such motions. In the view of the fact that the phenomenon of “dancing bodies” is little known the aim of our study was to research the action of non-ionizing electromagnetic radiation (EMR), in particular its temperature component, on the motility of vacuolar volutin granules of the yeasts. The yeast S. cerevisiae Y-517 of the Ukrainian Collection of Microorganisms at Zabolotny Institute of Microbiology and Virology of NAS of Ukraine was an object of this study. Motility of volutin granules was evaluated by counting cells with "dancing bodies" using luminescent microscopy and fluorescent dye DAPI at a final concentration of 5 mg/l. It was found that the number of cells with moving granules decreased by 8.2 times after 30 min of EMR irradiation at very high frequency band (VHF) (40.68 MHz, power 30 W). Over time this ability was recovered. At 1 hour after irradiation, the percentage of the cells with moving volutin granules was 2.2 times less than for control ones and - by 1.3-fold after 2 hours. The quantity of cells with "dancing bodies" did not change after 30 min exposure to EMR at extremely high frequency (EHF) band (61.22 GHz, 100 μW). Since the VHF has a temperature component, in contrast to microthermal action of EHF, it can be assumed that an increase of the temperature leads to a sharp reduction in the number of moving granules. The maximum percentage in control case (without electromagnetic action) of the thermal dependence of this phenomenon was observed at T 25-28 0C. It should be noted that the indicated above temperature, is optimal for the growth of the yeast S. cerevisiae. Its decrease or increase led to a marked "dancing bodies" reduction. Thus, these results suggested that Brownian motion caused by the thermal motion of the medium molecules, cannot be regarded as a mechanism for volutin granules moving. Since thermal dependence of this effect corresponded to the active growth processes of S. cerevisiae Y-517 can be assumed the involvement of the biological factors in volutin granules motion. However this biological component does not exclude Brownian character of this motility.

EFFECT OF WI-FI ELECTROMAGNETIC RADIATION (WI-FI EMR) ON PHOTOBACTERIUM PHOSPHOREUM LUMINESCENCE

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Today, the use of portable computers, connected to local area networks wirelessly, also known as Wi-Fi, has increased continuously. WiFi equipment operates in 2.4 GHz ultra high frequency (UHF) and 5 GHz super high frequency (SHF) ISM radio bands. A rapid development of Wi-Fi wireless networks led to a growing interest in studying the effects of Wi-Fi EMR on living organisms.

The potential biological indicator to assess the effect of Wi-Fi EMR is luminescent bacteria Photobacterium phosphoreum. Bioluminescence intensity of luminous bacteria is an integral indicator of their metabolism, which makes extensive use of bioluminescence as a sensitive indicator in the study of the action of various factors. The advantages of the bioluminescent assays are rapidity, sensitivity, simplicity, and availability for rapid monitoring of Wi-Fi EMR effects. The aim of the work was to study the impact of Wi-Fi router radiation on the intensity of P. phosphoreum luminescence.

P. phosphoreum IMV B - 7071 was cultured in a liquid medium and used in our research. Exposure of bacteria (1 ml) was carried out in exponential growth phase using TP-LINK TL-WR841N Wireless N Router with omnidirectional antenna (<6 dB, signal power ≤ 100 mW at a frequency of 2.4 GHz) for 5, 15 and 30 minutes. The intensity of bioluminescence was recorded with photomultiplier tube FEU-115M.

It was detected that TP-LINK TL-WR841N router Wi-Fi EMR affects P. phosphoreum IMV B – 7071 luminescence. Increasing exposure time of cells was accompanied by a decrease in bioluminescence. If the short steps Wi-Fi EMR (5 min) determined only minor changes in the level of luminescence (2-5%), the exposure for 15 min. reduced luminescence intensity by 16-23%. More substantial changes of bacterial luminescence were marked after exposure to EMR for 30 min. In this case, the level of bioluminescence decreased by 38-42%. Besides, temperature changes in the environment of the cells in all modes of exposure were observed.

Thus, these results suggest perspectives of P. phosphoreum IMV B- 7071 as indicator of low EMR action and can be used for further development of biosensor device.

GENETIC EFFECTS OF NON-IONIZING ELECTROMAGNETIC FIELDS ACTION

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An increase of the number and the variety of anthropogenic sources of radiofrequency electromagnetic fields (RF-EMFs) causes a high interest in studying the effects of non-ionizing radio waves on living organisms. Amongst many biological targets, the DNA molecule has received the greatest attention with respect to potential RF-EMFs damage. The aim of the current study was to evaluate the genotoxic effects of some RF-EMFs.

Three yeast Saccharomyces cerevisiae strains specific for the study of induction of direct mutations and disruptions of mitotic recombination were used. The first strain 1-PG-61 (MATα, rad2) is UV-sensitive, the second strain 1-PG-80 (MATα, rad54) is radiosensitive and the third one is PG-155 (MATa/α ade2-192ade2-G45rad2 rad2. These strains were made to change color of colonies from white to pink in case of the mentioned perturbations that makes possible the visual detection of the effects. The comet assay genotoxic test was performed with the cell culture of swine testicles (ST-cells), which are the epithelial cells that are close to their biological characteristics to human cells. The chromosomal aberrations were evaluated with the Allium-test with Allium cepa (onion) root cells; this is a WHO-accepted test on genotoxicity of RF-EMF.

The effects of very high frequency EMF (VHF EMF, 40.68MHz) and ultra high frequency EMF (UHF EMF, 2450MHz) both at power of 15W and 30W, and exposure duration 15 and 30 min, and extremely high frequency EMF (EHF EMF, 61220MHz, 100mkW, 30 min exposure) were evaluated.

The current EMFs were ineffective to make any changes of the yeast strains colonies color and showed no effects in Allium-test. While a significant increase of quantity of ST-cells comets was observed after VHF and UHF EMFs and not after EHF EMF.

The marked results suggest the genotoxic potency of VHF (40.68 MHz) and UHF (2450 MHz) EMFs, which may led to the double-strand DNA breaks detected with comet assay. Chromosomal aberrations and single-strand ruptures were not identified.

REGULATION OF *PHOTOBACTERIUM PHOSPHOREUM* LUCIFERASE ACTIVITY UNDER RADIOFREQUENCY ELECTROMAGNETIC RADIATION (RF-EMR)

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Electromagnetic radiation can affect various processes in bacteria: growth, survival rate, resistance to antibiotics, enzyme activities and other. It has been previously detected changes in Photobacterium phosphoreum luminescence intensity and mRNA abundance of gene encoding β-subunit of luciferase enzyme under RF-EMR. The pattern of changes depended on the type and duration of exposure. The present study aimed to research the possible regulatory mechanisms of luminescence under RF-EMR. It is known several regulatory mechanisms of luciferase activity in luminous bacteria. Among them is quorum sensing system and stimulation of lux-operon activity as response to DNA damages.

P. phosphoreum is luminous bacteria used in our study was cultured in liquid media and subjected to three types of electromagnetic radiation: very high frequency (VHF EMR), ultrahigh frequency (UHF EMR) and extremely high frequency (EHF EMR). To estimate effects of EMR on P. phosphoreum genome variability and expression of luxR regulatory gene we carried out amplification with 6 primers to short nucleotide repeats and performed qRT-PCR analysis with SYBR Green dye.

Amplification with primers to short nucleotide repeats allowed us to assess possible alteration of P. phosphoreum genome sequence caused by RF-EMR. Results revealed that the size of PCR-products varied from 200 to 3000 bp, the number of bands depended on primer sequence used and ranged within 4-10 amplicons per primer. There were no polymorphic fragments in amplicon patterns detected. Thus, RF-EMR did not evoke P. phosphoreum genome re-organization and most likely did not cause any DNA damages. Quantitative analysis of regulatory element of lux-operon transcription showed changes in luxR expression level after EHF EMR: an increase by 2 times after 5 min exposure and a decrease by 17 times after 15 min irradiation. There was no gene expression detected as a result of UHF EMR and VHF EMR of bacterial cells. It supposes that quorum sensing system may regulate luminescence intensity under EHF EMR but not UHF EMR or VHF EMR, which can induce other regulatory mechanisms.

Therefore, results obtained in our study revealed that RF-EMR led to rather epigenetic than genome changes in P. phosphoreum and regulation of lux-operon activity depended on the type of RF-EMR.

WAVELET ANALYSIS OF PERSONAL SOLAR UVR EXPOSURE

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Scaling properties of recordings of personal solar ultraviolet radiation exposure (pUVR) are investigated using the Wavelet Transform (WT) spectral analysis.

Personal UVR recordings are collected by UVR monitors designed to measure erythemal UVR (290-400 nm weighted with the erythemal action response). The UVR monitors are miniaturised, battery-powered UVR detectors with on-board data-logging and data-download capabilities adapted for personalised use. Since the monitors are inconspicuous and easy to forget or ignore, they are less likely to alter a person's usual activities and thus their UVR exposure. Sun exposure recordings of school children and outdoor workers in South Africa are analysed.

The aim of the analysis is to apply the theoretical approach of statistical physics in the investigation and quantification of dynamical behaviour of the pUVR datasets, and thus contribute to a better understanding of the personal solar UVR exposure patterns. Namely, WT power spectra have been used to characterise the scaling behaviour of various datasets from complex systems. It has been shown that the scaling properties are present in the climate and atmospheric data, and that they can be regarded as an indicator of the existence of a memory in the system. Hence, the pUVR series are investigated in search of similar properties.

A scaling behaviour in all analysed pUVR data sets is found, and with the increase in time of a person's solar exposure, the behaviour changes from uncorrelated to long-range correlated. The slopes of calculated WT power vary from 0, in the uncorrelated case of persons with erratic activities related to UVR exposure (school children), to close to 1 in the case of long-range correlated pUVR data, of persons spending longer periods in the sun (due to outdoor work, in the case of our datasets). This result could indicate that the slopes of WT power spectra may be used as indicators of pUVR exposure.

Peaks in the WT power spectra are also found, pointing to the existence of characteristic times in sun exposure behaviour. Characteristic peaks at approximately half an hour and an hour are present in all pUVR data, while the persons with longer sun exposure have additional peaks at longer periods. This behaviour of the WT power spectra could be used to typify different personal behavioural patterns related to solar UVR exposure.

LOW-INTENSITY PULSE-MODULATED ELECTROMAGNETIC RADIATION PROTECTS CELLULAR DNA FROM DAMAGING ACTION OF PHYSICO-CHEMICAL FACTORS *IN VITRO*

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The combined action of various physical and chemical factors on biological systems becomes unavoidable in modern conditions. A large number of potentially genotoxic environmental factors, including chemical agents, ionizing radiation and non-ionizing electromagnetic radiation (EMR), can cause direct damage to cellular DNA. It is assumed that non-ionizing EMR and low levels of reactive oxygen species can alter the nonspecific resistance and modify the level of DNA damage induced by genotoxic agents. To test this hypothesis, the combined effects of extremely high-frequency (EHF) EMR and various genotoxic agents (X-rays, hydrogen peroxide, and methyl methanesulfonate) on the induction of DNA damage in mouse whole blood leukocytes were studied.

Leukocytes in the whole blood immobilized in microscopic agarose slides were exposed to EHF EMR (carrier frequency of 42.2 GHz, incident power density of 0.1 mW/cm2, SAR of about 1.5 W/kg, exposure duration of 20 min) and/or to X-rays at doses of 1-8 Gy (dose rate of 1 Gy/min), and/or treated with hydrogen peroxide at a concentration of 20 muM or methyl methanesulfonate at a concentration of 2.5 mM for 10 min at 37oC. DNA damage was assessed with the use of an alkaline comet assay on percentage of DNA in a comet tail (tail DNA). All the experiments were conducted utilizing the "blind" experimental protocol.

It was shown that the preliminary exposure of the cells to pulse-modulated EHF EMR (42.2 GHz, 0.1 mW/cm2, 20-min exposure, modulation frequencies of 1 and 16 Hz) 25 min prior to treatment with genotoxic agents caused protective effects, decreasing the DNA damage on the average by 20-45%. Continuous EHF EMR was ineffective. The efficacy of pulse-modulated EHF EMR depended on type of genotoxic agent and increased in a series of methyl methanesulfonate – X-rays – hydrogen peroxide. Recently using a sensitive assay based on enhanced chemiluminescence in a peroxidase–luminol–p-iodophenol system, we have found that the exposure of physiological saline to pulse-modulated EHF EMR with effective parameters leads to the production of hydrogen peroxide at nanomolar concentrations. In this study we revealed that nanomolar concentrations (50 – 1000 nM) of exogenous hydrogen peroxide are capable of inducing the adaptive response in mouse whole blood leukocytes, protecting the cells from the subsequent action of X-rays at a dose of 4 Gy, hydrogen peroxide at a concentration of 20 muM, and methyl methanesulfonate at a concentration of 2.5 mM. Based on these findings we suppose that the mechanisms of protective effects of EHF EMR may be connected with an induction of the adaptive response by nanomolar concentrations of reactive oxygen species formed by pulse-modulated EHF EMR.

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ACTIVATION OF SYSTEM AND LOCAL ANTITUMOR MECHANISMS BY LOW INTENSITY ELECTROMAGNETIC RADIATIONS OF DIFFERENT FREQUENCY RANGES IN THE EXPERIMENTS *IN VIVO*

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Background and purpose. Previously, it was shown the antitumor effects of some non-ionizing radiations as the only factors (without special antitumor remedies). Low intensity of these factors allows us to speak about the indirect nature of their damaging effects on the experimental tumors. The studies of processes in the central and effector links of regulatory systems are necessary for experimental justification of these technologies. Methods. In experiments on more than 400 white outbred rats, males and females, with transplanted sarcoma 45 and Pliss lymphosarcoma the effects of infra low-frequency radiations (0,1 - 0,7 mT), as well as radiations of a microwave range and of extremely high frequency range (less than1 uW/cm2 – 10 mW/cm2) were investigated. In most cases the radiation with bioeffective frequencies were used. So, the resonance radiation, one of these factors, had the same frequency as the radiation generated by aqueous liquids under the influence of the certain radiations of millimeter range (SPE-effect). Frequency and amplitude modulation was often performed. Also the combined action of infra low-frequency and extremely high frequency radiations occurred in some experiments. In most cases the application of these factors was carried out in accordance with the regimes of activation therapy aimed at the development of integrated antistress reactions (Garkavi L.H., Kvakina E.B., Ukolova M.A., 1975-1990). The radiations were applied on the head and in some cases – on tumor zone. The effects of these factors were studied by methods of cytology, histology, histochemistry, electron microscopy and flow cytometry. Statistical analysis was performed with using of parametric and nonparametric criteria. Results. In the most successful experiments, tumor regression was observed in 40-60% of cases. Signs of increased lymphoproliferative activity in thymus and spleen, as well as increased interactions between thymocytes and mast cells, macrophages and spleen lymphocytes were observed under effective influence of the factors. In addition, signs of improved synthetic and secretory activity of the thyroid gland, as well as the relative activation of adrenal mineralocorticoid function were marked. In cases of effective impact of the factors changes in amount and composition of immune cells infiltrated of tumors with prepotency of lymphocytes and macrophages were noted. Simultaneously, signs of amplification of cellular interactions involving tumor cells, macrophages, lymphocytes, neutrophils and tissue basophils were observed. Conclusion. Antitumor effects of the investigated low intensity electromagnetic radiations, obviously, were induced by processes in neuroendocrine and immune systems with activation of the cellular immune reactions on last stages. All these processes have been caused by the development of persistent antistress adaptation reactions.

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OCCUPATIONAL EXPOSURE TO ELECTROMAGNETIC FIELDS IN ARC AND RESISTANCE WELDING

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Electromagnetic fields can be understood as a combination of an electric field and a magnetic field (EMF) that can be emitted as waves by many natural and artificial sources such as electricity. In industrialized countries, the increasing of the mobility and communications has led to an increase of human exposure to electromagnetic radiations.

Welders represent a group of workers who are exposed to EMF from welding machines. Workers performing welding tasks are exposed to magnetic fields from the welding processes. There are several types of welding processes but the most used are arc welding (MMA: Manual Metal Arc; MIG/MAG: Metal Inert Gas/Metal Active Gas and TIG: Tungsten Inert Gas, Plasma, SMAW: Shielded metal arc welding) and resistance welding.

This study attempted to assess the exposure to electric, magnetic and electromagnetic fields, of a group of workers at different workplaces in industries using welding processes and compare the results with legal limits and/or guidelines. In addition, the results should clarify the need of introducing measures to prevent and/or to reduce the exposure, at the moment of the investment and over the lifetime of the technology used.

There are recommendations and guidelines on limits of the exposure to static magnetic and on limiting the exposure to time-varying electric, magnetic and electromagnetic, established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). Recently, the European legislation was updated based on these guidelines through the publication of the Directive 2013/35/EU. Many studies have shown the ICNIRP reference levels for magnetic fields may be exceeded in both arc and resistance welding.

A set of measurements were carried out regarding the exposure to electromagnetic fields in three national companies. The measurements were carried out at different distances from the welding machine and from the cables, at different welder's positions, close to the welders head, chest, waist and hand/electrodes and also near to the welding cables and machine. The highest values was registered near the cables (1065 mT), for single sided spot welding, for arc welding (761,7 μT) and with resistance welding (646,8 μT). The results were above the action levels (ALs) of the European Directive 2013/35/EU.

WEAK INFLUENCES IN THE CONTEXT OF THERMODYNAMIC CONSIDERATION OF BIOEFFECTS OF ELECTROMAGNETIC RADIATION

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The general thermodynamic theory of effects of electromagnetic radiation has been developed in the second half of the 20th century and has given various laws of efficiency of conversion of energy for long-wave radiation (the Rayleigh-Jeans region) and short-wave radiation (Wien region). The boundary between these two regions lays in infra-red part of electromagnetic radiation. Efficiency of conversion of radio frequencies and the extra low frequencies submits to the Devyatkov law, and efficiency of conversion of energy in Wien region submits to the Weber-Fechner law [1,2]. These two regions give essentially different speed of increase of efficiency of process as function of intensity of influence. In the Rayleigh-Jeans region, change of efficiency from 0 to 1 occurs very quickly and demands a small interval of change of intensity of external influence. In the Wien region, it needs many orders of intensity for change of efficiency from 0 to 1.

The gamma radiation is the most short-wave electromagnetic radiation, and in this case the range of change of efficiency from zero to unit is extremely great. New and very interesting aspect of consideration is experimental studying of weak influences. Thermodynamic consideration at weak levels of influence supposes (allow) change of a direction of process: endergonic processes pass into exergonic ones and vice versa. It means that at weak influence harmful processes can become useful. The practical aspect of such changes is extremely interesting, but it is studied extremely poorly in experiment. It is possible to think, that the situation in experiment will change further. All the above-stated is fair and important for studying an environmental, natural, and artificial radioactivity.

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NON-IONIZING RADIATIONS AND PROTECTION

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Since its beginning, man is surrounded by radiations. Light and heat emanating from the sun are the main form of natural radiation, without which there would be no life on Earth. The last three decades represent a period of exponential growth in the application of new technological solutions in all areas of human life. Development of new technologies is in full swing and it's hard to keep track. New technologies carry up new risks, particularly to health of public. This paper presents an introduction to a form of "invisible pollution" of the environment - the so-called non-ionizing radiations, which are surrounded at every turn. Many years of experience of the author of this paper indicates a need systematically informing and educating the population in the specified area.

INFLUENCE OF LOW-INTENSITY RED AND NEAR-INFRARED RADIATIONS ON MICE AND THEIR F1, F2, AND F3 GENERATIONS

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The effect of low-intensity red and near-infrared radiations from the diode matrices (650 and 850 nm) and a He-Ne laser (633 nm) on the activation of the reserve natural defense system was studied by the production of reactive oxygen species (ROS) in blood cells, the induction of the cytogenetic adaptive response (AR) in bone marrow cells, the cellularity of the thymus and spleen, and the rate of the solid Ehrlich ascites carcinoma growth in mice in vivo. These effects were also studied on their offsprings (F1, F2, and F3). Animals irradiated with X-rays (0.1 Gy) served as a positive control.

The study demonstrated that the exposure of mice to red and near-infrared radiations, as well as low doses of X-rays, induced AR in bone marrow cells, as indicated by the micronucleus test, in blood cells revealed by the level of ROS production using luminol-dependent chemiluminescence, and from the cellularity of the thymus and spleen after irradiation with a challenging dose (1.5 Gy of X-rays). In addition, the radiations examined decreased the tumor growth rate.

In mice of the F1, F2 and F3 generations born from males irradiated with near-infrared light, the radiosensitivity to high-dose radiation decreased in bone marrow cells, and the AR was absent. The thymus weight decreased as in control mice exposed only to a dose of 1.5 Gy. In all generations, the tumor growth rate did not differ from that of offsprings from unirradiated males.

The experimental data obtained revealed a possibility of activating the natural defense system of mice and genomic instability in at least three generations of mice.

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PHARMACOLOGICAL ASPECTS OF RADIATION

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NITRIC OXIDE SYNTHASE INHIBITORS AS A NEW CLASS OF VASOACTIVE RADIOPROTECTORS

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The ability of nitric oxide synthase (NOS) inhibitors to increase vascular tone allows expect from them some radioprotective properties. We research the vasoactive and radioprotective properties of compound NS23, effective reversible inhibitor of NOS. Hemodynamic studies were carried out on male Wistar rats in hypotonic (a model of severe hemorrhagic shock) and normotonic condition. We analyzed (by monitoring in real time) the indices of heart rate, respiratory rate, systolic and diastolic blood pressure (AD), central venous pressure, cardiac output and peripheral vascular resistance. Radioprotective properties of NS23 were studied using 30-day survival test in male F1 (CBAxC57Bl6) mice exposed to 10 Gy g-radiation of 60Co. The survival of endo- and exogenous colony-forming cells in the bone marrow was studied in male mice exposed to g-radiation of 60Co. RESULTS. It is shown that in non-toxic doses (about 1/28 LD16) NS23 exhibits a powerful and long-lasting vasopressor effect So that a single dose of NS23 caused a deep increase in vascular tone and normalization of AD in rats in the state of extremely severe hemorrhagic shock after massive blood loss. At high doses (1/5 LD16) NS23 causes reflex changes in hemodynamics leading to a 40-45% decrease in systemic blood flow and development of transient hypoxia. Our studies have shown that NS23 is effective as radioprotector in small-toxic doses: optimum radioprotective dose is 1/4 LD16. The estimated value of Radiation Dose-Reduction Factor is 1.4-1.8. NS23 synergistically interacts with well-known radioprotectors possessing pressor effect - serotonergic and adrenergic radioprotectors (serotonin, mexamine, indralin). NS23 causes significant increase in the efficiency of such radioprotectors, even at low doses that do not have any radioprotective effect alone. CONCLUSIONS. High therapeutic breadth and radioprotective efficacy of NS23 show that NOS inhibitors can be the basis of new class of radioprotectors of emergency action, and can be valuable adjuvants to enhance the effectiveness of radioprotectors.

PHARMACOLOGICAL ASPECTS OF THE USE OF RECOMBINANT INTERLEUKIN-1 FOR RADIATION PROTECTION AND TREATMENT OF RADIATION INJURES

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The purpose was the substantiation of an opportunity of the use of recombinant interleukin-1β for the prophylaxis and therapy of radiation injuries caused by acute, prolonged, fractionated and combined irradiation.

Researches are executed on mice and rats. The estimation of radioprotective and therapy efficiency of interleukin-1β was carried out by criteria of survival rate, condition of bone marrowy, dynamic of peripheral blood cells, parameters of the functional and metabolic status of neutrophils and immune system condition of the irradiated animals.

As a result, it was shown that recombinant interleukin-1β, when used 24 hours before acute or prolonged gamma- or X-ray irradiation, combined external or internal irradiation, makes it possible not only to protect experimental animals from dying, but also protects cells of bone marrowy, prevents the development of leukopenia and reduces the disorders in functional-metabolic status of neutrophils in the peripheral blood. The receptor antagonist of interleukin-1 has radioprotective activity, appreciated on parameters of survival rate, a condition of hemopoiesis and quantity of cells in peripheral blood of irradiated animals, only at cytokine application 30-40 minutes prior to an irradiation.

After acute, prolonged or combined external and internal irradiation the recombinant interleukin-1β has a marked early therapeutic activity, if administered within 1 hour after an exposure to radiation. In case of fractional high-dose irradiation, a course of recombinant interleukin-1β treatment allows to preventing further intensification of leukopenia and to stimulate the restoration of peripheral blood cells number after radiation exposure is discontinued.

Good tolerance of recombinant interleukin-1β by healthy people and its ability to reduce of post-radiation changes in the immune system after irradiation of human blood samples in vitro have been shown.Results of our research allow drawing a conclusion on presence radioprotective and early therapy efficiency of recombinant interleukin-1β at various variants of external and combined radiation exposure.

A NOVEL METHOD FOR THE DETECTION OF KRAS MUTATION USING SCINTILLATION PROXIMITY ASSAY

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K-ras mutation testing is mandatory before prescribing anti-epidermal growth factor monoclonal antibodies in the treatment of metastatic colorectal and lung cancer. And in pancreatic cancer, K-ras may prove useful as a diagnostic biomaker. However, with the lack of standardization for K-ras mutation testing, there is a widely recognized need for external quality examination method. We describe a new highly sensitive method to detect the K-ras mutation using scintillation proximity assay. This configuration may be useful for other diagnostic systems including other biomakers for identification of patients likely to respond to such therapies.

RADIATION DETECTORS

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DOPANT CONCENTRATION AND HIGH-DOSE HIGH-TEMPERATURE THERMOLUMINESCENCE OF LiF: Mg, Cu, P DETECTORS

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The observed for the first time at the IFJ in 2006 high-dose properties of the LiF:Mg,Cu,P phosphor manifesting as high temperature thermoluminescence emission in the form of the TL peak with maximum at about 400°C (denoted as the TL peak 'B') with unusual properties, allow for the dose measurements in the kilogray range with this phosphor [1, 2]. However, the reasons for such behaviour of this highly sensitive thermoluminescence material (used routinely since the 1980s to the measurements of doses in the range of micro-, mili- and greys) after exposure to doses above 1 kGy were not explained so far. Since the earlier developed lithium fluoride phosphorus LiF:Mg,Ti, also widely used in dosimetry, does not present such amazing high-dose features, so therefore it is believed that the dopants play the lead role in this newly observed phenomenon [3].

In the search for the origins and mechanism of the high-dose TL emission in the form of the high-temperature peak 'B', at first the high-dose characteristics of different production batches of LiF:Mg,Cu,P detectors (produced at the IFJ in the years 2005-2014) were examined in order to check the influence of the production parameters on the high-dose characteristics of this phosphor. Some differentiation of the maximum intensity of the TL peak B for different batches have been observed, although the position of the maximum at the temperature axis remained the same and depended only on the exposure dose.

Then batches of LiF:Mg,Cu,P detectors with different dopants concentration were produced and comprehensive studies of their high-dose TL features have been performed in the different radiation fields (gamma, electron, proton, and neutron). Within each step of the research these characteristics were compared with the high-dose TL properties of typical MCP detectors' batch also produced in the frame of the experiment, which detectors were highly exposed simultaneously with the detectors from batches of varying dopants concentration. In the framework of this study the effect of varying the content of one of three dopants sequentially, namely magnesium, copper and phosphorus, while maintaining the typical concentration of the other two dopants in each case, have been studied. In this way, the impact of the type of dopants and their concentration on the occurrence and characteristics of the high-dose high-temperature TL peak 'B' has been verified. Comprehensive results of these studies will be presented during the conference.

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A STUDY ON PHOTOMULTIPLIER AFTERPULSES IN TL/OSL READERS

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In this work we present results of investigation of afterpulses in the photomultiplier Thorn EMI 9235QA built into the Daybreak TL/OSL reader. This type of a photomultiplier is also frequently used in the Risø and Lexsyg readers. The amplitude and the time interval between subsequent pulses were recorded with a laboratory made multichannel analyzer and an ultra-fast data acquisition board. We recorded afterpulses induced by single photons and by ionizing radiation from a number of radioactive sources (^{241}Am, ^{137}Cs, ^{60}Co, ^{90}Sr/^{90}Y) with different X/γ/α energies ranges and also induced by background radiation (muons and γ) at varying PMT temperature. Distributions of time intervals between pulses show that afterpulses accompany pulses caused by ionizing radiation following them up to 200 μs. The amplitude of observed radiation induced afterpulses corresponds usually to a single photoelectron. Most of afterpulses types have single photoelectron amplitudes with an exception of He^+ inducted afterpulses which appear after 480-800 ns after the main pulse and have significantly larger amplitudes.

For a single photon counts we report 7.8% of additional afterpulses and for background counts we report 25% of additional afterpulses which do not follow the expected single exponential time interval distribution. The afterpulses explain well pulse count overdispersion in the TL/OSL reader. In addition, this phenomena leads to an apparent increase of the photomultiplier sensitivity.

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A NEW DEVELOPMENT IN THICK SOURCE ALPHA-COUNTING

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In luminescence dating thick source α-counting is used to determine the concentration of the α-emitting natural radioactive ^{238}U and ^{232}Th series in order to calculate the environmental annual dose. From the total α-count obtained with the application of a planar ZnS:Ag scintillator, the number of counts originating from the respective series is determined with the use of so called pairs and fast pairs. The pairs and fast pairs are created from subsequent decays of $^{220}Rn \rightarrow {}^{216}Po$ (half-life = 0.14 s) $\rightarrow {}^{212}Pb$ and $^{219}Rn \rightarrow {}^{215}Po$ (half-life = 1.8 ms) $\rightarrow {}^{211}Pb$ respectively. In the current work we present the application of two methods of numerical modelling to generate spectra of temporal intervals between counts for given uranium and thorium series specific activities. From these spectra the number of pairs and fast pairs can be determined. Then we apply the commonly used formula to discern the counts originating from both series and compare the results with the input values. The modelling results are compared with the experimental time spectra obtained for commonly used reference materials.

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THERMOLUMINESCENCE GLOW CURVE PROPERTIES OF TLD-500 DOSIMETER

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In this paper, TL characteristics and glow curves of Al_2O_3:C dosimeter, known as TLD-500, were analyzed using different methods and software. The effect of heating rate (HR) and low dose (from 10 cGy up to 50 cGy) on TL glow curves of Al_2O_3:C chips have been investigated after β-irradiation. TL kinetic parameters were also calculated by using computerized glow curve deconvolution (CGCD), peak shape (PS), various heating rate (VHR) and three points (TP) methods. Furthermore, using Mathematica software, all TL glow curves of TLD-500 were decomposed in order to compare with the results of other methods and simulated after exposed different beta doses.

Key words: Thermoluminescence, TLD-500, dosimeter, glow curve, Mathematica

EFFECT OF HEATING RATE ON THERMOLUMINESCENCE OF LA-DOPED ZINC BORATE

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In this study, the effect of various heating rate (VHR) method on thermoluminescence (TL) characteristics of 1% La-doped ZnB_2O_4 phosphor (i.e. ZnB_2O_4:0.01La) was investigated. For this purpose, thermoluminescent material of ZnB_2O_4:0.01La was synthesized by nitric acid method. All TL measurements were made on using an automated Risø TL/OSL DA-20 reader and the sample was irradiated dose of 1 Gy with 90Sr/90Y beta source, which has 2.7 MeV energies of electron particles and 40 mCi activity. TL glow curves were recorded from room temperature (RT) to 450 °C in nitrogen atmosphere with different heating rate values from 1 °C/s to 10 °C/s. It was observed that total area and peak intensities of all glow peaks decrease and peak temperature shifts to higher temperature side with increasing heating rate. Furthermore, kinetic parameters of the TL glow peaks of ZnB_2O_4:0.01La phosphor were determined by the VHR method.

Keywords: Thermoluminescence, zinc borate, heating rate, glow curve

STUDY OF ELECTRON-INDUCED DEFECTS IN N-TYPE SILICON DETECTORS

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N-type silicon diodes have been irradiated with electrons in the energy range 1.5 MeV - 27 MeV, in order to change the ratio between cluster and point defects and to determine the relevant defects responsible for damage induced degradation of the detector performance. The electrical measurements showed the formation of small clusters already at 1.5 MeV and high fluences (1015 cm^{-2}). An increase of the introduction rates of both, point defects (VO,V2) and clusters (V3, E(30K), and H defects) with increasing energy is seen, showing a saturation starting at 15 MeV. Thus, the ratio of clusters to point defects increases by a factor of 10. The changes in the reverse current at full depletion proved to be partly correlated with the change in the configuration of the tri-vacancy (V3). Other defects contribute also at the dark current. This made possible to determine the value of the capture cross section for holes of the V3 defect in the single acceptor state. Furthermore, the change of the space charge density with irradiation and with time after irradiation is fully described by accounting the radiation induced trapping centers. Additionally, it is shown that while the generation of point defects is well describe by the classical Non Ionizing Energy Loss (NIEL) the formation of small clusters of defects is better described by the "effective" NIEL resulted from molecular dynamics simulations.

FORMATION, SEPARATION AND DETECTION OF EVAPORATION RESIDUES PRODUCED IN COMPLETE FUSION REACTIONS

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Some aspects of formation, separation and detection of evaporation residues (ER) produced in complete fusion reactions induced by accelerated heavy ions (HI) will be considered from the theoretical and experimental points of view. The use of the complete fusion reactions of different projectile and target nuclei is a way to obtain heavy proton-rich (neutron-deficient) nuclei at the border of the proton drip line and to study their properties. Analysis of production cross sections for these nuclei, which could be obtained in a wide range of their neutron numbers, allows tracing the changes in such macroscopic properties of heavy nuclei as their fission barriers [1]. Mechanism of the complete fusion of massive projectile and target nuclei is of interest, since its understanding allows us to predict an optimal way to synthesis of unknown nuclei [2]. Specific characteristics of ER produced in fusion reaction, for example, their energy and angular distributions, are important for modeling their extraction or separation from HI beams and from attendant competitive reactions which cause difficulties to detect ER in experiments [3]. Various schemes of experiments which are used to detect ER in reasonable background conditions will be considered. A right choice of experimental conditions becomes crucially important in experiments on synthesis of superheavy elements (SHE) at the end of the map of nuclides. Peculiarities of the separation, detection and identification of SHE produced in long-term experiments on their synthesis using intensive HI beams will be also considered.

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THERMOLUMINESCENCE GLOW CURVE ANALYSES OF CaB_4O_7:Dy PHOSPHOR

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The analysis of thermoluminescence (TL) glow curve of Dy doped CaB_4O_7 phosphor have been performed for this study. TL glow curve of β-irradiated CaB_4O_7:Dy shows three peaks at ~335, 530 and 675 K, with a heating rate of 2 K/s. The main peak at 530 K was found to consist of at least five overlapping peaks by using the Tmax-Tstop method. A curve-fitting technique was used to perform computerized glow curve deconvolution (CGCD) analysis of the complex peak of the dosimetric material of interest. The kinetic parameters, namely activation energy (E) and frequency factor (s), associated with the deconvulated main glow peak of CaB_4O_7:Dy at 520 K were evaluated using peak shape (PS) and isothermal luminescence decay (ILD) methods. The activation energies and frequency factors were calculated to be 0.72 and 0.72 eV and 8.76 × 105 and 1.44 × 106s-1, respectively.

THERMOLUMINESCENCE CHARACTERISTICS OF $Bi_4Ge_3O_{12}$ IRRADIATED WITH UV-RADIATION

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In this work, we present a detailed kinetic study of the thermoluminescence (TL) of $Bi_4Ge_3O_{12}$ (BGO) single crystals grown by the Czochralski process. Different dopants and concentrations were used for producing the material. The TL glow curves induced by UV radiation were measured between 50 ^oC and 300 ^oC. TL characteristics, namely glow curve structure, dose response and fading have been investigated. The kinetic parameters, activation energy (E) and frequency factor (s) of the TL glow curves have been determined by different methods such as various heating rate method, peak shape method.

BURIED GRAPHITE PILLARS IN SINGLE CRYSTAL CVD DIAMOND: SENSITIVITY TO X-RAY AND ELECTRONS

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Diamond is considered the most promising material for monitoring radiation sources like synchrotron light beams and nuclear particles as those produced by radioactive decay. Diamond is robust and radiation hard wide band-gap semiconductor with very low dark conductivity, low dielectric constant and a large breakdown electric field. Moreover, single crystal diamond shows the highest saturation velocity of both charge carriers with equal low-field mobility (2200-2400 cm2/Vs). Such physical features foster the development of stable, low noise detectors with fast transient response at expenses of a smaller signal amplitude in comparison to silicon sensors. In the last years this material has also demonstrated to be useful for devices fabrication demanding small pixels in order to improve spatial resolution of imaging detectors and 3D [1,2] architectures to deal with an increasing counting rate.

Here we present an all-carbon detector of 3D architecture without metallization suitable for spectroscopy of ionizing radiation and x-ray beam position monitoring. The single diamond crystal has been produced by a microwave plasma CVD technique. Local graphitization of the diamond plate (3x3x0.5 mm3) was performed with 400 fs pulses of VaryDisc50 laser (Dausinger+Giesen Gmbh) operated at 1030 nm wavelength and 1 MHz pulse repetition rate. The laser beam was tightly focused inside the diamond plate and moved in XYZ directions to form conductive graphitic electrodes on the surface and in the bulk.

Altogether 212 parallel buried graphite pillars, 400 μm long (deep) and 150 μm apart, were produced one by one, with the pillar diameter close to 30 μm. They were grouped in two series for different polarity and connected by graphitic strips on the surface (2.5 mm long, 50 μm wide and ~10 μm thick graphite strips, 300 μm apart).

Graphite contacts exhibit an ohmic-like behavior up to 300 V (i.e. at electric field strength of 1 V/μm). At the highest field strength, the current-voltage characteristic increases with stronger voltage dependence. The sensitivity to nuclear particles has been tested with a 90Sr source and digital pulse processing analysis, whereas the sensitivity to x-ray beam has been studied by using low-frequency modulation of a Mo-Ka collimated beam. The results of a study on sensitivity to impinging angle variations for electrons and x-ray will be presented. Results demonstrate the possibility to resolve angle less than 5 ° and that the laser graphitization is an effective technique to realize buried contacts in diamond.

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DEVELOPMENT OF $LiMgPO_4$:Tb,B OSL MATERIAL FOR PERSONAL DOSIMETRY

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One of the well-developed techniques for dose measurements is optically stimulated luminescence (OSL). Nowadays, the most commonly used in OSL dosimetry are Al_2O_3:C detectors. There is however still a huge demand to find new sensitive materials. Recently, it was found that the $LiMgPO_4$ phosphor might be a very sensitive material for OSL and TL dosimetry and could be one of the possible alternatives to the well-known Al_2O_3:C dosimeters.

The goal of this work was to investigate the optoluminescent properties of the new phosphor, namely lithium magnesium phosphate doped with terbium and boron, $LiMgPO_4$:Tb,B (LMP). This phosphor was made by solid state reaction between LiOH, $Mg(NO_3)_2{\cdot}6H_2O$ and $NH_4H_2PO_4$ in air. Tb_4O_7 (terbium oxide) and H_3BO_3(boric acid) were used to dope the phosphor with terbium (Tb) and boron (B) as starting materials during the preparation of the phosphor.

We used the automated Risø TL/OSL Reader Model DA-20 for measurements of the dosimetric properties of this material. The alpha (241Am) and beta (90Sr/90Y) sources which are built-in the reader were used for irradiation. The blue light emitting diodes were used for OSL simulation. The LMP phosphor (powder) showed high sensitivity to ionizing irradiation, better than the reference Al_2O_3:C detectors. The developed material has good repeatability of OSL signal. The dose response is linear in the range between 0.05 mG and 1Gy. These results indicate that the LMP phosphor can be considered as a potential new material for individual dosimetry (low dose range). The preliminary results show also that $LiMgPO_4$:Tb,B has relatively low fading, but these measurements are still ongoing.

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THERMALLY STIMULATED LUMINESCENCE PROPERTIES OF CaB_4O_7:Mn PHOSPHORS

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In this study, thermally stimulated luminescence (TSL) properties of CaB_4O_7:Mn phosphors have been investigated. It was prepared by sintering method. The TSL glow curves of Mn doped CaB_4O_7 sample has two glow peaks at 85 oC and 220 oC. Some dosimetric characteristics of the material such as sensitivity, fading and dose response were investigated. The kinetic parameters (order of kinetic (b), activation energy (E), frequency factor (s)) of the main peak at 220 oC were calculated using peak shape (PS), various heating rate (VHR) and isothermal luminescence decay (ILD) methods. Besides radioluminescence (RL) measurements of the material were investigated. The results of conducted studies showed that the CaB_4O_7:Mn phosphors have very high sensitivity which make them very valuable in low dose applications.

Keywords: Trap parameters, Thermally stimulated luminescence, Radioluminescence, Calcium borate.

OPTIMISED DETECTOR SYSTEM FOR LOCAL GOVERNMENT BODIES AND MUNICIPALITIES AND FOR THE EMERGENCY PLANNING ZONE OF NUCLEAR POWER PLANT

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Within the research project "Radiation monitoring systems of new generation" (MOSTAR) a system for monitoring of radiation situation has been developed in collaboration of SURO (National Radiation Protection Institute) with the ENVINET company. The system covers implementation of detectors for both municipalities and other public subjects as well as the civil ones, including citizens, and of stand-alone field units (battery and/or solar panel powered).

The system includes detection subsystem - dose-rate detectors available in various configurations of probes and accessories, communication subsystem - for data transfer to a central database and for remote control of detection units, central application for data storage, processing and presentation of monitoring results on websites and for remote control of the field units.

Implementation of the system can be of significant benefit to both a complement and specification of information on a radiation situation, as well as to an increase of public information in this field.

This work is developed based on the results of the Czech Ministry of Interior of the Czech Republic, Project ID VG20122015083.

THE EFFECTS OF PACKAGE MATERIALS ON THE SENSITIVITY OF RADFET FOR ELECTRON AND PHOTON SOURCES

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In the electronic system, packaging materials serve as electrical conductors/insulators, provide structure and thermal paths, and protect the electric circuits from environmental conditions such as moisture, hostile chemicals, and contamination. But, these materials change the radiation response of dosimeters such as RadFETs.

Radiation-sensing Field Effect Transistors (RadFETs or MOSFET dosimeters) with SiO2 gate dielectric have found applications in space, radiotherapy clinics, and high energy physics laboratories. Standard kovar lid have been generally used in the commercial RadFETs. For these reasons, the investigation of alternative lid materials to the standard kovar and determination of the effects of these materials on the radiation responses of the RadFETs are quite important.

The investigation of the deposited energy in the sensitive volume/active area of RadFETs is quite difficult with experimental methods due to the very small dimensions of gate oxide. Many researchers have preferred the Monte Carlo simulation method to determine the radiation response of RadFET dosimeters. Several codes such as Geant 4, Fluka can be used to follow the particles in a given medium. Among these, PENELOPE can be used the simulation of RadFETs because it does not cause the problems concerning the selection of correct step length.

In this study, PENELOPE Monte Carlo simulation code was used to investigate the effect of various lid materials on the radiation response of RadFET dosimeters. For this purpose, Au-20Sn, Ni-17Co-54Fe, Ti-24Al-11Nb, Ti-13Nb-13Zr, W-20Cu, Mo-30Cu, Al_2O_3, and Ta were used as lid materials and the radiation responses of RadFETs were investigated in the energy range of 250 keV – 100 MeV for electrons and 20 keV – 5 MeV for photon sources.

EXPERIMENTS WITH RADFET DOSIMETER IN ELECTRON-BEAMS IRRADIATION AND NUMERICAL COMPUTATION OF THE PHYSICAL SHIELDING FACTOR

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MOSFET electronic components are already the subject of several decades of research in various fields of dosimetry and radiation protection. Special interest appeared when these components are started to be used as dosimeters in radiotherapy with electron beams. However, if one looks much more serious in the wider scientific research horizon, all the results obtained in experiments with precisely defined energies of incident electrons can be used in other disciplines which consider the impacts spectra of cosmic radiation on electronic devices, which is especially importance for cosmic science and space research instrumentation. In this paper, one of the objectives was to examine the electrical characteristics specially designed ESAPMOS RADFET dosimeters in the experiments that were conducted on a linear accelerator installations. RADFET components are bombarded electron beams energy of 6 MeV and 8 MeV, and then are followed by changes in threshold voltage shift mean values depending on the change of absorbed dose is referred to as D(cGy) was determined in water. Conclusions performance RADFET components are more than encouraging in terms of further research to improve the linearity of the energy dependence as widely energy electrons. In the second part of the test complex structure of packaging components RADFET focus is placed on the determination of the energy deposited in layers that are of interest for the analysis of microscopic processes related to the recombination of radiation-induced electron-hole pairs. Transport incident electrons through all the layers of structure RADFET component type ESAPMOS was carried out numerical simulations of the Monte Carlo method using the software package FOTELP-2K12. On this occasion, were taken into account all the physical processes of interaction of electrons with materials given structure. When he conquered the numerical application of mathematical and physical model for determining the value of the absorbed energy as the energy deposited per unit mass in a given layers with different materials, it could be accessed defining physical shielding factor (PSF) for a given structure RADFET components. Physical shielding factor (PSF) is defined as the ratio of absorbed dose values, which in fact means that it is equal to the energy deposited when the RADFET is shielded with protection, and the RADFET without lid. When we know the energy dependence factor for PSF of RADFET with and without armour, can be carried out and the analysis of whether and to what extent the energy required compensating the electronic components. Monte Carlo simulations were performed for the transport of incident electrons from 4 MeV, 6 MeV, 8 MeV and 12 MeV. It can be concluded that the different energy of incident electrons there is a significant influence of material Kovar on the absorbed energy in SiO_2 and Si layers structure RADFET, in cases where Kovar used among other things as physical protection.

SHIELDING OF AN X-RAY COLLIMATOR AGAINST INTERFERING X-RADIATION

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X-ray bremsstrahlung diagnostics is a means for studying plasmas containing hot electrons with energies up to the low MeV region. The electron energy distribution function can be obtained by unfolding the bremsstrahlung spectra emitted by electrons when colliding with ions or neutral particles of the plasma. Examples are ion source plasmas heated by microwaves (ECRIS). Energy-resolved bremsstrahlung measurements are performed by using a scintillation-detector and a collimator made of high-Z material and placed between the detector and the plasma. Its plasma-exposed front part defines and delimits the geometric viewing cone of the detector and also that for X-rays with energies below about 100 KeV. Thus, in the low-energy case, such simple collimator arrangements can be used to measure the bremsstrahlung of the hot electrons without interfering thick-target bremsstrahlung and Compton scattered radiation. However, at photon energies above about 200 KeV the mean free path for photo-absorption becomes comparable with that for Compton scattering. In this energy regime the collimator's shielding material becomes transparent for X-rays like "milky" opaque glass panes for visible light. As a consequence, primary radiation, i.e., plasma X-radiation and high-intense thick-target bremsstrahlung laterally incident at the collimator may enter the viewing cone of the detector via Compton scattering. The Compton Effect gives rise to errors in measuring higher-energy X-ray energies and to an enlargement of the X-ray's viewing cone. The latter enhances the thick-target part of the incident bremsstrahlung and thus distorts the measured X-ray spectra and their spatial profile. To screen for this kind of interfering radiation, we insert a shielding diaphragm (Bpl in Fig.1 of [1]) in front of the collimator. Its borehole diameter is chosen slightly larger than that of the enclosed viewing cone, so that the borehole's lateral face is not visible by the detector. Thus, Compton-scattered radiation generated at this component cannot reach the detector directly; only multiply scattered radiation does. In [1], we give a rather conservative estimation of the flux density of the interfering radiation generated via Compton scattering within the shielding diaphragm and incident at the geometric viewing cone delimiter (secondary radiation). Referring to that, we concluded that, at least for X-ray energies up to 226 KeV, the shielding diaphragm prevents the measuring errors mentioned above. In this paper, we present a significantly improved calculation method of the flux density of the secondary radiation and discuss necessary assumptions about the intensity distribution of the primary radiation. The secondary radiation turns out to be emitted mainly by a thin cylindrical layer adjoining the inner borehole of the shielding diaphragm. Thus, our results reveal a much more efficient shielding than originally expected. For a photon energy K=600 KeV we calculate a suppression of the interfering radiation by a factor 3.3*10-3. As a consequence, we can derive collimator design principles that allow suppressing the influence of scattered radiation up to the low MeV energy region. As in [1], thick-target bremsstrahlung and multiply Compton-scattered radiation originating from the collimator and contributing to the secondary radiation are neglected.

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DEVELOPMENT OF GAMMA RADIATION DETECTION DAS FOR INDUSTRIAL PROCESS INVESTIGATION

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Radioisotopes as tracer have been extensively used in various industries such as refineries and petrochemical process in order to investigate their performances and abnormal phenomena during their operation. This study can be carried out by monitoring the dynamic behavior of process fluid that is tagged with radioisotope emitting gamma radiation. Since the technology has been considered as a powerful analysis method, there have been remarkable developments that extend to multi-dimensional visualization of process fluids, which has the same principles with the medical diagnostic technologies. Multiple radiation sensors should be mounted around an object under study and furthermore spectral radiation measurement is required in order to discern radioisotopes emitting different gamma photons. Since there is no commercially available data acquisition system for the radiotracer experiment, most relevant research groups had to design and build on their own. Those in-house systems can't promise the precise operation in cases where radiation spectrum signals are to be acquired from tens of probes within milliseconds. In this study, we designed and fabricated the high-speed gamma spectrum data acquisition system for the research on multi-dimensional visualization of industrial flow. The new DAQ system is a 36 channel counter and multi channel analyzer system for PMT signal readout in a single compact package. The system is fully remote controlled and data are read out at high speed through USB3 interface. Each channel has an independent high voltage supply for PMT, shaping circuit for high count rate and good energy resolution application, variable gain stage and high speed, high resolution ADC. 0.5 W high voltage module supplies operation voltage to PMT up to 1500 V, 0.33 mA in 12-bit steps. Signal from PMT is amplified at each input and analog-filtered with 100 ns shaping time for high count rate and good energy resolution application. The signal is converted to differential form and fed to 40 MSPS 12 bit ADC. Digitized signal is filtered again for further improvement in energy resolution. The system can operate either in count mode or in MCA mode. In either mode, event accumulation time for each channel can range from 10 ms to 24 days in 1 msec resolution. Control program is developed using LabVIEW. The software allows for setting and changing of all parameters including high voltage, threshold, counting time, etc. And there is also a high voltage plateau setting that allows for detector plateauing. The test with the DAQ system shows excellent performance in terms of its stability and efficiencies in comparison with the old version of the DAQ system. To be engaged into the study for multi radioactive particles tracking technology.

MONTE CARLO ANALYSIS OF RADIATION RESPONSES OF MOS CAPACITORS FABRICATED BY SOME RARE EARTH OXIDES

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Metal-oxide-semiconductor (MOS) structures are sensitive to ionizing radiation and are being used in various areas such as space, nuclear industry and radiotherapy. Because of the leakage current problem of the SiO_2 structures, researches are in progress on the alternative dielectric materials. Due to the structures used in radiation sensors are so small, it is very difficult to define the radiation response of devices using common spectroscopic processes. Device characteristics of new MOS structures have been modelling with the aid of Monte Carlo simulations. In this study, the radiation responses of MOS capacitors with Er_2O_3, Gd_2O_3, Yb_2O_3, and Sc_2O_3 gate dielectrics were investigated for photon and electron sources by Monte Carlo simulation method.

TL/OSL DETECTORS BASED ON $YAlO_3$:Mn CRYSTALS AND CERAMICS

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Application potential of Mn-doped $YAlO_3$ (YAP) for thermoluminescent (TL) dosimetry of ionizing radiation has been shown previously [1-2]. For this purpose, one of two types of detectors can be used. The first type detectors have green emission near 530 nm in the main TL peak at 200 °C [1], whereas the second type detectors have orange emission around 640 nm in the TL peak near 350 °C [2]. The first type detectors have strong daylight effect on fading and optical stimulation by blue light can be used for their readout. On the other hand, the second type detectors with TL peak near 350 °C have no daylight effect on fading.

High chemical and time stability, high sensitivity to ionizing radiation and radiation damage resistance, extremely wide range of linearity up to few kGy and the optical emission in visible are the most attractive properties of these dosimetric materials. In spite of the relatively high effective atomic number, this material is a good candidate for low, middle- and partially high-dose dosimetry of ionizing radiation, especially when tissue equivalence is not required.

The present work demonstrates main dosimetric properties as well as features of the TL and OSL readout of the first type detectors based on the crystalline or ceramic materials.

The crystalline detectors have been fabricated from the single crystals grown by the Czochralski method. Utilization of the technological approaches mentioned in [3] allowed to obtain the YAP:Mn,Hf crystals with the green TL emission that exceeds few times the emission of the YAP:Mn,Si crystals studied previously [1-2]. The ceramic detectors were made from the YAP:Mn,Hf nanocrystalline materials synthesized by the solution combustion method using urea as a fuel [4].

The crystalline detectors that possess simultaneously both the green (~200 °C) and orange (~350 °C) emissions are examined in details. The potentials and advantages of such detectors are discussed.

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PIXEL ARRAY DETECTORS BASED ON CVD-DIAMOND FOR UV AND X-RAY DETECTION

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Due to its peculiar physical characteristics, for several decades CVD-diamond has been considered one of the most promising material for the realization of detectors able to work in harsh environments and under high intensity ionizing radiation. Nowadays, different works demonstrate that diamond is effective for the realization of sensors able to detect deep UV photons, X-rays, gamma-rays, charged particles and neutrons to satisfy a wide range of research demands and industrial applications, too.

The wide band-gap of diamond leads to very low conductivity in dark conditions, so that efficient photoconductors can be thought as basic devices also for detectors in which a multi-pixel structure on a single CVD-diamond die is fabricated. Moreover, diamond shows peculiar properties in terms of thermal conductivity and visible-light transparency. In this case, it represents one of the most suitable materials for the detection of high-power UV laser emission or for sensing weak UV light also under high intensity background illumination.

In this work the realization and characterization of compact CVD-diamond multi-pixel detectors are described. Each pixel, arranged in a compact 8x8 array, has been connected to the input of a dedicated multichannel read-out electronic circuitry. Here, the electronic system was designed for the acquisition, the conditioning and the elaboration of the weak signal produced by each pixel, enabling a real-time beam profile reconstruction of the impinging radiation. The cross-talk between pixels can be easily limited by means of proper design of the array contacts, realizing intermediate guard rings where the same ground potential of the pixels has to be established. A back-side contact (semitransparent to satisfy the alternative possibility to be used as the light-receiving side of the sample) was mainly used for detector biasing.

To characterize the sensors in terms of sensitivity and radiation selectivity, the 8x8 array has been illuminated with monochromatic light obtained at the output of a double monochromator illuminated by a Xenon lamp. Such a 2-D photodetector then has been used for beam diagnostics of the impinging radiation as a function of wavelength and intensity conditions.

In addition, the data acquisition rate of about 2000 samples per second allowed the characterization of the pixel-array detector also under high intensity excimer-laser UV irradiation (ArF, 193 nm, 4.5 mJ/pulse, and 10-100 Hz of repetition rate) to evaluate the feasibility of a real-time beam monitoring of the laser light.

CdZnTe DETECTORS FOR VARIOUS APPLICATIONS

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CdZnTe nuclear radiation detectors of various designs and sizes are widely and successfully used for various applications due to their favorable detection properties - good energy resolution, high efficiency, small dimensions and weight and possibility of operating at room temperatures.

Depending of a task can be used detectors of a planar geometry or various unipolar detectors design. One of them is hemispherical or quasi-hemispherical detector. Progress in improvement of CZT crystals characteristic and in technology of detector fabrication allow production of high quality spectrometric quasi-hemispherical detectors with sensitive volumes from a very low of 0.5 mm3 to a few cubic centimeters. Now these detectors are routinely made and commercially available from RITEC company (Latvia).

Using CdZnTe detectors RITEC produces various devices for many applications. Planar CdZnTe detectors are used in a RITEC Personal Radiation Detector (PRD) γ-Tracer Model GT 2-1 and in Surgical Gamma-Probes. The PRD GT2-1 is a pocket-size energy-compensated dosimeter intended for a spot search of weak gamma-radiation sources.

Spectrometric quasi hemispherical detectors are used in various commercially available miniature spectrometric detection probes types SD310, SDP500 and SDP1500 which are very convenient for application in difficult for access places. The largest CdZnTe detector of 4 cm3 is used in a probe SDP4000.

Based on application of high quality spectrometric quasi-hemispherical CdZnTe detectors Gamma-Radiation Microspectrometer μSPEC was built. The μSPEC fulfills measurements of gamma-radiation spectra and storing it for processing in a PC. It is a self-sufficient very compact device consists of the high quality CZT detector, charge sensitive preamplifier, main amplifier, digital signals processor, high and low voltages power supplies and computer interface. The μSPEC communicates and powered from the PC via USB port. The changeable detection modules may contain detector of volume 60 mm3, 500 mm3 or 1500 mm3. The μSPEC is one of the smallest spectrometers in a world.

Examples of applications and some gamma-spectra obtained with various devices based on application of CdZnTe detectors are shown.

MULTI-SAMPLE AUTOMATED OSL MEASUREMENT DEVICE: AN OPEN-SOURCE PARADIGM

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In order to facilitate sequential automated measurements, an Optically Stimulated Luminescence (OSL) reader with a sample changer unit is designed and constructed. The significance of this device is its open source software and hardware utilization.

The essential control mechanism of this device is based on an Arduino DUE single-board microcontroller which operates an Atmel SAM3X8E ARM Cortex-M3 CPU running at 84 MHz's. Not only the sample positioning mechanism of the device, but also stimulation system, precise timing and photon counting are carried out using exclusively this single-board microcontroller unit. The device is able to establish connection with a host computer using the Universal Serial Bus (USB) 2.0 which enables users to have control over measurement device and collect data using host computer. The user friendly control software which is written in an open-source programming language can be run on any platform.

The stimulation system can be run through three commonly used stimulation modes known as continuous wave, linearly modulated and pulsed stimulations. The system employs high power emitting diode in visible region for stimulation and a bialkali photomultiplier tube module (Electron Tubes, DM016C) for luminescence emission measurement. Due to this PMT module's ability to count photons and produce TTL pulses as output, aforementioned single-board microprocessor is able to count them with its fast counter.

The measurement system is tested using common materials used for dosimetry and dating studies. The results of these test experiments and design considerations will be presented.

ADVANCED TEACHING WITH THE EMBEDDED MINI LAB: RADIATION SENSOR BOARD FOR ARDUINO AND RASPBERRY PI

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The aim of this paper is to present the new, innovative teaching approach and tinkering pedagogy towards developing the students skills in STEM domains (science, technology, engineering and mathematics) with aim to the designing the laboratory for radiation detector development. Involving from one side concept of social situatedness and connectedness, and from another the concept of independent, self-directed and self-regulated student learning, the project was based on assembling the mini-lab, Radiation Sensor Board for Arduino, that was originally designed to help people in Japan to measure levels of radiation in their everyday life after the Fukushima accident. As it was reported elsewhere, this product was an example of crowdsourcing. When Libelien designed the Radiation Sensor Board for Waspmote, the idea was simple: with the Arduino platform people will be able to have easily running their own detector at home while on the other hand with Waspmote platform authorities will be able to deploy autonomous sensor networks to send the radiation levels from dangerous areas using wireless sensor platform ZigBee and GPRS technologies. This paper present students developing project where the Sensor Board for Arduino was used as assembling, teaching tool. The Do-It-Yourself and Internet of Things can be used both in educational, and in the research and development purposes. Owning their own mini-lab at their disposal anytime, students worked at their learning speed. It also boosted the interest, confidence of students and highly affected three domains of learning: cognitive domain (activities like instrumentation, modeling, experimentation, data analysis and design, psychomotor domain (activities like manipulating the apparatus, sensory awareness) and affective domain (behavior and attitudes to learn from failure, creativity, collaborative communication, safety and ethics in the laboratory). We show that networking learning, supported by hands-on labs on chip, and an open source electronics prototyping platform as Arduino and Raspberry Pi, give great opportunities for teaching and learning the tinkering and inventing skills, an request we have to deal with it at the University of Montenegro. Such project support exploratory and serendipitous learning. It moved teaching from an emphasis simply on linear logic and programmed instruction, towards non-linear, networked, branching, hypertext views of learning, in which connections between knowledge are made and developed. It is based on principle of situated cognition and Vigotskian thought: situatedness, commonality, interdependency and infrastructure where learning is facilitated by an activity. The presented project integrate a Virtual Learning Environment, networking knowledge and student-owned movable laboratory on the chip, where radiation was used as a topic and where electronics was embedded and embodied.

COMPARISON OF VARIOUS STIMULATED LUMINESCENCE MEASUREMENT METHODS IN APPLICATION TO LITHIUM ALUMINATE

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Nowadays a widespread use (industry, medicine, science etc.) and occurrence (natural radiation) of ionizing radiation entails the evaluation of radiation exposure of employees and the population and environmental monitoring. For this purpose both active and passive detectors are used. Passive detectors are the detectors which do not require external power supply. The vast majority of passive detectors is based on luminescent phenomena, such as thermoluminescence (TL), optically stimulated luminescence (OSL) or radiophotoluminescence (RPL). No need for external power supply can both reduce the size of detectors and allows much longer measurements. Moreover, using passive detectors allows to store information about the accumulated radiation dose for a long time. At the same time such a wide range of diverse applications requires the use of radiation detectors with different properties. For this reason, there is a strong demand for the development and improvement of new techniques for measuring doses, including the development of new types of detectors based on different materials.

In this work we perform the comparison of different methods of stimulated luminescence of lithium aluminate. ($LiAlO_2$). The use of this material as an OSL detector can bring benefits in comparison to commercially used Al_2O_3:C. In particular, lithium aluminate has lower effective atomic number (10.7) than aluminum oxide (11.3), which resulting in lower photon energy dependence and it is also better tissue equivalent. Moreover presence of Li-6 enables application in neutron dosimetry. It was recently shown that lithium aluminate exhibits high OSL sensitivity (in respect to commonly used Al_2O_3:C), linear dose response and tolerable fading, which make it a promising material for further research. The purpose of this study is to describe some basic dosimetric properties of lithium aluminate using both thermoluminescence and optically stimulated luminescence readouts. Moreover, for OSL measurements different stimulation modalities (continuous wave OSL, linear modulation OSL, pulsed OSL) will be used.

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RADIATION DOSIMETRY PROPERTIES OF SMARTPHONE CMOS SENSORS

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During the last years several smartphone applications have been developed for measuring X-ray and gamma radiation dose rates. These applications rely on the CMOS sensor of the smartphone camera covered by black tape as ionizing radiation detector. In case of a large scale radiological incident smartphones could thus be very useful for data collection and personal dose assessment. However, it is very important to assess the reliability of these applications first.

In this work six different applications were tested by irradiating iPhones with calibrated X-ray and gamma sources. These studies showed that the measurement integration time should be taken at least in the range 10 to 25 minutes to obtain proper stabilisation of the measured signal for modest dose rates of about 10 µSv/h. All applications were found to have a linear dose rate response in the studied range from 2 to 1000 µSv/h. Most applications significantly over- or underestimate the dose rate and require calibration. A considerable energy dependence was observed below 100 keV but not for the higher energy range more relevant for accident scenarios. Different photon impact angles resulted in a variability of the measured dose rate of only about 10%.

Further studies are done during which the iPhones are attached to a phantom while being moved at different velocities along calibrated X-ray and gamma sources. This mimics better how the applications will be used in practice. We are also testing the POLISMART® II PM1904 detector. This pocket-sized X-ray and gamma detector from POLIMASTER can be connected to the iPhones and has an accompanying app.

DIRECT X-RAY DETECTORS BASED ON ORGANIC SEMICONDUCTING SINGLE CRYSTALS

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The light weight, simple processability, and mechanical flexibility of π-conjugated organic small molecules and polymers has recently led to remarkable research efforts towards the realization of new opto-electronic devices. Moreover, organic materials can be deposited and grown by means of easy, low temperature and low cost technologies as inkjet printing. In the field of ionizing radiation detection, organic semiconductors have been proposed so far mainly as indirect detectors, i.e. as scintillators or as photodiodes active materials [1]. Although direct detection of the ionizing radiation, i.e. its direct conversion into an electrical signal, allows to reduce the signal-to-noise ratio and the response time of the device, only few examples of organic-based direct detectors have been reported in the literature [2,3,4], all employing thin films of organic semiconducting or conductive materials. Nevertheless, the intrinsic working principle of such devices, i.e. the microscopic photon/charge-carrier conversion mechanism, is still under debate. We recently reported about the performances of an Organic Semiconducting Single Crystal (OSSC), namely 4-hydroxycyanobenzene (4HCB), as direct X-ray detector, operating at room temperature and in atmosphere, showing a stable and linear response with increasing dose rate [5]. Here a comparative study is presented on OSSCs based on several small molecules, namely 1,5-dinitronaphthalene (DNN), 1,8-naphthaleneimide (NTI), Rubrene, and an NTI derivative substituted at the N-position with a pyridine (NPy), with different molecular structures and polarizability, which crystallize with different geometries and molecular packing. In addition, crystals containing Si-atoms in their structure have been studied in order to evaluate the role of such elements in the photon/charge conversion process. The crystals were characterized as X-ray detectors employing a standard Mo target X-ray tube (35kV accelerating voltage) providing a wide range of dose rates (20-120mGy/s). The analysis of the correlation between the properties of the molecules employed and their different behaviors under the X-ray beam, e.g. in terms of sensitivity, amplitude and rise time of the response, allowed us to further improve our knowledge about the processes involved in the observed X-ray induced photocurrent signal. The high sensitivity values recorded at low voltages (between 5 and 50V at maximum), the linearity of the current response with increasing dose rate, together with the energy selectivity observed for most of the investigated crystals, pave the way for the realization of innovative low-cost, low-power consuming and radiation-hard X-ray detectors.

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A DOSIMETRY SYSTEM FOR REAL TIME DOSE MEASUREMENTS USING A COMMERCIAL MOS TRANSISTOR

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Introduction

The dose monitoring during radiotherapy treatments is very advisable in order to provide the exact dose. Ionization chambers or diodes can be used, as well as commercial system based on MOSFETs as the BMC MOSFETs (TN-502RD-H) (Best Medical Canada) or MOSkin (University of Wollongong, Australia). Our researched group developed a dosimetry system that has been used for commercial MOSFETs dosimeters and RADFETs without polarization (unbiased mode). However this reader measures the dosimetric parameter (source or threshold voltage, depending on the user configuration) before and after irradiation in off-line mode. Then, in this work the preliminary results of the evolution of our dosimetric system to measure in real time conditions of a commercial MOSFET, are presented.

Experimental setup

The irradiations were carried out in a LINAC Mevatron KDS (Siemens, Germany) with a radiation field of 25x25cm2 and 6 MV photons. The MOSFETs were placed under a buildup layers, made of solid water, in order to ensure electronic equilibrium conditions. Two set of transistors 3N163 (Vishay Siliconix) have been irradiated with gate-source voltage of 10 and 20 V during irradiation, respectively.

Reader unit and sensor module redesign

The reader unit was place into the bunker and connected via a USB extension cable to a PC. The reader was controlled by a java application developed for this experiment. A bias module has been developed and connected to the reader unit in order to polarize the MOSFET during irradiation. Two JFETs has been added to the pMOS, in order to short-circuit the terminals of the transistors in the three possible states:

Storage period: All JFETs in ON, thus all terminals of the pMOS are connected.

Bias period (Irradiation): JFET Q2 is CUT-OFF, and Q3 is ON. Therefore the source, drain and bulk are grounded and the gate is biased.

Readout period: JFET Q3 is ON, and Q2 is CUT-OFF. Thus the source and bulk; and drain and gate are connected, and the transistor is in saturation regime.

During irradiations, the gate bias voltage was applied among the different measurements. One measurement consists of the register of source voltage, the source voltage amplification by an instrumentation amplifier and the current thought the sensor, thus three pulses. Between two consecutive measurements, a time of 2 seconds elapses in order to increase the ratio of the bias time respect to the measurement time (without bias)

Preliminary results

The reader unit can carry out real time measurements (every 5 s) and bias the transistor during irradiation. The sensitivity achieves for 10 and 20 V was 50.3 and 55.8 mV/Gy, respectively. The main problem for 20 V bias was the variation of threshold voltage due to bias annealing. In a near future, a group of at least 3 or five transistors will be tested in these conditions to confirm these preliminary results.

STUDY ON POSSIBILITIES OF ESTABLISHING RADIATION DOSIMETERS BASED ON SILICON MICRO-PIXEL AVALANCHE PHOTODIODE

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Efficiency of MAPD-Z coupled to p-terphenil (C14H18) scintillator and WLS fiber are studied for detecting gamma rays (662keV-2614keV), beta particle (in energy range up to 2284keV) and fast neutrons (average neutron energy of 1 MeV) in this work. Limited number of the MAPD-Z pixels did not degrade count rate performance of the detector. Minimum detected energy for gamma ray was 511keV in the experiment. It was defined that p-terphenil (C14H18) scintillator with the MAPD-Z readout showed a good beta particle and fast neutron detection efficiency. High efficiency of the MAPD-Z photo-sensor and light yield of plastic scintillator gives a possibility to use such a combination as personal dosimeters and radiometers in the relevant fields such as nuclear power plant, medicine, industry and environmental radiation pollution.

RADIATION MONITORING DEVICES

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About half of the faults and failures of electronic equipment in space arise as a result of exposure to ionizing radiation of outer space, which manifests itself in the form of single and dose radiation effects. In this regard, requires constant radiation monitoring on board of the spacecraft.

In the development of the monitoring system, the specialists of the Branch of JSC “URSC” - “ISDE” had created integrated cumulative dose sensors. In comparison with the previous developed dose sensors the dose measurement limit was increased from 100 krad to 1 Mrad by using the modified sensor element. The entire measurement range is divided into 3 sub-ranges, which improves the measurement accuracy at a relatively low cumulative dose of radiation. New sensor operation is based on the principles of NMOS dosimetry that allows to approximate the way to control the space ionizing radiation impact to the specific effects that occur in the real electronic components. In addition to advantages such as low power consumption (â‰¤ 2 W), wide temperature range (from - 40 °C to + 50 °C) and relatively small weight and size characteristics, we should also mention simplicity of the device unit that allows a high probability of failure work, which is 0,985 during the term of active existence (15 years). At the moment the integrated cumulative dose sensors of the previous generation (with a limit of measurement up to 100 krad) are widely used.

Single effects occur in the integrated circuits in contact with heavy charged particles (HCP). To control these effects the Branch of JSC “URSC” - “ISDE” developed HCP detectors. The sensitive element of the sensor is a static random access memory (SRAM). The effects fixation is realized by data recording into all memory cells and further verification of these cells for data errors. In addition to HCP alarm, “URSC” - “ISDE” developed sensor of the particle characteristics created by space ionizing radiation on the basis of a diamond detector. It provides a measurement of HCP fluxes in four LET ranges (1 - 3, 3 -10, 10 -30 and more than 30 MeV×cm2 / mg). Also, the device provides a measurement of proton fluxes in four energy ranges. The measurement error is 10%.

Currently the modifying HCP sensor with the possibility of recording the spectral and energy characteristics of heavy charged particles with LET up to 60 MeV×cm2 / mg in the temperature range from - 55 °C to + 125 °C is developed.

PENETRATION DEPTH OF X-RAYS IN CYLINDRICAL X-RAY COLLIMATORS

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This presentation is an accompanying paper to my paper “Shielding of an X-ray Collimator against interfering X-Radiation ” [1] on the topic of collimator arrangements suitable for X-ray bremsstrahlung diagnostics of plasmas. In [2], we described a collimator arrangement used for bremsstrahlung measurements in the low-energy region and an improved method for extending its measuring range to higher photon energies. The main collimator part consists of an aperture at its forefront defining the geometric view cone and a long hollow-cylinder made of high-Z material. It encloses the radiation detector at its rear side. The improvement consisted in using a shielding diaphragm inserted in front of the aperture of the main collimator for shielding the detector ’s view cone against Compton scattered interfering radiation (Bpl in Fig.1 of [2]). In [1], we present a method to estimate the shielding efficiency of such a collimator arrangement, i.e. the stray radiation suppression effected by the shielding diaphragm. The shielding efficiency is strongly influenced by the attenuation of X-rays traversing the shielding diaphragm. The attenuation in turn is mainly caused by photo-absorption processes. Consider an X-ray being Compton-scattered at a particular location inside the shielding diaphragm and then directed to the front aperture of the main collimator. Such rays can enter the detector ”s geometric viewing cone after further Compton scattering events. The higher the X-ray photon energy, the smaller is the photo-absorption experienced by the photons and thus the smaller the shielding efficiency. On the other hand, the larger the dimensions of the shielding diaphragm, i.e. the larger the distances covered by the X-ray within the shielding diaphragm, the stronger is the photo-absorption experienced by the X-ray. Thus, knowing the covered distances within the shielding diaphragm is necessary for determining the shielding efficiency of the collimator. However, many different X-ray propagation paths of the described kind are possible. Thus, calculating their individual lengths, albeit being a well defined exercise from the pure geometrical point of view, is a very complicated task. We circumvent this difficult problem by determining that path covering the smallest possible distance within the shielding material. Using them, one obtains easy-to-calculate lower-estimates of the X-ray attenuation values needed for the main step in calculating the shielding efficiency, i.e. for integrating the attenuation of X-rays over the total volume of the shielding diaphragm [1]. In this contribution we outline the geometric reasoning for identifying such paths of minimal length. Three-dimensional propagation directions of X-rays entering and leaving the shielding diaphragm are considered.

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^{222}Rn DETERMINATION IN DRINKING WATERS - RAD7 AND LSC TECHNIQUE COMPARISON

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A procedure for the determination of ^{222}Rn in environmental water samples using liquid scintillation counting (LSC) was applied and optimized. A minimum detectable activity of 0.029 Bq l^{-1} in a 20 ml glass vial (10 ml water sample mixed with 10 ml of liquid scintillation cocktail) has been achieved during 300 minutes of measurement time. The procedure was compared with RAD 7 radon detector measurements. ^{226}Ra content in the water was determined by gamma-ray spectroscopy. Applications to drinking waters collected from public drinking fountains in the Vojvodina (Serbia) are presented with annual effective dose for ingestion and inhalation for adults calculated.

Key words: radon measurements, liquid scintillation counting, RAD7 spectrometer

$ZnS:Mn^{2+}$ NANOPARTICLES: INVESTIGATION OF THEIR POTENTIALS IN OPTICAL AND NUCLEAR DETECTION SYSTEMS

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The discoveries of nanotechnology in the last decade constituted important developments in many application fields. Quantum dots nanoparticles which have adjustable particle size under 20 nm and easy surface chemistry provide nanoscale imaging and sensing for both fundamental research and technical application areas like cancer cell targeting, biological and biomedical applications.

In this study, l-cysteine coated $ZnS:Mn^{2+}$ nanoparticles were prepared by precipitation of the sulfide from aqueous solution in the presence of the surfactant. A white precipitate formed which slowly re-dissolved at 60 °C after 30 min under formation of $ZnS:Mn^{2+}$ nanoparticles. The dispersion was dialyzed against water at room temperature for 4 days. In order to isolate the powder, the suspension was freeze-dried.

Surface analysis of synthesized ZnS: Mn^{2+} nanoparticles have been characterized using atomic force microscope (AFM) and scanning electron microscope (SEM) and structure analysis of these particles have been characterized using X-ray diffraction method (XRD). Electrical properties of $ZnS:Mn^{2+}$ nanoparticles were investigated with measuring relative resistance of created various thickness under UVB and Cs-137 radiation sources. In addition, the optical properties of $ZnS:Mn^{2+}$ nanoparticles were investigated with recording thermoluminescence emission exposure at different times. Results obtained from the experiments and analysis demonstrates that $ZnS:Mn^{2+}$ nanoparticles are sensitive to both UVB and ^{137}Cs radiation. As a result, this study shows that nanoparticles synthesized in this study have an application potential in nuclear detection systems.

DEVELOPMENT OF RADFET DETECTOR FOR PERSONAL DOSIMETER SYSTEM FOR EUROPEAN ASTRONAUTS

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Radiation environment in space is very complex, with varying contributions from photons, electrons, protons, and heavy ions. There is a need to measure radiation dose received by the astronauts onboard International Space Station (ISS), and the European Space Agency (ESA) has been supporting a collaborative research project aimed at development of a personal dosimeter for European astronauts at ISS.

The development of the personal dosimeter system is in the final phase, with the launch expected in the second half of 2015. The system is called "European Crew Personal Active Dosimeter (EuCPAD)" and consists of a base unit and several mobile units. Base unit is stationery and houses system electronics, Tissue Equivalent Proportional Counter (TEPC), and charging slots for mobile units. Mobile units are worn by the astronauts during their daily activities and consist of four dosimetric modules: thin silicon diode, thick silicon diode, Direct Ion Storage (DIS) dosimeter, and Radiation Sensing Field Effect Transistor (RADFET).

We describe the EuCPAD system and our efforts in development of the RADFET module for the EuCPAD mobile unit.

SILICON PHOTO-MULTIPLIER BASED RADIATION DOSIMETRY SYSTEM FOR SECURITY APPLICATIONS

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Silicon photo-multiplier (SPM) is a promising novel technology that could replace legacy photomultiplier tubes (PMT) in scintillator based radiation detectors. SPM main advantages over PMT are ruggedness and small size, low voltage, low cost, and insensitivity to magnetic fields.

We describe the development of a SPM based dosimetry system, consisting of gamma ray detector, neutron detector, read-out electronics, and application software. The system can be used as a module of a HANDHOLD detection platform or as a stand-alone unit. Applications of the system include security (portal and handheld monitors) and personal dosimetry.

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SKIN DETECTION METHODS USING SKIN COLOR INFORMATION: A REVIEW

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Human's face is a dynamic object and bears a high degree of flexibility, which has made face detection as a fundamental problem in computer vision. Therefore, face detection is the first and necessary stage in face detection systems with the aim to determine face location and its separation from the background. Face detection has various applications as like content-based image retrieval systems, video coding, video conferencing, and crowd surveillance. In the present article, we are going to provide a comprehensive examination regarding different face detection techniques, amongst which skin detection is used for face detection purposes. Skin detection is a prevalent and effective method for the detection and identification of different parts of the body and has been mostly considered in recent years due to its various applications. This is important because of resistance against rotation, scaling, and face occlusion. In this study, we are able to present complete evaluation and comparison between above-mentioned techniques due to the standardized tests shortages, but it will be possible to compare test results provided by the authors that are available in databases.

RADIATION EFFECTS IN ELECTRONIC DEVICES AND CIRCUITS

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SCHEMATIC TECHNIQUE FOR IMPROVEMENT OF THE RELIABILITY OF OPERATIONAL AMPLIFIERS IN ELECTRONICS FOR SPACE APPLICATIONS UNDER RADIATION IMPACT

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The technique for schematic compensation of radiation degradation of input parameters of operational amplifiers under radiation impact is experimentally demonstrated. It is shown, that external compensation circuit is able to significantly reduce degradation of input parameters of operational amplifiers.

Introduction: Operational amplifiers are base elements of modern analog electronic devices, which are widely used in the electronics for space applications. The impact of ionizing radiation of space environment leads to degradation of input parameters of operational amplifiers. The most radiation sensitive input parameters of operational amplifiers are input currents and input offset voltages. Radiation degradation of these parameters is able to affect reliability of electronic devices in spacecrafts during long space missions. Schematic technique for compensation of radiation degradation of input currents and input offset voltages in operational amplifiers is described in follow.

Results: For compensation of radiation degradation of input currents external bipolar transistors with current mirrors in emitter circuits are used. Base inputs of the transistors are connected to operational amplifiers inputs. The currents of transistors and operational amplifiers are directed oppositely. It enables to provide compensation of the degradation of input currents by radiation-induced excess base currents of external bipolar transistors. The compensation of the degradation of input offset voltage provided by resistor, which is connected to the input of operational amplifier and provides compensation voltage drop. The value of the resistor is calculated for best compensation of the degradation of input offset voltage. The emitter currents of external transistors and the resistor value were calculated using experimentally obtained total dose dependences of input offset voltage and input currents of LM124 operational amplifier. Since input stage of LM124 is based on p-n-p transistors, 2N2222 n-p-n transistors were used to provide opposite direction of compensation current. Irradiation of the circuit was provided by Co-60 isotope. It was obtained that the use of compensation circuit enables to reduce input current degradation by 77%. The degradation of input offset voltage was reduced by 71%.

Conclusion: The external compensation of input currents and input offset voltages, which is based on the use of discrete bipolar transistors and resistors, is able to significantly reduce radiation-induced degradation of input parameters of operational amplifiers. It enables to improve the reliability of analog electronic devices in space environment.

TEMPERATURE DEPENDENCE OF CMOS SRAM SENSITIVITY TO SINGLE EVENT EFFECTS

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The sensitivity to heavy-ion induced multiple cell upset (MCU) increases in modern nanometer-scale devices. This trend is caused by the shrinking of the distance between cells as well as by the decrease of cell upset voltage [1]. Taking into account the maximal multiplicity of upsets is important for a designer, since it allows to choose the right spatial separation distance between neighboring cells, which prevents single-word multi-bit upsets (SMUs).

Conducting experiments in critical conditions can improve the accuracy of radiation hardness estimations, including to Single Event Effects (SEE). In papers [2, 3] it is shown that temperature is one of the impact factors for SEE sensitivity. Mechanisms leading to increased sensitivity to SEL and SET at high temperatures have been extensively investigated in previous works. In this paper we validate the necessity for elevated temperature SRAM testing to single and multiple cell upsets (SEU and MCU) effects.

Two types of commercial 65 nm and 180nm CMOS SRAMs were investigated. The heavy ion irradiations were conducted at the Roscosmos facility «U-400» (JINR, Dubna, Russian Federation) in temperature range from 300 K to 400 K. Figure 1 shows the increase of MCU contribution and the maximum multiplicity of MCU with elevated temperature. Also temperature dependence of SEL sensitivity was estimated for 65 nm SRAM. Analysis of the possible causes of the temperature dependence of SEU and MCU sensitivity was conducted using TCAD and SPICE simulation. Major role of upset voltage decrease and temperature dependence of parasitic bipolar effect was established.

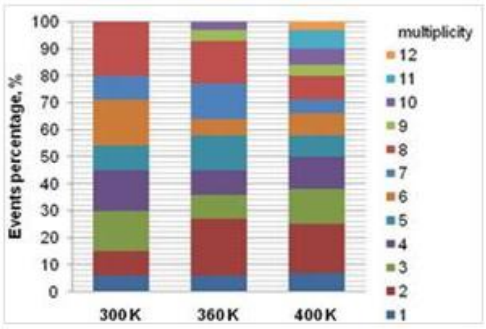

Figure 1. Distribution of SEUs and MCUs obtained under irradiation by Xe (LET=60 MeV·cm2/mg).

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TYPICAL PROCEDURE FOR ELECTRONIC COMPONENT SINGLE EVENT EFFECT TESTING USING LOW ENERGY ION ACCELERATORS

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Single event effects (SEE) are the most critical impact of space radiation influences in onboard electronic components (EC), which limits the lifetime of the spacecraft. So it's very important to know the features, which characterize sensitivity of every EC to SEE. Depending of functional class of EC and operation mode the worst case of SEE occurring may be determent.

Now in Russia for SEE testing we have unique Roscosmos test facilities, which provide test operations for all EC functional classes on hardness to all types of SEE. The test operation consists of some main stages of preparation to SEE testing:

- identification of EC (view, marking, weight, package type);
- x-ray and SAM control (the location of die, the die and package sizes, the package defects and other);
- control of electrical parameters (in accordance with datasheet, further repeated after each step);
- EC decapsulation;
- development of special tools (PCB) and software for carrying out tests;
- development of main test plan, including program and test procedure for each EC;
- irradiation by heavy charged particle for each EC;
- calculation of hardness characteristics based on the test results.

SAM and x-ray inspection permits the size and the location determination of the die and the package size for the future qualified decapsulation of EC. This method allows the identity determination of supplying EC for the tests. On this stage it is possible to control the package imperfection and find out the pirate EC.

The decapsulation can be carrying out by different methods: by chemical etching, mechanical and laser encapsulations. For better result we can also use the combination of these methods.

At the stage of program and method developing we can determine the operating mode of EC, switch-on schemes and the expected SEE. The typical demonstration of SEE for certain integral circuits (IC) and the conditions of test completion will be described in full paper.

The initial check is carrying out on using testers and allows to the measure all electrical specification of digital IC. There are special test boards for the performance test of analog and analog-digital IC. The special software joints all the using devices in one controlling system. This software also allows recording SEE automatically. The software is developing in LabVIEW with the use of National Instruments modular hardware.

The irradiation is carried out on the ion accelerator based on the isochronous cyclotron U-400 and U-400M which are situated in JINR (Moscow region, Dubna city), in the vacuum with residual pressure not more then 10-4mm Hg., with ion energy from 3 to 9 MeV/nucleon and with the uniformity not more than 10%. The IC radiation is carrying out until the registration level is reached more than 100 SEE or until the destructive failure is occurred or until the fluence is 107 cm-2. The irradiation area allows irradiating few IC contemporary that help you to save operating time of accelerator.

ANNEALING TEMPERATURES AND ACTIVATION ENERGIES FOR RECOVERY OF THE MAIN PARAMETERS OF ELECTRON IRRADIATED FZ SILICON

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Radiation processes (RP) are important instruments for enhancing semiconductor material parameters and device characteristics. For example, electron irradiation raises semiconductor resistivity (ρ) and lowers free carrier recombination lifetime (τ). After annealing these parameters recover almost to initial values, but lower temperature of ρ recovering, compared to temperature of τ recovering allows to use the RP for improving of high frequency semiconductor device characteristics. Temperature regimes of annealing are more or less known for CZ Si. The object of this work is to investigate the connection of the annealing parameters to the initial properties of FZ Si.

Silicon slices (orientation (100), n-type conductivity, resistivity range 600 - 1900 Ohm cm, diameter 60 - 80 mm, thickness 2 - 3 mm) were measured by Four-probe resistivity map and μ"‘PCD map equipment. Two series of annealing after electron (6 MeV) irradiation at temperatures of 100 - 300 °C and 300 - 550 °C were performed. Activation energies of ρ and τ recovery were estimated using Arrhenius law. It was shown that temperatures of ρ and τ recovering are smaller than in the CZ Si ones. So ρ may be recovered at 100 - 130 °C temperatures (250-300 °C in CZ Si) and τ - at 250 - 300 °C temperatures (400-500 °C in CZ Si). Activation energies of the ρ recovering are changed within 0.3 – 0.9 eV and correlated with the initial resistivity of a material. Activation energies of the τ recovering are changed within 1.0 – 2.2 eV. Increase of resistivity up to 100 000 Ohm cm after annealing at the temperatures 250 -500 °C were observed due to thermoacceptor effect. This effect may be used for improvement of the Si-based radiation detectors. The defect structure and interaction between the native and radiation defects are discussed.

The work was carried out using the equipment of the Joint Use Center "Materials Science and Metallurgy" (NUST «MISiS») with financial support from the Ministry of Education and Science of the Russian Federation in the framework of Increase Competitiveness Program of NUST «MISiS» (№– K2-2014-055)

IDENTIFICATION OF IC CHIPS BY IONIZATION RESPONSE COMPARISON ON THE EXAMPLE OF OP1177

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Radiation hardness of different samples of the same ICs can vary greatly from lot to lot depending on year or country of production. However, it is assumed that radiation hardness of samples from the same lot are the same, too. The new chip's uniformity test method based on ionization response comparison is offered.

The radiation test results of different lots the same IC's types, that were obtained for 25 years, show greatly TID hardness dispersion from lot to lot. The main reason is that IC's chips of the same COTS lot can be made on different foundries, can have slight topologies different. The chip's uniformity identification is the main way to decrease number of radiation tests, that allows to confirm TID's hardness without radiation experiments. The first identification method is based on visual comparison of chips high-resolution photos. The second one is based on comparison of radiation response maps, that are obtained with picoseconds focused laser beam scan of chip's surface.

In studying of radiation behavior of OP1177 (OpAmp) was found, that the same lot's samples had different TID hardness. Slight different of chips was verified by visual comparison of decapsulated IC's panoramic photos. After that chip's inhomogeneity was verified by picoseconds focused laser PICO-4 (SPELS, Moscow) scan and comprising of ionization response maps.

As a result:

- after visual comparison of topologies full match of marks was found which indicates what IC's is really from same lot, but differences in top layer of topology was observed;

- by differences can be seen various effective capacitance of chips, which, in turn, indicates what chips is really different;

- research indicates what radiation hardness chips from same lot can be vary by using different chips by manufacturer in same lot.

ANALYSIS OF TOTAL DOSE EFFECTS IN MODERN LINEAR ANALOG ICs

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Standard analog ICs are widely used in communication, sense and power systems of spacecrafts. The main types are operational amplifiers, voltage comparators and linear stabilizers. This paper is devoted to provide analysis of analog ICs degradation with increasing total ionizing dose (TID). The main goal is to identify general trends in radiation behavior and to make the recommendations for analog IC's radiation testing.

Operational amplifiers

Modern operational amplifiers are based on chips that are produced by CMOS or Bipolar technology. Topology basis define the main trends in radiation behavior of these ICs. Informative parameters set is offered, that allows to correct define TID's hardness. Further parameters-criteria set will discussed with examples of radiation behavior of different operational amplifiers types. After that the optimal parameters-criteria set will be defined.

Voltage comparators

The cores of modern voltage comparators and operational amplifiers are almost the same. So the main TID's effects are the same. But the differences in ouput cascades lead to different TID's behavior of amplifiers and comparators. Radiation degradation of modern voltage comparators will be discussed. After that the optimal parameters-criteria set will be defined.

Voltage linear stabilizers

There are a lot of stabilizers structure types, that are realized in different technology basis (CMOS, BiCMOS, Bipolar). Further radiation behavior of different stabilizer types and solutions will be observed. After that the optimal parameters-criteria set will be defined.

THE EFFECT OF Xe ION AND NEUTRON IRRADIATION ON THE PROPERTIES OF SiC AND SiC(N) FILMS PREPARED BY PECVD TECHNOLOGY

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Silicon carbide has attracted much interest for wide range of applications. The significance of this material follows from the fact that its electrical and optical properties can be controlled by varying the carbon, silicon and hydrogen composition of the film. Those properties of the film make the amorphous silicon carbide (a-SiC) an excellent alternative passivation layer material for silicon solar cells especially working in hard and space environment.

Silicon carbide (SiC) and nitrogen-doped silicon carbide (SiC(N)) films were deposited on P-type Si(100) substrates at various deposition conditions by means of plasma enhanced chemical vapor deposition (PECVD) technology using silane (SiH_4) methane (CH_4) and ammonium (NH_3) gas as precursors. The concentration of elements in films was determined by RBS and ERD analytical method simultaneously. Chemical compositions were analyzed by FT-IR spectroscopy. The films contain a small amount of oxygen. IR results showed the presence of Si-C, Si-N, Si-H, C-H, C-N, N-H and Si-O bonds. Raman measurements of SiC films were performed by using a Raman microscope with 532 nm laser. Raman results showed that films were amorphous with small amount of nanocrystalline phase. The current-voltage (I-V) characteristics of samples before and after Xe ion and neutron irradiation were measured. Irradiation of samples with Xe ions was performed in accelerator IC100 and irradiation of samples with neutrons was performed in IREN facility at JINR Dubna. The measured current increases more than one order after irradiation with neutrons and measured current increases slightly after irradiation with Xe ions.

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INFLUENCE OF 30 KEV PROTON IRRADIATION ON INDIUM SELENIDE-BASED PHOTOCONVERTERS

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Irradiation with protons is of interest because they are able to penetrate in a significant depth (from 0.1 μm to 1 mm) of materials subjected to irradiation and there are no complex radiation damages after such treatment. The aim of this work was to research the influence of 30 keV-protons with fluences of 1012-1013 cm-2 on electrical and photoelectric properties of p-n-InSe photoconverters (PCs). At the formation of homojunctions the technique of optical contact between two layered semiconductors was applied. For the crystals the values of σ||C were (1-5) ·10-2 (n-InSe) and (3-8) ·10-4 Ohm-1cm-1 (p-InSe). p-n-InSe PCs have well-expressed diode properties. For the unirradiated PCs the non-ideality factor of the I-V characteristics is n=1.7 that indicates on simultaneous existence of two charge transfer mechanisms - diffusion and recombination ones. Only after irradiation with a fluence of 1013 cm-2 the parameter n is found to be increased by 0.1. It indicates that the recombination component of the current slight by increases, what is due to radiation-induced defects.

For the p-n-InSe PCs only a good tendency of increasing the open-circuit voltage UOC by 3% took place. At the maximum irradiation dose the short-circuit current JSC decreases by 10% and at a dose of 1012 cm-2 the parameter JSC remains the same. The monochromatic volt sensitivity SU of the p-n-InSe PCs only improves (by 4 %) after an irradiation with a fluence of 1013 cm-2 that is in agreement with the behavior of the parameter UOC whereas the monochromatic current sensitivity SI decreases by 6 %. In the spectral range 0.5 to 1.02 μm the p-n-InSe PCs have essential photosensitivity with the maximum at λmax=0.83 μm. For the irradiated p-n-InSe PCs we have found a slight decrease in photocurrent in the long-wavelength spectral range. Additionally it is worth to note the presence of the excitonic maximum at Eex=1.26 eV, what indicates on keeping the structure perfection of InSe. It is seen that the initial sample is more sensitive in the short-wavelength spectral range. An increase of the rate of the surface recombination after the irradiation causes a decrease of photocurrent at λ< 0.48 μm by a factor of 1.5 to 4. But at λmax the increase of photosensitivity by 5 % was found. This means that the surface recombination essentially predominates over the bulk one. One automatically makes a conclusion that protons mainly affect surface absorption. The λmax value some shifts to the short-wavelength side and a small increase of the spectrum width δ1/2 at its half-height takes place after the irradiation. A possible reason for the observed effects is protonation of the frontal semiconductor.

The obtained results indicate on the absence of significant radiation damages in the investigated homojunctions. Si-based PCs (ITO-Si) showed a strong degradation at the same irradiation doses. For the maximum fluence the values of UOC, JSC, SI, and SU decrease by 35, 38, 15, and 94 %, respectively.

MODELING AND PSPICE SIMULATION OF RADIATION STRESS INFLUENCE ON THRESHOLD VOLTAGE SHIFTS IN P-CHANNEL POWER VDMOS TRANSISTORS

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In this paper the results of modeling and simulation of radiation stress effects in p-channel power VDMOSFET transistor have been presented. Based on the experimental data, threshold voltage shifts due to radiation stressing (parameters a and DOSE) are implemented into PSPICE model of the IRF9520 transistor. Appropriate analytical approximation of parameter a in function of gate voltage during radiation is proposed. Dependence of parameter a on VGATE is approximated with parabola function. Threshold voltage shift is modeled by auxiliary parametrically controlled voltage generators. Deviation between threshold voltages obtained by experiment and simulation are in the range from 0.03% to 0.38%. The calculated relative error of the simulated threshold voltages shift compared to experimental values vs. dose is in the range of 0.47 % to 16.13%. By iterative fitting of the simulated characteristics to the experimental ones, the value of transconductance parameter KP (the product of mobility and oxide capacitance) is determined. The transfer characteristics of the transistor are simulated and compared to the experimental ones. The proposed model gives transfer characteristics which are close to the measured ones. Difference is in the range 0.16% to 23.35% which represents a good agreement. The main drawback of this model is inability to model subtreshold characteristics.

WIDE RANGE DOSE X-RAY RADIATION INDUCED EFFECTS IN CONDUCTIVE BRIDGE RESISTANCE CHANGE NON-VOLATILE MEMORY DEVICES AND THE MATERIALS BUILDING THESE DEVICES

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Recently many new memory solutions based on memristive effect have been developed and some of them have been commercialized. The most promising among this type memory are the conductive bridge resistance change nonvolatile memory devices, often abbreviated, related to their application in memory integrated circuit solutions, as CBRAM. Neural networks containing CBRAM devices have been demonstrated, which enormously increased the interest towards this type of memory. The structure of the CBRAM non-volatile memory devices usually consists of one electrochemically inert electrode (built up by W or Pt), solid electrolyte (chalcogenide glass, doped with Ag or Cu) and electrochemically active electrode (Ag or Cu). Initially the device is in high resistance state (HRS). When electrical bias is applied, so that the Ag electrode becomes anode, Ag oxidizes on this electrode, dissolves in the solid electrolyte and the formed Ag ions traverse through the solid electrolyte until they reach the cathode where Ag undergoes reduction and forms Ag atoms deposit. Because the distribution of the electrical field, applied between the two electrodes, this Ag atoms deposit extends towards the anode and eventually bridges the two electrodes. At this moment the device switches to low resistance state (LRS).

The full characterization of these devices requires collection of data about their performance in radiation conditions, for example at x-ray radiation. This work presents our results related to the influence of low and high doses x-ray radiation. Subject of studies are pure chalcogenide glass films with different composition, as well as sandwiches of chalcogenide films and Ag films. It has been found out that the x-ray radiation causes changes in the structure of the chalcogenide films - as a result of radiation the structure of the pure chalcogenide material opens up which yields in intensive Ag diffusion. Consequently different Ag-containing compositions are formed with molecular formulas strongly depending upon the composition (i.e. structure) of the hosting chalcogenide glass film in which the diffusion occurs. The radiation dose outcome reaches a maximum at 2,000 krad x-ray radiation. These effects influence the performance of the CBRAM devices – causing decrease of their HRS and of the threshold voltage. The obtained test results for the CBRAM devices are discussed based on the structural organization and bond strength, characterizing the chalcogenide glass films, as well as the chemical potential for formation of Ag containing compositions and their molecular dependence upon the composition of the hosting chalcogenide glass film.

EFFECT OF RADIATION-INDUCED CHARGE NEUTRALIZATION ON THE SATURATION OF INTERFACE-TRAP BUILDUP

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The original mechanism of the interface-trap buildup saturation on high total absorbed doses based on radiation-induced charge neutralization (RICN) effect is presented.

Introduction: Ionizing radiation impact leads to degradation of electrical parameters of microelectronic devices. It is necessary to take this fact to account when dealing with microcircuits for space applications and high energy physics. Main physical reason of radiation-induced failures of spaceship and front end electronic equipment is buildup of interface traps at Si-SiO2 interface in semiconductor transistor structures. The study of kinetic of the interface-trap buildup on high total absorbed doses is the goal of the given work.

Mechanism of interface-rap buildup saturation: It is supposed that the positive charge of trapped holes in oxide is transformed through electron capture into a new defect (the AD center). The AD centers act as interface traps. The appearance of the A-D+ state leads to the annihilation of the AD center or annealing of interface trap. The annihilation process can be stimulated by radiation induced electrons. The competitive between accumulation and annihilation processes leads to saturation of the interface trap buildup.

The AD center can be formed via $E\times^{3}\gamma$ center (which is responsible for radiation induced positive oxide charge) by following mechanism. Positively charged Si atom in $E\times^{3}\gamma$ center is sp3-hybridized (tetrahedral configuration). The electron energy level in this defect strongly depends on the distance between Si+ and SiO atoms. The first electron capture by the $E\times^{3}\gamma$ center changes defect configuration, as result the distance between Si atoms being of intermediate value. The electrons in this configuration defect are expected to be in the intermediate sp2-sp3 configuration and could form diffusion orbital. This defect configuration may be assumed stable and electron energy levels are proposed to remain unchanged when one of the electrons is removed.

The value of density of interface traps in saturation depends on product of interface-trap accumulation rate and constant which is function of thermal velocity, capture cross-section of AD center, generation rate and electron yield of radiation induced electrons. The extraction of these parameters allows explaining the known experimental data. The alternative mechanism of the interface-trap saturation connected with the exhaustion of initial interface trap precursors is considered.

Conclusion: The original mechanism of the radiation-induced interface-trap buildup in saturation is described. The physical model is based on assumption that the positive charge of trapped holes in oxide is transformed through radiation-induced electron capture into a new defect. The proposed mechanism allows to explain the known experimental data.

THE NANOOPTICS EFFECTS IN LASER DRE AND SEE MODELING IN SUBMICRON MODERN ICs

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Several effects that occur during laser simulation of dose rate effects and single event effects in sub-micron integrated circuits are considered. A numerical and experimental study of laser radiation “extraordinary” penetration through a multilayer chip metallization was performed. A significant impact of the laser radiation polarization direction on the response of the ionization of the chip was shown. A method of accounting effects mentioned above in the radiation tests was formulated and justified.

Introduction

Pulsed laser radiation (LR) is widely used to simulate both bulk and local ionization effects in semiconductor devices and integrated circuits (ICs). However, modern chip surface multilayer metallization over sensitive area significantly limits LR penetration. The possibility and different mechanisms of "extraordinary" optical radiation energy penetration through sub wavelength apertures was demonstrated in previous works. The goal was to show efficiency of these models for the case of modern ICs with complete overlap of the sensitive area by multilayer metallization. Layout sizes in modern ICs have decreased to values, comparable with LR wavelength, which caused the mandatory impact of the LR polarization direction on IC’s radiation response. The purpose was to quantify this impact.

The Experimental Results

The experimental goal was to compare the IC’s ionization response from scanning the same area of the chip surface by focused LR at two orthogonal polarization angles. For both of polarization angles the amplitude of IC ionization response was not zero. At some points, the amplitude of ionization response differed more than twice. The similar results were obtained for different diameters of laser beam. Strong impact of laser polarization was found also for single event latchup effects.

The difference in the ionization response for two different polarization orientations diminishes if the laser beam diameter is expanded to the entire IC crystal. The ionization response of the whole IC crystal, irradiated by the non-focused linear polarized LR, differed by almost 15% for two orthogonal polarization angles.

Conclusion

The laser ionization effects modeling can be performed even for modern submicron chips with multilayer metallization. The ionization response of real modern submicron structure was found to depend upon the polarization orientation of laser radiation. This effect should be taken into account when simulating the SEEs using focused laser radiation. To achieve a conservative estimation of SEL using a linear polarized laser source one must perform scan of IC crystal by a focused beam with two perpendicular polarization orientations. To reduce this effect, however, the diffuser may be applied.

METHODICAL APPROACH FOR SEE SENSITIVITY ESTIMATION OF DIFFERENT FUNCTIONAL BLOCKS ON A SINGLE CHIP

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Traditional methods based on ion accelerators employment for SEE sensitivity characterization of ICs allow estimating the integral SEE sensitivity parameters averaged over the whole chip. At the same time different functional blocks can have quite different sensitivity characteristics. Some of them can be fully tolerant to some SEEs. This is a particular case for some test chips by means of which hardening by design methods are worked out. For such chips it is quite difficult to determine which block is more and which one is less tolerant to SEE based only on ion tests.

There are laser methods based on front side focused laser beam irradiation which allow qualitatively comparing the SEE sensitivity of different IC blocks. However significant errors can take place due to the difference in metallization density of those different blocks. Furthermore this method doesn't allow threshold SEE LET determining for an individual block. The effect of metallization can be partially taken into account by using local laser technique, yet this method becomes inapplicable in case the block is fully covered with metal. Further evolution of the method of combined use of laser and ions is proposed in this work for SEE sensitivity characterization.

Integral sensitivity characteristics are determined from ion test results. After that back side laser irradiation of a whole chip is performed. Through the analysis of the results of both ion and laser test laser energy is calibrated against ion LET. Next, laser tests of individual blocks are performed under focused laser beam and for a set of different laser energies. Thus the sensitivity characteristics of each block are determined.

The proposed technique was approved at test SRAM chip manufactured with bulk CMOS 0.18 um process.

This method also can be used for SEE sensitivity characterization of ICs which chip is partially covered by structural elements (such us metal pads, compounds, etc.)

CALCULATION OF RADIATION-INDUCED OXIDE AND INTERFACE CHARGE IN A GENERAL-PURPOSE MOSFET

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Introduction. Ionizing radiation produces interface and oxide trapped charges, which play a fundamental role when pMOS transistors are used as dosimeters. This influence has been investigated in the behaviors of densities of fixed traps in SiO2, $\Delta\overline{N}_{ft}$, and switching traps, $\Delta\overline{N}_{st}$, with a commercial transistor and compared with previous results on RADFETs.

Experimental setup. Five samples ofthe 3N163 commercial pMOS transistor, manufactured by Vishay Siliconix were studied. The samples were irradiated with all the terminals grounded with a 60Co source, the AECL Theratron-780. The sensor responses in subthresholdand saturation regimes were measured by a computer-controlled semiconductor parameter. The slopes of the IDS logarithm were calculated in the current range from 1nA to 1μA before and after irradiation. With the subthreshold study was determined the $\Delta\overline{N}_{st}$ whereas the $\Delta\overline{N}_{TOTAL}$ was obtained from the extrapolated curves in the saturation region.

Preliminary results. Because of the 3N163 is a commercial transistor, some parameters are not provided by the manufacturer, therefore we have estimated the substrate doping between $\overline{N}_D$= [1015, 1017] cm-3 and agate oxide thicknesses of 150, 200 and 250 nm. Preliminary results are shown in Table 1.

Table 1: Densities of total, fixed and switching trapped charges.

TOX (nm)	$\Delta\overline{N}_{TOTAL}$ (cm-2)	$\Delta\overline{N}_{st}$(cm-2)		$\Delta\overline{N}_{ft}$(cm-2)		% $\Delta\overline{N}_{st}$	
		Lower limit	Upper limit	Lower limit	Upper limit	Lower limit	Upper limit
150	4.1x109±1.3x108	2.1x109 ±1.3x108	3.1x109 ±2.0x108	1.9x109 ±2.2x108	1.0x109 ±3.0x108	53±2	76±3
200	3.1x109 ±10.0x107	1.6 x109 ±9.5x107	2.3x109 ±1.3x108	1.4x109 ±1.6x108	7.7x108 ±2.0x108		
250	2.4 x109 ± 8.0 x107	1.3 x109 ±8.0x107	1.8x109 ±1.1x108	1.1x109 ±1.3E8x108	6.2x108 ±2.0x108		

The switching trapped charges are predominat with a percentage between 53 and 75% for differently doped over the total density of trapped charges. This data contrast with previous results for 100 nm [1] and 400 nm [2] RADFETs manufactured by Tyndall National Institute in similar irradiation conditions. The contribution of $\Delta\overline{N}_{st}$for the 100 nm is 40.6% and for the 400 nm the fit linear with the dose in grey is $\%\Delta\overline{N}_{st}$ = 1.1 Dose+5.9, always with a contribution less than 40.5%.

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REQUIREMENTS AND ABILITIES FOR SINGLE EVENT EFFECT TESTING IN RUSSIA

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Space radiation is the main natural factor which limits spacecraft active lifetime. Its impact is manifested in electronic devices and circuits in the form of they errors and failures. Modern electronic components (EC) are the most sensitive to high energy particles (heavy ions and protons from galactic and cosmic rays) which lead single event effects (SEE). At this work we will show you the present state in field of single event effects testing and the main directions of development of Russian (Roscosmos) test facilities on hardness control to space ionizing radiation influence for EC.

The Branch of JSC «United Rocket Space Corporation» – «Institute of Space Device Engineering» for several years is functioning as a parent organization within Roscosmos on the subject of hardness control and assurance of EC to the space ionizing radiation and is working on the development and operation of the relevant test facilities. Currently Roscosmos test facilities provide test operations for all functional classes of EC on hardness to all types of SEE. A number of test facilities were created on the base of cyclotrons in Joint Institute of Nuclear Research (JINR), Dubna city, Moscow region, which have differential in the composition of output ions and their energy, the irradiation area, range of temperatures, by changeover time from one ion to another, vacuum pumping time. The designation and technical characteristics of test facilities will be presented. All test facilities are available to carry out tests (on request) there are no restrictions for foreign organizations.

The main direction for the development of EC testing aids on hardness to SEE from space ionizing radiation influence is to ensure the completeness and process of test optimization with increasing of their informational content, accuracy and the contemporary process of increasing availability, efficiency, productivity and decreasing of tests costs. The accuracy of tests is provided through their realization by approved standard methods (taking into account the specific character of realization for concrete test facility) with control of all possible types of effects to which the devices are potentially sensitive (and under an elevated temperatures for latch-up), ensuring the completeness of electrical parameters control of test object, the application of metrological certified test facilities and achievement of special Roscosmos requirements to carrying out tests.

SINGLE EVENT TRANSIENTS' INVESTIGATION IN MODERN FPGA CIRCUITS

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The reduction of design rules and following operation frequency increase for digital VLSI circuits such as FPGAs bring single event effects (SEE) to become the main factor for operational faults and failures of spacecraft equipment.

In order to estimate the impact of SETs on FPGAs functioning, two groups of experiments were set up. In the first group of experiments SETs in FPGAs test structures were investigated. Test structures were built according to 180 nm CMOS FPGAs Antifuse-RAM technology with two modes of loading configuration. The first mode is loading configuration in RAM of test structure. This mode allows multiple configurations' reboot which provide verification and debugging of the project. The second way of configuration is loading in Antifuse mode. Storing configuration information in the test structure operating in Antifuse mode was achieved by metal jumpers scraping and RAM power-down. SETs investigations were carried out at synchrocyclotron facility with short run heavy ions. Test structures included a chain of inverters. Configuration record in the test structures were carried out in Antifuse mode. The purpose of this group of experiments was to control the logic state of inverters chain output with automatic capture and analysis of emerging SETs. According to published data this class of VLSI design rules is characterized by SET duration from hundreds of picoseconds to tens of nanoseconds. In our experiment, SETs' duration from hundreds of nanoseconds to a few microseconds was recorded. The amplitude of recorded SETs varied from hundreds of mV up to supply voltage of test structures. Obtained results are not typical for this class of digital VLSI FPGAs. The development of recorded SET probably is connected to the RAM influence, which requires additional modelling of cell structure configuration memory which will be conducted in the final paper. In second group of experiments we investigated the SETs in XC5VLX50 Xilinx Virtex-5 family FPGA described in detail in [1]. It was experimentally proven that the SETs in FPGA Xilinx XC5VLX50, emerging in a configurable logic block circuit (CLB), does not extend beyond the CLB boundaries. Experimental results show that the research of the SETs in digital VLSI such as FPGAs is an important aspect for space applications.

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RADIATION BEHAVIOR FEATURES OF THE MODERN TRANSCEIVER ICS

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Transceivers are widely used for data transfer in the distributed systems of industrial and special purpose. There are many types of the transceiver ICs for the various communication standards (i.e. RS-485, LVDS, CAN, etc.). The peculiarity of distributed systems usage in a number of cases stipulates an increased requirement for radiation resistance.

The paper presents the analysis results of the transceiver ICs degradation caused by the ionizing radiation. The transceiver IC's structure analysis was held to define the parts of the IC chip that are most sensitive to ionizing radiation, as well as the critical modes of operation (both electrical and thermal). It was shown the follows:

- the most radiation-sensitive part of the transceiver system is the transmitter IC in most cases;

- it was found that several radiation effects (such as time loss of efficiency under pulsed radiation, degradation of supply current, etc.) allows to determine technology and uniquely characterize the type of transceiver IC.

The comparative analysis was done on the base of radiation experiments of more than 40 different types of transceiver ICs with the different data transfer standards, with the different production technologies, produced by different manufacturing companies from 2010 to 2014.

As a result:

- the analytical comparison of the level and cause of parametric and functional failures induced by the radiation influence, was done;

- the identifying method of the transceiver IC type by monitoring electrical and functional parameters during and after irradiation was developed.

MICROELECTRONIC CIRCUIT IDENTIFICATION METHODOLOGY BASED ON THE RESULTS OF THE RADIATION HARDNESS ASSURANCE TESTING

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Irradiation responses of each type of microelectronic circuits and its failures levels are the individual characteristics of the device, which has been obtained during radiation testing. These radiation responses and hardness levels are defined by a unique combination of library elements and functional blocks, applied materials and technologies, specific structural and topological implementation of the product and etc. They are defined by the transient and spectral characteristics of irradiation facilities as well.

It is important that radiation response of microelectronic devices to dominant radiation effects (dose rate, total dose, structural damage and single events) is determined by the radiation-induced reaction of both - functional elements and parasitic structures and is individual for each product. Thus, the array of radiation responses and parameters' dependencies could be employed as comprehensive product ID if normalized test procedure is used.

Such radiation validation of the product could serve as an informative addition to the widely used visual and x-ray identification methods, wafer lot, topology and dimensional inspection.

This is particularly important and critical for COTS and industrial integrated circuits (i.e., with no radiation hardness assurance in specification), where employment of crystals from different factories is common practice. Usually it is accompanied by a full product revision with no evidence in its package marking and paperwork and could result in circuit mistreatment.

In general, we can effectively reveal the undeclared changes in design, materials or manufacturing processes on the basis of radiation identification and as a result exclude counterfeit or undeclared products.

THE INFLUENCE OF THE DEVICE GEOMETRY ON THE PARTIALLY DEPLETED SOI TRANSISTORS TID HARDNESS

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The research is focuses on the differences in radiation behavior for transistors of different geometry, body tie contact types, device layer thickness and biasing. During the last years SOI technologies have been often considered as one of the most suitable approaches for applications where radiation hardness is needed. Full isolation of transistors reduces leakage current and parasitic capacitance and prevents latchup. However, the buried oxide (BOX) and body region induce different effects that can reduce the advantages of SOI technology [1]. Test structures including p- and n-type mesa-isolated partially depleted SOI transistors of different channel region length and width, various body ties contact types and device layer thickness were used in the research. Threshold voltage shifts of the top and bottom (parasitic) transistor and leakage current increase were chosen as the dose hardness criteria. Transistors were tested under different bias conditions: "ON", "OFF" and "TG". The substrate was grounded in most cases; however the "TG" bias was additionally tested with the negative offset voltage applied to the substrate. The experimental results of the research are dependencies of criterial parameters mentioned above on total dose. The value of threshold voltage shift may vary among transistors with different body tie contact type. As a rule, the worst operating mode is Transmission Gate ("TG") for transistors with independent body contacts and "OFF" for transistors with BTS (body-tied-to-source) blocks. That result generally corresponds with ones described in literature [2]. The threshold voltage shift is higher for the transistors with short channel, especially for transistors with short and wide one. Figure 1 shows the example of threshold voltage dependence on total dose.

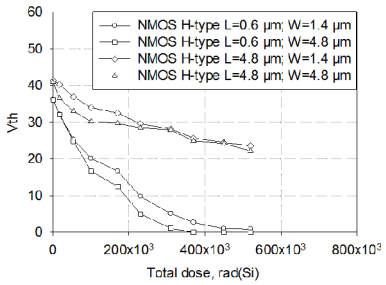

Figure 1. Dependence of bottom transistor threshold voltage on total dose.

The influence of aforementioned device parameters on dose hardness is further discussed in the paper.

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THE EFFECT OF Xe ION AND NEUTRON IRRADIATION ON THE PROPERTIES OF SiC AND SiC (N) FILM PREPARED BY PECVD TECHNOLOGY

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Silicon carbide has attracted much interest for wide range of applications. The significance of this material follows from the fact that its electrical and optical properties can be controlled by varying the carbon, silicon and hydrogen composition of the film. Those properties of the film make the amorphous silicon carbide (a-SiC) an excellent alternative passivation layer material for silicon solar cells especially working in hard and space environment.

Silicon carbide (SiC) and nitrogen-doped silicon carbide (SiC(N)) films were deposited on P-type Si(100) substrates at various deposition conditions by means of plasma enhanced chemical vapor deposition (PECVD) technology using silane (SiH_4) methane (CH_4) and ammonium (NH_3) gas as precursors. The concentration of elements in films was determined by RBS and ERD analytical method simultaneously. Chemical compositions were analyzed by FT-IR spectroscopy. The films contain a small amount of oxygen. IR results showed the presence of Si-C, Si-N, Si-H, C-H, C-N, N-H and Si-O bonds. Raman measurements of SiC films were performed by using a Raman microscope with 532 nm laser. Raman results showed that films were amorphous with small amount of nanocrystalline phase. The current-voltage (I-V) characteristics of samples before and after Xe ion and neutron irradiation were measured. Irradiation of samples with Xe ions was performed in accelerator IC100 and irradiation of samples with neutrons was performed in IREN facility at JINR Dubna. The measured current increases more than one order after irradiation with neutrons and measured current increases slightly after irradiation with Xe ions.

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EVALUATION OF SOME FAULT DETECTION TECHNIQUES IN WIRELESS SENSOR NETWORKS

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Wireless Sensor Network (WSN) consists of a set of inter-related elements called “nodes”. These nodes have several parts, the most important of which is the energy source for each node. Due to the limitations with these sources, nodes may become faulty or lose their efficiency that will lead to the decrease in throughput and consequently reduction of output and efficiency of the network. In fact, sometimes due to the aforesaid damages, major part of connections will be lost. Therefore, it is essential to have fault tolerability among network components especially the nodes in order to decrease these damages and their influences on the network. In reality, fault tolerability, fault identification, and fault resolving will lead to the increase in reliability and validity of connections inside the network. Fault management in wireless sensor networks are divided into three sections: Fault detection, fault identification, fault optimization (system restore). As a matter of fact, fault detection is considered to be the first step towards fault management in a network. This unidentified fault has to be detected and identified truly by the network system. So many techniques are proposed for fault detection in wireless sensor networks, each with different advantages and disadvantages depending upon the type of applied technique such as distributed, concentrated, etc.

The aim of this article is to introduce various fault detection mechanisms in wireless sensor networks and the comparison of three algorithms as set forth.

OPTICAL PROPERTIES AND ELEMENTAL COMPOSITION OF THE FILMS DEPOSITED USING THE PLASMA FOCUS INSTALLATION

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Currently, the obtaining of films of various materials in a low vacuum (~ 10-3 - 10-2 Torr) is an interesting problem, while conventional methods require a vacuum ~ 10-7 - 10-8 Torr.

The aim of this study was to investigate the possibility of spraying optically transparent metal films using such devices as Plasma Focus (PF) [1]. Operating pressure of plasma forming gas in the installations PF usually is several Torr.

Metal films on substrates were obtained as a result of erosion of the anode material in an electric discharge of capacitors of the PF installation. Material of the anode contains copper, tungsten and stainless steel type H18N9T. Plasma forming gases were deuterium, nitrogen and argon. As substrates were used glass and metal plates.

Found that, depending on the geometry of the substrate relative to the plasma jet, it is possible to obtain sufficiently uniform optically transparent films of copper and its compounds. The measured transmission spectra in the wavelength range of 0.3 - 1.0 μ, and an analysis of the elemental composition of the films using a scanning microscope with X-ray microanalyzer allow us to conclude that the film contains a large number of uncontrolled impurities: C, W, Al, Si, Mn et al.

It is shown that the content of impurities in the films can be considerably reduced in the manufacture of the PF anode assembly of the single-element material such as pure copper.

High adhesion with the surface film of the substrates can be explained by high velocity of plasma jet ~ 100 km / s.

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OPTICAL CONTRAST FORMATION IN TA-C FILMS BY ION IMPLANTATION

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Samples of thin film (d=40 nm) tetrahedral amorphous carbon (ta-C), deposited by filtered cathodic vacuum arc (FCVA), have been implanted with Ga+ at ion energy E=20 keV and ion doses D=3.1014 - 3.1015 cm-2. This results in optical properties modification, best manifested by a significant shift of the optical absorption edge to lower photon energies as obtained from optical transmission measurements. This shift is accompanied by a considerable increase of the absorption coefficient (photo-darkening effect) in the measured photon energy range (0.5 - 3.0 eV).The observed optical effects could be attributed both to additional defect introduction and increased graphitization, as confirmed by X-ray photo-electron spectroscopy measurements. The optical contrast thus obtained (between implanted and unimplanted film material) could be made use of in the area of high-density optical data storage using focused Ga+ ion beams.

Ga^+ ION IMPLANTATION INDUCED MODIFICATION OF TA-C FILMS

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Thin film samples (d=40 nm) of tetrahedral amorphous carbon (ta-C), deposited by filtered cathodic vacuum arc (FCVA), have been implanted with Ga^+ at ion energy E=20 keV and ion doses D=3.1014 - 3.1015 cm-2. The Ga+ ion beam induced structural modification of the implanted material results in a considerable change of its optical properties, displayed in a significant shift of the optical absorption edge to lower photon energies as obtained from optical transmission measurements. This shift is accompanied by a considerable increase of the absorption coefficient (photo-darkening effect) in the measured photon energy range (0.5 - 3.0 eV). These effects could be the result of additional defect introduction and increased graphitization, as well as of the accompanying formation of bonds between the implanted ions and the host atoms of the target, as confirmed by infra-red (IR) and Raman measurements. The obtained optical contrast (between implanted and unimplanted film material) could be made use of for information archiving, in the area of high-density optical data storage while using focused Ga^+ ion beams.

RADIATION IN MEDICINE

12

RADIOPHARMACEUTICALS IN DIAGNOSIS AND THERAPY

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Radiopharmaceuticals or radioactive drugs are the main subjects of research in filed of radiopharmacology. Radiopharmaceuticals are used in the field of nuclear medicine as markers for diagnosis and treatment of many diseases, and their application has became very important for different clinical trials. The term radioisotope, which in its general sense refers to any radioactive isotope (radionuclide), has historically been used to refer to all radiopharmaceuticals, and this usage remains common. Technically, however, many radiopharmaceuticals incorporate a radioactive tracer atom into a larger pharmaceutically-active molecule, which is localized in the body, after which the radionuclide tracer atom allows it to be easily detected with a gamma camera or similar gamma imaging device. The main pharmacotherapy of those drugs is conducted in field of oncology, endocrinology, cardiology and rheumatology.

In this professional paper, the most important radiopharmaceuticals will be presented, together with their basic characteristics and application in diagnosis and therapy.

Drugs such as Strontium 89 (Metastron®), samarium 153 (Quadramet®), and Radium- 223 (Xofigo®) represents radiopharmaceuticals that can be used for tumors that have spread to the bones (bone metastases). These drugs are given in veins (intravenously or IV), so that they go into the blood circulation. They travel through the body and build up in the areas of the bone where there is cancer. The radiation they give off then kills cancer cells and eases the pain caused by bone metastases.

Radiopharmaceuticals are often used in treatment of thyroid cancer. The thyroid gland absorbs nearly all of the iodine in the blood. Because of this, radioactive iodine (also called radioiodine or iodine 131) can be used to destroy the thyroid gland and thyroid cancer with little effect on the rest of the body. This treatment is often used after thyroid cancer surgery to destroy any thyroid cells left behind. It's also used to treat some types of thyroid cancer that spread to lymph nodes and other parts of the body.

Radio-labeled antibodies are man-made versions of immune system proteins that attack only a specific molecular target on certain cancer cells. When put into the bloodstream, the antibodies act as homing devices. They attach only to their target, bringing tiny packets of radiation directly to the cancer. Radio-labeled antibodies are used to treat some non-Hodgkin lymphomas, especially those that don't respond to other treatments.

Phosphorus 32 (also known as P-32 or chromic phosphate P 32) is put inside brain tumors tumours that are cystic (hollow) to kill the tumor without hurting the healthy parts of the brain. In the past, P-32 was given into a vein (as an IV) as a common treatment for blood disease - polycythemia vera. P-32 was also placed inside the abdomen as a treatment for ovarian cancer.

Key words: Radiopharmacology, radiopharmaceuticals, drugs, diagnosis, therapy

COMPARISON OF DOSE AND IMAGE QUALITY OF FULL FIELD DIGITAL, COMPUTER RADIOGRAPHY AND FILM/SCREEN MAMMOGRAPHY UNITS

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Mammography is the most important diagnostic method for the early detection of breast cancer. The objective of mammography examination is to obtain accurate diagnostic information while keeping the dose as low as possible what is achieved by comprehensive quality assurance program. During past 8 years several quality audits of mammography systems were performed in Croatia; primarily aimed to the centres included in the national breast screening program. At that time most of mammography units were film/screen (FS) based and therefore developing process deficiencies were frequently found. Quality assurance/quality control (QA/QC) program was missing in most of the surveyed centres. In the last few years there was a significant increase of digital systems due to its better efficiency in image archiving and absence of developing process problems. In this work image quality and dose of different types of mammography systems were compared.

Siemens Mammomat 3000 using FS and computer radiography (CR) systems at University hospital of Osijek and full field digital (FFD) GE Seno Essential at hospital Vukovar were compared. All components of the FS system are under strict QA/QC program and used routinely for screening. CR AGFA DR-M system have special mammography program and uses screen with pixels size of 50 microns, but is not used for screening at the moment. Patient dose assessment was performed in terms of average glandular dose (AGD), and image quality was assessed using phantoms to estimate high and low contrast resolution, contrast and image quality score. Phantom images acquired on digital systems were analyzed on mammography dedicated workstation with 2x5MP monitors, non diagnostic PC monitor (1.3MP), and dryprinted film with 1:1 and 1:2 print ratio to validate earlier identified clinical practices.

Patients' doses were well below proposed limits for all systems, and FFD unit showed significantly lower AGD for thicker breasts. Image quality was always degraded in digital systems when non diagnostic monitor was used or image is printed, especially when printed decreased in size. Despite that, digital systems always showed equal or better detection of simulated low contrast lesions than FS system. High contrast resolution was superior at FS system due to limitations in pixel size of digital units, but when resolution was estimated using low contrast resolution pattern, FFD system with diagnostic monitor was comparable to the FS system. FFD and CR systems show the highest and the lowest phantom image scores, respectively.

Our results showed that improved contrast resolution of FFD mammography despite reduced spatial resolution allows superior or equal phantom object detection compared to FS mammography. The clinical use of digital mammography (FFD or CR) may generally improve image quality with equal or lower breast doses, but all advantages could be diminished with inappropriate use of digital techniques or if QA/QC is missing.

ADJUVANT CHEMORADIATION WITH PREVENTIVE PARA-AORTIC CONFORM IRRADIATION IN ENDOMETRIAL CANCER II-III FIGO MULTIMODAL TREATMENT

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The purpose of the study.

To evaluate the impact of adjuvant taxane-platinum-based chemoradiation with preventive para-aortic zone irradiation to outcome improvement in endometrial cancer II-III FIGO patients.

Materials and Methods.

From January 2008 to April 2014 database of 250 EC patients' medical histories and outpatient cards was analyzed retrospectively; all cases were re-staged according to 2009 FIGO classification.

115 patients with endometrial cancer II-III stage were considered eligible and were included in the study in two arms. 49(43%) pts. were enrolled in research group A. All of them undergone total hysterectomy, with pelvic lymphadenectomy in 18(36,7%), pelvic–para-aortic lymphadenectomy – in 8(16%) of them, followed by adjuvant chemoradiation. Image–guided external beam radiotherapy combined with brachy had been performed in 100%, 33(61%) patients were supplemented with para-aortic lymph node irradiation to the level of Th12-L2. All patients then received 2-6 courses of taxane-platinum adjuvant chemotherapy. Total mean dose to pelvic (obturator, internal/ external/ common iliac) and para-aortic lymphnodes TD44Gy (30–50Gy) was achieved, with increase to 60Gy (36–74) in the vaginal vault because of Ir–192 HDR brachytherapy.

66 (57%) patients were enrolled in control arm B; all of them undergone total hysterectomy, with pelvic lymphadenectomy in 14 (21%) and pelvic–para-aortic lymphadenectomy in 7 (10, 6%) of them, followed by conventional external beam radiotherapy on the pelvic region TD 40–44Gy, added by Co-60 HDR brachytherapy to vaginal cuff.

Results.

The median follow-up was 12 months (range, 1-79 months). We registered the significant improvement in overall and disease-free survival in arm A, with 11% decrease of loco-regional relapse rate (from 20% to 9% in stage II pts., from 36% to 21% in stage III pts.) and 11% decrease (from 22% to 11%) of distant metastasis rate in stage III pts. Treatment was tolerable: no significant difference in adverse effect rates and grade was registered in arm A in spite of irradiation field extension, mainly because of specific therapeutic prevention.

Conclusions.

Adjuvant taxane-platinum-based chemoradiation with preventive para-aortic zone irradiation improves one year overall survival, disease-free and cancer-specific survival for patients with II-III FIGO with acceptable side effects rate.

QUANTIFICATION OF DOSE CONSEQUENCES DUE TO CTV-PTV MARGIN CHANGE MEASURED WITH EPID

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The purpose of this work is to check the enclosure of PTV with a certain isodose line if the CTV-PTV margin is changed from default margin to the margin calculated from the portal measurements.

We recorded retrospectively the errors in a number of patients obtained with portal measurements on setup fields in all three directions. The region of pelvis was considered and the portal images obtained with the EPIDs were compared with DRR images of the setup fields generated from the TPS. For review purposes 30 patients were taken and the positional errors in vertical, longitudinal and lateral direction were recorded for each patient. For each patient a new target structure PTV was formed based on the margins calculated from the portal measurements. The new PTV is recorded and the isodose values for minimum and mean dose in the PTV were also recorded. These results were compared with the respective isodose values in the original plans.

Based on these measurements it was found that the sum of systematic and random errors for the above mentioned directions are 0.8 cm, 0.5 cm and 0.7 cm respectively. Because all newly found CTV-PTV margins are less than the generic ones (which are 1 cm in all directions), the average value of minimum isodose line enclosing PTV increases by 3.5%. With the new margins the values of the PTVs are shrunk by 21% in average.

This shows that the effort should be made in order to determine the real CTV-PTV margins in all clinical cases. In that way it will be possible in some cases to treat smaller target volume with the same confidence for succesful outcome as with plans with generic margins.

Key words: PTV margin, treatment uncertainty

MEASUREMENT OF CHARGED PARTICLE YIELDS FROM THERAPEUTIC BEAMS IN VIEW OF THE DESIGN OF AN INNOVATIVE HADRONTHERAPY DOSE MONITOR

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Hadrontherapy is a technique that uses accelerated charged ions for cancer treatment. The high irradiation precision and conformity achievable with heavy ions enhance the Radio Biological Effectiveness (RBE) of such therapy while helping sparing the surrounding healthy tissues and Organs at Risk (OAR). To fully profit from the improved therapy spatial selectiveness, a novel monitoring technique, capable of providing a high precision in treatment feedback on the dose release position, is required. Here we propose a novel approach based on the simultaneous detection of secondary protons and prompt photons that are emitted at large angles with respect to the therapeutic beam incoming direction and are correlated with the Bragg Peak (BP) position and the related dose release.

In the first part of this contribution we will show briefly our results from a campaign of measurements at different beam facilities, such as fluxes and energy spectra for secondary particles produced by 4He, 12C and 16O ion beams of therapeutic energies impinging on thick PMMA phantoms. Such measurements afford a solid evidence that the rate of produced protons and prompt photons is large enough to supply the particle sample needed for a fast online monitor operating during a typical treatment that will be capable to provide the required millimetric spatial resolution.

In the second part of this contribution we will present the novel dual mode hadrontherapy monitor, named "Dose Profiler" (DP), exploiting, simultaneously, the backtracking of secondary charged particles and prompt photons emitted during the irradiation of the patient. The Dose Profiler, whose final layout has been optimized using a dedicated Monte Carlo simulation based on the aforementioned experimental results, combines a tracker detector made of scintillating fibers and a calorimeter built with pixelated LYSO crystals, for gamma detection and energy measurements. Six tracking squared layers, built from two orthogonal planes of squared scintillating fibers, will provide the particle direction information, while the LYSO crystals will measure the particle energy.

A first tracker layer has already been assembled and a preliminary evaluation of the detector performances has been done using cosmic rays. The fibers system detection efficiency and the optical cross talk as well as other preliminary performances obtained with dedicated test beams will be showed.

TREATMENT PLAN OPTIMIZATION IN PARTICLE THERAPY USING NANODOSIMETRIC QUANTITIES

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Treatment plan optimization for therapy with protons and heavier ions is an active field of research addressing the challenge to create a uniform biological response in the target. The current dose prescription practice, based on absorbed dose multiplied by a relative biological effectiveness (RBE) factor, has known limitations. A novel treatment-plan optimization strategy using measurable or simulated nanodosimetric quantities rather than biophysical models is proposed.

The feasibility of the novel optimization approach was investigated by simulating proton and carbon treatment plans consisting of a single or two opposing spread-out Bragg peak fields with the Geant4 Monte Carlo toolkit. A simple linear target volume comprising a row of five cubic voxels of 5 mm side length was embedded inside a cubic water phantom. The tracks of individual charged particles of the mixed radiation field produced at different depths in the target volume were simulated with Geant4-DNA. Due to the large computation time needed for the step-by-step transportation of particles, a scoring strategy was used dividing each target voxel and adjacent normal-tissue voxels into a series of microscopic sub-volumes. Within these sub-volumes, Geant4-DNA models were activated, while the standard condensed-history transportation was used in the rest of the voxel volume. Simulated tracks were sampled with randomly placed cylinders of 2 nm diameter and 16 nm length, representing DNA segments in which individual molecular damages such as strand breaks can interact, and the number of ionizations in each cylinder (the ionization cluster size) was scored. Ionizations clusters were categorized as “small clusters” with 2-3 ionizations and “large clusters” with 4-10 ionizations, and their absolute yields were chosen as biologically significant nanodosimetric descriptors of radiation quality. The fluences of the pencil beams in each field were optimized in order to create an equal yield of small and large clusters throughout the SOBPs.

The carbon ion plans showed a much larger depth-dependence of ion cluster size distributions and yields of small clusters than the proton plans. For the single-field SOBPs, the optimization goal of equal yields of small and large clusters throughout the target was not achieved, due to the lack of beams from the opposite direction balancing out the increase of large cluster yields with depth in the single beam. On the other hand, a uniform spatial distribution of both small and clusters was obtained by optimizing opposing-field SOBPs for proton and carbon ion plans.

We have tested the feasibility of a novel approach of particle therapy optimization by creating uniform plans with equal yield of small and large ionization clusters. Future investigations need to demonstrate that this approach is also feasible for more complicated beam arrangements and that it leads to a biologically uniform response in tumor cells and tissues.

EVALUATION OF 3-D REAL-TIME TARGET POSITIONING ACCURACY DURING SPINAL RADIOSURGERY

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Stereotactic Radiosurgery require high precision of patient positioning and target localization. We evaluate the 3-dimensional real time target positioning accuracy using optic guided patient positioning system, ExacTrac (BrainLab, Germany), during spinal radiosurgery procedure. The system is based on real time detect multiple body markers attached on the skin landmarks of patient's body. We investigate the selected 8 metastatic spinal tumor cases. All of tumors commonly closed to thoracic spinal code.

To evaluate the real-time target positioning, we had checked out isocenter positioning per every 20milliseconds for 45seconds during spinal radiosurgery. And we compare the 3-dimensional positions of body markers to corresponding positions of reference CT image.

Average 3-dimensional real time isocenter positioning translation were 0.07 ±0.17mm, 0.11 ±0.18mm, 0.13 ±0.26mm, and 0.20 ±0.37mm in the x(lateral), y(longitudinal), z(vertical) directions and mean spatial error, respectively. And body rotations were 0.14 ±0.070, 0.11 ±0.070, 0.03 ±0.040 in longitudinal, lateral, table directions and mean body rotation 0.20 ±0.110, respectively.

In this study, the maximum mean deviation of real time isocenter positioning translation during spinal radiosurgery was acceptable accuracy clinically.

IN VITRO AND *IN VIVO* INVESTIGATIONS OF BORON NEUTRON CAPTURE THERAPY

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Boron neutron capture therapy (BNCT) is a promising approach for therapy of human brain tumor. The accelerator-based epithermal neutron source based on novel tandem accelerator with vacuum insulation and lithium neutron producing target was proposed and created in the Budker Institute of Nuclear Physics. Stationary proton beam with 2 MeV energy, 1.6 mA current, 0.1% energy monochromaticity and 0.5% current stability has just been obtained. Neutron generation is realised through 7Li(p,n)7Be reaction. Epithermal neutron flux is formed by Beam Shaping Assembly.

The possibility to use this source for BNCT was tested on a model in vitro and in vivo. Here we present and discuss the results of these investigations. The BNCT effect was demonstrated at neutron radiation of glioblastoma cell line U87 and normal human fibroblast cell line MRC-5 incubated in a medium with and without boron phenylalanine. A proposal to increase the beam parameters to at least 2.5 MeV and 3 mA is discussed. This will allow to fulfil BNCT at the facility at the nearest future.

COMPARISON OF THE USEFULNESS OF PBC AND AAA IN THE RADIOTHERAPY PLANNING SYSTEM

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One of the main goals of radiotherapy is to achieve tumor control and minimize normal-tissue damages. For this reason radiation oncology requires high accuracy, which implies no more than 2 - 3% uncertainty levels in the treatment planning calculations [1]. This is extremely challenging, when heterogeneous tissues such as lungs and bones are involved [2]. To verify the accuracy of the dose calculation algorithms numerous approaches might be performed. The most common is point dose, one-dimensional profile and two-dimensional isodose line comparison with experimental measurements [1]. Due to limitations of photon dose calculation methods, a new Pencil Beam Convolution algorithm had been recently developed.

In this study results of transport modeling and the deposited spatial distribution of the dose obtained by Anisotropic Analytical Algorithm (AAA) and Pencil Beam Convolution algorithm (PBC), were compared to measurements recorded during the experiment. To achieve meaningful conclusions, two parameters: dose difference (DD) and distance to agreement (DTA) were taken into consideration and examined. The irradiation of human chest was simulated using anthropomorphic phantom. For dose detection gafchromic EBT films were used and digitally analyzed via Epson Scanner. Preliminary results showed that the AAA, with its complex accounting of heterogeneities, provides more accurate estimate of the dose within an area of a high density gradient, than PBC does. The data accuracy derived for given parameters was on level: DD (5%) 83.4% and DTA (3mm) 99.0%, implicating AAA as an appropriate in radiotherapy treatment planning.

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ESTIMATIONS OF VARIATIONS IN LUNGS' MOTION IN EXTERNAL BEAM RADIATION THERAPY

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This was an experimental study deals with detection, measurement and analysis of the periodic physiological organ motion during external beam radiotherapy; to improve the accuracy of the radiation field placement, and to reduce the exposure of healthy tissue during radiation treatments. The importance of this study was to detect the maximum path of the mobile structures during radiotherapy delivery, to define the planning target volume (PTV) and irradiated volume during both inspiration and expiration period and to verify the target volume. The results showed (body contour was equally (3.17 + 0.23 mm), for left lung displacement reading (2.56 + 0.99 mm) and right lung is (2.42 + 0.77 mm) which the radiation oncologist to take suitable countermeasures in case of significant errors. In addition, the use of the image registration technique for automatic position control is predicted potential motion. The motion ranged between 2.13 mm and 12.2 mm (low and high). In conclusion, individualized assessment of tumor mobility can improve the accuracy of target areas definition in patients undergo Sterostatic RT for stage I, II and III lung cancer (NSCLC).

IONIZING RADIATION EXPOSURE OF KOREAN POPULATION FROM DIAGNOSTIC RADIATION IMAGING

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The number of diagnostic medical radiation procedures has been increasing worldwide. The increasing trend was also observed in Korea due to the following reasons: coverage of national medical insurance for new examination types, which were not covered previously and increasing concerns about the health of the general public. Diagnostic radiation imaging is valuable tool in modern medicine. However, medical radiation imaging results in radiation exposure and thus potentially negative health effects such as cancer. One study was recently begun to estimate diagnostic radiation exposure to Korean population. For the study, we collected radiation dose data for various types of diagnostic radiation examinations, including computed tomography (CT), and conventional radiography and fluoroscopy. For CT, previous studies measured CTDI and DLP and collected CT setting parameters with more than 200 CT scanners. Mean DLP values in Korea were 760, 373, 551 mGy cm for head, chest, and abdomen examinations, respectively. For radiographic examinations, previous studies measured ESD under typical x-ray equipment settings at more than 350 hospitals. Mean ESD ranged from 0.2 mGy (wrist AP) to 8.8 mGy (L-spine LAT). In general, lumbar and thoracic spine imaging resulted in high dose (3.1-8.8 mGy). Pelvis, abdomen, hip, skull, cervical spine, clavicle, shoulder, and chest imaging resulted in intermediate dose (0.9-3.1 mGy). Extremity imaging resulted in low dose (0.2-0.6 mGy). For mammography, average glandular dose for each imaging was 1.16 mGy. For dental radiography, dose area products were 59, 107, 128 mGy square cm for periapical, panoramic, and cephalic x-rays, respectively. Effective doses for the various types of diagnostic radiation examinations will be calculated using the Monte Carlo simulation. The calculated effective doses and the statistical data of annual number of the procedures will provide diagnostic radiation exposure level to Korean population.

STAFF DOSES IN PEDIATRIC BARIUM MEAL PROCEDURES

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Ionizing radiation has become an indispensable tool in medicine when it comes to diagnosis and therapy. However, its use should happen in a rational manner, taking into account the risks to which the staff is being exposed. Barium meal (BM), or upper gastrointestinal (GI) studies, using fluoroscopy, are widely used for gastroesophageal reflux disease diagnostic in children and professionals are required to stay inside the examination room to position and immobilize pediatric patients during the procedure. Therefore, it is very important that professionals strictly follow the technical standards of radiation protection. According to the ICRP recommendation, the annual limit equivalent doses for eyes, thyroid and hands are, respectively, 20 mSv, 150 mSv and 500 mSv. Based on those data, the aim of the current study is to estimate the annual equivalent dose for the eyes, thyroid and hands of professionals, who perform BM procedures in children. This was done using LiF:Mg,Cu,P thermoluminescent dosimeters (TLDs) in 32 procedures; 2 pairs were positioned near each staff´s eye, 1 pair on each professional's neck and 2 pairs on both staff's hands. The results of the estimative of annual equivalent doses, for eyes, thyroid and hands, were respectively: 14- 30 mSv, 9-13 mSv and 17-52 mSv. Only the closest staff to the patient exceeded the annual equivalent doses in the eyes (around 50% higher than the limit set by ICRP). However, the comparison of thyroid and hands doses with results from other studies, performed in the BM procedure, shows lower values than the present study. Therefore, the optimization implementation is necessary, so that the radiation levels can be reduced. Work supported by CNPq, CAPES and Fundação Araucária.

HADRON CANCER RADIATION THERAPY AND GANTRIES

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The cancer affects one of three persons in the world today. In the successful treatment to cure the cancer it is some times necessary to apply additional radiation treatment. Some times the localized tumors are not possible to remove by operation. The hadron cancer therapy is very successful in these cases. Usually the X-rays and other radiations are used to attack the localized cancer tumors. Even in the most sophisticated IMRT - Intensity Modulated Radiation Treatments or so called cyber knife the X-rays, or IIGRT (Image Guided Radiation Therapy), or RTPM-Real Time Position Management) side effects are unavoidable. The X-rays propagate through the human body and beyond delivering the unavoidable radiation along their path to all live cells not only to the cancerous tumor. The most serious are the cardiovascular side effect and are more important in the case of the children treatment. The protons or heavy ions, on the contrary, deliver radiation around the Bragg peak very much localized in the tumor. Most of the lost energy due to Coulomb scattering or Nuclear Straggling is deposited around Brag peak depending on the ion energy. Advantages of hadron cancer therapy with respect to other radiation treatments are obvious and the number of hadron facilities together with a number of patient's treatment is exponentially rising. Today the number of patients treated by proton cancer therapy is 105743 (June 2014), C-ions 13119, and with all other ions to total number is 122449. The newest facilities in Europe are Heidelberg in Germany Carbon, proton and other ions, CNAO- in Pavia-Italy Carbon, proton and other ions, Tsukuba, Chiba, Huyogo Shizuoka, Koriyama-City, Ibusuki, Gunma, Nagoya, Tosu (Saga-Himat), Wanjie and Lanzhou in China, 17 proton therapy facilities in USA, PSI Switzerland - proton, Sweden, almost finished Carbon-proton facility in Vienna Austria, TRIUMF Canada, Dubna-Russia, Poland Krakow, South Africa, France- Nice and Orsay, Czech Republic Prag, etc. The talk will describe in introduction to the hadron cancer therapy treatment, list the major methods - accelerators and gantry types, and at the end author will describe recent developments on the carbon/proton gantries and his published patents in the field.

ASSESSMENT OF ORGAN DOSE IN PEDIATRIC PATIENTS UNDERGOING COMPUTER TOMOGRAPHY EXAMS

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Pediatric CT dosimetry has been a matter of great study lately in the scientific community because the dose is higher than in most of the radiographic procedures. This study was performed at the Little Prince Children's Hospital in Curitiba-Brazil, using a GE fifth-generation CT scanner, model BrightSpeed. Data were collected from 724 patients divided into 5 age groups, 0 year, 1 year, 2-5 years, 6-10 years and 11-16 years, according to the recommendation of the European Commission. The dose for different ages was analyzed and compared with international protocols regarding the CTDIvol, DLP and organ dose for a cranial, abdomen and chest CT. The dose values were collected from the equipment. The results obtained were compared with computer analysis values. They were used in this study to calculate the organ dose and to compare with the reference dose levels established by the European Community. Using the computer simulation program of the Caldose group and the EUR MSCT protocols, the relevant radioprotection magnitudes to the study, which are the organ dose values related to the procedure, were determined. The level of dose length product (DLP) , using the CTDI100,air previously established, was also obtained and compared with the dose reference level established by the European Community and the Good Practice Guide from the UK. The CTDIvol values are in the range of 1.37 to 6.08 mGy, the DLP values are between 19.71 and 279.12 mGy.cm. The values found so far are within the limits of the reference levels. Work supported by CNPq, CAPES and Fundação Araucária.

PAEDIATRIC COMPUTED TOMOGRAPHY: ASSESSMENT OF RADIATION DOSE AND RISK AWARENESS AMONG STAFF INVOLVED IN DIAGNOSTIC PROCESS

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Diagnostic radiology using x-rays has been undergoing fast changes in technology and practices that have implications on radiation safety of the patient, as use of paediatric computed tomography (CT) that has been rapidly increasing in recent years. With growing use comes growing concern about associated risks, in particular in radiosensitive population groups, as children. There is a paucity of information about level of radiation dose and risk awareness among staff involved in CT as paediatric radiology staff and referring physicians as pediatricians. The aim of this work is to provide wide information about awareness among staff involved in paediatric radiology process Serbia, including tertiary and secondary care hospitals and taking into account largest possible number of centers with focus on the medical exposures and dose levels, dose and risk levels in paediatric CT, patients radiosensitivity, risk communication and basic justification and optimization issues. A questionnaire was prepared to collect information on status of dose and risk awareness in paediatric CT. A total 262 participants: radiologists (147), radiographers (43), pediatricians (20) and others (52) were asked to give answers to 10 questions, requiring numerical data, qualitative assessment or just simple yes/no answer. Of 262 responders only one third is aware that medical exposures are not limited (26-38% in different staff categories). Similarly, only 20% of radiographers, 33 % of radiologist, 27% of others and none of pediatricians considered medical exposures as a major contributor to the total dose from man-made sources of radiation. Only 37% of radiographers, 51% of radiologists and 60% of pediatricians stated that CT responsible for approximately 50% dose of all x-ray examinations. More than 90% of responders are aware of higher radiosensitivity in children, but only 55% of pediatricians, 67 % of radiologist and 81% of radiographers knew that children receive higher dose is adult exposure parameters are used in paediatric CT. Most of the responders had certain association between CT examination and cancer development, however only 10-25% in different staff categories knew actual risk magnitude. More than 80% of responders in all staff categories appreciated role of radiologist in justification. Finally, almost all responders stressed the importance of risk communication with parents. Although there are some encouraging points, awareness of radiation protection issues among paediatric radiology staff and pediatricians can be considered unsatisfactory, indicating a need for efficient training and awareness actions.

DESIGN OF A NEUTRON BEAM FOR BORON NEUTRON CAPTURE THERAPY CONSIDERING A PORTABLE NEUTRON SOURCE

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Abstract. Worldwide, Boron Neutron Capture Therapy (BNCT) treatments on brain tumor have been recently or are currently conducting on several facilities. A proper and high fluency of thermal or epithermal neutron source is required for this application. In this research, the possibility of using the Inertial Electrostatic Confinement (IEC) machine as a compact portable neutron source could be analyzed for this medical application instead of a large nuclear reactor facility. In addition of neutron source, an optimized BSA (Beam Shaping Assembly) is designed to gain an adequate thermal and epithermal neutron flux in agreement with the IAEA recommendations. Monte Carlo calculations were carried out by using the MCNPX code to determine the suitable materials for the design of the thermal neutron beam at BSA exit window. Various material arrangements of reflector, moderator, collimator and filters have been investigated to achieve the recommended limits for fluxes and doses. The thermal neutron flux calculated was approximately 2.12×109 n/cm2.s which is acceptable to perform significant experiments on superficial brain tumors.

Key words: BNCT, Thermal neutron, BSA, IEC

QUALITY ASSURANCE OF THE MEDICAL LINEAR ACCELERATOR USING 2D DETECTOR ARRAY IN THE CLINICAL CENTRE OF MONTENEGRO

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Introduction: In the Clinical Centre of Montenegro, we established a weekly protocol for the quality assurance (QA) program of the medical linear accelerator, based on recommendation of IAEA, ESTRO, SSRMP, IPEM and AAPM. In this work, we presented the results of sex-month evaluation photon beams dosimetry parameters, for medical linear accelerator Siemens ONCOR Expression (Siemens Healthcare, Erlangen, Germany), and detailed QA program for this measurement.

Materials and methods: To performing the weekly test we used the PTW 2D-ARRAY seven29 (PTW, Freiburg, Germany). It is a two-dimensional ion chamber array, consisting of 729 (27 x 27) vented ion chambers, with separately housed evaluation electronics. The parallel-plate chambers are 5 x 5 x 5 mm in size, and have a center to center spacing of 10 mm; 2D array was placed under water-equivalent material, and irradiated to evaluate photon beam parameters: absolute central axis doses (outputs), the transverse and longitudinal symmetry and homogeneity measurements and light/radiation field congruency. Output is separately checked with ionization chamber which have

Results: Our weekly QA measurement of central axis doses showed the reproducibility error of absolute central axis dose comparing with calibrated ionization chambers less that 2%; the transverse and longitudinal symmetry and homogeneity for photons beams showed the good stability, with deviation which is less of 0,5%.

Conclusion: During the sex-month QA, of our medical linear accelerator Siemens ONCOR Expression, we observed a good stability for all dosimetry parameters.

THE CHANGE IN RADIATION EXPOSITION IN PATIENTS WITH RENAL COLIC; OUR EXPERIENCE FOR OVER A DECADE (2004-2014)

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Medical technology and the protocols in establishing diagnosis in patients with renal colic and urolithiasis have been changed in the past decade. We have made a retrospective analysis of the diagnostic radiologic approach ten years ago and in the present. The purpose of our analysis was to realize if the advanced technology means advantage or disadvantage for patients with renal colic.

Out of 132 patients hospitalized for renal colic in 2004 in 128 a KUB (kidney, ureter, bladder) plain radiography was performed, and the other 4 were excluded because of pregnancy, where an ultrasound was the first and only choice in diagnosis. Additionally, an ultrasound was performed in 17% and an IVU in 82%. That means that maximal radiation dose that patients underwent during the hospitalization a decade ago did not go over 3.7 mSv. The sensitivity of both ultrasound and IVU is 61% and 70% respectively, with specificity 97% for ultrasound and 95% for IVU, so the diagnosis was well established.

On the other side we have analyzed hospitalized patients with renal colic diagnosed during 2014,a total of 113, in all of them KUB plain radiography performed. The sensitivity and specificity of KUB radiography is 44-77% and 80-87%, respectively. Ultrasound was performed in 93% of the patients, IVU in 57%of the patients and enhanced CT in 43% of the patients. By means of all these data we found out that maximal exposition dose of radiation was 28.7 mSv .

Considering all of the above we concluded that there is a significant elevation in the radiation dose used for the diagnosis of the patients hospitalized with renal colic. That is the reason why the guidelines change from year to year and only by following their recommendations and protocols we should avoid unnecessary exposition. When a clinical Question can be answered equally or near equally by two or more imaging modalities regarding their specificity and sensitivity, it is the modality with the least harm and lowest cost that should be selected.

EFFICIENCY ASSESSMENT OF A DIGITAL AND CR MAMMOGRAPHY SYSTEMS

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Introduction: Breast cancer is the most common cancer among women. It is the first cause of cancer death among women in Iran. Mammography is the most effective method for screening and detecting early-stage breast cancer. Furthermore, improvement in digital technology has been caused to replace conventional mammography with CR (computed radiography) and digital systems and so it has created challenges in medical centers. Mismanagement on exposure techniques to have minimum patient dose with respect to appropriate image quality has been caused that despite of having inherent effectiveness, these machines not to have a significant effect on reducing entrance surface dose (ESD). The aim of this study is to assess the efficiency of two mammography systems (digital and CR) according to the collected data by these machines.

Materials and methods: In this study, EI (exposure index) was used to evaluate the effect of digital mammography in reducing ESD and so absorbed dose of patient. Related data to the exposure of a group of patients (about 200 exposures) in automatic mode (AEC) was reviewed and exposure techniques such as kVp, mAs, breast thickness, the amount of compression and filter were acquired. Then the EI of each image was recorded. To evaluate the efficiency of CR mammography, a solid state dosimeter (piranha) and a breast phantom (PMMA) was used. In semiautomatic mode, by adjusting the breast thickness at 2 and 4 cm by using breast phantom in various kVps from 23-30 kV, ESD and mAs were measured. After that these parameters were compared to the acquired data from a conventional mammography machine that was tested under the same conditions.

Results: In digital mammography, the calculated EI showed that for 82% of exposures the EI is in "High exposure area" and just for about 18% of exposures it is in the "Ideal exposure area". In CR mammography the acquired mAs and ESD were more than twice in comparison to the conventional mammography.

Conclusion: According to the fact that one of the most important benefits of digital mammography is reducing patient absorbed dose, low skill in using different modes of system by technologists, inadequate training by dealers manufacturer, insufficient skill for calibrating systems by representatives and having no obligation to reduce patient dose with respect to image quality have caused to be far from the main aim of using digital and CR mammography. So they have not adequate effectiveness in hospitals. Therefore the lack of some legal, moral and medical requirements and commitments about good and proper use of CR and DR mammography systems exist in medical centers which should be resolved.

STRUCTURAL AND THERMODYNAMIC CHANGES IN THE NACL SOLUTIONS UNDER THE IRRADIATION

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Nowadays water-electrolyte systems are widely used in medicine. Among the most important applications is restoration of the salt water balance after the radiation therapy. It is quite important as the irradiation and temperature influence a lot of thermodynamic and structural properties of the water-electrolyte solutions in the human body. That may lead to different physiological changes, e.g. body temperature increase, stomach syndrome, etc. The above justifies the importance of the of the objective of the presented report devoted to the structural and thermodynamic changes observed in the infinitely diluted NaCl in water solution at different temperatures under the irradiation. The above liquid system is analyzed in the computer simulations conducted in DL-POLY 4 package. Simulations show that irradiation changes the character of Na^- and Cl^- interaction already at T=310 K when without irradiation such changes are observed only at T=315 K (critical temperature for the human body). Hence, it can be seen from our results that irradiation shifts the critical body temperature toward lower values. Otherwise it means the appearance of some “effective” temperature in the non-equilibrium system different from the real one. There also observed some structural changes. Among them is the formation of ordered structure around Cl- that leads to formation of third and forth hydration shells.

ASSESSMENT OF RADIATION EXPOSURE OF NUCLEAR MEDICINE STAFF

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Introduction: The nuclear medicine staffs are exposed to radiations emitted from different radionuclides like 131I and 99mTc associated with each nuclear medicine procedure. According to the Radiation Ordinance, an effective dose limit of 20 mSv each year has been laid down for persons employed in radiation work. The aim of this work was to analyze the historic records of the external radiation doses to staff members working in our nuclear medicine department for the past three years(2011-2013). Film badge dosimeters were used until 2011, and then replaced by thermoluminescent dosimeters (TLD). Materials and methods: Radiation doses to 2 nuclear medicine physicians, 2 NM technicians, 1 radio-pharmacist, 1 medical physicist and 1 auxiliary personnel were monitored using TLD. These dosimeters war worn by the staff members at the level of the chest on the front part of the body. As a summary we have measured radiation exposure of 7 people every day during the mention period in our nuclear medicine department in 7 procedures, including elution of 99mTc from 99mMo/99mTc generators, syringe preparation, radio pharmacy kit preparation, injection, accompanying patients, SPECT/CT scan, oral 131I preparation. Results: After correction of natural background dose the mean annual radiation dose was evaluated: to the physicians, (1.24 ± 3,26mSv), NM technicians (0.12 ± 0.70mSv), radio-pharmacist (1.75 ± 3,05mSv), medical physicist (0.20 ± 0,84mSv) and auxiliary personnel (0.20 ± 1,53mSv) respectively. Conclusion: The results from this study showed that annual effective radiation doses to nuclear medicine department staff members were within permissible levels.

PET/CT IN NSCLC WITH BRAIN METASTASES

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PET/CT is a method for diagnosis, staging and evaluating the effect of lung cancer treatment. The lung cancer is one of the cancers with most frequent localization of the metastases in brain. Materials and Methods: We have studied with 18 FDG-PET/CT 42 patients, 24 male (57.1%) and 18 female (42.9%) between 41 to 71 years of age, diagnosed with non-small cell lung cancer (NSCLC) and brain metastases by 63 examinations. Examinations have been executed on integrated apparatus Phillips Gemini TF (2009). 18FDG has been applied by i.v. injection with activity 0.14mCi/kg. Patients are staged by TNM classification. Survival has been evaluated by Kaplan-Meier method, for comparison of studied groups the log rank (Mantel-Cox) has been applied. Results: Multiple metastases in brain have been detected in 7 patients (16.7%). Hypo-metabolic have been found in 7 patients (16.7%), with hyper-metabolic - 8 (19%), with ring-like - 7 (16.7%). In patients with metastases operated on, in the area of the operative intervention a hypo-metabolic zone has been found. New metastases have been found in 3 patients after operation. The median of survival of the patients with NSCLC in months for stage II and III has been estimated to 25.2 months and for stage IV to 12.9 months and total survival to 16,8 months (P=0.03).Conclusion: Survival of the patients with NSCLC with brain metastases is significantly dependent on the clinical stage. The median of survival in patients to III stage is double times longer than the median of survival of patients in IV stage. The median of total survival is estimated to 16.8 months. Most common histological form of the lung cancer in case of metastases in brain is adenocarcinoma. The established by PET/CT lesions in asymptomatic patients change the staging and in some cases therapeutic management.

Keywords: lung carcinoma, NSCLC, brain metastasis, PET/CT.

NEW RESULTS ON THE MEDICAL RADIOISOTOPE ^{211}At PRODUCED USING THE ALPHA PARTICLE BEAM

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The ^{211}At is an alpha particle emitter, a radionuclide with high potential for the use in Targeted Alpha Therapy (TAT) in treatment of small tumors and metastases. Alpha particles, thanks to their large linear energy transfer (LET α ~100 keV/μm) are very well suited for double-strand breaking of malignant cells. Their range in tissue is of ~ 40-100 μm which corresponds to the dimension of few cells.

The activities of ^{211}At were produced using the internal He^+ beam of the U-200P cyclotron at the Heavy Ion Laboratory of the University of Warsaw via the ^{209}Bi(α,2n)^{211}At reaction. A thick bismuth layer (100 μm) was deposited on the aluminium backing and wrapped in the aluminium foil (20 μm) in order to retain bismuth that can possibly evaporate during irradiation. The beam current was monitored every time by the 10 μm copper foil irradiation. Target sandwiches were irradiated with a perpendicular beam of He^+ with the energy of about 32 MeV and the intensity of 200-600 nA. The beam current limitation is due to the temporary lack of efficient cooling system of adopted internal target station The bombarding energy was determined by measuring the ratio of the ^{210}At/^{211}At radioisotope activities. When necessary, the aluminum foils were used in order to decrease the beam energy.

The main goals of our work were the measurements and calculations of experimental and theoretical thick target production (TTY) and saturation (SY) yields. In this work we discuss the relatively large discrepancies of TTY and SY values published in literature in comparison to our results.

RENAISSANCE OF THE BORON NEUTRON CAPTURE THERAPY, BNCT

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Boron Neutron Capture Therapy (BNCT) is a radiation therapy for cancer that uses epithermal neutron beam. The potential applications of BNCT are impressive: tumours of complex shapes, cancer in multiple forms, recurrent cancer.

The basic principles of the treatment were proposed many years ago. Several epithermal neutron beams have been constructed at various locations: at Massachusetts Institute of Technology MIT (USA), Brookhaven National Laboratory BNL (USA), Petten (the Netherlands), Helsinki University of Technology (Finland), Studsvik (Sweden), Nuclear Research Institute Rež (Czech Republic), Tokaimura and Kumatori (Japan) and Bariloche (Argentina). All these conventional BNCT systems involves an research nuclear reactors to produce neutrons what excludes those installation out of the hospital systems . For medical application such facilities should offer an ease of access, good maintenance, and high performance. The main problem for BNCT was obtaining and optimizing an epithermal neutron source not in the reactor.

New generation of BNCT facilities uses an accelerator instead of a nuclear reactor, which has made it possible to produce neutrons within hospitals. Some prototypes of such equipment were constructed in various institutions all around the world but always production of neutrons was not satisfactory for BNCT (to low fluxes – one order of magnitude lower i.e. at the level of 108 neutrons per second per square centimeter). Currently new prototype of facility is being tested in Japan (adequate for BNCT i.e. 2x109 n cm-2 s-1). BNCT got recently status of renaissance around the world after informing worldwide by Japanese University that neutron generator for BNCT, which could be installed in hospitals, will be commercially available in 2016. The government of Japan is eager to sell this new technology overseas as part of its economic growth strategy.

At present, there are three BNCT facilities treating patients (two in Japan and one on Taiwan in China). Two other facilities are expected to start treating patients in 2015 (Japan, Argentina). Several facilities are performing biological experiments. There is no regular BNCT facility in Europe at the moment.

It is planned to build unique European BNCT research station for preparation in all associated sciences even preclinical trials for further clinical studies based on neutron generator. The station is planned to be situated at Polish MARIA research reactor at National Centre for Nuclear Research in świerk, where BNCT research and beam construction projects were restarted in 2012. It would give the possibility to research, develop and train every area concerning BNCT. In BNCT procedure, several medical devices are required for BNCT treatment such as treatment planning system, patient positioning device and radiation monitors. There is necessity to train physicists knowledgeable about neutrons and accelerators to participate in the research, as well as health-care professionals.

EFFECT OF QUALITY REFERENCE MAS ON IMAGE QUALITY AND RADIATION DOSE IN PEDIATRIC COMPUTED TOMOGRAPHY EXAMINATIONS

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Introduction: There has been an increase in the use of computed tomography (CT) imaging in the recent past, contributing more than 40% of the radiation dose from all X-ray procedures. The higher radio-sensitivity of pediatric patients puts them at greater risk of developing radiation induced cancer. More attention is required in establishing dose reduction strategies and it needs to be continuously explored. With the introduction of multislice-CT (MSCT), the traditional exposure factors, such as tube-current-time product (mAs), have modified meanings. The Quality Reference mAS (QRmAs) is used as an indicator of image quality when image acquisition parameters are set on 128-slice Siemens Definition Flash CT scanners. This study was conducted to assess the effect of QRmAs on contrast-to-noise ratio (CNR), and patient dose in pediatric CT imaging, using pediatric phantoms. Methods: The ATOM dose verification phantoms (Models 704 & 706) from Computerized Imaging Reference System (CIRS Inc., USA) representing 1-year old and 10-year old patients were scanned on a 128-slice Siemens Definition Flash CT (Siemens Medical Systems, Germany) scanner. The 1-year old phantom was scanned at 80 kV and QRmAs values between 200 & 350. The 10-year old phantom was scanned at 80 kV and QRmAs of 200 to 350 and at 100 kV and QRmAs between 120 and 300. In all 3 protocols, seven different QRmAs values were used, while all other parameters remained unchanged. The volume CT Dose Index (CTDIv) for each acquisition was recorded from the CT scanner's on-screen data display. The contrast-to-noise ratio (CNR) for bone vs soft tissue and soft tissue vs lung were measured. Statistically significant difference in CNR for various QRmAs settings was tested using 1-way analysis of variance (ANOVA) at $p < 0.05$ level. Results: The CNR values decreased as the QR mAs was reduced in all 3 protocols and the reductions were statistically significant ($p<0.006$) in both regions. The CNR values reduced from 49 ± 4 to 40 ± 2 for the 1-year old phantom and from 40 ± 2 and 32 ± 1 for the 10-year old phantom at 80 kVp as the QRmAs was reduced from 350 to 200. When the QRmAs was reduced from 300 to 120 at 100 kVp, the CNR decreased from 53 ± 2 to 40 ± 2 for the 10-year old phantom. The CTDIv varied from 0.66 to 0.38 mGy, 1.23 to 0.70 mGy and 2.42 to 0.97 mGy for the 1-year, 10-year at 80 kVp and 10-year at 100 kVp respectively. Post-hoc tests revealed no significant differences in CNR ($P >0.28$) when QRmAs was reduced by 20% from the scanner manufacturer's recommended values. Conclusion: As QRmAs is reduced, both CNR and CTDIv decreased. However, radiation dose reduction of the order of 20 % can be achieved by modifying manufacturer recommended acquisition parameters without significantly degrading image quality in pediatric CT examinations.

RADIOLOGICAL IMAGES AND PROGNOSIS OF PNEUMOCONIOSES IN FUNDAMENTAL INDUSTRIES IN BULGARIA

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The object of the study were lung X-ray findings and diseases of 480 quartz exposed miners from coal mining, and lead-zinc mining, 120 workers exposed to mixed asbestos/quartz containing dust (MAQCD), and control group of 28 non-exposed individuals. ILO International Classification of Radiographs of Pneumoconiosis (ILO'80) was used for x-ray reading and diagnostics. Methods: A cross sectional case control study of x-ray finds on chest radiographs was done. Information for dust exposure was collected. SPSS software was used. Results: P1/1 small round opacities were found amongst 8(40.0%) black, 6(30.0%) brown, 2(10.0%) anthracite coal miners, and 4(20.0%) workers exposed to MAQCD. P 0/1 were detected amongst 11(9.5%) brown coal miners, 24(21.1%) black, 10(18.9%) - anthracite coal miners, 34(27.9%) lead - zinc ore miners, and 8(7.5%) workers, exposed to MAQCD. P0/1 were found amongst 11(9.5%) brown, 24(21.1%) black, 10(18.9%) anthracite coal miners, and 34(27.9%) lead - zinc ore miners, and 8(7.5%) workers exposed to MAQCD. P 1/0 were detected amongst 9(7.8%) brown, 39(28.3%) black, 14(26.4%) anthracite coal miners, 40(32.0%) lead -zinc miners, and 12(11.2%) workers exposed to MAQCD. t0/1, t1/1, and t ½ irregular opacities were found amongst 10(8.6%) brown, 22(19.5%) black mining, 13(24.5%) anthracite coal mines, 3(2.4%) lead zinc miners, and 30(27.8%) MAQCD exposed workers. S2/1 - s3/3+ irregular opacities (asbestosis) were found amongst 12(11.1%) MAQCD exposed workers. t2/1-t3/3+ (asbestosis) were detected amongst 28(25.9%) MAQCD exposed workers. Pl (pleural fibrosis, plaques) was detected amongst 53(49.1%) MAQCD exposed workers, 27(22.0%) lead-zinc miners, 6(11.3%) anthracite, 9(7.8%) brown, and 8(7.1%) black coal miners (P <0.0001). Calcified pleural plaques (PLC) were detected amongst 10(83.3%) last workers exposed to MAQCD, and 2(1.8%) black coal miners. Pl and PlC were predominated amongst MAQCD exposed workers (P <0.0001).Conclusion: We found 1/1 initial silicosis amongst 16 miners, 4 1/1 mixed pneumoconioses due to MAQCD exposure in KZM, 43 asbestoses amongst workers in Steam power plant and brakes production. The average MAQCD exposure was 16 years with 17 year latent period. The asbestos pleural fibrosis and calcified plaques were predominated. The high dust levels in the mines, the levels of MAQCD, the dose/effect studies information, and the dynamics of pneumoconiosis diseases allowed us to prognosticate the development of silicosis, asbestosis and asbestos pleural diseases in future 10-15-20 years.

THERAPEUTIC USE OF X-IRRADIATION DURING THE 1950S AND ITS DELAYED HEALTH CONSEQUENCES: TC COHORT IN THE MAKING

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Large scale outbreak of Tinea Capitis (TC, ringworm) occurred in Former Yugoslavia (FY) during 1950s. TC is relatively benign fungal disease most commonly affecting children of school ages, where low sanitation and hygiene act as precipitating factors especially in collectives. Only westernmost FY member states (Slovenia and Croatia) were to some degree spared from the outbreak. Epidemic proportions were unprecedented, forcing the former Yugoslavia health authorities to initiate a nationwide eradication campaign. Application for assistance was also made to the UNICEF, which provided significant financial and logistic support. The campaign took place from 1950-1960 and encompassed field screening of almost 2 million individuals, while treatment was provided to at least 100,000.

Until discovery of Griseofulvin in 1960, the only TC treatment available was based on X-ray induced scalp hair removal, followed by the topical application of anti mycotic remedies. Irradiation doses applied were standardized through Kienbock-Adamson protocol, while the whole procedure was considered fully safe and represented international standard of care.

Many years later, however, it was demonstrated that this type of exposure to X-rays can lead to serious delayed health consequences, occurring many years or indeed decades after the treatment. Mean latency period is nowadays established to be as long as 35 years, while main risk relates to increased incidence of both benign and malignant neoplasms in the head and neck regions.

Present research first started in 2005. Together with our colleagues from Israel we were able to confirm all historical and public health aspects of the campaign in Serbia, where at least 50,000 children had received the TC treatment. These persons are now in their 60s and 70s, since greatest majority of them were aged 4-15 years at the time of campaign. Finally, our archive search rewarded us with discovery of hospital protocols from Belgrade Mycosis Hospital (BMH), largest of the four specialized TC institutions established exclusively for this purpose in Serbia. This material contained personal details for some 25,000 patients treated in Belgrade.

Serbian Ministry of Health sponsored transcription of the BMH records into electronic format in 2012. This represented the first step in our efforts to put in place a cohort of as many former TC patients as possible. In order to achieve this goal it was necessary to confirm their identity through various public sources, and later on gain access to their vital and morbidity status.

In 2012 an international consortium was formed, lodging an application for joint research to the FP7 Framework. The research was envisaged to first assist in putting together the Serbian TC cohort, and later on focus on studying effects of X-irradiation to determine the contribution of the non-coding genome to susceptibility at low doses.

At present, we processed almost 14,000 former TC patients as a part of initial stages of cohort recruitment. This will be followed by selection of controls, both from the general population and amongst the unexposed siblings. We expect that eventually there will be as many as 18,000 former TC patients, a minimum of 1,000 general controls, and several thousand of unexposed siblings in the cohort. We also believe that this cohort could represent a valuable source of information for the wider scientific community.

THE VALUE OF DUAL / WASH ^{99M}TC-MIBI PARATHYROID SCINTIGRAPHY AND THE UTILITY OF ULTRASOUND IN PREOPERATIVE LOCALISATION OF ABNORMAL PARATHYROID GLANDS IN PATIENTS WITH PRIMARY HYPERPARATHYROIDISMUS

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Background and objectives: Accurate preoperative localization of the hyperfunctional parathyroid glands is essential for surgical success in patients with primary hyperparatyroidismus. In contrast with bilateral neck exploration, an accurate preoperative imaging, which is mainly based on ^{99m}-Tc MIBI parathyroid scintigraphy is mandatory when planning minimally invasive parathyroid surgery. Aim of this study was to evaluate the value and diagnostic accuracy of dual – wash ^{99m}-Tc MIBI parathyroid scintigraphy and added value of ultrasound for preoperative localization of hyperfunctional/enlarged parathyroid glands in group of patients with primary hyperpyrathyreoidismus (pHPT).

Methods: 31 consecutive patients with biochemical diagnosis of pHPT who underwent minimally invasive parathyroid surgery was enrolled in the study. All patients were referred for high resolution ultrasound and preoperative dual –wash ^{99m}Tc-MIBI parathyroid scintigraphy, preoperatively. Early and late planar and SPECT imaging of neck and mediastinum were taken 20' and 120' after i.v. application of 740 MBq ^{99m}Tc- MIBI. Scintigraphic and ultrasound findings were compared with pathohistological analysis.

Results: MIBI scan was true positive in 30/31 patients (96%). SPECT scintigrams had added value in 3 patients (10%). Pathohistological findings after minimally invasive parathyroid surgery were: 21/31 patients (68%) had solitary parathyroid adenoma, 9/31 patients (29%) had nodular parathyroid hyperplasia, and 1/31 patient was false positive (hyperfunctional thyroid tissue). Sensitivity, specificity, positive and negative predictive value of ultrasound was 58%, 100%, 100% and 8 % in this group of patients.

Conclusion: Dual - wash ^{99m}Tc-MIBI parathyroid scintigraphy is very sensitive and accurate diagnostic method for detection of hyperfunctional parathyroid glands in patients with pHPT and should be used as the first imaging method in this group of patients. The ultrasound is less sensitive, but very specific tool for localization of enlarged parathyroid glands in pHPT. The combination of MIBI scan and ultrasound has significant diagnostic value in selecting patients with pHPT who would be suitable for unilateral neck exploration.

THE PATIENT DOSE ESTIMATION FROM MEDICAL EXPOSURE FOR THE PERIOD 2010-2013

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In order to reduce the risk associated with diagnostic medical exposure by optimizing the quality of radiological imaging, a nation-wide evaluation concerning the monitoring of the patient radiation protection in diagnostic radiology and interventional radiology was initiated in 2006, but functional since 2009.

All providers of radiology and medical imaging examinations have to record patient data and relevant information for assessment of doses received by patients from medical exposures to ionizing radiation. Ministry of Health through the National Institute of Public Health centralizes the data of medical exposure to ionizing radiation reported by providers of radiology and medical imaging examinations and elaborates an annual report. The forms for reporting the centralized data contain the exam type, procedure code, total number per exam type and its distributions on age groups and gender groups. Dose information is available in terms of DAP-meter values or entrance surface dose for conventional X-ray procedures and DLP indication for CT procedures. For estimation, we assume that, in one year, the total number of reported procedures per number of reporting units is proportional with the total number of estimated procedures per total number of units in the whole country.

In the actual study, the frequency of X-ray examinations for 2010-2013 years (including the conventional radiology, interventional radiology, computed tomography and dental radiology) and mean effective dose per procedure were estimated. Summary of the mean effective dose (mSv) for X-ray procedure types performed at the national level for Top 20 (defined by RP 154) and for all X-ray based radiology is presented in Table 1.

Table 1. The mean effective dose (mSv) for X-ray procedures performed in 2010-2013 years

Main results	Mean effective dose (mSv) in 2010	Mean effective dose (mSv) in 2011	Mean effective dose (mSv) in 2012	Mean effective dose (mSv) in 2013
Plain radiography Top 20	0.33	0.56	0.23	0.29
Fluoroscopy Top 20	9.60	5.23	1.72	1.83
Cardiac angiography	4.83	8.11	6.91	11.02
CT Examinations Top 20	3.20	8.41	9.72	7.66
All Angiography and Interventional radiology	3.00	7.42	9.97	11.46
SUM all X-ray based radiology ex. Dental	0.49	1.16	0.95	1.10
Dental	0.28	0.09	0.02	0.03
SUM all X-ray based radiology	0.46	1.04	0.83	0.95

For some X-ray procedure types, we remark significant differences between 2010-2013 years, concerning the mean effective doze per modality, without important changes in radiological practices in the period 2010-2013. We suspect that the data regarding the patient doses were incomplete and/or incorrectly registered and reported from different causes (for example: insufficient number and qualification for medical physicists, bad understanding of radiation protection rules by the medical staff). Taking into account the new Council Directive 2013/59/EURATOM provisions concerning the medical exposure, it is very important to find the best modalities for improvement of patient dose registering and reporting system.

COMPARISON OF THE DOSIMETRIC ACCURACY OF INTENSITY MODULATED RADIATION THERAPY PLANS WITH DIFFERENT DOSIMETRIC SYSTEMS

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Intensity modulated radiation therapy (IMRT) is a technique of the 3D conformal radiation therapy. In this method, irradiated fields can be separated in to many subfields which are called segments. Each segments' radiation doses can be adjusted. IMRT plans have complex segments and lots of high gradient dose regions. Therefore, quality assurance of IMRT plans is very important. The aim of this study is performing quality assurance (QA) tests of IMRT plans by using different dosimetric systems and comparisons of results. Twenty patients IMRT plans' QA were tested with using ionization chamber (IC), 2D Array, Gafchromic EBT 2 film and Electronic Portal Imaging Device (EPID). Gamma analysis method was used for dosimetric comparison of the two dimensional detector systems. Based on our comparison, we think that, ionization chamber is insufficient for QA of the IMRT plans. IC can measure only one point dose. It has inadequate spatial resolution. In terms of reproducibility and reliability 2D Array is the successful dosimetric system. Before every QA, 2D Array must be calibrated. This system needs electrometer, cables and computer so it is not practical. We saw that, gafchromic EBT2 films results did not pass the gamma analysis around the end of the fields. After all film analysis, we obtain that Gafchromic EBT2 film's dose response is not good for low dose region. EPID is the detector array device which attached the LINAC with mechanical arm. This device does not need any extra systems or cables. EPID has amorphous silicon detectors. Therefore, one time calibration and monthly control is enough. After examination of the obtained results, we saw that EPID is the successful dosimetric system for high and low dose region. In terms of reproducibility and reliability EPID is well done and its time saving system for clinics which have high workload.

IS RADON PROGENY DEPOSITION ON THE SKIN IMPORTANT IN RADON THERAPY?

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For Radon therapy the therapeutic effects are mainly attributed to radon and radon progeny inhalation. However, the importance of radon progeny (Rnp) deposition on the skin is increasingly recognized. In either form of therapy, exposure to a radon atmosphere and exposure to radon in thermal water, Rnp deposit on the skin of patients. Deposition is controlled by the physical conditions of the exposure situation and will lead to different Rnp activities on the skin relevant for dosimetry. For exposure to a radon atmosphere, together with disequilibrium of Rnp with radon gas and aerosol size distribution, the Rnp concentration on the skin decreases as ^{218}Po > ^{214}Pb > ^{214}Bi/^{214}Po. In contrast to a radon atmosphere Rnp in thermal water are in equilibrium; According to the experimental findings they adsorb on the skin and desorb again after the next decay in the decay chain. This behaviour results in Rnp activity ratios equal to the ratios of their half-lives. In any situation, Rnp deposited on the skin will remain on the skin and partly penetrate into deeper skin layers where emitted a particles may hit biologically relevant Langerhans cells.

Elaborate experiments of Rnp deposition in both exposure situations, radon atmosphere and thermal water treatment, have found considerable activity concentrations. Even in the exposure situation of a radon atmosphere the Rnp deposition on the skin outnumbers Rnp deposition in the lung at least by one order of magnitude. Due to the penetration into deeper skin layers part of the alpha energy deposited in the epidermis may reach the Langerhans cells, which are considered crucial for the immune response.

DEVELOPMENT OF THE *IN-VIVO* DOSIMETRY FOR BRACHYTHERAPY BASED ON DIAMOND AND RADFET DETECTORS

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A project on development of in-vivo dosimetry during brachytherapy will be presented. The project aims for development of array of dosimeters composed of single crystalline diamond and RADFET detectors which can be inserted in the brachytherapy catheters and subsequently used during the therapy for two purposes: on-line verification of dose rate and received dose and localization of the treatment source. We will present the initial detector studies with source measurements and GEANT4 simulations of the phantom. A newly developed compact readout system that can on-line monitor up to 16 (Krambi popravi) sensors mounted on a thin flexible hybrid circuit of small dimensions will also be presented.

THE EFFECT OF RADIOTHERAPY OF MALIGNANT TUMORS OF THE ORAL CAVITY ON THE TISSUE OF THE STOMATOGNATHIC SYSTEM

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Radiation therapy causes changes in the cell mitosis and ultrastructural cell elements, and has an impact on the function and life of cells. Neoplastic cells reproduce faster than normal tissue cells and that is used for their selective destruction, but at the same time normal tissue cells can often suffer too. Dental complications caused by radiotherapy are local and are related solely to the radiation region within the stomatognathic system. Depending on the time when complications appear, they can be early and late. The occurrence of complications and their symptomatology depend of organs which have been treated, the treated volume and the dose of received radiation. The cells of the hematopoietic system, epithelial and endothelial cells show particular sensitivity to the effects of radiotherapy. In the area of the oral cavity the vascular changes that cause disorders of oral mucosa, salivary glands, teeth and bone tissue are the most striking. The paper describes in detail possible complications of radiotherapy ranging from mild to the most difficult that occur after application of high doses of radiation. However, the complications have to be accepted as a risk in the treatment of malignant tumors of the oral cavity and can be minimized by a careful radiotherapeutic approach.

RESPIRATORY MOTION IMPACT ON LIVER TUMOR TARGET VOLUME DEFINITION IN RADIATION THERAPY

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The purpose of this study was to explore the liver tumor movement depending on the patient's respiratory and liver segment, in which the tumor is located. This objective was put to task to compare the liver tumor target volume, obtained by CT and MRI, and determine the tumor position changes depending on liver segment.

Free breathing Four-dimensional CT (4DCT) based planning and pre-treatment MRI were performed for 35 patients with 44 malignant lesions. The Clinical Target Volume (CTV), and the Internal Target Volume (ITV) were contoured on the basis of the MRI co-registered with Maximum Intensity Projection (MIP) CT study. It was determined in tumor volume increase due to respiratory movement and position changes in the amplitude differences of liver segments and hilus of the liver.

Each segment of the existing CTV deflection amplitude average value of LR, AP, CC directions on MRI: 1S – 9,6; 10,4; 8,9mm, 2S – 15,6; 11,6; 1,3mm, 3S – 9,6; 10,2; 9,3mm, 4S – 13,6;10,9;5,0mm, 5S - 6,5; 8,1; 10,8mm, 6S – 6,8; 6,9; 10,9mm; 7S – 8,1; 8,3; 11,8mm, 8S – 9,4; 11,0; 10,6mm, hilus of the liver 17,4; 11,4; 22,2mm. CTV/ITV average value: 1S – 3,7/13,6cm3, 2S – 10,5/30,8cm3 , 3S – 5,9/22,8cm3 , 4S – 6,3/29,3cm3 , 5S – 12,2/27,2cm3 , 6S – 6,8/16,8cm3 , 7S – 9,3/19,9cm3 , 8S – 6,4/35,2cm3 , hilus of the liver - 4,8/28,6cm3 . The mean reduction of CTV and ITV volumes, achieved by use of MRI, was 25%.

It is very important to define precisely the ITV before radiation therapy, which includes all liver tumor position changes during breathing.

OPTIMIZATION OF RADIOTHERAPEUTIC TREATMENT AND THE PROGRAM OF QUALITY ASSURANCE IN IONIZING RADIATION THERAPY

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Background. The Program of Quality Assurance (PQA) in Ionizing Radiation Therapy (IRT) addresses the most important problems of assuring the quality of IRT utilization in the treatment of patients with neoplasm. In this context, the IRT value grows considerably, hence the implementation of PQA is of great significance. The study concentrates on a detailed description of the PQA as concerns the activity involving IRT devices applied in the IRT departments (rooms) of public medical/sanitary institutions, science research institutions etc., where IRT is employed using technogenic sources and ionizing radiation generators.

Material and methods. For the performing of the study, annual statistics reports about the activity of the IRT, and data of Cancer Registry of the Oncology Institute of the Republic of Moldova were analyzed. The work also includes an in-depth description of the personnel categories involved in PQA, possible errors in radiotherapy, the responsibilities of the bioengineer in this program, importance of source calibration, the impact of the quality control in PQA, the role of topometric training, the interaction between the medical and technical personnel and the patient.

Conclusions. Optimization of IRT is very important and necessary in the Republic of Moldova. PQA incontestable contributes to reducing specialist's errors in planning correct treatment, dictates the need of team work and proper delegation of the responsibilities in co-optation of other professionals, performance of duty of Bioengineering, the influence of quality control of profile installations, meaning accurate topographic planning, applying several methods of work, quality assurance program assuming the major importance.

Key words: Quality assurance program, Ionizing Radiation Therapy, Cancer treatment

NEW DEVICES TO DETERMINE FIELD AND DOSIMETRIC QUANTITIES IN RADIOTHERAPY

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New solid-state based detectors, characterized by high sensitivity, small dimension, simple readout, low-cost and good rejection of unwanted radiation components, have been applied to determine field and dosimetric quantities in radiotherapy with high-Energy linacs. Typical applications to neutron and photon measurements are described in this work, showing technical potentialities and applicability of the new devices.

IN-VIVO AND *EX-VIVO* ELEMENTAL ANALYSIS OF COMPLEX BIOLOGICAL SAMPLES

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The measurement of elemental content in complex samples, while leaving those samples entirely intact, presents particular challenges. The sample could be a unique work of art, an archeological artifact, a tooth or a human subject. In the present contexts of clinical research of novel nanoparticle based therapies determination of trace levels of gold nanoparticles presents a challenge for the advancement of this promising novel cancer therapy.

This presentation is focused on the use of energy dispersive x-ray florescence and the particular challenges presented by complex biological samples. Calcified tissues measurements, in vivo and ex vivo, have become widely appreciated alternative analytical methods to measure accumulation of elements in human tissues. Constraints imposed by this rather unusual form of analysis, together with a brief description indicating the range of elements for which such analyses have been established in our laboratory will be presented. Measurements of three elements is then presented in more detail.

In vivo bone strontium, although presently not in widespread use, offers the potential for essential information in the study of the reported benefits of strontium based medication for the treatment of osteoporosis. Similarly tooth ex vivo X-ray fluorescence measurement of many elements, such as manganese and iron, could provide more insights in assessing cognitive and behavioral function in adolescents with environmental exposure.

To conclude, our current work on the total reflection X-ray fluorescence based method for the in situ low-level quantification of gold, in the form of gold nanoparticle, in human cell cultures and tissues, will be included.

ORAL MUCOSITIS - PREVENTION AND TREATMENT OF PATIENTS WITH ANTINEOPLASTIC THERAPY

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Patients at the radiation and chemotherapy often come to the appearance of oral mucositis. Antineoplastic therapy in head and neck area damae healthy cells division of oral epithelium, connective tissue cells and bone cells due to cytotoxic effects of radiation. Changes in the oral cavity, recognised as oral mucositis begin on the third day, a maximum reach of the twelfth to the fourteenth day of radiation therapy and chemotherapy. Tissue changes are the result of free radicals that change the genetic material of cells, forming mitotic cells were incompetent or cause cell death. Keratinization disorder occurs, epithelial atrophy, atrophy and degeneration of collagen fibers, vascular changes, ulceration and necrosis. There is dryness of the mouth, frequent identification of fungi, especially Candida species and Gram-negative bacteria of the genus Enterobacteriaceae. Prevention and treatment of oral mucositis is a major challenge for oncologists and dentists. The most important dentist aim is to fix the all changes in oral cavity before cytostatic, and especially before radiation therapy to the head and neck. It involves the extraction of residual roots, repair carious teeth and periodontal treatment. In the oral mucositis treatment it is recommended the habits of ideal oral hygiene, drugs which are coated and protect the mucous membranes of the mouth, acting analgesic, anesthetic and accelerating the healing of ulcers, as well as proper nutrition these patients. Permanent control and operation in terms re-motivation of these patients will facilitate oral complaints of these patients and allow them to receive the necessary oncologic therapy.

EFFECTIVENESS OF EPITHERMAL NEUTRON BEAM AND GAMMA RADIATION SHIELDING FOR BORON NEUTRON CAPTURE THERAPY

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The biological effects of different boron compounds in the Boron neutron capture therapy (BNCT) research are usually tested on small animals. In case of LVR-15 research reactor (Rez, Czech Republic), the biological effect is studied on 6-days old sewer rats. Regrettably, irradiated rats died a very short time after the end of irradiation, probably as a result of high radiation dose which was received by a whole body. Therefore, special protective casks were designed to reduce unnecessary radiation (mainly from gamma and neutrons). These protective cylinders protect the body of a rat while leave its head unshielded. Two construction materials were considered – boron (in the form of boron carbide) and cadmium. This contribution tries to find the more suitable material by measuring the radiation dose from its individual component. Effectiveness of the neutron and gamma shielding was monitored by activation foils and thermo luminescent detectors. As a result of measurement, boron carbide was found to be a better choice due to its ability to absorb neutrons without production of high energy gamma radiation.

DENTAL PATIENT PREPARING FOR RADIOTHERAPY OF MALIGNANT TUMORS OF THE FACE, JAW AND NECK

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Patients will be conducted radiation therapy of malignant tumors of the face, jaw and neck carry some risk and every dentist should be aware of the possible complications that radiotherapy could caused. Therefore, patients who are preparing for radiotherapy require special dental treatment. It involves healing inflammatory changes in the oral cavity, remove soft and hard deposits from teeth, repair of all carious teeth, as well as the extraction of gangrenous teeth and residual roots. Special attention is paid to the extraction of teeth. Extraction is safest to perform 2 - 3 weeks before the start of radiotherapy in order to the soft tissue completely healed. Extraction of teeth during and immediately after radiotherapy is risky because of the difficulty in wound healing conditioned by radiation and possible occurrence radioosteonecrosis and radioosteomjelitis. In these cases it is necessary using of antibiotics and continuous monitoring of patients. At present of wounds which are no healing or progressive radioosteonecrosis is necessary to perform a surgical resection of the affected soft tissues and bone, which in combination with hyperbaric oxygen gives good results.

ASSESSMENT OF PROTON AND NEUTRON ABSORBED DOSES IN PROTON THERAPY OF DEEP AND SEMI-DEEP TUMORS INSIDE THE LIVER USING MONTE CARLO METHOD

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Introduction: Liver cancer is the third leading cause of cancer death in the world. The Bragg Peak effect and short range of proton are the advantages of proton therapy over other forms of radiation therapy. In this study, proton beam energies were considered 180 and 250 MeV. These energies typically used to treat the liver tumors. When the protons move through the body, interact with the atoms of tissues and produce secondary particles such as neutron. The purpose of this research is, assessment of proton and neutron absorbed doses in tumoral and healthy tissue of liver in proton therapy of deep and semi-deep tumors.

Material and methods: In this research, passive proton beam delivery system made by Hitachi company was simulated by MCNPX2.6. This simulation consists of 8 steps of range modulation wheel (RMW), contoured scatterer, range shifter and collimators. Also, MIRD phantom was used to simulate the patient's body. For this purpose a tumor with diameter of 5 cm was designed and placed in the depth of 11 cm inside the liver. The proton source was modeled as a Gaussian distribution function with a mean energy of 200 MeV. So, the appropriate range shifter was assigned and proton absorbed doses per source particle for tumor and healthy tissue of the liver were estimated. To investigate the influence of secondary radiations, neutron equivalent absorbed doses per source particle were also calculated. In the next step, a tumor with diameter of 5 cm in the depth of 6 cm was considered. So proton and neutron absorbed doses per source particle for tumor and liver were calculated by simulation of proton therapy system with mean energy of 180 MeV. These simulations were run with as many as 107 source protons. Results: In this research, proton and neutron absorbed doses in tumor and liver were calculated by substitution of appropriate range shifter and simulation of each steps of the RMW. In deep tumor proton therapy simulation, proton absorbed doses in tumor and healthy tissue of the liver was calculated as 3.32×10-12 and 4.57×10-13Gy/par respectively. Neutron equivalent absorbed doses were also calculated as 3.37×10-14 and 1.85×10-14Sv/par. For semi deep tumor, proton absorbed doses in tumor and liver were calculated as 1.94×10-12 and 2.04×10-13 Gy/par. Also neutron equivalent absorbed doses were computed as 1.61×10-14 and 6.34×10-15 Sv/par respectively.

Conclusion: For the semi-deep tumor the ratio of proton absorbed dose in tumor and healthy tissue of the liver is 9 and this ratio is 7.26 for the deep tumor too. Also the ratio of neutron equivalent absorbed doses in tumors and liver is almost 2.The results showed that tumor absorbs the maximum dose while the healthy tissue absorbs the minimum dose. Since the absorbed dose in healthy tissue increases the risk of secondary cancer affection, the consideration of methods to decrease the dose is very important in liver proton therapy.

THYMUS GLAND AND RADIATION IN PEDIATRIC X-RAY DIAGNOSIS OF RESPIRATORY DISEASES

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The thymus gland is located anatomically in the anterior superior mediastinum, between the two lungs, in front of the heart and behind the sternum. The thymus is a specialized organ of the immune system. It is highly variable in size and appearance and increases in size from birth to puberty, but the child grows more, so the thymus appears smaller in older children. It is well known from literature data that as a consequence of radiotherapy the thymus decreases in size however the effect of doses applied in diagnostic is not described.

After many years of experience in x-ray diagnostics with children, we have noticed that there is a peculiar process possibly taking place. Namely, it seems that a fairly regular thymus size reduction exists at children after exposure to low dose chest x-ray irradiation.

The radiograms of 119 children in the age of 0-5 years were analysed. All these patients were exposed to two X-ray examinations in the period of Sept 1, 2013- August 31, 2014 according to medical indication in Children Hospital Srebrnjak, Zagreb. Each examination contains posteroanterior (PA) and profile position. Worthy of note that in this period all together 3093 children were examined in this hospital, 1972 of them were in the investigated age group, however only 119 were exposed to double radiograms.

50% of the investigated patients (59) showed enlarged thymus at the first exam. It could be seen from the control radiogram that 19 children had significantly smaller thymus while in case of 33 patients the decrease of thymus size was discrete. Radiological report of 6 patients did not show any change in size of thymus while in 1 patient inversion was found.

Taking into account that thymus has very important role in maturity of T-lymphocytes and development of immunology tolerance these empiric statements are important for radiation protection of children in X-ray diagnostic of chest.

MODIFICATION RADIATION EFFECTS BY WATER WITH THE REDUCED CONTENT OF DEUTERIUM AND HEAVY ISOTOPES OF OXYGEN

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That long-term consumption of water with a low content of deuterium and heavy isotopes oxygen accelerates the rise of mass mice. Phase fluctuations, reducing or increasing the hematological parameters, were the adaptive nature. These fluctuations do not extend beyond the physiological range of values for this species.

It is shown that support of rodents on deuterium depleted water (DDW) for 14 days before radiation exposure causes a decrease of the first cell cycle duration, which was increased by radiation, an increase in the mitotic index and the frequency of formation of aberrant mitosis 24 hours after ^{60}Co gamma irradiation in doses of 1, 2, and 4 Gr. Discussed radiomodifying properties of DDW it should be noted: increase output after irradiation of bone marrow cells with aberrant mitoses on a background of increased proliferative activity of the bone marrow.

It is established that the therapeutic use of DDW with 35 - 90 ppm (deuterium) increases survival of irradiated mice to 40 and 55.5 %. Body weight saving. Treatment of acute radiation sickness stimulates hematopoietic recovery.

DIAMOND DETECTORS FOR THE RADIATION QUALITY ASSESSMENT OF THERAPEUTIC ION-BEAMS

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In radiation therapy the effects produced by the ions on tumor and healthy cells change constantly after entering the body of the patients; for a fixed dose of protons the biological effectiveness increases at the end of the path by 40%, while for carbon it increases by 300%. The outcome of the treatment depends on the assessment, in each geometrical point, of the biological effectiveness of the radiation, which can be evaluated using two physical parameters: dose and radiation quality. The radiation quality characterizes ionizing beams in terms of their energy spectra and particle types.

In the case of photon radiation therapy the biological effectiveness is independent of the radiation quality and therefore only the absorbed dose is used. The determination of the radiation quality is essential for ion-beam therapy and today this is done indirectly using semi-analytical models implemented in the treatment planning systems. Recently some studies focused on direct estimation of the radiation quality with devices specifically developed to be used in phantoms and, possibly, during the treatment.

Among others, single-crystal chemical-vapor-deposition (scCVD) diamond detectors have been proposed because of their unique characteristics of tissue equivalence, compactness, radiation hardness, and simple polarization.

The collaboration between the Austrian Institute of Technology, ENEA - Centro Ricerche Frascati, Rome Tor Vergata University, and EBG MedAustron developed the first prototype of diamond microdosimeters. Other collaborations have been set up with INFN project MITRA, Zurich ETH and Ruđer Bošković Institute in Zagreb to further investigate the characteristics of these microdosimeters and test them in different radiation fields.

The research is now focusing on specific aspects which concern the implementation of these devices in clinics which include the miniaturization of detectors, the estimation of detector aging due to dose and radiation quality, the study of specific electronic components for noise reduction, the possibility of detector clustering, the orientation of the detector toward the radiation beam, and biological and functional compatibility.

Results are presented on a series of Monte Carlo simulations and experimental data collected for different radiations (alpha particles, carbon ions, silicon ions, protons, and neutrons) and different geometrical sizes of the detector (thickness from 300 nm to 6 μm, and cross area from 40 μm2 to 5 mm2). In particular, a study on the emission of secondary electrons as result of the irradiation of primary ions in different conditions is presented. The relative contribution to the energy imparted by primary and secondary particles is described in correlation to thickness and cross area of the sensitive volume.

Original results are presented on signal degradation due to the accumulated dose from silicon and carbon ions with energies of few megaelectronvolts on a scCVD diamond of 450 nm of thickness.

RADIOTHERAPY UTILISATION RATE FOR CANCER IN LITHUANIA (2011-2012)

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Background. Future state radiotherapy infrastructure plans need different estimates including radiotherapy utilisation rate for different sites of cancer.

Materials and methods. The electronic questionnaire was sent to the all 4 radiotherapy centers in Lithuania: Vilnius, Kaunas, Siauliai and Klaipeda, in order to get treatment guidelines and quantities of patients different sites treated by prescribed radiotherapy methodology with primary or secondary intent.

Results. The response regarding 2011 and 2012 treatment results was analysed. The external beam radiotherapy was used for approximately 31.8% of new cancer cases in Lithuania. More frequently radiation therapy was applied treating breast and prostate carcinomas, 23.1% and 20.5% respectively.

Among all irradiated patients, brachytherapy was applied to 7.4% of the new cancer patients. In 2011 this method was used for treating malignant tumours of several locations, the most of them consisted of gynaecological (72%) and prostate (22%) tumours.

The more deep analysis should be presented during RAD2015.

The obtained results should be used calculating the demand of radiotherapy equipment and human resources for period till 2025.

HIGH-DOSE RATE (HDR) IR-192 BRACHYTHERAPY APPLICATION OF BASAL CELL CARCINOMA

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Objectives: High dose rate (HDR) surface (skin) brachytherapy uses Iridium-192 source and places it in close proximity to the target lesion using a remote afterloader and delivers it precisely on specified depth from specialized catheters or applicators that are applied to the target tissue. HDR brachytherapy performs direct radiation dose delivery to the surface with rapid falloff (inverse square law) thereby sparing deeper healthy tissues. The treatment is painless and noninvasive and may also result in less tissue destruction and scarring in sensitive facial areas such as the nose, ear, lip etc. Because of its localized effect and possible hypofractination, the overall treatment time is significantly less than external beam radiotherapy, with faster recovery times than invasive techniques.

Methods: Conformable custom moulds are often used for irregular surfaces like the ear or nose. In this case, custom mould was constructed from thermoplastic material. Treatment catheters were fixed to the material, providing a custom fit to the treatment target. A great care was taken to ensure that the catheters met the afterloader's minimum turn radius so that the source wire (Ir-192) could easily move through catheters. Treatment times were optimized in treatment planning system using Brachyvision software from Varian. A dose of 45 Gy in 15 fractions (5 times a week) was prescribed to a patient with basal cell carcinoma. Prescribed dose was delivered 7mm in depth. An additional lead eye plaque was placed under thermoplastic mask for radiation protection.

Results: The prescription dose of 45 Gy was completed in 15 fractions, five times a week. All lesions resolved with treatment and there have been no recurrences reported to date.

Conclusions: With excellent local control rates, cosmetic out-comes, and minimal long-term toxicities, HDR brachytherapy with surface applicators should be considered to be among the first options for treatment of basal-cell-carcinoma patients.

DOSIMETRIC VERIFICATION OF DIFFERENT 3D CONFORMAL RADIOTHERAPY (3D-CRT) TREATMENT PLANS BY USING TISSUE EQUIVALENT SOLID WATER PHANTOM AND ION CHAMBERS AT KYAMCH CANCER CENTER

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Quality Assurance (QA) in radiotherapy treatment planning process is essential to ensure that the dose calculation is performed correctly and to minimize the likelihood of accidental exposure External independent audits play an important role in quality assurance programme in radiation oncology facilities. An independent audit programme has been undertaken to review the whole chain of activities in 3D conformal radiotherapy (3D-CRT) workflow, from patient data acquisition to treatment planning and dose delivery. As a part of independent audit programme, this study was undertaken for dosimetry verification of treatment planning and delivery process at KYAMCH Cancer Center, Sirajgonj, Bangladesh. The audit was based on the IAEA recommendation. A solid water phantom was scanned with a computed tomography unit (CT) and treatment plans for different test cases involving various beam configurations suggested by the IAEA were prepared on different treatment planning systems (TPSs) such as PrecisePLAN, XiO, Ergo++ and Monaco at KYMCH Cancer Center. The phantom was irradiated following the treatment plans for these test cases and doses in specific points were measured with different ionization chambers coupled with electrometer. The differences between the measured and calculated doses were analyzed.

The measurements were conducted for different photon beam energies and TPS calculation algorithms. The deviation between the measured and calculated values for all test cases made with advanced algorithms were within the agreement criteria, while the larger deviations were observed for simpler algorithms. The number of measurements with results outside the agreement criteria increased with the increase of the beam energy and decreased with TPS calculation algorithm sophistication. The external independent audit helped the users to better understand the operational features and limitations of their TPSs and resulted in increased confidence in dose calculation accuracy using TPSs. The independent audit results indicated the shortcomings of simpler algorithms for the test cases performed and, therefore the transition to more advanced algorithms is highly desirable. The audit could also help the users to appreciate the properties, qualities and operational characteristics of treatment planning systems and to better understand their limitations.

DOSE VOLUME CHARACTERISTICS OF PATIENTS WITH MALIGNANT GLIOMA TREATED WITH POSTOPERATIVE RADIOTHERAPY USING TWO DIFFERENT TREATMENT TECHNIQUES

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Introduction. Postoperative combined chemoirradiation is the standard therapeutic option for patients with malignant glioma. Modern imaging techniques allows more precise definition of treatment volumes. There are two possibilities for the realization of postoperative radiation treatment in patients with malignant glioma. The first, represented by European research groups do not recommended reducing the target volume during therapy (30 fractions), while the second, recommended by North American research groups recommends two-phase treatment technique.

Material and methods. Total of 34 patients were treated in 2 groups, 19 were treated with 2 phase radiotherapy technique, while 15 were treated with a one phase technique. 16 patients were males while 18 were females. Median age of patients was 55 years (range of 25-75 years). Treatment volumes (GTV, CTV, and PTV) were contoured on transversal CT simulator images, using pre-operative MR. Additional volume receiving a dose greater or equal to 57 Gy was generated for every patient plan.

Results. Analysis of dose volume parameters of patients, has shown no significant difference between the mean volumes in the first stage of treatment (GTV1), (135,20 cm^3 vs. 101 63 cm^3, p = 0.9641), while the analysis of mean volume receiving radiation dose equal to or greater than 57 Gy, has shown significant difference (568,85 cm^3 vs. 757,80 cm^3, p = 0.00134)

Discussion. Existing treatment modalities allow reducing the size of the volume receiving a dose greater than or equal to 57 Gy. To assess the clinical distinction of these two methods of treatment, we need long-term follow-up of patients, which will include time to progression, survival, mental status and quantification of quality life parameters

ASSESSMENT OF RECEIVED DOSE BY FAMILY MEMBERS OF IN-PATIENTS TREATED WITH I-131

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Aim: The effective dose value of family members of in-patients treated with radioiodine I-131 is not only the main concern regarding the discharge of the patients, but also of great importance for assessing the planned public exposure. In this study we measured the effective dose received by family members of in-patients thyroid cancer treated with radioiodine I-131 considering administrated activity, discharge dose rate, patient specific effective half life and result of post treatment planar imaging.

Materials and methods: Thermoluminescent dosimeters (TLD 100) were given to family members of 40 volunteer patients (65 Adults and 8 children ≤ 15 yrs) and placed in front of their torso for 5 to 21 days. The mean age of the family members was 41.16 years. The mean administered activity to patients was 140.14 ±30.9 mCi in the range of 100–200 mCi. Dose rate of patients were measured with a calibrated survey meter on 3 and 24 hours after I-131 administration and also before patient discharge. Planar whole body I-131 imaging was also acquired one week later. The oral and written radiation safety instructions based on the guidelines prepared by the American Thyroid Association were given to patients and family members before leaving the hospital. Recorded TLD dose values were exceeded to unbounded dose.

Results: The mean value of discharge dose rate was 37.6 μSv/h in the range of 15 - 120 μSv/h. The calculated effective half life varies between 0.41 days to 1.9 days. The mean value of unbounded dose was 220 μSv with minimum and maximum of 100 μSv and 1600 μSv respectively. The planar images interpreted by a nuclear medicine specialist show the metastasis of differentiated thyroid cancer in 17 patients.

Conclusions: Considering the discharge dose limit of 70 μSv/h at a distance of one meter away from the patient, as well as hospitalization of at least 1 day, the received dose by family members were less than 1000 μSv for 94.4 percent of family members in an infinite measuring time interval. Moreover, independent of administrated activity, broad metastases and/or higher biological half life were two main factors resulted in higher dose to family members. Therefore, non-thyroid dosimetry at a distance of one meter is highly recommended for discharging of these patients.

Key words: Radioiodine therapy, Family members, Effective Dose, Thermoluminescent dosimetry

ISOLATION OF NO-CARRIER-ADDED ^{195M}PT FROM NEUTRON IRRADIATED ^{193}IR TARGET FOR MEDICAL PURPOSES

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The term “theragnostics” appeared in the last decade and implies combination of diagnostics and therapy in one procedure with the same drug. The ground of such approach in nuclear medicine is radionuclide/radionuclide pairs, which can be applied for diagnostics as well as for therapy of cancer diseases. ^{195m}Pt is a perspective radionuclide for such approach. Along with its convenient half-life period (4.02 days) its decay is accompanied by low energy γ-radiation (E_γ = 98,9 keV, I_γ = 11,4%), as well as multiple Auger electrons (an average of 33 electrons per decay). Emitted γ-rays allow to conduct imaging and Auger electrons effectively treat tumor tissue without causing radiation dose to healthy tissues. I.e. using the same radiopharmaceutical of platinum one can accomplish selective delivery of radioactive source to a tumor and subsequent scanning.

None of the ^{195m}Pt production methods lead to the ^{195m}Pt accumulation with sufficient specific radioactivity in no-carrier-added form.^{195m}Pt production by activation of ^{194}Pt with thermal neutrons and in the reaction ^{192}Os(α,n)^{195m}Ptis not being used in practice. The method based on double neutron capture by the ^{193}Ir nucleus with consequent population of ^{195m}Pt through β^- decay was discussed [1]. To answer this question we irradiated enriched ^{193}Ir (98.4%) at the reactor IBR-2 in Dubna. Irradiated Ir target was dissolved electrolytically in hydrochloride acid medium using graphite electrodes. ^{195m}Pt was isolated by extraction chromatography on TEVA resin using solutions of hydrochloric acid of various concentrations as eluents. For optimization of separation technique Kd of Ir and Pt was determined on different resins in static mode and influence of carrier was investigated. Details of the separation scheme will be presented.

Results show that ^{195m}Pt is produced by the following way: ^{193}Ir$(n,\gamma)^{194}$Ir$(n,\gamma)^{195m}$Ir$\beta^- \rightarrow$ ^{195m}Pt. Sufficiently large values of nuclear reaction cross sections were obtained. Conclusions about real perspectives of this method for ^{195m}Pt production will be discussed.

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THE BENEFITS OF EXTERNAL FUNDS FOR TRAINING MEDICAL STAFF ON THE EXAMPLE OF GREATER POLAND CANCER CENTRE

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Purpose: The objective of the following paper is to analyze the possibilities and potential benefits of applying for external funds, e.g., European funds, for the training of both medical and administrative staff in healthcare institutions in Poland. Lack of money and imprecise regulations contribute to constant changes within Ministry of Health in Poland, However, since Poland's EU accession, funds aimed at investments and training became more and more accessible. EU's flagship initiatives, i.e. Separate Calls, and Horizon 2020 Calls open the doors for new possibilities and sources of funding.

Materials and Methods: The following, selected, projects are the main sources of external funds devoted to training at the GPCC:

ACCIRAD - Guidelines on a risk analysis of accidental and unintended exposure in radiotherapy. GPCC has won a tender announced by the European Commission to perform a study on the implementation of the Council Directive 97/43/EURATOM (Medical Exposure Directive, MED) requirements aimed at the reduction of the probability and the magnitude of accidents in radiotherapy and to develop guidelines on a risk analysis of accidental and unintended exposures in external beam radiotherapy. Partners of the project: ESTRO, TUDOR, FIB HCSC, STUK, ASN. Human Capital Programme - supports medical sector and pays special attention to employees' adaptation within workplace environment. GPCC participates in a Project funded by Centre of Postgraduate Medical Education concerning the education of physicians from deficit areas such as oncology. Courses on radiotherapy and gynecologic oncology for specializing physicians have been organized within this Project. Qualified physicians are eligible for reimbursement of travel and accommodation expenses in line with the established rules.

Results: The above projects and initiatives are crucial for the functioning of a health institution like Greater Poland Cancer Centre as apart from the financial contribution they yield positive educational results on its medical staff. The educational dimension of the above-mentioned projects is visible through:

- organization of workshops

- completion of 25 courses by the specializing physicians (2010-2014)

Due to the educational dimension of a given venture the accessibility of education is higher as such projects enable that.

Conclusions: Poland has been facing the biggest challenges in terms of financial standing of its healthcare institutions for many years. In the face of mounting debt and change of ownership many healthcare institutions have to increase the already high management and medical standards. Thus, it is worth noting that external funds play crucial role in Poland's healthcare institutions as they are essential for their proper functioning.

THE INCIDENCE OF HASHIMOTO'S THYROIDITIS AND OTHER BENIGN AND MALIGNANT THYROID DISEASES AMONG PATIENTS UNDERWENT THYROIDECTOMY DUE TO DIFFERENTIATED THYROID CARCINOMA

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Introduction and aim: Many studies have reported several thyroid diseases including Hashimoto's thyroiditis (HT) as a potential risk factor for differentiated thyroid carcinoma (DTC). Currently, there are no data on association of DTC with HT and other thyroid diseases in Southeast Serbia. Thus, the aim of this study was to assess the incidence of Hashimoto's thyroiditis and other benign and malignant thyroid diseases among patients with differentiated thyroid carcinoma

Patients and methods: The study included 97 (80 women and 17 men) patients with DTC from Southeast Serbia underwent total thyroidectomy (throughout the years 1991 to 2014) and radioiodine ablation. Mean age at the time of surgery was 48.7 ±12.4 yr (from 14 to 75 years), and at the time of this evaluation 53.6 ±13.2 (18-87 years). Thyroid diseases were diagnosed post-operatively by pathological examination.

Results: 24 of 97 (24.7%) patients had Hashimoto thyroiditis (HT-DTC group). DTC associated with HT was found only in females. In patients without HT (non-HT-DTC group) there were 76.7% females and 23.3% males ($p<0.0001$). Malignant thyroid diseases apart from DTC were found in 2 of 97 (2.06%). Both of them had medullary thyroid carcinoma and belonged to non-HT-DTC group. Coexisting benign thyroid diseases were present in 32 of 73 patients (43.8%) of non-HT-DTC group, and the most frequent were nodular colloid goiter, solitary follicular adenoma and adenomatous multinodular goiter. In HT-DTC group only 12.5% of patients had other associated thyroid disease.

Conclusions: Our results showed a high incidence of Hashimoto's thyroiditis among patients with differentiated thyroid carcinoma that may point out this disease as a risk factor for DTC. Other thyroid malignancies associated with DTC were found in a small proportion of patients. Coexisting benign thyroid diseases were found in a high proportion of patients with DTC who did not suffer from HT.

Key words: differentiated thyroid carcinoma, Hashimoto's thyroiditis, other malignant and benign thyroid disease

STATUS OF THE PROJECT OF RADIO ISOTOPE COMPLEX RIC-80 (RADIO ISOTOPES AT CYCLOTRON C-80) AT PNPI

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Presently cyclotrons play a very important role in the production of radionuclides for medicine. It is very important that from a very large set of different radionuclides produced with cyclotrons it is possible to select a lot of ones with appropriate nuclear-physics characteristics for medical use and the amount of these nuclides is much larger than produced for this purpose with the reactors. Only cyclotrons and other types of particle accelerators give the possibility to produce radioisotopes for PET diagnostics. At PNPI (Petersburg Nuclear Physics Institute) the cyclotron C-80 with the energy of extracted proton beam of 40-80 MeV and the proton current up to 200 μA is constructed. At present time the project of radioisotope complex RIC-80 (Radio Isotopes at the cyclotron C-80) at the beam of the C-80 has been developed. General purpose of RIC-80 is production of a wide spectrum radionuclides for diagnostics and therapy. These are the isotope-generators ^{68}Ge, ^{82}Sr, ^{81}Rb, pharmaceuticals with use of ^{111}In, ^{123,124}I, ^{223}Ra radionuclides and many others. In the presented submission the project of RIC-80 complex with three target stations for isotope production has been discussed. The peculiarity of the proposed radioisotope facility consists in the use at one of the target station the mass-separator with the target-ion source device for on-line or semi on-line production of a high purity separated radioisotope beams. Some developments of the target prototypes for production of different medical radionuclides have been discussed as well.

EVALUATION OF CHEST TUBE DRAINAGE FOR A PERIOD OF TWO YEARS IN PATIENTS WITH PNEUMOTHORAX

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Aim: The main aim of the study is to report our experience with chest tube drainage as a small surgical procedure for the treatment of spontaneous, traumatic and iatrogenic pneumothorax. The study analyzed the average chest tube drainage duration according to the type of pneumothoraces, complications of chest drainage and comorbidity.

Methods: The study included 181 patients treated by chest tube drainage between the period from 1st January 2011 to 21st December 2012. This is a retrospective study conducted at the Department of Chest Surgery, University Clinical Centre in Sarajevo.

Results: The average chest tube drainage duration was 6,1 ±5,4 days. Patients who showed complications related with a chest drainage placement had an average chest tube drainage duration 13,4 ±9,2 days, and those without complications 5,7 ±3,2 days. Patients with the presence of comorbidity had the average chest tube drainage duration 7,6 ±6,1 days ($p < 0,05$); [$t = 6,454$; $p = 0,0001$], whereas in patients without comorbidity had 6,1 ±4,4 days ($p < 0,05$); [$t = 4,618$; $p = 0,005$]. According to the type of pneumothorax average chest tube drainage duration was: primary spontaneous 6,1 ±3,4 days, secondary spontaneous 11,7 ±8,8 days, traumatic 5,3 ±2,1 days, iatrogenic 5,2 ±3,7 days. One chest drain was placed in 148 (81,8%) of patients and two drains were placed in 33 (18,2%) patients, ($p<0,005$),[$\chi 2= 7,066$; $p = 0,001$].

Conclusion: The study shows that males are more at risk than female. Most cases of pneumothorax completely resolved with a single chest drain. The chest tube drainage duration in patients with complications of chest drainage and comorbidity was longer compared to healthy patients.

Key Words: pneumothorax, chest drainage, spontaneous, traumatic, iatrogenic

RADIATION MEASUREMENTS

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LUMINESCENCE AND DOSE RESPONSE OF MONOCLINIC ZIRCONIUM OXIDE AFTER IRRADIATION BY PULSED ELECTRON BEAM

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Zirconium oxide is a wide-gap dielectric material which is used for high temperature and corrosion resistant coatings, in laser and optical devices and as a sensor material, in particular as a radiation detector. The application of ZrO_2 with different phase compositions as a thermoluminescent (TL) detector of beta-, gamma- and UV-radiation is discussed in literature. The measurement of the absorbed dose of pulsed electron beams with the energy of 100-300 keV is an important task of radiation dosimetry. These beams are used in radiation technologies and scientific investigations. The absorbed dose of ionizing radiation can reach 1-100 kGy. However TL and dosimetric properties of ZrO_2 after this type of irradiation are not investigated. This paper deals with the study of luminescent and dosimetric properties of ZrO_2 irradiated by a pulsed electron beam. The objects of the study were ZrO_2 samples in the form of compacts 10 mm in diameter and 1.5 mm thick. They were made of the powder with the particles of micron dimension by a single-axis cold moulding in steel mould at the specific pressure of 1000 kgf/cm2. X-Ray diffraction studies reveal that all the samples show monoclinic atomic structure. The 480 nm emission band, which is associated with oxygen vacancies and titanium ions according to the literature data, is present in photoluminescence (PL) spectrum. The maximum in the excitation spectrum of this band is registered at 280 nm. The emission band at 480 nm is also observed in the spectra of pulse cathodoluminescence. It was found that PL in this band is subject to thermal quenching in the range of T=50-200 ^oC. The TL glow curve of the samples under study consists of two peaks: A at 150 ^oC and B at 260 ^oC (heating rate is 2 $^oC/s$). The samples were irradiated by an electron beam with the energy of 130 keV, pulse length of 2 ns and current density of 60 mA/cm2. The TL output of peak A decreases with the growth of heating rate. This TL feature can be associated with the thermal quenching of luminescence. The TL kinetic parameters of peak A were determined using different methods: analysis of TL isothermal decay curves, peak shape method, variation of heating rates and curve fitting. These methods give similar results: activation energy E=0.87 eV; frequency factor S=4×1010 s-1; kinetic order b=1. The intensities of TL peaks A and B increase sublinearly with the dose in the range of 1-100 kGy and go as D0.25 and D0.32 respectively. The obtained results show the possibility of TL high-dose dosimetry of pulsed electron radiation with the use of monoclinic zirconium oxide.

MEASUREMENT OF α DECAY PAIRS IN THE ENVIRONMENTAL SAMPLES

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Studies of natural radioactivity content in the environmental samples were carried out using the delayed coincidence measurements of α decays. This technique is sometimes used in TL/OSL dating to determine the annual dose from the decay chains. For delayed coincidence measurements of α decays each sample is powdered. Next a thick layer of powdered sample is placed on a top of the ZnS screen in a tight plexiglass container. The scintillations resulting from the α decays are detected with the photomultiplier tube and the electrical pulses are fed into a dedicated multichannel analyzer (MCA). In our work we enhanced electronics used routinely by applying more robust MCA which is capable of measuring both the amplitude and the time between the pulses simultaneously. This is used to detect α pairs resulting from the subsequent decays of ^{220}Rn → ^{216}Po (half-life = 0.14 s) → ^{212}Pb and ^{219}Rn → ^{215}Po (half-life = 1.8 ms) → ^{211}Pb (in the environmental samples the mean time between pulses is much longer than the above mentioned half-lives).

If one assumes a secular equilibrium of the decay chains in a sample the above mention pairs count rate and total α count rate can be used to estimate the specific radioactivity of the decay chains parent radioisotopes ^{232}Th,^{238}U and ^{235}U (Aitken, 1985).

The main advantage of this method is that it is quite inexpensive and do not require time consuming sample pretreatment. In addition, only several grams of material are needed to perform such measurement.

In order to verify the method applied, the results obtained from the environmental samples were compared with independent results obtained with well established semiconductor-based α and γ spectrometry techniques.

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ESTABLISHING A PROCEDURE FOR DETECTION OF IRRADIATED FOOD BY PHOTOSTIMULATED LUMINESCENCE

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There are several methods including different procedures for enhancing food quality. One of them is the method that applies ionizing radiation. This technology is used as a pasteurization method to destroy harmful microorganisms in some spices and herbs. Development of this method and commercial use of ionizing radiation to add extra value and enhance food quality, trade with this kind of food, legislation and regulations arise the need of reliable and routine tests for detection of irradiated food. All methods for detection of irradiated food are based on physical, chemical, biological or microbiological changes caused by treatment using ionizing radiation.

When minerals are exposed to ionizing radiation, they accumulate radiation energy and store it in the crystal lattice, by which some electrons remain trapped in the lattice. When these minerals are exposed to optical stimulation, they gain energy and trapped electrons are released. The reason for this phenomenon, called optically stimulated luminescence or photostimulated luminescence, is the recombination of released electrons with holes when they are exposed to light with a certain wavelength.

There are two photostimulated luminescence methods: screening method, by which signal is recorded from the sample; and calibrated method for verification, by which the same sample is exposed to a certain dose of ionizing radiation, after which it is tested for the second time. Using certified samples which include irradiated and non-irradiated paprika standards, the new procedure for detection of irradiated food is established. Both methods of photostimulated luminescence are applied on samples. Calibrated method is done after a treatment with Co-60 with a radiation dose of 1 kGy. Obtained results from irradiated and non-irradiated paprika standards approve the new procedure. In order to study the relationship between radiation dose and intensity of the luminescence signal, an experimental study is done on non-irradiated paprika standard which includes irradiation by Co-60 with different doses and then detection by photostimulated luminescence. This experimental results show that the intensity of the luminescence signal increases as the radiation dose increases.

This is a new method for detection of irradiated spices in Republic of Macedonia applying photostimulated luminescence. The protocol is made according to European and national rules and standards. Its implementation strengthens national regulations and helps to achieve acceptance by consumers.

RESULTS FROM RADIONUCLIDE INTERLABORATORY INTERCOMPARISON IN SEDIMENT AND FISH

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Regarding the external quality control of the measurements, during 2014 the Vinča Institute for Nuclear Sciences from Belgrade in Serbia and South Transdanubian Inspectorate for Environmental Protection, Nature Conservation and Water Management from Pécs in Hungary, have participated in intercomparison exercise, which has been organized and developed in the framework of Serbian-Hungarian subcommittee for water quality. The subcommittee experts have coordinated an intercomparison exercise on gross alpha and gross beta activity, ^{90}Sr activity and gamma spectrometry measurement in the sediment and fish samples with natural and artificial radionuclides. The scope of the intercomparison was to obtain information on the degree of agreement between the two laboratories.

The samples were collected in October 2013 from Danube river near Mohács in Hungary. The samples were prepared in laboratory in Pécs. The four-surface sediment was collected, packed in a container made from nonradioactive material, sealed and labelled to avoid mix up and contaminations. Each sediment is dried at 105°C to constant weight, sieved and the fraction less than 0.25 mm is taken. Two fishes were caught. Each fish was cooked and after that dried to constant weight, fragmented and homogenized.

Participating laboratories had to measure the activity of the radionuclides detected in each sample, with particular attention to natural radionuclides (from the uranium and thorium series and ^{40}K) and ^{137}Cs. Each laboratory was requested to apply its own routine procedure for such measurements using its most recent efficiency calibration and its usual source of nuclear data.

Considering the uncertainties of measurements, a good agreement between the results obtained by two laboratories has been ascertained. Such a comparison gave laboratories an opportunity to compare their work and results and help in evaluation of their analytical performance.

MONITORING OF TRITIUM ON THE SITE OF NOVI HAN REPOSITORY FOR RADIOACTIVE WASTE, BULGARIA

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Novi Han Repository for Low and Intermediate Radioactive wastes is situated 30 km from Sofia, Bulgaria and accepts radioactive waste from scientific labs, industry, medicine, etc. more than 50 years. Tritium sources present in the repository inventory and tritium determination is an essential part of the environmental monitoring.

The environmental monitoring program includes sampling and analyses of water samples from repository site (borehole wells), from restricted area (surface waters) and from supervised area (surface waters and drinking waters). A new method for ^{3}H determination in air was developed recently. Continuous sampling of tritium was carried out by the device $V_3H_{14}C$ (VF, Czech Republic) on the repository site. Tritium was absorbed by blue silica gel beads (4-6 mm diameter). The device has two channels - with and without Pt-catalyst (for oxidation of the organic compounds to HTO. For desorption of tritium from exposed silica gel the unit DJ-500 (VF, Czech Republic) was used. The liquid aliquots were measured on a liquid scintillation spectrometer TRICARB 3180/TR.

The results are in good comparability with the values obtained by operated portable flow-through ion chamber-based tritium monitor.

Monitoring results indicate that tritium concentration in air is elevated near old repository unit for solid radioactive waste which contains historical wastes. Some measures were proposed for the decreases of migration of tritium in air and water.

NON-DESTRUCTIVE SIMULTANEOUS DETERMINATION OF WATER CONTENT AND DRY DENSITY OF POROUS MATERIALS BY COMPTON BACKSCATTERING OF GAMMA RAYS

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First, a short presentation is made of our previous work on measuring moisture in porous materials by a non-destructive method based on the Compton backscattering of gamma-rays. (D.B. & I.B., Rom. Rep. Phys. 63(2011)61). Then, an extension of this method is made, by proposing two non-destructive methods for the simultaneous measurement of both water content and dry density of porous materials. In both these methods, a comparison is made between measurements on the wet object and a on dry sample of the same composition (reference). In the first method, a single mono-energetic source is used (for example, ^{241}Am) and a minimum of two measurements at two different depths (defined by the geometry of the source and detector collimators) within the wet object and dry reference are needed. The second method is based on the use of a dual source (that is, a stack of two sources with widely different energies, for example, ^{241}Am and ^{137}Cs) and just one measurement is needed, at one depth within the material and the reference. These methods are suitable for porous materials which do not modify their volume under water absorption, which is the case of most building materials. As such, these methods have an application potential, for example, in works of historic monument restoration.

INFLUENCE OF DOPANT CONCENTRATION ON LOW AND HIGH-DOSE THERMOLUMINESCENCE OF LiF:Mg,Cu,P POWDER

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The thermoluminescence phosphor based on lithium fluoride doped with magnesium, copper and phosphorus (LiF:Mg,Cu,P) is widely used as highly sensitive detector. Discovered in 2006 high-temperature emission of LiF:Mg,Cu,P detectors irradiated with doses above 1 kGy, opened new possibility for high-dose measurements. The new method developed at the Institute of Nuclear Physics (IFJ) is based on the presence of high-temperature TL peak "B" in the glove-curve of highly irradiated LiF:Mg,Cu,P detectors [1, 2]. The TL peak "B" as a dosimetric peak, plays a significant role in the TL measurements of radiation doses ranging from 30 kGy up to 1 MGy. The shape of thermoluminescence glow-curve of MCP phosphor strongly depends on absorbed dose. Starting from a few kGy where only the 'tail' of the main dosimetric peak 4 is raised, the high-temperature peaks appear in the glow-curve at higher doses. Finally above 50 kGy dose peak "B" becomes dominant.

During our research we have observed that the TL peak "B" appears not for all LiF:Mg,Cu,P luminophore samples. The shape of a glove-curve depends not only on the dose but also on concentration of dopants. The goal of our work was to examine how concentration of copper and magnesium ions influence the thermoluminescence of LiF:Mg,Cu,P powder. Samples of the MCP phosphor with concentration of copper from 0 up to 0.1 mol% at fixed concentration of magnesium and samples with magnesium from 0 up to 0,4 mol% at fixed copper were studied. All various samples in the form of powder were irradiated by Cs-137 gammas with small dose of 20 mGy or high dose of 100 kGy by Co-60 gammas and read-out with thermoluminescence reader RA-94.

Obtained results for high-doses show that major role in the presence of high temperature peaks in the TL glow-curve, especially the TL peak "B", plays magnesium dopant. Copper influences significantly low temperature peaks. The data for lower doses are in agreement with previous reports [3].

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A NEW METHOD TO DATE SOLAR SALT AFTER BITTERN-SEPARATING PROCESS BY MEASURING RADIONUCLIDE K-40

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Mineral quantity of natural salts after bittern-separating process for 1 ~ 8 years were measured by ICP-AES and HPGe gamma spectrosocpy system. Gamma ray emission radio active elements K-40 linearly. Proportional to potassium, was measured by HPGe gamma spectroscopy system. Depending on the time of the deliquescence process, micro mineral elements in natural salt rapidly decreased for the first three years including potassium elements. This decrease was big enough to be used as standard to discriminate period of deliquescence year.

An empirical equation for bittern-separating time and K-40 was displayed and it can be used in case of traceability document to date natural salt. This also could be used as a easy technique to obtain reference data for environmental condition of sea water.

IDENTIFICATION OF LEAD SOURCES IN LAKE KARAGOL SEDIMENTS USING STABLE LEAD-ISOTOPE RATIOS

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Karagol has had the area of 2 km² (2 ha) and mentioned Tantalos legend in mythology, located height of around 800 meters from the sea level in the plain at the Yamanlar Mouth foothills, about 40 km away from the centre of Karsiyaka district of Izmir. The southeastern part of the lake has a maximum depth (it is about 7-7.5 m) and towards north and west sides depth values are fallen into 1.8 meter.

Although a few study related to the radiometric survey in Lake Karagol are present, there are not appear to one that ^{210}Pb dating (or sedimentation rates) has been determined using alpha spectrometry. In addition heavy metals, trace elements and lead-isotopic analyses were realized for investigation of relations between sediment characterisation and element concentration. ^{210}Pb concentrations were determined using alpha spectroscopic method in Ege University laboratories, heavy metals and lead-isotopes were determined by ICP-MS method in Acme Analytical Laboratories (Vancouver). Three sediment cores obtained from different locations in Lake Karagol via a gravity corer to realize vertical sampling and cores were sliced at 1 cm intervals.

Sedimentation rate varied between 0.330 ± 0.008 cm y^{-1} and 0.023 ± 0.001 cm y^{-1} along to core S-3. In this station sediment dating realized at 23 cm core depth and it cost of the 192.83 years for formation of sediment thickness. In S-2 station sedimentation rate varied between 0.313 ± 0.009 cm y^{-1} and 0.006 ± 0.001 cm y^{-1} along to core. In this station sediment dating realized at 25 cm core depth and it cost of the 228.8 years for formation of sediment thickness. Last station is the S-1. Sedimentation rate varied between 0.421 ± 0.017 cm y^{-1} and 0.009 ± 0.002 cm y^{-1} along to core. In this station sediment dating realized at 22 cm core depth and it cost of the 270.15 years for formation of sediment thickness.

The observed lead-isotope ratios varied from 18.56 to 32.22 for $^{206}Pb/^{204}Pb$, 15.31 to 38.00 for $^{207}Pb/^{204}Pb$, 37.64 to 93.17 for $^{208}Pb/^{204}Pb$, 1.14 to 1.25 for $^{206}Pb/^{207}Pb$, and 2.34 to 2.54 for $^{208}Pb/^{207}Pb$ in S-1 station. They varied from 19.39 to 22.31 for $^{206}Pb/^{204}Pb$, 16.47 to 18.00 for $^{207}Pb/^{204}Pb$, 39.95 to 44.29 for $^{208}Pb/^{204}Pb$, 1.16 to 1.28 for $^{206}Pb/^{207}Pb$, and 2.31 to 2.56 for $^{208}Pb/^{207}Pb$ in S-3 station. When glanced to the lead- isotope ratios it can be seen that source of lead in sediment cores are natural.

BACKGROUND SPECTRUM CHARACTERISTICS OF THE HPGE DETECTOR LONG-TERM MEASUREMENT IN THE BELGRADE LOW-BACKGROUND LABORATORY

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The Belgrade low-level background laboratory, built in 1997, is shallow (25 m.w.e) underground space (45m^2) which is constantly ventilated with fresh air against radon. The muon intensity (about 3.5 times less than at ground level), radon concentration (suppressed to averaged value of 13 Bqm^{-3}) as well as gamma-ray background are monitoring for more than eight years. After long-term measurement using the radio-pure HPGe detector with 35% relative efficiency, the measured data includes radionuclide concentration of detector surroundings, estimation of background time variation due to radon and cosmic-rays as well as MDA values for typical samples of water matrix. The detailed characteristics of gamma-ray background spectra are here presented.

CHARACTERIZATION OF REFERENCE NEUTRON FIELDS AT POLISH SECONDARY STANDARD DOSIMETRY LABORATORY

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Radiation Protection Measurements Laboratory (LPD) at the National Centre for Nuclear Research (NCBJ) is the only one calibration laboratory in Poland with reference neutron fields. The fields were established with the use of well-specified radioactive neutron sources of bare ^{252}Cf, ^{241}Am-Be and ^{239}Pu-Be and their well-known emission rates and anisotropy. They were installed in the center (1 meter above the floor) of dedicated, neutron irradiation room, which is 4 × 4 × 16 m in size. Occasionally we use steel, paraffin and LiF moderators (spectrum filters) to form mixed neutron+gamma fields and modify their dosimetric parameters.

For calibration purposes series of experiments were performed to extract particular components of the neutron radiation along the calibration bench (e.g. direct neutrons, in-scattered and backscattered). The reference neutron fluence rates were determined through the measurements carried out with a transfer instrument, Studsvik - Alnor 2202 D neutron monitor, calibrated in National Physical Laboratory (NPL), Teddington, UK. The latest recalibration of the area dosimeter was done at NPL in 2013.

To determine neutron and gamma dose rates in our mixed fields, additional measurements were carried out. Series of measurements of an absorbed dose were taken with the REM-2 tissue equivalent recombination chamber and GW2 high pressure Al+CO_2 ionisation chamber, both designed and developed at NCBJ. Obtained results and total uncertainty of determined parameters were discussed.

DEVELOPMENT OF STANDARD REFERENCES FOR GAMMA KNIFE RADIOSURGERY FACILITIES

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Background and Purpose: Verification of absolute value of absorbed dose and relative distribution of radiation in Gamma Knife radiosurgery is essential and critical for securing treatment effectiveness and safety. This important task is, however, performed by the manufacturer itself and its validity is not assessed by medical physicists in many clinical sites. In this project, we aim at building a reference data set of Gamma Knife dosimetry and distribute them to clinical sites.

Methods: we designed and constructed a PMMA water equivalent phantom suit to the Gamma Knife unit. The diameter of the phantom corresponding to 8 cm water depth was determined from the electron density measurement of PMMA. The phantom consists of outer part which has a hemi-spherical shape and is attached to the Leksell G frame firmly. The inner part which has a cylindrical shape can readily be inserted and replaced depending on measurement modality. CT images of the phantom were obtained and phantom geometry was verified. The absolute dose rate absorbed in water and relative dose distributions have been measured at 14 out of 18 Gamma Knife sites in Korea. Two ion chambers(PTW 31010 and Exradin A016) and MD-V2-55 radiochromic films were used for dose rate and distribution measurement, respectively. Electrometers, barometers, and thermometers of national standard quality were used in experiments.

Results: Average differences of the measured dose rate from the calculated values are 2.3+/-1.3% for PTW31010 and 3.5+/-1.4% for A016. After correction of the calculated value using the electron density of the solid water phantom of Leksell Gamma Knife, the differences were reduced to 1.4+/-1.4% and 2.6+/-1.6%, respectively. Interestingly, the measured dose rates were larger than calculated values in 13 out of 14 sites. Average values of the measured full width at half maximum (FWHM) of the 16mm collimator of model Perfexion were 21.8+/-0.3mm, 22.1+/-0.3mm, and 17.5+/-0.1mm in x, y, and z direction respectively. Corresponding calculated FWHM values are 21.4mm, 21.4mm, and 17.2mm, respectively. After correction of electron density of the phantom, absolute dose rate of 14 Gamma Knife sites were all within the acceptance limit, +/-3%. Also, the FWHM values were all within the acceptance limit, +/- 1.0mm, except one in y-direction which has 1.1mm larger FWHM.

Conclusion: From the results of this study we could estimate the distribution and standard deviations of the dose rate and FWHM values of the Gamma Knifes in Korea. Based on these data and recommendations on standard radiation measurements, we will build the standard reference data for Gamma Knife's in Korea.

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LET SPECTRA OF THE JINR PHASOTRON RADIOTHERAPY PROTON BEAM

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The experimental results of the linear energy transfer (LET) measurements at the radiotherapy proton beam of the JINR Phasotron are presented. The LET spectra of the clinical proton beam were measured out at several points of the depth dose distribution from the beam entrance to the Bragg peak region and in the modified beams using a small 256-channel LET spectrometer-dosimeter LIULIN-4C with a silicon (Si) semiconductor detector with an effective area of 10 mm × 20 mm and a thickness of 300 microns. LIULIN measures energy deposition in Si of each particle passing through the detector; the spectra of energy deposited in Si can be transformed to the LET spectra. Measured spectra can be used to analyze the effects of radiation to biological objects.

THERMOLUMINESCENCE DOSIMETRY FOR VERIFICATIONS OF TREATMENT PLANNING SYSTEMS FOR CONFORMAL AND VMAT RADIOTHERAPY TECHNIQUES

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Introduction: Many papers show that thermoluminescent detector (TLD) is a good choice for medical dosimetry since it gives accurate measurements of ionizing radiation. Medical dosimetry apples thermoluminescence dosimetry which is a specific method of radiation measurement in practical applications and techniques of external beams, interstitial, intracavitary and intraluminal irradiation in cancer management.

Objectives: The paper presents results of the research on the radiation dose received by a patient during the radiotherapy process such as conformal radiotherapy and VMAT techniques. During each of these processes, a patient receives a specific dose, both in- and out-of-field, which may cause side-effects, e.g. early reactions as well as induce secondary tumors. Doses calculated by the treatment planning systems (TPSs) were compared with doses measured by TLDs.

Materials and Methods: The aim of the experiment was to measure doses deposited in an anthropomorphic phantom to estimate the actual patient dose. Within the phantom, TLD-100 were placed in- and out- of treatment field during every stage of the radiotherapy process involving ionizing radiation. Measured doses were compared with those calculated by TPS. The treatment plan for head-and-neck (H&N), chest, pelvis area was prepared in Oncentra External Beam TPS using 6 MV beam and calculation algorithms: Collapsed Cone Convolution (CCC) and Pencil Beam (PB). The comparison was performed for doses within the Planning Target Volume (PTV), a high dose gradient and out-of-field area. The same plans were prepared in Monaco TPS for the VMAT technique with Monte Carlo algorithm.

Results: According to the report IAEA TRS No 430 doses measured in points within low and high dose gradient areas should not differ more than 4% from the planned values. The maximum dose difference obtained for these points was 5% and 6% using CCC and PB algorithm, respectively. In the area of high dose gradient for which a 'distance criteria' was applied, all the values obtained were within tolerance limits. For VMAT technique the differences were very wide from 0.1% to 10%.

Discussion: TLD technique seems to be one of the best tools for doses verification in conformal techniques. For VMAT technique TLDs gave larger differences possibly due to the detectors themselves and the angle of incidence of radiation [1,2]. These problems will be discussed.

References:

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A PHANTOM FOR DOSIMETRY AUDIT OF RADIOTHERAPY TREATMENT PLANNING SYSTEMS

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Introduction.

In the radiotherapy Treatment Planning Systems (TPS) various calculation algorithms are used (Pencil Beam Convolution PBC, analytical anisotropic algorithm AAA, Monte-Carlo). The accuracy of dose calculations has to be verified. Numerous phantom types, detectors and measurement methodologies are proposed to verify the TPS calculations with dosimetric measurements. A heterogeneous slab phantom has been designed within a Coordinated Research Project (CRP) of the IAEA.

Materials and methods.

The heterogeneous phantom was developed in the frame of the IAEA Coordinated Research Project. The phantom consists of frame slabs made with polystyrene and exchangeable inhomogeneity slabs equivalent to bone or lung tissue. Special inserts allow to position TLD capsules within the polystyrene slabs below the bone or lung equivalent slabs and also within the lung equivalent material. Additionally, there are inserts that allows to position films or ionization chamber in the phantom. The inserts enable comparisons of the doses calculated by TPSs for specific beams in specified points with the measurements performed with various detectors. The doses were measured with TLD and Gafchromic EBT2 films. The comparisons were performed for a number of TPS (Eclipse from Varian, XiO from CMS, Oncentra MasterPlan from Nucletron, Panther from Prowess, PrecisePlan and Monaco from Elekta, Pinacle from Philips) and for a number of linear accelerators (Varian, Siemens, Elekta) in several radiotherapy departments in Poland within the framework of the Quality Assurance audit programme in Poland.

Results.

Eleven Polish radiotherapy centers (of 30 in total) were audited. Seven different TPSs and twelve calculation algorithms were examined in the presence of inhomogeneities. In four of them the film measurements were performed for small field sizes (2 cm × 2 cm and 2 cm × 5 cm) in homogenous polystyrene material. Generally, most of the results from TLD were within 5% tolerance. Differences between doses calculated by TPSs and measured with TLD did not exceed 4% for bone and polystyrene equivalent materials. Under the lung equivalent material, on the beam axis the differences were lower than 5% whereas inside the lung equivalent material, off the beam axis – in some cases were around 7%. The dose profile measurements with films for small fields differ from calculations up to 8%.

Conclusions.

The comparisons results for calculations and the measurements allow to the detect limitations of TPS calculation algorithms. The audits performed with the use of heterogeneous phantom and TLD or films seem to be an effective tool for detecting the errors in the TPS performance or configuration at the audited radiotherapy departments.

The project was supported by the IAEA CRP grant.

EVALUATION OF PATIENT AND STAFF DOSE DURING PACEMAKER PROCEDURES

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A pacemaker is a device that helps regulate the rhythm of the heart as well as the rate at which it beats, the process of installing the pacemaker conducted under high dose of x-ray; this is a result of the complexity of process and the length of their time, so the patient and staff are exposed to high radiation doses, But the proportion of the benefit of the process is greater than the ratio of rays damage. This research studies the dose of pacemaker procedure to 193 patients for three types of pacemakers under fluoroscopic control, and found that the dose calculation (mGy cm2) had high variation from the standard value. The mean value of DAP (mGy cm2), ESD (mGy) and FT (min) for male were (447.21 ± 0.07), (4.47 ± 0.02) and (11.68 ± 0.02) respectively. The mean value of DAP (mGy cm2), ESD (mGy) and FT (min) for female were (403.59 ± 1.4), (4.03 ± 0.01) and (11.38 ± 0.12) respectively. The mean value of flouro time (min) for (VVI), (VDD) and (DDD) are (07.30), (12.24) and (27.50) respectively. The mean value of DAP (mGy cm2) for (VVI), (VDD) and (DDD) are (240.09 ± 1.03), (614.05 ±0 .07) and (643.50±2.01) respectively. The mean value of ESD (mGy) for (VVI), (VDD) and (DDD) are (18.45 ± 0.07), (40.31 ± 0.12) and (42.24 ± 0.01), respectively.

GROSS BETA ACTIVITY IN WATER BY CERENKOV METHOD

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Cerenkov effect occurs when the charged particle velocity in a medium is larger than the speed of light in that medium. Cerenkov radiation is produced in water by ß-emitting radionuclides of energy greater than 265 keV. The advantages of the Cerenkov method for gross beta activity determination are simplicity of sample preparation, low cost, possibility of reusing the sample, easy discard and efficiency unaffected by chemical quenching. The disadvantages are that the method is applicable only to beta emitters with energies above the threshold, and the counting efficiency is lower when compared with other liquid scintillator. The aim of this study is to compare the background, efficiency, Minimum Detectable Activity (MDA) and Figure Of Merit (FOM) for the determination of ß-emitting radionuclides using two scintillation counters, Quantulus and Hidex. The equipment 1220 Quantulus™ Ultra Low Level Liquid Scintillation Spectrometer is composed by two photomultipliers and has the advantages of having an extremely low background for performing radioactivity measurements; the Hidex equipment, model 300-SL, is composed by three photomultipliers. In order to evaluate these parameters, for both equipment, three standard solutions of gross beta activity were used and analyzed in triplicate. The initial step of pre-concentration of the water samples consisted of heating on a hot plate, at a temperature of 80 °C, until reduction of the volume by a factor of 32. An aliquot of 20 mL of each sample was measured in the appropriate vial. The results obtained for the 1220 Quantulus™ equipment were: background 1.74 ± 0.08 cpm, efficiency 0.059 ± 0.002 cps dps^{-1}, MDA 0.35 Bq L^{-1} for a counting time of 60 minutes and FOM 20. The results obtained for the 300-SL Hidex were: background 24.9 ± 0.4 cpm, efficiency 0.049 ± 0.004 cps dps^{-1}, MDA 1.6 Bq L^{-1} for a counting time of 60 minutes and FOM 0.96. It can be concluded from the results obtained that both equipment are suitable for the determination of gross beta activity by Cerenkov method, although the 1220 Quantulus™ performance was better. The performance of the determination of gross beta activity in water was carried out by participating in a Proficiency Test organized by Instituto de Radioproteção e Dosimetria. The values obtained for the normalized standard deviation (D) were below 2, indicating a good precision and accuracy for both equipment.

RADIONUCLIDES IN THERMAL GROUNDWATERS IN SERBIA

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Concentrations of gross alpha and beta activity, and also activity concentration of specific radionuclides like ^{40}K,^{137}Cs, ^{232}Th and ^{226}Ra were determined in 17 samples of the thermal groundwater collected in South-East part of Serbia (Ribarska Banja spa, Niška Banja spa, Bujanovačka Banja spa, Sijarinska Banja spa, Vranjska Banja spa and Tulare).

These waters are mainly used in balneology and recreation, but some of them are used for drinking purposes and in water supply to heat buildings, greenhouses and agriculture. It is very important to determine the gross alpha and beta activity in those waters in order to use them safely. The upper limit for gross alpha activity in drinking water is 0.5 Bq $\cdot l^{-1}$ and for gross beta activity concentration it is 1 Bq $\cdot l^{-1}$ /ICRP, 1991; WHO, 1993; Official Gazette of RS, 2011). In analyzed water gross alpha activity is from 0.020 ±0.002 to 4.1 ±0.4 Bq $\cdot l^{-1}$, while gross beta activity is <0.3 Bq $\cdot l^{-1}$. The isotopes ^{40}K, ^{137}Cs, ^{232}Th and ^{226}Ra in groundwater are important for understand circulation of groundwater.

Gross alpha/beta activity was determined on low-level LSC Quantulus 1220. And activity concentrations of specific radionuclides were determined by gamma-spectroscopy method on high-resolution HPGe gamma spectrometer produced by CANBERRA.

MODERN DETECTION DEVICE FOR REMOTE MAPPING OF THE RADIATION FIELD

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Poster presents a small, light-weight dose rate meter (based on a plastic scintillator) which can be applied for remote measurements, developed in the research project MOSTAR. The detector has been designed so that it can be used for remote-controlled devices in areas of high contamination or in inaccessible terrain. Poster shows calibration of the detector and results of measurements using this detector mounted on a mobile robot (UAG) or unmanned aerial vehicle (UAV). These measurements were carried out during a field experiment with dispersion of La-140 in Boletice and on a polygon in Třebíč where 'lost' point sources were placed.

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DETERMINATION OF U, Th, RARE EARTH AND METALS IN SOIL AROUND IPEN FACILITIES

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For the assessment of the quality of the soil, it is important to check possible contamination due to anthropogenic influence. The aim of this study is to determine natural radionuclides (U and Th), rare earth (Ce, Eu, La, Lu, Sm, Tb and Yb) and metals (As, Ba, Co, Cr, Cs, Fe and Sc) in soil samples around Instituto de Pesquisas Energéticas e Nucleares (IPEN) facilities. IPEN is located in the city of São Paulo, Brazil, and comprises several facilities spread over an area of about 500,000 m², the buildings covering 85,000 m². IPEN comprises several nuclear and radioactive facilities. The determination of the radionuclides, rare earth and metals was carried out by Instrumental Neutron Activation Analysis. The technique consisted of irradiating approximately 150mg of the sample during 8 hours at a neutron flux of 10^{12} $n.cm^{-2}s^{-1}$, at the nuclear research reactor IEA-R1 of IPEN. The induced radioactivity was measured by gamma-spectrometry with a hyper-pure germanium detector, with 25% relative efficiency and resolution of 2.10 keV at 1332 keV. The concentration of the analyzed elements was determined by comparing the activity obtained in the samples with that obtained with the standard reference material IAEA SL-1 and IAEA SL-3. The results obtained for U, Th, rare earths and heavy metals were compared with literature values.

A REAL-TIME UNDERWATER GAMMA-RAY NaI(Tl)MONITORING SYSTEM ON A MARINE BUOY

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A real-time underwater gamma-ray monitoring system using a 76.2 x 76.2 mm NaI(Tl) detector was designed and installed on a marine buoy. The efficiency calibration of NaI(Tl) detector for in-situ gamma-ray measurements was performed using the Monte Carlo simulation with the MCNPX code considering the geometry of view of the detector, and validated by comparing analysis results by in-situ gamma-ray spectrometry method and laboratory measurement for K-40 radioactivity concentration in seawater. For the validation, the seawater samples were collected at the points that the monitoring systems were deployed and the K-40 activity concentration in the samples was analyzed by using a HPGe (High Purity Germanium) detector. The gamma-ray energy spectra were also obtained by the monitoring systems on each site, and the K-40 activity concentration in each site was analyzed with the detection efficiency determined by using the MCNP simulation. The K-40 activity concentration by two different ways was in good agreement within their uncertainties. The Minimum Detectable Activity (MDA) for artificial radionuclides was also estimated.

MEASUREMENT OF PATIENT DOSE IN VASCULAR INTERVENTIONAL RADIOGRAPHY

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Cardiac catheterizations have contributed greatly to the treatment of heart diseases. However the radiation exposure to the patient is significantly higher compared with other radiological examinations. The objectives of this study are to evaluate the level of radiation dose received by the patients in order to introduce local diagnostic reference levels. A total of 108 consecutive patients who underwent cardiac catheterization using Dose-area product (DAP) were measured. The mean of DAP ± SD of therapeutic and diagnostic cardiac catheterization procedure was (80.84 ± 25.09) mGy.cm^2 and (67.04 ± 26.65) mGy.cm^2 respectively and for male, female and total was (74.87 ± 41.33, 72.52 ± 27.91 and 73.84 ± 35.75) mGy.cm^2 respectively. The mean of fluoroscopic time ± SD of therapeutic and diagnostic cardiac catheterization procedure was (6.10 ± 4.51 and 5.31 ± 2.96) minutes respectively and for male, female and total was (7.6 ± 6.67, 5.90 ± 3.70 and 6.89 ± 6.26) minutes respectively. The mean of entrance surface dose ± SD of Therapeutic and diagnostic cardiac catheterization procedure was (80.8384± 25.08, 67.0351± 26.649) mGy respectively, and for male, female and total was (74.87 ± 41.33, 72.52 ± 27.91 and 73.84 ± 35.74) mGy respectively. The study concluded to the fact that the patients received relatively high dose but the dose is necessary to enable the diagnosis or treatment and there are still minor differences with global standards .

UNCONVENTIONAL MATERIALS AS FORTUITOUS RETROSPECTIVE LUMINESCENT DOSIMETERS IN CASE OF A RADIOLOGICAL EMERGENCY EVENT

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In the aftermath of a radiological accident or terrorist attack, rapid and accurate assessments of absorbed doses of exposed individuals are imperative for an appropriate triage before medical treatment. The methods used in accident dosimetry for dose reconstruction include biological, physical, and computational techniques. While some of these methods are time consuming and intrusive, others do not have great sensitivity. The established luminescence methods used for retrospective dose assessment use materials containing quartz and feldspars, such as bricks, tiles and porcelains collected from local buildings. Sample preparation is necessary in this case as well as the application of computational methods to derive the dose received by humans. In order to overcome these disadvantages, several studies suggest the potential usage of personal objects as well as dental ceramics for accident dosimetry. In this context, we have investigated the optically stimulated luminescence (OSL) as well as thermoluminescence (TL) of various electronic components and chip card modules removed from mobile phones, as well as several brands of feldspathic ceramics employed for the fabrication of the external layer (veneer) of dental crowns in order to contribute to the documentation of such materials for accident dosimetry purposes. Among all tested samples, the alumina rich resistors and one type of feldspathic dental ceramic seem particularly promising for retrospective dosimetry. These components and materials have a significant potential as retrospective luminescence dosimeters in terms of the fact that they display bright TL and OSL signals, a linear dose response, good reproducibility and homogeneity, as well as a degree of fading that is not hampering their potential use. The low limit of detection in the case of these materials is of an order of magnitude of mGy. These results, alongside with the widespread availability of these materials are leading us to conclude they are suitable candidates for rapid dose assessment.

EVALUATION OF PATIENT AND STAFF DOSE IN BRAIN INTERVENTIONAL RADIOGRAPHY

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Interventional Radiology (IR) refers to a range of techniques which rely on the use radiological image guidance (X-ray fluoroscopy, ultrasound, computed tomography [CT] or magnetic resonance imaging [MRI]) to precisely target therapy. IR improved the diagnosis many of the diseases. This study aimed to Evaluation of Patient and staff dose in brain interventional Radiography. A total of 100 patients were examined in royal care hospitals.

Effective doses, and the corresponding risks of radiation-induced cancers, are presented for patients undergoing many IR procedures. The dose–area product (DAP) was used to quantify the amount of radiation used to perform IR procedures. The results were tabulated in the Tables (mean ± standard deviation (sd)) and the range of the readings in parenthesis. The dose values in diagnostic radiology are small, therefore the dose were presented in milli-Gray. For dose calculation, this result spatial for male and female respectively. Patient individual exposure parameters were recorded (tube voltage (kV=70±0), tube current and exposure time product (mAs=10.25 ± 7.55; 686 ± 597.20) and source to image distance (SID=97.20 ± 1.64, 97.82 ± 8.384) ,age=(41.00 ± 11.74; 744.70±17.44) and ESD(11.53 ± 9.50224; 11.53±9.50224) and DAP(1238.8±1123.06, 1153.3±950.22413) and f.t (4.22 ±. 86; 5.73±1.60) and D.O.P(32.75 ± 1.893, 34.50 ± 6.05)

The correlation coefficient which is defined as a measure of the degree of linear relationship between two variables, usually labeled X and Y used in this study to describe the relation between two variables affect patient dose ESD(mGy) against tube current time product(mAs) and floro time(f.t) and dose area product (DAP) . And (DAP) against duration of procedure(D.O.P) Positive correlation coefficients were obtained between these values. This means if the value of mAs or kV increases the value of the ESD increases.

X-RAY BEAM CHARACTERIZATION FOR CALIBRATION OF DOSIMETER USED IN RADIATION PROTECTION PRACTICE

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The use of X-ray facilities in calibrating radiation measuring equipment requires an exact knowledge of the radiation field. X-ray spectrums are made monochromatic by proper filtration recommended by several international organizations. Air kerma is widely used as reference quantities specified by different calibration laboratories and calibration of dosimeter used for individual and environmental monitoring requires the knowledge of conversion coefficients between the air kerma and an appropriate protection quantity. In the present study, characterization of X-ray fields for X-ray beam irradiator X80-225KV is performed as per ISO narrow beam qualities. Characterization of X-ray fields involved in half value layer, effective energy, beam homogeneity coefficient and consistency of X-ray production from the generator (kV and mA) is conducted. A discrepancy of half value layer has been observed for N200 beam code by -8.5% which leads to the deviation of effective energy by -7.7% with a standard deviation of 1.3%. The conversion coefficients from the air kerma to dose equivalent that satisfying the condition of ICRU sphere is established for the obtained radiation qualities and compared with values referred by other standard laboratory is discussed. A deviation of 0.87% has been observed for H*(10) and H ¢(0.07) for two different calculations (ISO and BCRU empirical relation) which is insignificant. Conversion coefficients for Hp(10) and Hp(0.07) has also been calculated for ICRU four element tissue and hence for PMMA slab phantom and ISO water phantom is calculated by the MCNP generated backscattering factor is presented.

EFFICIENCY OF AN HPGe DETECTOR IN DEPENDENCE ON SOURCE-DETECTOR GEOMETRY FOR POINT AND VOLUME SOURCES

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Variations in efficiency of the ORTEC HPGe detector depending on the source-detector geometry (different distances from detector and different geometries at the same distance), were experimentally determined and analyzed, using the Czech Metrology Institute calibration sources. The point EFS X (mixture of radionuclides), point EFS (one radionuclide), volume 50 ml and 200 ml (type CBSS 2) sources, were put on detector (central position), as well as at the holder corners for several source-detector arrangements, and measured for the same measuring times. Obtained results are discussed in regard to particular gamma ray, as well as source position (in a comparison with the central one). So, efficiency in the central position (either at height of 0 cm, or at a height of 10 cm) was the highest for all considered gamma rays. The ratio of *central position efficiency* and efficiency in positions at the holder corners (positions labeled as 1, 2, 3 and 4) for the point source was the highest for the 59.54 keV (^{241}Am) - from 41.5 for position 4 to 48.68 for position 2 (zero-height), and from 2.18 for position 4 to 2.84 for position 2 (at the height of 10 cm). Smaller discrepancies have been determined for the 661.62 keV gamma ray (^{137}Cs): 7.24 (the highest for position 2) at the zero height and 1.51 (the highest again for position 2) at the height of 10 cm. For the gamma ray of 1836.06 keV (^{88}Y) it is 5.53 (position 2) at zero-height, and 1.52 (position 2) at the height of 10 cm. The same ratio between the efficiencies for ^{137}Cs and ^{88}Y gamma rays was registered - for all four out-central positions at the zero height, as well as for positions 2, 3 and 4 at the height of 10 cm.

The cylindrical 50 ml calibration source was also measured and considered in similar way, and the highest discrepancies of efficiency ratio between central and out-central positions were registered for ^{241}Am (position 3 for the zero height, and position 4 for the height of 10 cm). Efficiency ratios (central/out-central) for ^{137}Cs and ^{60}Co were 3.67 and 3.23, respectively (if positioned directly on the detector), and 1.38 and 1.44, respectively (for the height of 10 cm).

In a consideration of the 200 ml cylindrical source, discrepancies of the efficiency ratio between central and out-central positions 2 and 4, for a height of 1 or 10 cm, were in the range from 1.24 (^{137}Cs, for position 4 at the height of 10 cm) to 4.24 (^{241}Am for position 2 at the height of 1 cm). As in the case of the 50 ml source, similar discrepancies of the efficiency ratio were shown for ^{137}Cs and ^{60}Co for both heights, and for ^{241}Am - in particular for position 4.

SPECIFICITIES OF APPLICATION OF ANALYTICAL METHODS IN RADIOACTIVE WASTE MANAGEMENT

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In this article are presented analysis of special cases of certain types of radioactive waste and specificity of analytical methods which have been applied in the identification and quantification of contained radionuclides. In the article are presented the case studies in working with radioactive waste that is stored in the central storage of radioactive waste in Montenegro, which is managed by CETI.

Scope of radioactive waste management is very complex and involves many individual stages. Radioactive waste can occur in many different forms. One of the major problems in radioactive waste management is to determine activity and/or activity concentration of radionuclides in radioactive waste. In many cases due to lack of information about initial activity, the only way is to determine the source activity by applying some of the classic analytical methods of analysis of radionuclides. In the case of radiation source which belongs in the category of sealed radioactive sources (SRS), this is the least problem, because SRS's are sources of relatively small dimensions and with well-defined geometries, which is usually cylindrical. In this case, even on the basis of dose rate measurement, source activity can be very well determined.

Problems arise in cases of radioactive sources - radioactive waste in special form or shape. Some of these types of radioactive waste are compasses with fluorescent colors that contain Ra226 and tritium as well as metal alloys for special purposes, which contain Th232. In these cases we have a radioactive material which is located at several places on the body of the compass, or homogeneously distributed throughout the mass and volume of the metal parts. In both cases the geometry is unfavorable and requires special analytical approach.

Due to the described problems, the analysis of gamma emitters we have been doing on HPGe detectors and the calibration of efficiency is performed using the point calibration standard with a mix of radionuclides while the tritium analysis was performed on a liquid scintillation counter. In this article, we described this analysis and all the specifics that followed this analytical approach. In all cases we got valid results, based on which we were able to determine and classify radioactive waste.

Key words: radioactive waste management, gamma spectrometry, liquid scintillation counter, calibration standard, efficiency calibration,

DOSE DELIVERY UNCERTAINTY DUE TO TREATMENT PLANNING SYSTEM DOSE CALCULATION

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A relatively simple and fast method was proposed for checking out a calculative precision and an underlying database relevancy of external radiotherapy department treatment planning system (TPS).

We used a monolithic, cylindrical PMMA phantom for the experiment with a cylindrical measuring chamber being introduced through the narrow channel into the phantom's center. The symmetry of the phantom helped us with a devising a criterion to estimate the TPS's performance and capacity. The "box" planning technique was one of choice, wherein four squarely profiled, equally weighted radiation beams were oriented in four, mutually orthogonal directions: AP, PA, LL and RL. We made five distinctive treatment plans applying this technique , all of them made on a single set of CT-slices, with a common referent point in space and with the same total dose per plan. The only difference between these plans was in a field size of the four-beam set composing a plan.

We used two ionization chambers for the test: NE 2571, FARMER type of cylindrical chamber, and PTW N31009, pinpoint type of cylindrical chamber. The FARMER chamber is widely accepted as a standard in a water phantom dosimetry. The problem with this chamber is its reduced response for small field sizes (i.e. 2x2 cm2), so we needed the small-sized, pinpoint chamber to monitor the FARMER chamber reading for small field sizes.

The experiment has shown some imperfections of the MU-value calculation algorithm incorporated into the TPS. Four beams of a single plan ended up with different MU-values, although they were designed by the planning process to have an equal weight. By rule, through all five plans the direction LL had been assigned with a minimum, while the direction RL with a maximum MU value. The other two directions took MU values between these two extremes. Another problem detected here was the observation of a systematic reduction in total dose with regard to the TPS plan's prediction of 2 Gy. Both instruments registered these reductions, but they were more conspicuous with the pinpoint chamber. In addition, with small field sizes, 2x2 cm^2 and 3x3 cm^2, dose reductions were further increased because, in these cases, the beam boundary had been too close to the chamber volume. Considerable dose reductions could also indicate a non-applicability of the chamber calibration coefficient for small field sizes as well as a non-equivalency of the measuring set-up and measuring conditions between the water phantom, reference dosimetry and the PMMA phantom dosimetry of this case.

DOES THE HIGH BACKGROUND RADIATION CAUSE CONGENITAL MALFORMATIONS? - A CASE CONTROL STUDY

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High background natural radiation areas provide a unique opportunity to investigate chronic low dose effects on human health with reasonable accuracy. The south west coastal region of Kerala, India is one among the known High Background Radiation Areas (HBRA) in the world where a very large number of people residing for many generations are exposed to high levels of natural radiation. Over the last few decades there have been two schools of thought arguing for and against the possibility of radiation exposure causing some serious health effects on people. It has also been reported that the number of congenital malfunction cases in the region is high but no scientific research has so far been done to identify the correlation, if any, between radiation exposure and congenital malformations. It is at this juncture we have made an investigation on the role of background radiation on congenital malformations namely Mental Retardation (MR) and Cleft Lip/Palate (CL/CLP). Case-control study was used to estimate the relative risk of a disease with respect to one or more specific risk factors. Case-control study designs are used to estimate the relative risk for a disease from a specific risk factor. In the present investigation we have used a 1:3 matched case-control study in which we selected controls based on some characteristic(s) of the case. To conduct the study 358 cases and 1074 suitable controls were chosen from the region. The major radiation exposure components namely inhalation and external dose rates were estimated. The state of the art technology was employed for the passive time integrated inhalation dose measurements. External dose measurements were carried out in both active and passive methods. Major confounding factors such as gestation, mothers chewing habit, mother's blood pressure, mother's anaemia, forceps delivery and the like were considered for the analysis. The detailed investigation, which was carried out in about four years, in search of a correlation between the natural high background radiation and the congenital malformations namely mental retardation and cleft lip/palate seen in the HBRA in Kerala suggest no statistically significant association of either mental retardation or cleft lip with high level natural radiation.

HIGH ACTIVITY SPECTROMETRY AND TOMOGRAPHY OF IRRADIATED MATERIALS IN HOT-CELL

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The purpose of the paper is to present experimental settings for high activity dosimetry with focus on determination of activity of specimens from surveillance program of nuclear power plants.

All reactors are undergoing surveillance program to ensure that their pressure vessel are serviceable. This is ensured by irradiating steel specimens, which has same parameters as steel, which was used for pressure vessel. Testing these irradiated specimens allows to determine durability of pressure vessel.

In our facility we have 21 hot, 29 semi-hot cells. Hot cells are used for preparatory and auxiliary operations with irradiated materials, e.g. receiving of irradiated materials, unloading of containers and evaluation of detectors to determine the neutron fluency, irradiation temperature. Semi-hot cells are used for mechanical testing and determination of structure characteristics.

Our hot cells are authorized to dispose of activity up to 4000 TBq. In one of the hot-cells is located HPGe detector with low efficiency, which allows us to measure specimens with activity up to 1 Tbq. The configuration of experiments allows to directly measure the samples of 22mm in diameter and set the activity distribution trough the sample with tomography.

Currently in cooperation with Research Center Rez, we are tracking dependence of activity and neutron fluency of various types of steel. The fluency is determined by spectrometry of wire, which is irradiated together with specimens.

USING POTASSIUM NITRATE TO MEASURE THE INTEGRAL CHARACTERISTICS OF THE PULSED ELECTRON RADIATION

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Objective

The aim is to study the possibility of using potassium nitrate as a chemical dosimeter for measuring the integral characteristics of pulsed electron radiation and to estimate the dose absorbed by the study system.

Material and Methods

The radiation source used in the high-current electron accelerator developed in the laboratory №1 which is located in the Institute of High Technology Physics of Tomsk Polytechnic University with maximum electron energy 450 keV. Technical parameters of the accelerator: impulse are 350-500 kV. Tok voltage electron beam pulse to 1.5 kA. Pulse frequency of 1-50 pulses / s. The total energy of the electrons in a pulse of 15 J. The current density on the target is 10-30 A /cm2. Pulse duration is 120 ns. Chemical dosimeter based on KNO3 prepared from twice recrystallized reagent mark "chemically pure" to remove the nitrite ions contained herein in small quantities. The thus prepared potassium nitrate compressed into tablets of 12 mm diameter and 2 mm thick, which were dosimetry detectors. Determination of nitrite ions produced after irradiation was carried out by chemical means KNO3 with Griess reagent according to standard procedure.

The intensity of the staining solution, measured at a wavelength of 540 nm, proportional to the concentration of the nitrite ions produced by the irradiation of a radiation sensor.

For comparison, the absorbed dose of radiation is used based film in the color indicator TS XVID dose recommended for estimating the dose range of 1-50 kGy.

Results

It is found that the results of the study of the possibility of using potassium nitrate for dosimetry of pulsed electron radiation with an electron energy of 500 keV. One of the final products formed after exposure of potassium nitrate, nitrite ion is a radiation-chemical yield of which is constant and it equals 1, 6 ions / 100 eV. Measuring the concentration of nitrite ion with Griess reagent was determined the absorbed dose in any geometric point of the irradiated volume. Comparative results obtained using the dose indicator for color film.

Conclusions

1. It is calculated the maximum range of pulsed electron radiation in the solid nitrate in solution.
2. It is shown that the crystalline material can be used as chemical dosimeter. In solution, the same radiochemical yield nitrite ion depends on the absorbed energy and the amount of water, thus it does not satisfy the requirements for chemical dosimetry.
3. It is investigated the process of activation of an aqueous solution of a pulsed electron radiation and interaction of the products with the solute.

MOSFET DETECTORS IN VERIFICATION OF PLANNED DOSE IN RADIOTHERAPY

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Monitoring of the dose applied to a patient is an important aspect of the quality assurance (QA) in the radiotherapy. The *in vivo* dose measurements enable to collect information whether the dose was deposited correctly and what is its value.

The measurement of the entrance dose allowed for obtaining information concerning the kind of radiation, applied number of monitor units, the presence and the return of the wedge being a modifier of the beam and other aspects associated with arranging the patient during therapy. The measurement of the exit dose allowed for answering the question concerning the size and the density of irradiation area of the patient's body.

The in vivo dosimetry can serve as the method to verify the new implemented procedures in radiotherapy and to serve as an indicator in assessing the value of the dose for an organ at risk. Above all its main purpose is to protect the patient against mistakes which can appear in the conducted treatment.

In order to verify doses given to patients subjected to the standard radiotherapy and TBI (Total Body Irradiation), previously calibrated MOSFET detectors were applied. Their main advantage is a very small active area equal to 0.04 mm2. Physical dimensions of the packed MOSFET detector are 2.0 × 1.3 × 8.0 mm which make these detectors a perfect tool for doses measurements at a point. Moreover, direct and simple readout of the dose is their advantageous feature in comparison with, for example, TL detectors.

If the recorded dose differed from the planned dose by over 5%, the verification of the problem was performed in the following steps: (i) the check of the adjustment of the therapeutic apparatus, (ii) the renewed arrangement of the patient on the therapeutic table and (iii) the repeated measurement.

Altogether, there were performed 1072 measurements of entrance doses at persons subjected to the standard radiotherapy, from which 636 cases at 15 MV photon beams, 328 at 6 MV photon beams and 108 at the most often used electron beams. In the case of TBI technique the in vivo dose measurement was performed for 158 patients.

A full statistical analysis of the obtained results concerning the differences between measured and planned doses for the examined groups of patients for beams of photons generated with voltages 6 MV and 15 MV will be presented. In case of in vivo measurements of patients for which the irradiation was carried with an electron beam of energy 6 MeV, 9 MeV, 12 MeV the verification of the dose was done for 108 measurements for 85 patients.

Detailed description of the results will be presented at this work.

Measurements performed *in vivo* showed that MOSFET detectors are proper and convenient measurement tool for routine applications in radiotherapy.

REAL-TIME MONITORING OF GAMMA RADIATION DOSE RATE USING RADFET

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The possibility of using RADFET for the real-time measurement of gamma radiation dose rate has been investigated experimentally. A RADFET sample manufactured by Tyndall National Institute, Ireland, has been investigated under gamma radiation exposure from Co-60 source. The RADFET has been exposed to various dose rates, and the induced bulk current has been measured in real-time when the bulk was successively biased with 0, 10, 20 and 30 V during irradiation. The current read-out was unstable for 0V bias, but when the bulk was biased, a very good stability of the induced current has been observed and the variation of the induced current with respect to the dose rate was in accordance with the power law, whereas the sensitivity of the current read-out was linear with respect to the applied bulk bias voltage.

ESTIMATION OF ABSORBED DOSE DURING PROCESS INTERRUPTION IN RADIATION PROCESSING

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The quality control system enables the standardization of product quality. Dosimetry has an important role in the quality control of radiation processing. The area of radiation processing which is governed most strictly by regulations is radiation sterilization. This process is used as the example to describe the new method for establishing the effect of process interruption on absorbed dose in the Radiation Plant of the Vinča Institute of Nuclear Sciences. Establishing the effect of process interruption is one of requirements in international regulations, but there are no recommendations for its implementation. A new method has been worked out by graphical extrapolation. The advantage of this method is the ability to carry it out during the sterilization process.

The suitable place is chosen where absorbed dose is expected to be the most influenced by source transit, i.e. the most close to the source. In the same time, it should be convenient and reproducible for placing dosimeters. Alanine dosimeters were irradiated on this place in time intervals: 2 min., 4 min., 6 min., 8 min., 10 min. Measurements of time starts when the button to lift source is pressed and stops by pressing the button for process interruption (to sink source down). The absorbed doses were measured by MiniScope MS300 ESR spectrometer using AER'EDE Version 2.0.4. software for dose calculation. The function of absorbed dose versus irradiation time is linear as expected. The extrapolation back to zero time gives the maximal absorbed dose that can be delivered to product during source transit. In our experiment this absorbed dose obtained by this method is 154 Gy.

PERSONAL RADIATION DETECTOR γ-TRACER GT2-1 WITH CdZnTe DETECTOR

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Personal Radiation Detector (PRD) γ-Tracer GT2-1 had been developed with focus on gamma-radiation detection, search and gamma-radiation source localization function, enhanced PRD features and isotope energy pattern analysis. The device complies general requirements and includes all regular PRD class device features as well as supplementary modes as Multi-Channel Scaling (MCS), Spectrometer, Librarian driven analysis and Data Log recorder. The GT2-1 uses detector module build around 400 mm3 counting grade planar CdZnTe detector.

Choice of CdZnTe brings high efficiency of gamma-radiation registration and low energy discrimination level down to 30 keV while volume used is small. GT2-1 is made with power consumption in mind, typical lifetime after full battery charge exceeds 600 hours in a measurements mode.

Energy compensation techniques are employed for dose rate calculation. Typical accuracy in the energy range of 30-1500 KeV is better then 10% for factory calibrated devices.

GT2-1 is featuring librarian driven isotope identification function. Basic concept is use of library of pre-calibrated user-defined isotope patterns being compared with isotope under test. Identification algorithm is made to evaluate isotope energy pattern match. Algorithm execution results in tested isotope and library match and results indication in graphical form.

The device search mode employs proprietary Background Variation Tracking (BVT) algorithm. Implemented search and gamma-radiation source localization mechanisms facilitate the user in fast (1-3 sec) detection of weak gamma-radiation sources with intensity in 1.5-3 times exceeding the background level. Analysis of time intervals between adjacent pulses in the input sequence is used to yield numeric characteristics that further displayed in user-friendly graphical form. Dedicated GUI approach and sound capabilities are tailored to search activity flow and aimed to gain operator experience.

Dedicated Search algorithm implementation allows to use the device as a home land security detector by services responsible for radioactive materials relocation control like those in the airports, border control, toll, etc.

Test results of GT2-1 in Search mode are presented.

EVALUATION OF DOSIMETRIC CHARACTERISTICS OF A GLASS RLD PERSONAL DOSIMETER

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Thermoluminescence Dosimeter (TLD), Optically Stimulated luminescence (OSL), and Radio-photoluminescence Glass dosimeter (RPL) are commonly used as passive integrating luminescence dosimeters.

This study assesses some dosimetric characteristics of a DVG-1m ® glass RPL dosimeters type, inclusive of linearity of response, inhomogeneity of samples, energy and angular dependency.

The results show the high value of energy and angular dependency for low energy X-ray which is required a new filtration design on the dosimeter badge.

A MICROBIAL DOSIMETRIC SYSTEM FOR GAMMA RADIATION USING THE RADIATION-RESISTANT BACTERIUM, DEINOCOCCUS

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Gamma (γ)-ray irradiation is now firmly established as a method of sterilization for food and medical devices, hence the need for the development of suitable indicators for monitoring radiation exposure. Here, the feasibility of using Deinococcus showing strong resistance to both desiccation and ionizing radiation as a dose indicator of gamma radiation exposure was evaluated. Three Deinococcus strains having different levels of radiation resistance, Deinococcus radiodurans (DRD), Deinococcus radiopugnans (DRP), and the DRD pprI mutant (DRM), were selected to develop an appropriate dose indicator for a broad range of exposures. DRD, DRP, and DRM cultures with different numbers of cells (~107 to 103 colony forming units [CFU]/100 μl) were lyophilized and subjected to various doses of gamma radiation to determine a critical dose that inhibited bacterial growth completely. Finally, a combination of DRD at ~107 and ~106 CFU, DRP at ~105 CFU, and DRM at ~104 CFU successfully indicated exposure to 5, 10, 20, and 30 kGy of gamma radiation, respectively. This study shows the possibility of developing a qualitative indicator of radiation exposure using Deinococcus.

NATURAL RADIACTIVITY FROM BUILDING MATERIALS IN SPAIN

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The industrial construction sector is very important in Spain. Building materials used in this industry are sources of radiation from natural radionuclides they contain. The European Commission published some recommendations to facilitate the trade of these materials in the E.U. The studies about this subject have increased notably during last years. This, probably, can be associated with the increase interest from natural radiation radiological risk on indoor exposure.

The activity concentration of building materials must meet the basic standard specified in Directives of E.U. as well as specific aspects of NORM industries.

The evaluation of environmental impact caused from the radionuclides of building materials is made by the Nuclear Safety Council (C.S.N.), CIEMAT and some radioactive environmental laboratories. The University of Malaga is developing the ARMAC Project to analyze the composition and the radioactivity of the materials used in building. The samples were supplied by manufacturers and it has been made a physic-chemical characterization of the samples received. The chemical composition of the samples of cement, brick, ceramic and roofing tile has been made using ICP-MS and XRPD. XRPD is a powerful tool for material characterization in general, and cements materials in particular. The use of the Rietveld method has allowed quantifying the clinkers and cements measured by laboratory x-ray powder diffraction (LXRPD) giving their accurate phase assemblage. The results of these analyze shows near 72 different elements. The higher concentrations are of Na, K, Ca, Al, Fe and Si.

All building materials have varying amounts of natural radionuclides. They belong to natural radionuclides of uranium (^{238}U) and thorium (^{232}Th) series, together with the radioactive isotope of potassium (^{40}K). The concentration of the natural radioactivity in the selected cements and ceramics were conducted with a coaxial ReGe detector. The energy an absolute efficiency calibration of the spectrometer was made using a sample certificated by IAEA-312 and IAEA-385. Software use to analyze the spectrum is the Cenie-2000 v.2.0 Canberra Nuclear. The activity concentrations are ranged between 67.4, 29.1 and 267.1 Bq/Kg from ^{226}Ra, ^{232}Th and ^{40}K respectively from samples of Portland cements.

To compare the radiological effects of the materials used in the building which contain ^{226}Ra,^{232}Th and ^{40}K, a common index is required to obtain the sum of activities and according to RP 112 the absorbed dose in air can be calculated. Some indices dealing with the assessment of the excess gamma radiation arising from building materials such as external and internal hazard indices and gamma -concentration indices, In this study the gamma -index is calculating as proposed by the European Commission $I_\gamma = I\ (C_{Ra}, C_{Th}, C_K)$ where C_{Ra}, $C_{Th}$and C_K are the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in $Bq.kg^{-1}$, varying between 0.17 and 0.29.

RADIATION MONITORING VEHICLE OF A NEW GENERATION

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Within the research project MOSTAR was for needs of modern radiation monitoring vehicle proposed and realized inner transformation of ordinary car. Poster presents car-borne system with a basic spectrometry identification, determination of heading to source using by two detectors located on lateral sides of vehicle, dose rate logging and their mapping. Part of a monitoring vehicle is a semiconductor spectrometric trace for quick qualitative and quantitative evaluation of samples of living environment and other detectors for field measurement.

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RESPONSE OF COMMERCIAL SILICON CARBIDE SCHOTTKY DIODE TO GAMMA RADIATION

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The properties of a commercial silicon carbide (SiC) Shottky diode as current read-out gamma radiation dosimeter. A SiC Shottky diode manufactured by Cree has been selected for experimental investigation. The diode has been subjected to gamma radiation from Co-60 source. For various dose rates, the current read-out of the diode has been measured in real-time using a high performance source-measuring unit. During irradiation, the diode has been operated in five different biasing modes: without voltage bias, and with reverse voltage bias with -50V, -100V, -150V and -200V. Obtained results have shown that the induced current for unbiased mode is very low, in the order of several pA, and quite unstable. For that reason, operating the investigated Shottky diode as gamma radiation sensor in unbiased mode is not feasible. However, with reverse biasing, a very good stability of the induced current has been observed, wherein the sensitivity is proportional to the reverse bias voltage, while the induced current is proportional to the dose rate according to the power law. It has been demonstrated that the selected diode can provide reliable response for the range of dose rates from 0.6 Gy/h to 30 Gy/h, and can withstand the total doses of at least 30 Gy.

INDOOR RADON MEASUREMENTS IN THE GRANODIORITE AREA OF BERGAMA (PERGAMON)-KOZAK, TURKEY

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Indoor radon levels in 20 dwellings of rural areas at the Kozak-Bergama (Pergamon) granodiorite area in Turkey were measured by the alpha track etch integrated method. These dwellings were monitored for eight successive months. Results show that the radon levels varied widely in the area ranging from 11+1 to 727+11 Bq m-3 and the geometric mean was found to be 63 Bq m23 with a geometric standard deviation of 2 Bq m-3. A log–normal distribution of the radon concentration was obtained for the studied area. Estimated annual effective doses due to the indoor radon ranged from 0.27 to 18.34 mSv y-1 with a mean value of 1.95 mSv y-1, which is lower than the effective dose values 3–10 mSv given as the range of action levels recommended by International Commission on Radiation Protection. All dosimetric calculations were performed based on the guidance of the UNSCEAR 2000 report.

RESULTS FROM TESTING OF A NEW CdZnTe DETECTOR

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Cadmium Zinc Telluride (CZT) is a suitable material for use in room-temperature semiconductor detectors. Due to the high atomic numbers, high density, and the wide bandgap, CZT detectors ensure high detection efficiency and are widely and successfully used for different gamma-ray applications. A new experimental CZT detector designed and developed at the Charles University was tested at the NRPI in Prague. It consists of two main parts – the module with 1cm3 CZT cubic crystal and the module of electronics. The CZT crystal is sensitive to photons of energy between 20 keV and 2000 keV. In the first phase the detector was tested with the aim to achieve high resolution of peaks and optimal shape of peaks in the whole energy range, efficiency calibration for basic geometries and angular dependence of detector efficiency. Energy resolution at 661.6 kev line 11.4 kev (1.72%) was attained with use of 1024 channel range. These properties of the CZT detector (1cm^3), measured spectra and minimal detectable activity were compared with a smaller quasi-hemispherical detector (0.5 cm^3) and with a small HPGe detector (relative efficiency 35%). In the second phase the detector was tested in a real fission field for several levels of dose rate that could occur in case of nuclear power plant accidents. The real fission spectrum was created by irradiation of a small amount of enriched ^{235}U fuel in experimental reactor.

THERMOLUMINESCENT DETECTORS FOR MEASURING OF PROTON DOSES IN SPACE AND FOR ACCELERATOR BEAM DOSIMETRY

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Thermoluminescent (TL) detectors (LiF:Mg,Ti and MCP:Mg,Cu,P) are the basis of the most widely exploited passive methods of dose measurement in at least two crucial fields of application: cosmic radiation in space and accelerator beam dosimetry i.e. proton radiotherapy.

Cosmic radiation is one of the main potential causes of health detriments in human space missions. Over 90% of cosmic radiation dose on Earth orbit comes from protons. TLDs, are practically unmatched as a tool for passive dose measurements in space.

Radiotherapy with proton beams is a very successful and modern method of cancer treatment. The number of proton therapy facilities all over the world grows each year and in February 2011 the proton therapy of eye tumours was started at the IFJ PAN in Krakow, as the first proton treatment in Poland and in the Central Europe.

The basic dosimetric tools in protontherapy are ionization chambers. However, TLDs are also widely applied, being unrivalled in phantom measurements of spatial dose distribution. Due to their small dimensions, they do not disturb the radiation field and allow obtaining good resolution. Therefore, understanding of luminescence processes in luminophors irradiated with heavy charged particles - protons are crucial for correct dose evaluation in at least two mentioned fields. Accordingly, properly understanding aspect such as proton dose/energy response or relative TL efficiency of the TL detectors are essential. Moreover, available data concerning this subject are not straightforward. Especially the efficiency of the most widely applied LiF:Mg,Ti to light ions (H and He with Linear Energy Transfer, LET < 5 keV/μm) relative to gamma-rays, may significantly exceed unity. However, many others show the efficiency close to unity or even lower. In order to resolve this issue and hence to increase dose measurements accuracy and reliability in two described fields, a systematic research investigations were started at the IFJ PAN.

The presentation will show the results of the proton measurements for TLDs (i.e. relative TL efficiency, proton dose/energy response) and variety other experimental factors which were studied. The measurements were realized exploiting three proton beam accelerators. Two of them at the Cyclotron Centre of Bronowice IFJ PAN (exploiting the 60 MeV proton beam of the AIC-144 cyclotron and 230 MeV proton beam from PROTEUS-230) as well as at the Helmholtz Zentrum Berlin using the 70 MeV proton beam.

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A RADIATION TOLERANT TOTAL IONIZING DOSE MONITOR MODULE (TIDMON) BASED ON COMBINED FLOATING GATE AND RADFETS SENSORS

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The efforts towards an improved resolution and accuracy of the TID measurements for the new online radiation monitor at CERN (RADMON) lead to the research and study of a new type of dosimeter sensor: the Floating Gate DOSimeter (FGDOS). The high resolution (~30 mrad) of this kind of sensor is advisable for the radiation monitoring in the tunnel of the LHC and its injector chains where the radiation levels are low and a high resolution is requested. A comparison with the well-known RadFet dosimeter is necessary and advisable in order to understand the favorable parameters of the FGDOS and its performances. With this in mind, we developed a radiation tolerant TID monitor (TIDMon) that can host up to four FGDOS and two RadFets. The sensors are positioned in a 5 cm diameter circle to improve the uniformity of the irradiation, especially when testing in collimated beams. The system is built in such a way that all the configurations of the FGDOS dosimeter, such as the injection voltage, the control gate bias and the type of FGDOS outputs, can be changed by the user remotely. This makes the TIDMon a convenient experimental setup board to scope all the potentiality of the FGDOS. The FGDOS embedded readout circuitry permits to convert the sensor internal current in a periodic signal which is read by a FPGA. For what concerns the RadFets, its voltage threshold shift is measured by injecting a current in the sensor and reading out the source-drain potential. Also for the RadFet several parameters can be set by the user, for example, the gate biasing potential and the gain on the output voltage. The board is provided with a PT100 temperature sensor placed underneath the sensors. Temperature reading is necessary for the temperature compensation of the RadFets and Floating gate, but also for a direct comparison with the temperature sensor embedded in the FGDOS.

In order to extent its TID lifetime, the embedded electronics for the read out is kept few cm far away from the sensors, but still on the same board. Nonetheless, the radiation tolerance of the readout electronics is required when using the TIDMon in experimental facilities, such as a mixed radiation field or a ^{60}Co source, where the beam is not collimated, and thus, the entire board is irradiated. Therefore, TIDMon is based on selected and qualified COTS components, which can stand up to 20 krad.

The TIDMon will be first tested in a ^{60}Co gamma source and then in a mixed radiation field such as the one of the CHARM facility at CERN. The results of the RadFets and FGDOS will be analyzed and compared in both the irradiation campaigns.

SPATIAL DISTRIBUTION OF NATURAL RADIONUCLIDES IN SOIL, SEDIMENT AND WATERS IN OIL PRODUCING AREAS IN NIGER DELTA REGION OF NIGERIA

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Activity concentrations of natural radionuclides (^{226}Ra, ^{232}Th and ^{40}K) in the soil, sediment and water of oil producing communities in Delta and Rivers States were determined using γ-ray spectrometry. The mean soil/sediment activity concentration of ^{226}Ra, ^{232}Th and ^{40}K in onshore west in Delta state is 40.2±5.1Bqkg^{-1}, 29.9±4.2Bqkg^{-1} and 361.5±20.0Bqkg^{-1} respectively, the corresponding values obtained in onshore east1 of Rivers state is 20.9±2.8Bqkg^{-1}, 19.4±2.5Bqkg^{-1}and 260.0±14.1Bqkg^{-1} respectively. While the mean activity concentration of ^{226}Ra, ^{232}Th and ^{40}K in onshore east 2 of Rivers state is 29.3±3.5Bqkg^{-1}, 21.6±2.6Bqkg^{-1} and 262.1±14.6Bqkg^{-1} respectively. These values obtained showed enhanced NORMs but are well within the world range. All the radiation hazard indices examined in soil have mean values lower than their maximum permissible limits. In drinking water, the obtained average values of^{226}Ra, ^{228}Ra and ^{40}K is 8.4±0.9, 7.3±0.7 and 29.9±2.6Bql^{-1} respectively for well water, 4.5±0.6, 5.1±0.4 and 20.9±2.0Bql^{-1} respectively for borehole water and 11.3±1.2, 8.5±0.7 and 32.4±3.7Bql^{-1} respectively for river water in onshore west. For onshore east1, average activity concentration of ^{226}Ra, ^{228}Ra and ^{40}K is 8.3±1.0, 8.6±1.1 and 39.6±3.3Bql^{-1} respectively for well water, 3.8±0.8, 4.9±0.6 and 35.7±4.1Bql^{-1} respectively for borehole water and 5.5±0.8, 5.4±0.7 and 36.9±3.8Bql^{-1}respectively for river water. While in onshore east2 average value of ^{226}Ra, ^{228}Ra and ^{40}K is 10.1±1.1, 8.3±1.0 and 50.0±3.9Bql^{-1} respectively for well water, 4.7±0.9, 4.0±0.4 and 28.8±3.0Bql^{-1} respectively for borehole water and 7.7±0.9, 6.1±0.8 and 27.1±2.9Bql^{-1} respectively for river water and the average activity concentrations in the produced water^{226}Ra, ^{228}Ra and ^{40}K is 5.18±2.14Bql^{-1}, 6.04±2.48Bql^{-1} and 48.78±13.67Bql^{-1} respectively. These values obtained are well above world average values of 1.0, 0.1 and 10Bql^{-1} for ^{226}Ra, ^{228}Ra and ^{40}K respectively. The overall results show that soil and sediment in the area are safe radiologically but the result indicates some level of water pollution in the studied area.

Keywords: Radioactivity, soil, sediment and water, Niger Delta, Gamma detector

$LiMgPO_4$ HIGH-SENSITIVE OSL DOSIMETERS PREPARED BY MICRO PULLING DOWN CRYSTAL GROWTH TECHNIQUE

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The most widespread methods of radiation dosimetry are those based on stimulated luminescence phenomena. Probably, the most common is still thermoluminescence (TL), but recently, optically stimulated luminescence (OSL) becomes more and more widely applied technique. However, the number of available OSL materials is quite limited, what stimulates efforts for seeking new dosimetric materials, usually in the form of complex oxides crystals.

The dynamic development of researches on materials dedicated for OSL measurements is dictated by the fact that only one luminescent material, Al_2O_3: C, is currently used in this field. There is a lack of alternative OSL materials. However, in recent years, the works indicating high OSL sensitivity of $LiMgPO_4$ (LMP) compound have been published. This material gained popularity thanks to its characteristics, which are suitable for personal dosimetry applications [1], dosimetry of high radiation doses, in kGy range [2], as well as for real time dosimetry [3]. The neutron dosimetry also constitutes a potential field of application, because of the content of lithium, which has a relatively high cross section for thermal neutron capture. The material exhibits high OSL sensitivity, when activated with terbium and boron, but its TL sensitivity is much lower, as compared to the compound activated with terbium only. The important advantage of this material, in comparison to the commonly used in dosimetry LiF-based detectors, is its dose-response characteristic, which is linear up to about 1 kGy.

Within this work, $LiMgPO_4$ crystals were grown by micro pulling down technique. It was probably the first ever attempt to produce LMP crystals by this method. The as-grown crystals were cut into smaller pieces and irradiated with different b-particle doses. TL and OSL spectra were measured with the automatic Risø TL/OSL-DA-20 reader under the different modes of stimulation. The dose-response dependence, reproducibility, the lowest measurable dose and short-time fading were investigated. The OSL dose-response was found to be linear up to around 1 kGy, what makes this material suitable for high dose measurements. Discrepancies between successive measurements did not exceed 10 %. The lowest measurable dose, defined as three standard deviations from the signal of unexposed detector, was determined around 0.5 mGy. About 73% of the initial signal value was measured after 24 hours from the irradiation. For longer periods of time the level of signal stabilizes so that there was no further loss of signal observed. The obtained results tend to suggest that $LiMgPO_4$ crystals may be considered as promising dosimeters for both personal and high dose dosimetry.

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NATURAL RADIATION LEVELS IN THE GRANITIC AREAS OF THE WESTERN ANATOLIA/TURKEY: A CASE STUDY FROM ÇATALDAĞ GRANITOID PLUTON

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A radiological survey of the granitoid areas throughout the Western Anatolia were conducted during 2007-2014. As a part of this radiological survey, this paper presents results obtained from Çataldağ pluton which lies on the northeastern of the Western Anatolia. In the investigated area, the activity measurements of the natural gamma-emitting radionuclides (^{226}Ra, ^{232}Th and ^{40}K) in the granitic rock samples and soils have been carried out by means of NaI(Tl) gamma-ray spectrometry system. The activity concentrations of the relevant natural radionuclides in the granite samples appeared in the ranges as follows: ^{226}Ra was 21-115 Bq kg^{-1}; ^{232}Th, 14-103 Bq kg^{-1} and; ^{40}K, 450-1194 Bq kg^{-1} while the typical ranges of the ^{226}Ra, ^{232}Th and ^{40}K activities in the soil samples are found to be 4-130 Bq kg^{-1}, 5-114 Bq kg^{-1} and 54-1279 Bq kg^{-1}, respectively. Based on the available data, the radiation hazard parameters associated with the surveyed rocks/soils are calculated. The corresponding absorbed dose rates in air from all those radionuclides were always much lower than 200 nGy h^{-1} and did not exceed the typical range of worldwide average values noticed in the UNSCEAR (2000) report. Furthermore, the data are also used for the mapping of the surface soil activity of natural radionuclides and the corresponding gamma dose rates of the surveyed area.

HIGH-VOLUME AEROSOL SAMPLERS FOR MONITORING SURFACE AIR RADIOACTIVITY

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There are six surface air sampling stations In Moscow. They are in different areas - industrial, residential and park. Two types of sampling stations of surface air (Typhoon 4 and Typhoon 5) are used. There flow rates are 1,000 and 3,000 cubic meters per hour, respectively. Petryanov tissue filter material (FPP-15-1,5) is used. Comparison of Typhoon 5 with U.S. PM 10 sampler showed good agreement of Be-7 and Pb-210 volumetric activity measurements. Usually in the lower atmosphere of Moscow, we register the following background volume concentrations of radionuclides: A (7Be) = n · 10-3 Bq/m3; A (22Na) = n · 10-7 Bq/m3; A (40K) = n · 10-5 Bq/m3; A(-137Cs) = n · 10 -7 Bq/m3; A (210Pb) = n · 10-4 Bq/m3; A (226Ra) = n · 10-7 Bq/m3; A (232Th) = n · 10-7 Bq/m3, where n = 1 ÷ 10. As a result of the accident at the “Fukushima” nuclear power plant, caused by an earthquake, there were releases radioactive substances into the environment. Many countries reported on the flow of radioactive aerosols from Japan and the contamination of the environment, as well as food. Intake of radioactive aerosols in Moscow was registered at radiation monitoring stations of SIA “RADON”, march 23, 2011. The maximum value of volume concentration was observed on April 4-5 and reached 2,7· 10-3 Bq/m3 and 6,8·10-4Bq/m3 for 131I and 137Cs, respectively. The activity ratio of 131I aerosol form to gas form (3,3) was obtained by comparing the Petryanov aerosol filter and coal-silver filter. The 131I fallout have been defined by high–walled stainless steel pot. Since the activity ratio of 137Cs to 134Cs is an important parameter characterizing the source of radioactivity, we have determined this value (1,4). Classifying of radioactive aerosols by particle sizes was carried out using the filters pack technique. Layers of filter pack are made of filters with different resistance. It was assumed that the size distribution is described by a lognormal law. Results of determination of AMAD for different radionuclides of cesium are close to one another. It shows the correct sizing. AMAD for iodine slightly lower, probably due to the presence of gaseous forms of iodine and, possibly, the influence of sorption - desorption processes.

ANGULAR VARIATION OF THE DOSE EQUIVALENT RATES IN REFERENCE BETA RADIATION FIELDS: MEASUREMENTS WITH AN EXTRAPOLATION CHAMBER AND RADIOCHROMIC FILM

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The International Organization for Standardization recommended reference beta radiation fields for calibrating and determining the energy response of dosimeters used for radiation protection purpose. The Beta Secondary Standard 2 (BSS 2) is a beta source system that provides radiation fields with certified values of absorbed dose to tissue and the derived operational quantities for area and personal monitoring: the personal and the directional dose equivalents in 0.07 mm depth, Hp(0.07) and H'(0.07), respectively. As part of the characterization of the BSS2 in the Calibration Laboratory in Belo Horizonte, Brazil, a 23392 model PTW extrapolation chamber was used to study the angular variation of the dose equivalent rates in the $^{90}Sr/^{90}Y$ and ^{85}Kr beta radiation fields. Measurements were done at 20, 30 or 50 cm source-detector distances at incidence angles from -60^{o} to 60^{o} with 5^{o} increments. Ionization currents were corrected to the reference ambient conditions, the polarity effect, the leakage current and the true-null electrode spacing of the chamber; beam transmission factors to 0.07 mm tissue were also considered. Angular variation factors were calculated by the ratio between the corrected ionization current at normal and at each incidence angle of the beam. Angular variation of the dose equivalent rate was also determined with Gafchromic radiochromic films positioned on a 5 cm PMMA slab phantom. Results showed that there is an asymmetry, probably caused by misalignment of the radiation field. The angular correction factors determined by the extrapolation chamber showed discrepancies from the certificate values from -2.4% to 5.0% for $^{90}Sr/^{90}Y$ and 2.0% for the ^{85}Kr. Differences between the angular variation factors determined by the extrapolation chamber and the radiochromic film suggested that some correction factors that are dependent of the beam incidence angle should be determined and applied to the chamber measurements. This work stressed the need to determine the correction factors of the actual radiation field in the Calibration Laboratory instead of adopting recommended values.

LONG-TERM STABILITY OF RADIOTHERAPY DOSIMETERS CALIBRATED AT THE POLISH SECONDARY STANDARD DOSIMETRY LABORATORY

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Unidos 10001, Unidos E (10008/10009) and Dose 1 electrometers from 14 radiotherapy centres were calibrated 3-4 times over a long period of time, together with Farmer type (PTW 30001, 30013, Nuclear Enterprises FC65G and Scanditronix-Wellhofer 2571) cylindrical ionization chambers and plane-parallel Markus type chambers (PTW 23343 and Scanditronix-Wellhofer PPC05). The longterm stability of a charge reading and a calibration factor was examined over a long period of time for each electrometer and chamber, respectively. All measurements were carried out at the same laboratory, by the same staff, according to the same IAEA recommendations. On the basis of the long period of repetitive establishing correction coefficients for nonlinearity and calibration coefficients for the same electrometers and ionization chambers, a good long term stability of the dosimeters used in Polish radiotherapy centres was observed. These values were within 0.1% for electrometers and 0.3% for the chambers. Furthermore, these values were not observed to vary over time. The observations confirm the opinion that the requirement of calibration of the dosimeters more often than every 2 years is not justified.

AEROSOL CONTAINING NATURAL RADIONUCLIDES IN ZIRCON INDUSTRY

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Zircon is one of popular materials to make the products such as refractory block and welding flux. Zircon is well used due to good heat endurance. However zircon contains naturally occurring radioactive materials. Many kinds of manufacturers deal with zircon to make products. Therefore, the workers in the plants are subjected to radiation exposure. However, radiation doses to workers resulting from chronic inhalation of radionuclide-containing airborne particulates have not been adequately addressed. Recently Natural Radiation Safety Management Act became effective in Korea for protection against ionizing radiation from minerals, raw materials, byproducts, etc. Radiation dose due to the inhalation of aerosols containing natural radionuclides depends on aerosol properties, including aerosol size, concentration, shape, density, and radioactivity. The objective of this study is to characterize the aerosols in the zircon industry for internal dose assessment. Eight-stage cascade impactor was employed to sample aerosols at various processing areas in three zircon companies. The samples were used for characterization of aerosol concentration in the air, size distribution, and shape analysis. Aerodynamic diameters of airborne particulates ranged 0.03 - 100 μm with the highest concentration at the particle size range of 4.7 - 5.8 μm or 5.8 - 9.0 μm. Aerosol concentrations in the air varied widely depending on processing area, ranging 0.001 - 10 μg/L. The aerosols appeared as spheroids or rough spherical fragments across most sampling areas and sampled size intervals, but some aerosol samples showed cylindrical shapes from some sampling points. Radioactivity concentrations of Ra-226 and Ra-228 were 1,800 - 4,000 Bq/kg and 430 - 620 Bq/kg for zircons (zircon sand and zircon silicate), 120 - 160 Bq/kg and 22 Bq/kg for dusts from the dust chambers, and about 1200 Bq/kg and 120 Bq/kg for refractory blocks. The aerosol densities were 4.3 – 5.7 g/cm^{3}for the zircons, 2.8 – 3.3 g/cm^3 for the dusts, and about 2.8 g/cm^3 for refractory blocks. The database established in this study can be used for the accurate dose assessment of workers due to inhalation of aerosols containing NORM. Moreover, this data will be implemented to develop safety standards and guidelines to manage NORM industry.

GAMMA RADIATION INDUCED EFFECTS ON ELECTRICAL PROPERTIES OF PURE TeO_2 AND $(TeO_2)_{0.8}(In_2O_3)_{0.2}$ THIN FILMS

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In the present work, we have studied the changes in electrical properties of metal oxide thin films of pure TeO_2 and $(TeO_2)_{0.8}(In_2O_3)_{0.2}$ under the influence of gamma radiation. Thin films of thickness 250 nm were prepared by thermal evaporation method. In order to understand the energy dependence of changes in electrical properties, current versus voltage characteristics before and after gamma irradiation were studied at different gamma doses using disc type 60Co and 137Cs gamma radiation sources. Subsequently, the variations of the current density with the gamma dose have been obtained at different applied voltages. It has been found that the current density increases near linearly with the gamma radiation dose up to a certain gamma dose and decreases thereafter. The changes were found to be severe for higher gamma energies. The sensitivities of TeO_2 thin films were found to be in the range of 0.145 - 6.40 nA/cm2/μGy and for $(TeO_2)_{0.8}/(In_2O_3)_{0.2}$ the sensitivity ranges from 1.11 to 2.62 nA/cm2/μGy. The observed results clearly indicate the use of these metal oxide thin films in real time gamma radiation dosimetry and sensing.

INDOOR RADON CONCENTRATIONS IN RUFAA AND AL-HASAHISA TOWNS IN THE CENTRAL PART OF SUDAN

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Indoor radon was systematically surveyed in the towns of Rufaa and Al Hasahisa in the central part of Sudan. The radon concentrations were measured in 276 measurements, using CR-39 etched track detectors. The radon concentration in the corresponding towns was found to vary from (86 ± 10) Bqm^{-3} in Al-Hasahisa to (66 ± 8) Bqm^{-3} in Rufaa, with an average of (76 ± 9)Bqm^{-3}. Assuming an indoor occupancy factor of 0.8 and 0.4 for the equilibrium factor of radon indoors, we found that the effective dose rate from ^{222}Rn in the studied towns ranges from (2.18 ± 0.26) to (1.67 ± 0.20) mSv per year and the relative lung cancer risk (RRLC) for radon exposure was 1.078 to 1.059% in Al Hasahisa and Rufaa towns respectively.

The recorded values of indoor radon concentration in this study are much lower than the radon action level as recommended by ICRP-1993, lower than the new reference level set by WHO and below the action level recommended by the Environmental Protection Agency (EPA). The values of the radon effective dose rate in this survey are slightly larger than the “normal” back ground level as quoted by UNSCEAR-2000, but way below even the lower limit of the recommended action level as reported by the ICRP-1993. The reported values of RRLC are almost negligible.

STUDY OF SAMPLE MATRIX INFLUENCE ON HPGe DETECTION EFFICIENCY BY MONTE-CARLO SIMULATIONS

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Gamma spectroscopy is the most frequently used technique for radionuclide identification. Precise determination of full-energy peak efficiency curve for specific sample matrix presents one of the major challenges in gamma spectroscopy. Detector efficiency curve doesn't depend only on characteristics of the detection system, but also on sample geometry and matrix. In addition, efficiency depends on several factors such as the energy of incident gamma rays and other effects like coincidence summing and self-absorption.

Gamma spectroscopy measurements performed for environmental monitoring purposes, imply the use of large number of different samples with low activity concentrations of natural radionuclides.

Efficiency curve can be determined experimentally via reference sources with known activity concentrations of radionuclides, which cover the gamma energy range of interest. Reference sources should have characteristics as close to the analyzed samples as possible, in terms of geometry and matrix (density and composition).

In this paper, we will determine full-energy peak efficiency (for 60-1800 keV energy range) for coaxial HPGe detector both experimentally and using Monte-Carlo simulations. We will then compare experimental and simulated efficiency curves obtained for reference standard of cylindrical geometry.

Furthermore, by Monte-Carlo simulations, detection efficiency for six voluminous samples with different matrices, also in cylindrical geometry, will be derived. The analysis of sample matrix influence on HPGe detection efficiency will be done by comparison of obtained Monte-Carlo simulation results.

BACKGROUND IN A TEST OF DETECTING COOPERATIVE PARAPOSITRONIUM ANNIHILATION BY THE 32-CRYSTAL SPECTROMETER ARGUS

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Parapositronium – a singlet positronium ground state, has the total angular momentum of electron and positron forming the atom $J_s = 0$, magnetic quantum moment m = 0, and its annihilation spectrum is dominantly created by the 511 keV discrete photons. A process of cooperative emission of annihilation photons (*cooperative* annihilation) by a system of positronium atoms, i.e., annihilation superradiance, had been considered by other researchers, and the theory of annihilation superradiance in a system of parapositronium atoms for two-photon annihilation was constructed (two interacting parapositronium atoms; emission of the 1022 keV photons flying apart at an angle of 180°). The 32-crystal spectrometer ARGUS, with 16 detector pairs at an angle of 180° capable of registering double gamma coincidences, with lead collimators (80 mm in diameter) mounted on each detector – was used to test the phenomenon. Parapositronium annihilation spectra were acquired using ^{22}Na ($A = 4\times10^5$Bq) as a positron source, and SiO_2 (as "positronium forming" medium; probability: 32 %), as well as Al (as „positronium not forming" target) used as a blank – for estimation of the background events. In the case when after emission of two starting positrons from ^{22}Na (i.e., the 1275 keV nuclear photons) coincident registration (respecting the spectrometer time resolution) of four annihilation photons should be considered as a six-fold coincidence event, experimentally obtained counting rates were – 0.25 s^{-1} (SiO_2) and 0.23 s^{-1} (Al), while theoretically predicted – 0.34 s^{-1}. The main background process competitive to a registration of the parapositronium cooperative annihilation is four-fold coincidence event (the two 180° detectors register 1275 keV photons, and two – summing of the 511 keV annihilation photons), with experimental counting rates – 0.026 s^{-1}(SiO_2) and 0.023 s^{-1} (Al), as theoretically predicted – 0.023 s^{-1}. On the other hand, cooperative annihilation should be a four-fold coincidence event (the two 180° detectors register 1275 keV photons, and two – 1022 keV photons), which has not been registered by the ARGUS spectrometer (theoretically predicted counting rate – 1.7×10^{-5} s^{-1}). The analyses showed that probability of detecting the parapositronium cooperative annihilation will increase significantly with increasing positron source activity, but also with decreasing diameter of lead collimators.

BUILD-UP PMMA PLATE EFFECT ON CALIBRATION OF TLD READER

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The routine monitoring of the occupationally exposed individuals constitutes an integral part of radiation protection program implemented at the Vinca Institute of Nuclear Sciences (INNV). The Individual monitoring service (IMS) at the INNV, accredited according to quality standard EN ISO/IEC 17025, for monitoring workers is using Harshaw 6600 Plus automatic reader and thermoluminescent dosimeters (TLD) from two manufacturers (Harshaw, RadPro international GmbH). Working procedures are implemented according to Technical Recommendations for Monitoring Individuals Occupationally Exposed to External Radiation, RP 160 (European Commission, 2009). Among general consideration, RP 160 is suggesting that routine calibration of dosimetry system should be performed taking into consideration secondary charged particle equilibrium. As TLD system in use at IMS INNV comprises of TLD reader and of TLD cards, this consideration should be applied in both cases: when the reader and the TLD cards are being calibrated. During reader calibration, secondary charged particle equilibrium can be ensured using build-up PMMA plate of certain thickness placed in front of dosimeters.

In this paper, influence of the build-up plate on reader calibration is being analyzed. This influence is observed through changes in reader calibration factor (RCF). RCF values obtained during reader calibration procedure with and without 2 mm thick build-up plate are presented. Exposures of whole body TLDs placed on slab phantom were done with 137Cs radiation source located at Secondary Standard Dosimetry Laboratory (SSDL) at INNV. TLDs from both manufacturers had 2 detectors for measuring the dose equivalent at the depths of 10 mm and 0.07 mm. TLD reader was calibrated to measure effective dose in terms of Hp(10) and local skin dose in terms of Hp(0.07). RCF values for detectors measuring Hp(10), from both manufacturers, when irradiating without the plate were around 5% higher than RCF values obtained when irradiations were done with the plate. Values of RCFs for detectors measuring Hp(0.07) were around 1% higher when the plate had not been used. As RCF value is inversely proportional to measured dose, reader calibration without build-up plate, in terms of Hp(10), would lead to underestimated dose values. The observed RCF deviation of Hp(0.07) detector is regarded as consequence of exposure conditions uncertainties. In conclusion, if a constant geometry and constant operational conditions of TLDs are achieved, the only part of the TLD system that is not stable for a long time period is the TLD reader. To avoid inaccurate results, RCF should be orderly checked and reader calibration should be done according to widely accepted standards, currently in effect.

THERMOLUMINESCENCE MEASUREMENTS OF MIXED RADIATION FIELD AT THE PROTON CYCLOTRON FACILITIES AND EXPERIMENTAL HALL OF THE CYCLOTRON CENTRE BRONOWICE

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LiF-based TL detectors are widely used for dosimetry in the range of doses from a few micrograys up to several kilograys, also at mixed radiation fields [1,2]. Based on the newly discovered behaviour of LiF:Mg,Cu,P detectors at high and ultra-high doses, a new method of TL measurement of radiation doses ranging from micrograys up to a megagray, has been recently developed at the IFJ [3]. Furthermore, LiF detectors containing ^{6}Li are sensitive to slow neutrons; their response to these neutrons is suppressed by using ^{7}Li-enriched lithium. Pairs ^{6}LiF/^{7}LiF detectors allow distinguishing between neutron/non-neutron components of radiation field.

The Proteus C-235 cyclotron at the Cyclotron Centre Bronowice of the IFJ is now a source of protons for nuclear physics, medical physics, material science and radiobiology, and in the near future, also for radiation therapy of cancer. The device is equipped with energy degrader and selector (ESS) that allows to bring adjustable beam energy in the range of 70 MeV to 230 MeV. Accelerator and experimental halls are located in the bunker with thick walls and ceiling of 3-4 m, which provides the human-shield and the environment protection against ionizing radiation.

The last year TL measurements' results (which are in the process of publishing) has shown wide air kerma gradients in the Cyclotron Hall, especially around the ESS, during the operation of the machine. In this study four types of LiF-based TL detectors were used to measure spatial dose distributions from a mixed radiation field at the Cyclotron Hall, this time with emphasize to ESS surroundings and the Experimental Hall during operation of the machine. The response of: standard LiF:Mg,Ti (MTS-N) and ^{7}LiF:Mg,Ti (MTS-^{7}), equivalent to TLD-100 and TLD-700 respectively, and high-sensitive LiF:Mg,Cu,P (MCP-N) and ^{7}LiF:Mg,Cu,P (MCP-7), equivalent to TLD-100H, TLD-700H, respectively, was investigated. All detectors were produced at the Institute of Nuclear Physics (IFJ), Kraków.

The experiment confirmed the effectiveness of the TL detectors in the mixed radiation field measurements and validated suitability of different TLD types for dosimetry of the mixed radiation at our Cyclotron Centre. Through the use of detectors based on natural lithium, containing 7.59 atomic percent abundance of Li-6 isotope, and Li-7 enriched detectors, it was possible to separate neutron and non-neutron components of the radiation field. Comprehensive results of these studies will be presented during the conference.

Acknowledgements: This work was partly supported by a research project from the National Science Centre, Poland (Contract No. 2013/09/D/ST2/03718).

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RADON IN WORKPLACES IN KHARTOUM TOWN, CAPITAL OF SUDAN

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The main objective of this study is to assess the health hazards due to radon gas accumulation and to compare the concentrations in different kinds of workplaces. However, a typical person spends about one-third of the day at their workplace. A survey was made of radon levels in workplaces in Khartoum, the capital of Sudan. For this purpose, a number of 231 measurements were performed in Pharmacies, Schools, Restaurants, Health Care Centers, Offices, Shops, Libraries and Internet coffee shops using CR-39 solid state nuclear track detectors (SSNTD).

Results show that the mean radon concentrations ranged from (33 ± 8) Bqm^{-3} in Health Care Centers to (84 ± 13) Bqm^{-3} in Restaurants, the overall average of concentrations was recorded to be (54 ± 10) Bqm^{-3}. The effective dose from ^{222}Rn in workplaces ranges from (0.84 ± 0.21) in Health Care Centers to (2.11 ± 0.32) Restaurants with an average of (1.35 ± 0.24) mSv per year . The relative lung cancer risk for radon exposure in all workplaces was found to be 1.048 %.

These results indicated the importance of performing this type of measurement because the exposure of workers can reach high values in some workplaces.

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GEANT4-BASED HADRON INTERACTION OPTIMIZATION FRAMEWORK

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Hadron therapy is an external beam radiotherapy for oncology radiation treatment. The main advantage of hadron therapy is essential physical properties of such particles. On the other hand there are lots of challenges while implementing and using such particles in real treatment case.

Geant4 is a simulation framework is a platform for "the simulation of the passage of particles through matter," using Monte Carlo methods. The key issue is that the usage of this platform cannot be done as black-box without understanding how the specific physic model works and the choose of appropriate model is up to user based on his own experience.

In this study we present our framework for testing and easy switching between different physical models without program recompilation. The framework contains Python-based GUI for choosing physical models and several running options and C++ classes with boost library for Geant4 for switching physical models at runtime. There are also several functions as saving internal states and continuation run of Geant4-based program, finishing program by time or when the necessary relative error at detector reached and some other functions which may be useful in practice.

The framework was used during experimental study on neutron beam facility with neutron generator NG-24 14.5±1 MeV performed at MRRC, Obninsk, Russia. It allows us to optimize simulation tasks, e.g. assess absorbed dose at tissue-equivalent target with and without proton equilibrium as well as turn off some unnecessary interactions for this task. We conclude that it is sufficient to use G4HadronElastic model for elastic neutron reaction for all energies, G4BinaryCascade for 0-10 MeV and G4INCLXXInterface for >10 MeV for inelastic neutron reaction while all the other particles are handled with only electromagnetic physics G4EmLivermore/G4EmStandart_option3. The usage of HP package is redundant for this tasks. The simulation results are in good agreement comparing with relevant data and the resulted speed-up of simulation is 40% faster comparing to standard FTFP_BERT/QGSP_BIX model and up to 4 times comparing to *HP models.

Now we focused on experiments with carbon ion beam where the usage of such optimization framework may be very useful.

STABILITY OF IONIC CENTERS AND RELAXATION DYNAMICS IN IRRADIATED "ICES"

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The interaction of ionizing radiation with frozen gases, so called "ices", is of considerable interest in many, quite diverse fields, including condensed matter physics and chemistry, material and surface sciences, dosimetry and astrophysics. Irradiation of ices results in creation of lattice defects, charged centers, formation of reactive atoms and fragments, desorption of atoms, ions and molecules from the surface, a considerable amount of information about the radiation-induced processes can be gained by recording luminescence spectra of the solid during irradiation and by applying activation spectroscopy (AS) methods.

The presentation covers our recent findings in the field of radiation effects in ices with a focus on the stability of ionic centers and relaxation paths in an electron bombarded noble-gas solids doped with N_2 and solid N_2. The study is an extension of our systematic research on the subject [1]. For the purpose we employed the combination of cathodoluminescence (CL) spectroscopy with current and optical AS. Three relaxation emissions were monitored simultaneously upon controlled warming-up of the pre-irradiated ices: thermally stimulated exoelectron emission (TSEE), thermally stimulated luminescence (TSL) in visible, NUV and VUV ranges and the total desorption yield by pressure measuring above the sample.

Recording the luminescence spectra sequences on exposure time enabled us to keep track of the beam-induced modification of the ices. It was shown that the reactions of charged species dominate at low temperatures. Reactions of neutrals start at the later stage of relaxation and initiate relaxation cascades via radiation mechanism [2]. The limits of thermostability of ionic centers were found to be conditioned by the energy spectrum of trap levels. It was shown that the mobile electrons are key particles driving the relaxation processes in pre-irradiated ices. Spectroscopic evidences of neutralization reactions via the dissociative recombination of molecular ions Ne_2^+ and N_4^+ were obtained for the first time.

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COMPARISON OF NANODOSIMETRIC PARAMETERS OBTAINED WITH THE MONTE CARLO CODES PARTRAC, PTra AND GEANT4-DNA

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The nanoscopic pattern of ionising radiation (IR) has long been related to the spatial and temporal distribution of DNA damage and the biological effectiveness of IR. Monte Carlo simulation of this pattern, called track structure, is a crucial tool for estimating nanodosimetric quantities that are not directly measurable in biological tissues. This work compares nanodosimetric parameters of track structure (NPTS) obtained by using the Monte Carlo track structure codes PARTRAC [1], PTra [2] and Geant4-DNA [3].

Two simplified target geometries were used to calculate NTPS: a liquid-water cylinder of 2.3 nm diameter and 3.4 nm length, representing a 10-base-pair DNA segment, and a liquid-water cylinder of 6 nm diameter and 10 nm length, representing a nucleosome. The comparison of the three codes was performed for incident electrons with energies ranging from 20 eV to 1000 eV, protons of energies between 3 MeV and 10 MeV, and alpha particles with incident energies of 8 MeV, 10 MeV and 20 MeV. The radiation field was simulated as a monoenergetic pencil beam, incident on the surface of the liquid-water cylinders and placed at half of the cylinders' height. The ion beam energies were matched to those used for cell irradiations performed at the PTB ion microbeam facility as part of the BioQuaRT project [4].

In nanodosimetry, the physical features of charged particles passing or penetrating a given target volume at a given or random distance are described by probability distributions of the number of ionisations produced within the volume, referred to as the ionisation cluster size ν. This probability distribution, which characterises the radiation quality Q associated with the particle track, also depends on the geometry and orientation of the target volume. In this work, these probability distributions and their statistical moments, such as the mean ionisation cluster size $M_1(Q)$, were compared for all three codes. The results generally showed a good agreement between the codes for all particle types and energies. An exception was found for incident electrons with energies below 150 eV, where results obtained with PTra deviated from those of the PARTRAC and Geant4-DNA codes.

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MEASUREMENT OF THE STOPPING POWER FOR CARBON IONS IN WATER USING INVERTED DOPPLER SHIFT ATTENUATION

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Due to its locally well-confined dose distribution, carbon ion cancer treatment has gained interest during the last decades. The most important region is where the so-called Bragg peak is formed within the tissue. In this region, the stopping power for the carbon reaches the maximal value. For treatment planning and clinical dosimetry in carbon ion therapy, the stopping power of water for carbon ions is the key quantity, since tissue comprises mostly of water.

However, experimental data does not exist for the stopping power of water in the liquid phase for carbon ions with energies in the highly important region where the maximum stopping power occurs. In this energy range, the carbon ion velocity is comparable to those of the valence electrons of the traversed medium. Therefore, determination of the stopping power by theoretical models, which are based on the mean ionization potential and the effective projectile charge, is subject to large uncertainties. Stopping power data presently used in clinical practice are derived from measurements in water vapor or D_2O ice and disregard phase effects.

In view of these facts, a project has been launched at the PTB to measure the stopping power of liquid water for carbon ions in the energy region of the maximum stopping power. The measurement is carried out by using the inverted Doppler shift attenuation method. In this method, excited carbon nuclei are produced by means of the nuclear reaction $^{12}C(\alpha,\alpha')^{12}C^{*}$. The energies of the gamma quanta emitted by the excited carbon projectiles during their slowing-down in water are shifted to higher energies according to the Doppler effect. The stopping power of water for carbon ions can then be determined by the comparison of the Doppler-shifted gamma energy spectrum in water to that obtained in vacuum.

A measurement for the feasibility study was carried out and provided encouraging results [1]. The experimental setup and the preliminary results of the feasibility study will be presented.

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CORRELATIVE AND PERIODOGRAM ANALYSIS OF DEPENDENCE OF CONTINUOUS GAMMA SPECTRUM IN THE SHALLOW UNDERGROUND LABORATORY ON COSMIC RAY AND CLIMATE VARIABLES

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The continuous gamma spectrum, Cosmic ray intensity and climate variables; atmospheric pressure, air temperature and humidity were continually measured in the Underground laboratory of Low Background Laboratory in the Institute of Physics Belgrade. Other climate variables used in the analysis; wind speed, precipitation and soil temperature are obtained from nearby meteorological station. The obtained gamma spectrum, measured using HPGe detector, is split into three energy ranges, low, intermediate and high ending with energy of 5MeV. For each of the energy intervals periodogram and correlative analysis is performed. The correlation analysis of dependence of continuous gamma spectrum on cosmic ray intensity and climate variables is performed. Periodogram analysis is done using Lomb-Scargle periodograms. The difference of linear correlation coefficients are shown and discussed, as well as the differences in resulting periodograms.

STUDIES OF THICK TARGET BREMSSTRAHLUNG SPECTRAL PHOTON DISTRIBUTIONS IN THE PHOTON ENERGY REGION OF 1-100 KEV FOR ^{90}Sr BETA PARTICLES

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Measurements of bremsstrahlung spectral photon distributions in thick targets of Al, Ti, Sn and Pb targets, produced by complete absorption of ^{90}Sr beta particles, are undertaken with Si(Li) detector in the photon energy region of 1- 100 keV. The experimentally measured bremsstrahlung spectra are compared with the theoretical results obtained from Elwert corrected non-relativistic Bethe Heitler (EBH), modified Elwert corrected relativistic Bethe Heitler (F_{mod}BH) theories for ordinary bremsstrahlung (OB) and Avdonina and Pratt theory (F_{mod}BH +PB), which includes the contributions of polarization bremsstrahlung (PB) alongwith the OB in the total bremsstrahlung (BS). In the low energy region, where the contributions of PB into BS are dominant, the present results indicate the correctness of FmodBH+PB theory, which is described in terms of stripped atom approximation (SAA). But at the middle and higher energy region of the bremsstrahlung spectrum, where the contribution of PB is negligible and the screening effects on OB are still important, the FmodBH theory is more close to the experimental results. Hence, the screening effects during the production of bremsstrahlung in the target material cannot be neglected while describing the bremsstrahlung spectrum in middle and high photon energy regions, as considered in case of SAA.

OPTICAL CHARACTERIZATION OF GAMMA-INDUCED METASTABILITY IN GLASSY ARSENIC TRISULPHIDE

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Radiation-induced metastability in chalcogenide glasses (ChG) deals with nature of defective states caused by destruction of existing bond arrangement following structural relaxation towards metastable state with new distribution of covalent chemical bonds. Destructed by high-energy gamma-irradiation covalent bonds can be renewed *intrinsically* via direct interaction of bond-constituting atoms with nearest neighbors forming a channel for *own (intrinsic) bond switching*, or *extrinsically* due to interaction with impurity chemical environment. In the first case, the diamagnetic pairs of over- and under-coordinated atoms possessing an excess of positive and negative electric charge (*charged defects*), respectively, appear in a glassy backbone. In the latter case, some kinds of impurity products can be formed preferentially at the surface of ChG, the most essential being induced by interaction with absorbed oxygen, which replace chalcogen in its bonding within glassy network. Thus, the *intrinsic radiation-induced effects* occur to be permanently admixed with *extrinsic impurity-related ones*, forming a complicated picture of competitive relaxation input in the overall balance of radiation-induced physical effects, where these channels cannot be well distinguished. Under such condition, the methodological route allowing unbiased observation of these channels has attained a vital importance, especially from viewpoint of practical implementation of induced functionality in a variety of ChG systems. In this work, we shall present an adequate methodological solution of this problem exemplified by high-dose gamma-induced effects in glassy g-As_2S_3.

Two types of experimental measuring protocols was utilized for study of gamma-induced optical effects in g-As_2S_3, these being realized in *direct* and *backward measuring chronology*. In the former, the optical transmission spectra were recorded ex-situ for the same glass sample taken in non-irradiated (just before irradiation) and gamma-irradiated (one month after irradiation) states. The second type of optical measurements was performed *in-situ*, recording optical transmission spectra for the same gamma-irradiated and further annealed sample. The smallest inaccuracies were shown to be provided within the latter measuring protocol owing to elimination of errors associated with (1) sample reinstallation in a spectrometer and (2) time separation between subsequent cycles of optical spectra recording for initial unirradiated and gamma-irradiated samples. As a result, the impacts of impurity-related and intrinsic γ-induced effects on the optical transmission spectra can be reasonably separated. It is shown that impurity-related radiation processes (connected mainly with surface oxidation) depresses optical transmission in near-band-gap region, while intrinsic ones (realized as defect formation) shifts optical absorption edge towards larger wavelengths.

UP-CONVERSION PROPERTIES OF NOVEL OXY-FLUORIDE PHOSPHORS BASED ON ER3+ -DOPED NANOGLASCERAMICS

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Development of high-techs claims production of stable, energy-conserving and eco-friendly equipment. One of such techniques in optics is based on the upconversion effect. The basic ideas on upconversion were generated more than 50 years ago in papers by N. Bloembergen and F. Auzel. Later, for several decades this process, which is actually an anti-Stokes type of radiation, was widely studied by many authors and had several important applications among which are shortwave lasers, various opto-electronic devices, biophosphors, etc. To date the interest to the phenomenon of upconversion has received a new impulse due to the synthesis of modern matrix elements that contain various nanocomposites.

Oxyfluoride glasses and based on them nanoceramics, that combine benefits of low-phonon energy of fluorides, chemical durability and mechanical stability of oxides, and high optical quality of silicate glasses are of special interest. In this paper transparent oxyfluoride silicate precursor glasses and glass ceramics with the novel composition SiO_2 - PbO - PbF_2 - Er_2O_3, SiO_2 - GeO_2 - PbO - PbF_2- Er_2O_3, SiO_2 -Al_2O_3 - Y_2O_3 - Na_2O - NaF - LiF - Er_2O_3 -YbF_3 doped with Er^{3+} and co-doped with Er^{3+}/Yb^{3+} ions were synthesized and investigated. Various structural and spectral analyses were done. X-ray diffraction analysis (XRD) and Er^{3+} absorption spectra revealed precipitation of PbF_2 nanocrystals dispersed in the glassy matrix. Under 980 nm laser excitation, intense green, red and near IR bands of upconversion luminescence (UCL) were recorded both before and after the heat treatment. Precursor glasses display themselves sufficient intense upconversion emission in green, red and near IR ranges of spectra. Dramatic rise of UCL intensity by factor of ~ 150 was recorded for glass ceramic. To our knowledge, for the first time the structural features of glass ceramics characterized by the small-angle neutron scattering (SANS) showed the cluster organization of PbF_2 nanocrystals. Obtained results may be implemented for enhancement of quantum efficiency of various UC-based devices.

Ge-As-Se CHALCOGENIDE GLASSES AS RADIATION-RESISTANT SENSING MATERIAL FOR FIBER-OPTICAL TEMPERATURE SENSORS

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Fiber-optical temperature sensors (FOTS) are known to be one of the most perspective sensing devices revealed a number of essential advantages over known counterparts, such as immunity to electromagnetic interference, lightweight, small size, high sensitivity, large bandwidth and simplicity in implementing multiplexed or distributed sensors, etc [1,2]. But despite achieved progress in the last years, the development of high-reliable FOTS of the fire alerter capable to work in the hazard radiation environment is an actual problem up to now.

It was shown recently that the most radiation resistant FOTS appear to be the semiconductor absorption sensor (but only in comparison with fluorescence and Fabry-Perot cavity sensors) [2]. This sensor contains a semiconductor crystal (temperature-sensitive functional element) like GaAs being put to the fiber tip and coated with a dielectric mirror. The main operation principle of this FOTS is grounded on a well-known temperature dependence of semiconductor band gap that changes the optical transparency of sensing element. However, operation of fire alerter based on this kind of FOTS in the hazard radiation conditions is limited by the radiation dose of few hundreds of kGy [2] because of accompanied radiation-induced structural damages that influences the optical properties too and distorts the real magnitude of pure temperature induced effect.

In this work we report on the fundamentals of practical design of the FOTS of thermal fire alerters based on semiconductor chalcogenide glass of the $Ge_{0.18}As_{0.18}Se_{0.64}$ composition that possess a wide operation temperature range as well as high time stability and irradiation resistance (up to the dose of few MGy) [3,4]. A signal response model is developed for the probe type fiber-optical temperature transducer and its characteristics have been analysed. It is shown that the temperature measurement sensitivity by means of arbitrary light intensity change registration is constant in the temperature range 25-90 ^{o}C and equal to 0.8%/^{o} for optimal parameters of sensing element and commercially available components. Advantages of proposed sensor used in thermal fire alerters are analyzed including combined ones as well as possible ways of its modification. In part, it is shown that owing to rather wide linearity range of transducer characteristics one can implement the lead temperature estimation in the next time instants using its change speed that allows potentially reducing the time of reaction after fire appearance for 4-7 min.

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INFLUENCE OF HIGH ENERGY IONIZING RADIATION ON SINGLE MODE OPTICAL FIBER PROPRIETIES

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The properties of single mode optical fibers change when they are exposed to high energy electron and photon beams. When the optical fiber is exposed to high energy ionizing radiation physical degradation occurs in the structure of the optical fiber. In order to quantify this effect the radiation induced attenuation has been measured. Measurements show a dependence of the radiation induced attenuation to the exposure dose. Radiation induced attenuation in the optic fiber was measured before, during and after electron beam exposure for two types of single mode optic fibers and for two wavelength values.

The results of the measurements have lead to the conclusion that these types of optical fiber can be used for measuring either high or low doses of irradiation.

DYNAMICS OF IRRADIATION: FROM MOLECULES TO NANO-OBJECTS AND FROM MATERIAL SCIENCE TO BIOLOGY

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We discuss microscopic mechanisms of irradiation in clusters and molecules. We consider the case of isolated molecules/clusters [1] and/or in contact with an environment [2]. We use Time Dependent Density Functional Theory (for electrons) coupled to Molecular Dynamics (for ions) and follow explicitly in time both irradiation and response of the system. Examples are taken from free metal clusters, from fullerenes, from molecules of biological interest and from clusters deposited on a surface or embedded in a matrix [2,3]. We analyse in particular the properties of emitted electrons (photo electron spectra, angular distributions...) which constitute a key tool of analysis of the properties of irradiated clusters and molecules [4,5]. We also discuss the possibility of pump and probe scenarios (opening the road to manipulation at the molecular scale) with help of dedicated laser pulses, exploring in particular very short times scales down towards the attosecond domain.

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DELAYED ELECTRON PHOTOEMISSION FROM NACL CAUSED BY ELECTRON-STIMULATED DESORPTION PROCESS

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It is well known that irradiation of a solid can cause not only some volume changes in the bulk (mainly by creations of various point defects) but also its decomposition. This desorption process, or, more adequately processes, are very fast (typically finalized within time shorter than 10-14 s) and are realized mainly by desorption of atoms or ions. Simultaneously, beside these effects, irradiation with electrons or photons is accompanying by prompt secondary emission of these particles. Secondary electrons are characterized by their kinetic energy distributions which extends from zero electronvolt up to kinetic energy of primary electrons which corresponds to electrons scattered elastically. Intensity of emission of true secondary electrons (with typical kinetic energy lower than several electronvolts) is determined not only by scattering processes but mainly by the value of work function (for metals) or electron affinity (in the case of semiconductors and insulators). Typically, for alkali halides the value of electron affinity is very low and sometimes can be even negative. In the case of NaCl structure the flat (100) surface of a crystal can be composed by positive or negative ions only, which can strongly influence on electron emission intensity.

In the experiments thin layer of NaCl deposited on Si(100) surface were periodically exposed to the sequence of two short (around 10 ns) electron beam pulses, first without and second with slightly delayed accompanying short light pulse. Using a time-of-flight spectrometer it is shown that according to the proceeding desorption process, and subsequent changes in the surface composition, delayed electron photoemission appear and disappear periodically.

RADIATION-INDUCED DESORPTION OF EXCITED MOLECULES FROM NITROGEN FILMS

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Radiation effects in solid N2 attract much attention in various fields of research including material and surface sciences, physics and chemistry of interstellar space and solar system, particle physics. Desorption or sputtering is among the most intensively studied radiation-induced phenomena. Electronic desorption of solid nitrogen was studied under excitation with electrons, ions and photons. Current state of the problem is given in [1]. Despite extensive studies mechanisms of electronic sputtering and the role of charged defect centers are still not well understood.

In the present work radiation effects in solid nitrogen irradiated with an electron beam were studied with emphasis on the role of charged centers in radiation-induced phenomena. Spectroscopic evidence of the excited N_2^* ($C^3\Pi_u$) molecule desorption was obtained for the first time and mechanism of the phenomenon based on recombination of electron with intrinsic charged center N_4^+ was proposed. The experiments were performed employing luminescence method and activation spectroscopy techniques – spectrally resolved thermally stimulated luminescence TSL and thermally stimulated exoelectron emission TSEE [2].

In the near UV range we registered the emission of second positive system – the transitions between C3Πu and B3Πg excited molecular states. The distinctive feature of this emission is the coincidence of the observed bands with those detected in the gas phase spectra. This feature suggests that nitrogen molecules N_2^* desorb in an excited state and emit light in the gas phase. Experiments on probing the samples in depth by the electron beam energy variation and experiments with thin films (< 100 nm) discriminating in such a way radiation-induced processes in the bulk and at the surface support this assignment. The study of relaxation emission – spectrally resolved TSL and TSEE enabled us to restore the desorption scenario and elucidate the role of charged defect centers. The dissociative recombination of N_4^+ with electron is suggested to be a key process underlying the desorption of electronically excited molecules.

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RADIATION EFFECTS IN BOROSILICATE RADIOACTIVE SLAG BEARING GLASSES

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Actinide-containing radioactive slags composed of major SiO_2, Al_2O_3, CaO, and FeO_x and minor Na_2O, K_2O, MgO, P_2O_5 needs to be converted to solid stable forms suitable for a long-term storage. Currently nuclear wastes are subject to vitrification with production of borosilicate glasses. The nature of paramagnetic defects in the radioactive slag bearing borosilicate glasses in the series (wt.%): x Slag oxides (SO), (100-x) $Na_2B_4O_7$ using electron paramagnetic resonance (EPR) was studied. The glasses were produced in a resistive furnace at a temperature of up to 1500 K and g-irradiated to an absorption dose of 100 kGy. EPR spectrum of the irradiated source $Na_2B_4O_7$ glass is typical of this formulation (four lines due to boron-oxygen hole center - BOHC). Incorporation of 20 wt.% SO transforms this spectrum into a single nearly symmetric line (g = 2.012, D = 4.6 mT) with unresolved hyperfine structure (HFS) due to magnetic B isotopes. At x=40 an additional response due supposedly to a center with axial symmetry ($g_{\varsigma(}$=2.014; $g_{\wedge}$=2.004) is overlapped with the line due to unresolved HFS. For the glass with x=60 the spectrum is similar while the spectrum for the glass with x=80 is markedly different.

The spectra of irradiated glasses with x =0 and x=20 recorded at 77 and 300 K are similar whereas they are different for the glasses with x=40, 60, and 80. This complex spectrum is due to superposition of the strong line of Fe(III) and several radiation-induced centers. Computer simulation of the spectrum of irradiated glass with x=80 exhibits overlapping of the lines due to nearly isotropic g factor (2.0036 ±0.0003) with partly resolved HFS due to BOHC with tetrahedrally coordinated boron, and axial symmetry singlet with $g_{\varsigma\varsigma}$= 2.014, $g_{\wedge}$= 2.005. Because this singlet is appeared in the spectra of irradiated high-slag glasses containing SiO_2 it may be assigned to silicon-oxygen hole center where the hole is located at SiO_4 tetrahedron with one or two bridging oxygen ions. Thus the structure of glasses with high slag content is built from the chains primarily formed by $SiO_{4/2}$ and $BO_{4/2}$tetrahedra bonding Me^+ and Me^{2+} ions including radioactive ^{137}Cs and ^{90}Sr isotopes thus strongly retaining them in the glass network and preventing their release to the environment.

IRRADIATION INFLUENCE ON THERMODYNAMIC PROPERTIES OF LIQUID SYSTEMS

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In order to describe the non-equilibrium processes ongoing in the liquid systems under the irradiation it is important to know thermodynamic and structural changes made to them. In our report we present an attempt to describe the influence of the irradiation on liquid systems within the formalism of statistical mechanics. To start with the BBGKI chain is used for the non irradiated equilibrium system. The same description is used for the perturbated system under irradiation that is in the stationary nonequilibrium state. The system of integro-differential equations is obtained is obtained to describe the liquid system under irradiation, characterized by the distorted distribution function in the momentum space. Solving those equations allows calculating pair distribution function of the perturbated system. The obtained results are extended for the case of high order correlation functions. Our results show that thermodynamic properties of the nonequilibrium system under irradiation are the same as of the equilibrium one but at effective temperature that is higher than the real one of the nonequilibrium system.

ANALYTICAL INVESTIGATION OF POTTERY FROM DIFFERENT NEOLITHIC PERIODS IN THE SOUTH-EAST OF ALBANIA

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Pottery analysis reveals information regarding the daily life and cultural aspects of the society of the ancient period. The technical skills of the ancient potters have been the subject of active research for gaining a deep insight of forgone culture.

The archaeological materials from these sites, mostly ceramics, constitute a unique case that could give information about the technological development of those societies from Early Neolithic to Eneolith.

The application of sophisticated statistical and/or multivariate methods of analysis on large experimental datasets obtained by modern analytical techniques has proven to be a useful tool for supporting archaeologists' hypotheses regarding the age and provenance of artefacts as well as technologies and trade routes used in their manufacture and distribution.

In this paper we will consider the results of the investigation obtained by analysis using different methods like EDXRF, XRD and Optical Microscopy (OM) of territories located in the south-east of Albania from Early Neolithic to Eneolith.

The excavations have shown that in some sites the humans have been living without interruption throughout the Neolithic period.

A STUDY OF THE CHANGES IN THERMAL DIFFUSIVITY INDUCED BY GAMMA-IRRADIATION OF POLYETHYLENES

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The effects of high-energy radiation on static thermal properties (heat capacity and thermal conductivity) and their relation to structure changes, produced by gamma irradiation of various polyethylenes (PEs), were widely studied in the past using conventional Differential Scanning Calorimetry (DSC) measurements. In this work we used photoacoustic, non-destructive, dynamic technique, to evaluate thermal diffusivity of non-irradiated and irradiated low density and high density polyethylenes (LDPEs and HDPEs), in order to correlate it with the initial structure differences and with the influence of gamma radiation on the structure evolution. For this reason, LDPE and HDPE samples were exposed to a wide range of absorption doses (up to 2400 kGy) of gamma radiation, in the air. Frequency-dependent photoacoustic measurements of amplitude and phase characteristics, ranging from 10 Hz to 20kHz, were done. The radiation-induced effects have been observed and discussed in the light of thermal diffusivity changes. Our results show that dynamic thermal measurements, such as frequency-dependent photoacoustic ones, could improve our understanding of the influence of gamma radiation on the structure and the changes of thermal properties of the polymers.

FORMATION OF DIAMAGNETIC AND RADICAL PRODUCTS IN CRYSTALLINE NITRATES BY UV LIGHT AND GAMMA RAYS

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The mechanism for paramagnetic centers formation under the radiolysis of crystalline alkali nitrates was studied in detail, their formation under the irradiation by ultraviolet light has not studied extensively. Photolysis of alkali nitrates by 254 nm light do not results in the radical formation. Photolysis with high-energy light was studied fragmentary and it deal with paramagnetic products formation only. In this paper, we have extended the range of light used for photolysis and studied paramagnetic and diamagnetic products formation.

It is known that end photoproducts in nitrate crystal at 300 K by 254 nm light (low pressure mercury lamp with uviol glass) are peroxynitrite, nitrite, and molecular oxygen. EPR signals in irradiated KNO_3 single crystal by 254 nm light at 77 K and at 300 K were not registered. Irradiation of KNO_3 at 300 K by light with low pressure mercury lamp with a quartz bulb (it emits 254 and 185 nm light), results in nitrite, peroxynitrite, and ozonide.

The photoinduced optical absorption spectra, EPR spectra, and kinetics of accumulation of photolysis products under the photolysis of KNO_3 and $Ba(NO_3)_2$ single crystals by 222 and 172 nm light were studied. The irradiation of KNO_3 at 300 K by 172 nm and 222 nm light does not results in any EPR signals, at the same time, singlet line due to O_n^- in $Ba(NO_3)_2$ was registered.

Photolysis of KNO_3 by 172 nm at 77 K results in singlet lines with spectroscopic parameters due to the radicals $O^-$and O_3^- based on the literature data. Irradiation both with 222 nm at 300 K and with 172 nm at 77 K results in two types of paramagnetic centers registered in ESR spectra, one of which is NO_2 and O^- and the other six being in magnetically nonequivalent positions is non-identified.

One can assume that the formation of the paramagnetic centers under irradiation with the vacuum UV light occurs by several stages. At photon energies from 5.2 to 5.5 eV peroxynitrite and nitrite can be formed only. With increasing photon energy O^- and NO_2 can be formed. We suggest that the pairs of NO_2^- and O, O^- and NO_2 are formed in the first stage. Further, the oxygen atoms react to form the molecular oxygen, which can be reacted with O^- to form ozonide. The mechanism of their formation is discussed.

IRRADIATION RESPONSE OF P AND N TYPE Sm_2O_3 MOS CAPACITORS

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Radiation effects on the electrical properties of metal–-oxide–semiconductor (MOS) devices and integrated circuits (IC) are complex in nature and have changed much during decades of device evolution. Electronic devices in art-of-state technology contain numerous types of oxides and insulators. Ionizing radiation can induce significant charge buildup in these oxides and insulators leading to device degradation and failure. To circumvent this problem and finding out radiation hard materials, gate dielectrics with high dielectric constants are should be investigated. Therefore, we aim to study possible effects of gamma irradiation on the electrical characteristics of Sm_2O_3-based MOS capacitors. The Sm_2O_3 thin films were deposited on p and n–type (100) Si substrate by reactive RF sputtering. To study the response of MOS devices to irradiation over a range of doses, MOS samples were irradiated using a Co-60 gamma-ray source for 1 gray and 4 grays. Capacitance-voltage (C-V) and conductance-voltage (G/ω-V) measurements were performed at high frequency (1 MHz) before and after gamma irradiation. Results demonstrate that significant changes have been observed in the capacitance and conductance characteristics of Sm_2O_3 pMOS capacitors due to the reordering and restructuring of radiation-induced defects in the devices structure. On the other hand, Sm_2O_3 nMOS capacitors are interestingly exhibiting good irradiation resistance i.e. no significant changes have been observed on measured capacitance and conductance over dose ranges.

THERMAL STABILITY OF OPTICAL CENTERS IN SPINEL CERAMICS GENERATED BY HIGH ENERGY ELECTRON IRRADIATION

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Magnesium aluminates spinel (MAS-$MgAl_2O_4$) single crystals and transparent ceramics have excellent dielectric and optical properties and are prospective for the use in electronic and optical devices, as insulators, windows and sensors. Many applications of this material are based on optical and luminescent properties of nominally pure and doped with different ions. Searching for dosimeters materials based on the thermoluminescence or optically stimulated luminescence (OSL) leads to conclusion that MAS is the prospective material for this purposes due to a high OSL signal linearly related to the absorbed dose. It should be noted that centers responsible for OSL signal is still need to be identified.

We provided the investigations of the optical absorption spectra and radioluminescence in electron irradiated magnesium aluminates spinel ceramics in dependence on annealing temperature. The transparent spinel ceramics were irradiated with 16 MeV electrons to fluences of 4.2·1016, 1.1·1017 and 3.3·1017 el/cm_2 at temperature about 320K. The measured absorption spectra demonstrate several overlapping bands which were for convenience divided in two ranges: bands at photon energy of $h\nu<4$eV which are related to hole centers at cationic vacancies, and bands at photon energy of $h\nu>4$eV which are identified with electron centers at anionic vacancies. The annealing of irradiated samples by step of 50K and subsequent measurement of absorption spectra at room temperature shows different dependences of the bands intensity on annealing temperature. The bands of the first range were thermally destroyed after annealing of irradiated samples to temperature of 570K. The intensity of absorption bands of the second range at this temperature is decreased in 2.5 times and full annealing of optical centers created by electron irradiation was observed at temperature of 870K.

The radioluminescence at the excitation with X-rays in unirradiated and irradiated and subsequently annealed samples demonstrates several bands in the spectral range of 6.2-1.45 eV. In the UV region the wide intense band at 4.75 eV was identified to electron-hole recombination emission at anti site defects, and low intensity bands at about 3.5 and 2.6 eV which belong to emission of F-type centers. The dependence of these luminescence bands on the annealing temperature indicates the complex processes of charge carriers transfer between lattice defects under irradiation and annealing. Also, the very prominent radioluminescence bands at 2.38 and 1.8 eV were observed which previously identified to emission of unavoidably existing impurity ions of Mn^{2+} and Cr^{3+}, respectively. The correlation of optical absorption and radioluminescence on the annealing temperature allow us to clarify the mechanisms of radiation induced optical center formation and thermally stimulated destruction in magnesium aluminates spinel ceramics.

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LOW-ENERGY ELECTRON DAMAGE OF DPPC MOLECULES - A NEXAFS STUDY

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In cancer research the radiation dose delivered to different organs presents a critical parameter for destroying the cancer cells' DNA, but the biochemical pathways that bring cells to death in many cases start at the cell membrane whose major part are lipid molecules. In our NEXAFS experiment, we exposed a mono- and multilayer lipid films supported on gold to a spatially and energetically well defined electron beam (20 eV), simulating the charged particle avalanche produced in the exposure of the biological tissue to a high-energy ionizing radiation (X- and g - rays, ions, etc). The major difference between the two samples was the shape of the structure at the energy above 535 eV. Comparison of our results with previous experiments (NEXAFS database1), shows that the O=C and O-C s* resonances are placed very close to the carboxilate group (COO) at 532.5 eV and the one from the water bonds (O-H) at 540 eV. As for the nitrogen, N 1s band changed from one dominant peak to three after double irradiation of the sample. Nitrogen edge shows a clear decrease in the sigma* resonance on the C-N bond thus proving that electron irradiation has an effect on the DPPC film.

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PHASE AND STRUCTURAL TRANSFORMATIONS IN METALLIC IRON UNDER THE ACTION OF AR IONS

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By the use of *Mössbauer* spectroscopy after effects of irradiation of metal iron with 18Ar ions of medium energies (54.3 MeV) have been studied.

Irradiation with heavy ions leads to a structural disordering of the alpha-Fe lattice and to the appearance of a amorphous gamma-phase iron (line width 0.45 $mm \times s^{-1}$) in the bulk metal at a depth of about 6 μm at front of the target. Heating in the vicinity of the thermal spike leads to an expansion of the substance and to the appearance of local deformative stresses around the thermal spike. If the bombarding ion energy is high (as it is in our case), many lattice atoms are shifted out of their nodes in the cascade, which causes the displacement spike to form and the crystal lattice to be disordered and amorphized. The formation of amorphous iron layers, might lead to an increase of the isomer shift (0.10 mm/sec relative to alpha-iron) due to larger interatomic "Fe - Fe" distances.

In the near-surface (depth, down to 400 nm) it is an oxidized iron phase, gamma-FeOOH that is present alongside with alpha-Fe. It is felt that a large number of radiation-induced defects (70 vacancies per one bombarding ion), combined with the target air-cooling system applied, can provoke corrosion processes to occur on the metal surface.

The author would like to express his sincere appreciation to Mr. Kudoyarov M. (A.F. Ioffe Physico-Technical Institute, St. Petersburg) for the irradiation of iron samples.

ELECTRON STRUCTURE, PHYSICAL PROPERTIES AND X-RAY SPECTRA OF RM_2X_2 (R = R.E.; M = FE, NI, CO, CU; X = P, SI)

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The rare earth - transition metal - X -s p-elements intermetallic compounds are interesting as materials for the nuclear fuel reactors constructing. The relatively high heat resistance and high neutron absorption cross-section make the very perspective their application as neutron capture materials. The investigation on possible application of these compounds for the radio engineering, electronics, computing technology, etc, are in progress. The electric conduction, thermo ionic and magnetic properties are investigating as well. The family of formula RM_2X_2 is one of the numerous families of ternary intermetallic compounds that have been reported in the literature.

High-energy spectroscopy (XES, XAS and XPS) has been used to study the electron structure of the investigated new ternary intermetallic compounds. The calculations of electron energy bands E(k) and partial DOS for compounds were performed by the semi relativistic linear muffin-tin orbital method without considerations of spin-orbit interactions.

Effective filling numbers of electrons in different bands of components in $R.E.M_2X_2$ compounds have been calculated. On the basis of the obtained, photoelectron, X-ray emission spectra and calculation of density of total and partial electron states in $R.E.M_2X_2$ compounds, the localization of electron of s- and p-states of Si(P) has been established within the energy ranges 14-7 eV and 7-2 eV, respectively. These states of Si (P) are hybridized with 4p-states of M atoms. The electron occupation of the d-states of the M atoms has a dominant influence on the degree of their hybridization. Between the experimental and calculated X-ray emission spectra $R.E.M_2X_2$good agreement has been obtained. L_{III} - absorption spectra Ce and Yb in ternary $Ce(Yb)M_2X_2$ compounds were obtained at 78K and 300K using a tube spectrometer equipped with an RKD-01 co-ordinate detector. The mixed valence state of Ce and Yb was obtained in the $Ce(Yb)M_2X_2$.

The valence band electronic structure of a compound with the $HfFe_2S_2$ crystal lattice type has been established for the first time based on X-ray emission spectroscopy measurements. Band structure and theoretical spectra of X-ray emission bands of atoms located in non-equivalent crystallographic positions are calculated by means of the LMTO method in non-relativistic approximation. A satisfactory agreement between theoretical and experimental data is achieved. ^{57}Fe Mössbauer absorption measurements confirm iron atoms occupying non-equivalent positions in the crystal lattice.

FRAGMENTATION OF DNA CONSTITUENTS BY ION IMPACT

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The EMRP Joint Research Project BioQuaRT [1] aims to develop measurement and simulation techniques for determining the physical properties of ionising particle track structure on different length scales, and to investigate at the cellular level how these track structure characteristics correlate with the biological effects of radiation. In this scope, fragmentation cross sections of DNA constituents for protons and helium ions have been measured in an energy range between 300 keV and 16 MeV. After parametrisation, these cross sections will be used in a simulation tool for micro- and nanometric track structure properties. Fragmentation cross sections for pyrimidine, tetrahydrofuran and trimethyl phosphate, which represent two of the DNA bases, the sugar and the phosphate residue of the backbone, will be presented.

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POLYMERIZATION OF C_{60} FULLERITE FILMS UNDER ELECTRON IRRADIATION

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Polymerization and structural transformations of fullerite C_{60} caused by external pressure, UV light, intercalation of metal atoms have been extensively studied and are well-known processes. Irradiation of fullerites with high energetic particles - ions and electrons - lead s not only to formation of defects but also to more complicated processes, such as formation of chemical bonds between the molecules – polymerization. The conditions of these processes and level of polymerization are not determined.

The crystal structure, electron and vibration properties of C_{60} fullerene films under irradiation with high energy electron irradiation were studied.

C_{60} fullerene films with thickness d=2000 were prepared by vacuum sublimation of C_{60} powder on Si(100) substrate and irradiated with the electrons (Ee=1,8 MeV), doses varied from 0 to 25,0 MKGy. Changes of crystal structure were studied by X-ray diffraction method (=0.17902 nm). Vibration spectra were studied by Raman spectroscopy (Ar^+ laser, 514.5 nm, laser spot area 0.3Ñ…2,5 mm^2, intensity did not exceed 2 W/cm^2). Electron spectra were studied by photoluminescence (Ar^+ laser, 514.5 nm) and spectral ellipsometry methods.

It is shown that low doses of the irradiation lead to polymerization effects: splitting of Ag(2) vibration mode, appearance of new diffraction maxima, widening of luminescence maxima. At high doses of the irradiation the degradation of the films was observed.

THE MECHANISM FOR RADIOLYSIS OF ALKALINE EARTH NITRATES

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Radiolysis of alkali and alkaline earth nitrates results in nitrite. Recently, it has been found out that it is peroxynitrite that is one of the radiolysis products of crystalline alkali nitrates [1]. Peroxynitrite is formed from high-energy excited state of the nitrate ion - NO_3^{-*} (> 4.8 eV) both in water solution and in solids [2,3]. Since NO_3^{-*} can be formed under radiolysis of alkaline-earth nitrates it can be assumed that peroxynitrite can be formed too. The goal of the present investigation is to study peroxynitrte and nitrite formation under g-irradiation of crystalline alkaline-earth nitrates.

The powders of alkaline earth nitrates were grown by slowly evaporating from the solutions. The formulas $Ca(NO_3)_2{\times}4H_2O$ and $Mg(NO_3)_2{\times}6H_2O$ were determined based on the water content in crystalline hydrates. The samples were irradiated with ^{60}Co g-rays at ~310 K. The optical reflectance spectra of the samples were recorded by means of a "Shimadzu UV-2450" spectrophotometer.

Irradiation of the samples results in new band in the optical reflectance spectra, whose maximum position at 344, 348, 335, and 338 nm for crystalline $Mg(NO_3)_2{\times}6H_2O$, $Ca(NO_3)_2{\times}4H_2O$, $Sr(NO_3)_2$, and $Ba(NO_3)_2$, respectively, is observed. Based on literary data it can be assumed that broad band in g-irradiated $Sr(NO_3)_2$ and $Ba(NO_3)_2$ is due to peroxynitrite. In contrast, the narrow band in g-irradiated crystalline $Mg(NO_3)_2{\times}6H_2O$ and $Ca(NO_3)_2{\times}4H_2O$ is due to nitrite.

The initial stage of the radiolysis of crystalline alkali nitrates results in the charges with holes in valence band and electrons in the second high energy conductivity band. In anhydrous alkaline-earth nitrates an electron from this band can relax to the first conductivity band to generate ~ 6 eV with subsequent formation of a high-energy excited state of the nitrate ion [4]. Triplet high-energy excited state of the nitrate ion can be dissociated to form the nitrite ion and singlet ones can be transformed to form the peroxynitrite ion. Electrons from the first conductivity band and the holes from the valence band can be recombined without dissociation.

We assume, that in hydrated alkaline-earth nitrates, when an electron from the second conductivity band relax to the first conductivity band it generate energy sufficient for the ionisation of the water molecule to produce the complex [e^-, H_2O^+]. At the same time a high-energy excited state of the nitrate ion does not form. Thus, it is possible to consider the radiolysis of hydrated alkaline-earth nitrates as the one of water solution of the nitrate salts.

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ESTIMATION OF EXTERNAL GAMMA RADIATION DOSE FOR ^{137}Cs IN THE MOUNT IDA /KAZDAGI, TURKEY

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In 2010-2012, an extensive study was performed in forest sites of Mount IDA (Kazdagi)/Edremit 26 years after the Chernobyl accident. The ^{137}Cs activity concentrations were determined by gamma-ray spectrometry in the forest soil layers (O_L, O_F+O_H and A horizons) separately. Based on 341 surface soil samples and 118 soil profiles, activity concentrations of ^{137}Cs in O_L horizons varied between 0.25 ± 0.14 and 70 ± 1 Bq kg^{-1}, while the ranges of ^{137}Cs activity concentrations in O_F+O_H and A horizons were 13 ± 1 – 555 ± 3 Bq kg^{-1} and 2 ± 1 – 253 ± 2 Bq kg^{-1}, respectively. The external gamma-dose rates at 1m height above a flat area for ^{137}Cs were determined from the observed vertical distribution of ^{137}Cs within the soil depth profiles. From the values of the ^{137}Cs activity and of the bulk density in each soil layer at each site, simple numerical integration of the functions for the cases of exponential, Gaussian or log-normal distributions was made. In this connection, the external dose-rates from the ^{137}Cs in the investigated area ranged between 0.36 nGy h^{-1} and 11.72 nGy h^{-1} with a mean of 4.17 nGy h^{-1}. Interpolated radiological maps of the external dose-rates determined from the observed vertical distribution of ^{137}Cs are drawn as a contour map.

FRUITION OF BIOLOGICALLY-WEIGHTED RADIATION QUANTITIES BASED ON A MULTI-SCALE APPROACH

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Funded within the European Metrology Research Programme (EMRP) [1], the joint research project “Biologically weighted quantities in radiotherapy” (BioQuaRT) [2] aims to lay the foundation for biologically-weighted radiation quantities based on a multi-scale approach. This approach uses measurement and simulation techniques to determine the physical properties of ionising particle tracks on different length scales (from about 2 nm to 10 µm), which are then correlated with biological effects of radiation.

The work within this project can be divided into four complementary lines of research. The first is the development of advanced micro-calorimeter prototypes for the direct measurement of lineal energy. By comparison with miniaturised tissue-equivalent proportional counters and silicon-based microdosimeters, these devices would enable possible correction factors to be determined for condensed phase effects and tissue-equivalence.

The second line of research is an intercomparison among the only three operative nanodosimeters for establishing a correlation of measured particle track-structure parameters on different length scales in the nanometre range. A prototype multi-scale measurement device, which integrates a nanodosimeter and silicon microdosimeter, has also been developed to characterise radiation quality of ion microbeams for radiobiological cell experiments.

Measured and evaluated data sets of DNA cross sections, together with quantification of particular radical and reactive oxygen species, constitute the third line of research. These data provide the final input for the fourth research line, which is the development of a multi-scale simulation tool addressing micrometric and nanometric track structure properties and their link to early biological effects. Results obtained with this multi-scale model will be benchmarked with those obtained from aforementioned radiobiological measurements on initial DNA damage and late effects.

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[1] URL: http://www.emrponline.eu/

[2] URL: http://www.ptb.de/emrp/bioquart.html.

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CROSS SECTIONS FOR IONIZATION OF DNA CONSTITUENTS BY PROTONS

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A multi-scale track structure simulation program based on interaction cross sections of DNA constituents is being developed within the framework of the EMRP Joint Research Project "BioQuaRT" [1]. This work aims to investigate at the cellular level how these characteristics correlate with biological effects of radiation. For realistic track structure calculations at this length scale, measured ionization cross sections of DNA constituents are required as input for developing realistic parameterized model functions representing the scattering probabilities in these simulations.

In the present work, double differential cross sections for the ionization of pyrimidine, tetrahydrofuran and trimethylphosphate by protons with energies in the Bragg peak regions were measured. The first molecule represents two of the DNA bases, and the other two represent the sugar and the phosphate residue of the DNA backbone. The experiments were carried out at the new 150 keV ion accelerator facility at the PTB. An electrostatic hemispherical electron spectrometer was used to detect the secondary electrons emitted at angles between 30° and 135° relative to the ion beam direction. The measured spectra were converted into absolute cross sections using the transmission and detection efficiency of the spectrometer, obtained from measured secondary electron spectra from the collision of 200 eV electrons with THF usingelectron cross section data for elastic scattering and ionization of THF reported by Baek et al. [2].

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EXPERIMENTAL NANODOSIMETRY PAVING THE WAY FOR A NEW CONCEPT OF RADIATION QUALITY

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Experimental nanodosimetry aims at establishing a new concept of radiation quality that builds on measurable characteristics of the particle track structure. Three different types of nanodosimeters have been developed [1-3], which vary in operating gas, detected particle type and size of the equivalent nanometric target in biological matter. These devices measure the frequency distribution of ionisation cluster size – that is, the number of ionisations produced by single ion tracks in a specified target volume.

Within the European Joint Research Project *BioQuaRT* (Biologically Weighted Quantities in Radiotherapy) and the MITRA project funded by INFN, experiments have been carried out with different types of nanodosimeters measuring the same radiation qualities of carbon ion beams [4-6]. Measurements with the PTB Ion-counter and LNL StarTrack nanodosimeters were performed at the LNL Tandem accelerator facility, whilst those with the PTB Ion-Counter and NCBJ Jet-Counter took place at the Heavy Ion Laboratory of Warsaw University.

Taking into account the differences of the three nanodosimeters, the ionisation cluster size distributions measured with these devices are in good agreement. These measured cluster size distributions were then used to derive a universal relationship between the cumulative probabilities Fk for a cluster size $\nu \geq k$ and the mean ionisation cluster size M_1 produced in a nanometric volume. Plotting these Fk values as a function of M_1 reveals saturation effects similar to those of radiobiological cross sections as a function of LET. By comparing the aforementioned universal curves to the yield of different biological endpoints available in literature, a significant quantitative correlation was established.

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LONG-TERM ATMOSPHERIC DEPOSITIONAL FLUXES OF RADIONUCLIDES AT MALAGA (COASTAL MEDITERRANEAN STATION)

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The deposition of radionuclides on the ground represents an important factor in environmental radioactivity monitoring. To predict the long-term radiological consequences of an accidental deposition of the radionuclides to the ground, it is a prerequisite to know the environmental long-term behaviour of these radionuclides and a relatively large number of values is required for statistically meaningful conclusions ^{210}Pb is a nuclide used in studies of atmospheric research, oceanography and marine geology .^{7}Be is a another radionuclide used as tracer and chronometer in aquatic and atmospheric systems. Both ^{7}Be and ^{210}Pb are highly particle active and they are easily scavenged by aerosols. Little attention is paid to ^{40}K in airborne materials. Its origin is lithogenic and is mainly originated from the suspension of soil. ^{40}K is found in most types of soil and can easily be transported by re-suspended material. This nuclide has been previously associated with the arrival of coarse re-suspended material (PM10, particulate matter with a diameter below 10 μm) from the African continent.

The specific activities of ^{7}Be, ^{210}Pb and ^{40}K varied from 0.6 to 8.3 Bq L^{-1} (mean = 2.6 Bq L^{-1}), 0.05 to 1.3 Bq L^{-1}(mean = 0.41 Bq L^{-1}) and 0.02 to 0.84 Bq L^{-} (mean= 0.23 Bq L^{-1}) , respectively. The temporal variations of radionuclides exhibit similar seasonal behaviour with low values in winter-autumn months and maximum values in spring-summer months. The time variations of the different radionuclides concentrations have been discussed in relation to various meteorological factors and the mean values have been compared to those published in recent literature for other sites located at different latitudes. Bulk depositional fluxes of ^{7}Be, ^{210}Pb and ^{40}K have been evaluated for period of measurements. Bulk depositional fluxes of ^{7}Be , ^{210}Pb and ^{40}K varied between 4 and 1779 Bq m^{-2} $month^{-1}$ (annual mean = 1300 Bq m^{-2} $year^{-1}$), 1.17 to 102 Bq m^{-2} $year^{-1}$ (annual mean = 150 Bq m^{-2} $year^{-1}$ and 0.47 to 81 Bq m^{-2} $year^{-1}$ (annual mean = 70 Bq m^{-2} $year^{-1}$) Data on the atmospheric depositions of radionuclides in Málaga show that the seasonal variation is not uniform from year to year and the amount of rainfall controls mainly the depositional fluxes. A positive correlation has been found between the fluxes and amount of rainfall, the rainfall duration and the number of wet days .A negative correlation has been found with the number of dry days .There is a statistically relationship between ^{7}Be and ^{210}Pb fluxes indicating that removal behaviour from the atmosphere is relatively similar.

ELECTRONIC-POSITRON (PAIRINO'S) STRUCTURE OF NUCLEAR SUBSTANCE (MATTER)

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For the benefit of a electronic-positron structure the representations about an annihilation of the electronic-positron pairs, formation in substance electronic-positron of pairs under activity action of a gamma radiation, electronic and positron character of a beta radiation in nuclei are worked.

The new mechanism of a physical phenomenon, well explored to the present moment, with the conventional interpretation - mechanism of an annihilation of a free positron on electrons of substance is offered. That is the conventional point of view is those, that during annihilation the electron burns down, disappears or is transmuted into a gamma-quantum. In opinion of the author any facts or the proofs of such interpretation do not exist.

The following mechanism therefore is offered: an electron and positron at coming together are discharged by two gamma-quantum and form pairino (unloaded electron - positron state with gravitational mass "m" about 2 eV, with compensation by electric charge, about an electrino by positrino interaction); that is the mechanism "cold" (low, is less than 10 KeV, energies) synthesis of pairino. The given mechanism of phenomenon of annihilation is more realistic.

Decrease or enlargement of the number of pairinos in nuclei and as free nucleons, pairinos, electrinos, positpinos is a factor of destabilization in the matter and or environment.

DESIGN AND DEVELOPMENT OF A HIGH ENERGY ELECTRON IRRADIATION STATION FOR MULTI-DISCIPLINARY EXPERIMENTS

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In the framework of the ELI-Beamlines project, a laser-plasma based electron beamline, HELL, is being constructed. One of the goal of HELL beamline is to deliver well characterized electron beams to a user's station where samples or detectors could be placed. Most important features of these beams are their ultra-short duration (<1 ps), energy in the range 5-250 MeV and size from cm down to <1 mm. Those features make them attractive for different applications like radiotherapy or pulse radiolysis.

Two are the main drawbacks in applying laser-plasma electron beams for irradiation purposes: a broad emission of low energy electrons and a high divergence of the beams.

In this work the design of the user's station is presented, dealing with beam transport by a system of magnetic fields and monitoring dose deposition along beam path and minimizing activation of the components.

Finally experimental data of the preliminary tests of some components are presented.

RESEARCH OF DOSIMETRIC CHARACTERISTICS OF FUEL CONTAINING MATERIAL

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In case of serious nuclear reactor accident the molten fuel can melt through the reactor containment and radioactive material can escape into the environment. A core-catcher filled with a sacrificial material is suggested under the reactor vessel to prevent such release of radioactivity. The sacrificial material should fix up thermal and chemical stabilization of the melt and prevent the creation of undesirable aerosols during the following years. This paper estimates the absorbed dose in hypothetical material for different types of radiation. The main part of the dose comes from alpha, beta and gamma radiation. Based on the estimates and calculations the irradiation experiments were designed at the LVR-15 nuclear research reactor. The model for the design of calculations and experiments is based on the operation and properties of the VVER 1000 nuclear power plants, especially the type of fuel, vessel construction, and biological shielding. The corium simulating samples with different composition of sacrificial material were irradiated. At present, they are stored in a hot cell and regularly monitored. The special capsule for irradiation of samples was designed and tested. The capsule allows to irradiate samples without or with thermal neutron shielding. The irradiation conditions of the experiments are described in this paper.

ON THE FORMATION OF A SUPERLATTICE OF VACANCIES OR NANOVOIDS WITHIN THE ISOTHERMALLY IRRADIATED CUBIC CRYSTALS

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Within the crystals under irradiation, the modulated structures can be formed. Formation of a superlattice of nanovoids is an intrinsic property of many crystalline materials under irradiation. This property is technologically important in respect to operations and maintenance of nuclear reactor materials as well as to applications of functional materials under irradiation, since a material having strong tendency to form a vacancies' superlattice is expected to be resistant to the radiative swelling.

The report is concerned with study of conditions of formation of dissipative modulated structures of vacancies' subsystem in irradiated cubic crystals. A kinetic model for the influence of external noises such as fluctuations of the vacancies' generation rate and inhomogeneity of irradiated cubic crystal on the formation of nanoscale modulated dissipative structure in a spatial distribution of vacancies is considered. For instance, with f.c.c. crystal as a model of the irradiated functional material, the numerical and analytical calculations of energy parameters for 'strain-induced' and 'electrochemical' interactions of vacancies within the f.c.c. crystal are carried out. Their behaviour near and far from the centre of the f.c.c.-lattice reciprocal-space Brillouin zone (particularly, on its surface) is studied. The temperature dependence of spatial period $d(T)$ of the modulated dissipative structure of vacancies' subsystem in f.c.c. crystal is numerically forecasted and analysed, taking into account the total ('electrochemical' + 'strain-induced') interaction between vacancies. Such $d(T)$-dependence is also determined by the kinetic characteristics of vacancies' redistribution.

As shown, if density of dislocations is temperature independent, the period of the dissipative modulated structure in a spatial distribution of vacancies decreases slightly with temperature increasing and is conditioned by 'electrochemical' interaction of vacancies. Accounting (empirical) temperature dependence of density of dislocations leads to increasing the dissipative modulated structure period with temperature that is caused by the entropy factor and 'electrochemical' interaction of vacancies. The period of superlattice of nanovoids increases with temperature since it is determined only by their elastic interaction. As quantitatively illustrated, the temperature interval of stationary existence of the dissipative modulated structure in vacancies' subsystem density distribution in f.c.c. crystal is narrowed, if external fluctuations of nonzero rate of generation of point defects are activated.

Key words: vacancy, 'strain-induced' and 'electrochemical' interactions, modulated structure, superlattice of vacancies.

APPLICATION OF ANALOGIES BETWEEN RADIATION PHYSICS AND A HEAT TRANSFER FOR MODELING OF POWER INTERACTION OF PHYSICAL OBJECTS

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The laws of physics, in particular, thermodynamics, the laws of energy balance, momentum, simple and convenient in the local approach when solve differential equations and the corresponding boundary value problems. But the real physical processes occur in systems with extended sizes over long time intervals and in this plan are nonlocal integral properties. The method of thermal dosimetry allows to investigate experimentally not local and integrated indicators of processes of power interaction thermodynamic of nonequilibrium systems. Thermal dose - is an integral characteristic of the temperature influence on the object is equal to the area of the graph of temperature versus time. In the international system of units the thermal dose has dimension degree for a second. At negative temperatures influence is characterized by negative doses. For practice the stand-alone unit named by Stephane (St) - degree for a minute is offered. It is visible that 1 St is equal to the 60 degree * second. Calorific values of municipal solid waste, rubber, plastics, waste motor oil, coal crumbs, etc. were measured in gas generator antiradonovic ceramic furnaces (authoring), in which 10 liters of boiling water for 5-10 minutes with a mixture of dry rubber and waste wood. The area under the curve on a graph of temperature increase in water volume determines the measured value - temperature dose S. The corresponding balance equation for heating water has the form

$$S=k*H*m*t \quad (1)$$

where S-thermal dose k - coefficient of heat transfer furnace, taking into account the loss of heat from the flue gases, H-calorific fuel (MJ kg), m-fuel weight (kg),m - total time of burning fuel. It is established that calorific abilities of fuel compositions of mix of a larch and coal, plastic, rubber, the fulfilled oil vary ranging from 10,2 MJ/kg to 18,8 MJ/kg. High-energy components such as rubber and plastics proportionally increase power consumption of fuel compositions. Also the method of thermal dose established an optimum dose of cooling with liquid nitrogen of seeds of oats, wheat, salad. Optimum doses of cooling at which there is an increase in percent of viability of seeds on average by 20% are established, is shown that the increase in a dose of cooling (from-0,28 to -0,841 MSt) leads to linear increase in growth rate of biomass. Processes of healing of wounds on laboratory rats are also investigated. It is established that when cooling with vapors of liquid nitrogen within three minutes at an experimental rat the wound healed in one days, and at a control sample the wound healed in 7 days.

Thus, the method of thermal dose comprises the new not local phenomenological principles allowing to describe a wide range of processes of a power exchange of open nonequilibrium thermodynamic systems.

ELECTRON SPECTRUM EFFECT ON LIF RESPONSE TO 6 MV PHOTON BEAM USING MONTE CARLO AND BURLIN CAVITY THEORY

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Purpose: To evaluate electron spectrum effect on LiF response using Monte Carlo and Burlin cavity theory.

Method: Dose to medium to dose to cavity factors were calculated and compared using the full electronic equilibrium spectra produced by 6 MV and its maximum electron energy in several media including water, polystyrene, aluminum, iron, copper, lead, bone and lung. The full electronic equilibrium spectra were calculated using Beamdp Monte Carlo Simulation. The Burlin General cavity theory is applied to obtain the response of LiF to 6MV in the media considered using two different methods. In the first method, the full electron spectra were used to calculate the response of dosimeters. In the second method, calculation is based on the maximum energy.

Results: At 6MV, the maximum difference between two f values computed from two methods is 2 % for bone, lung, aluminum, copper, water, polystyrene and iron whereas it is nearly 10 % for lead. In the literature this value does not deviate more than 5% for Co-60-gamma-rays in lead.

Conclusion: The results indicate that the differences between calculated f factors using the electronic spectrum and the maximum energy of 6 MV are insignificant except lead.

Keywords: Effective mass attenuation coefficient, Monte Carlo, LiF, Cavity Theory

THE AUTHENTICATION OF COMPLIANCE BETWEEN THE LIGHT AND RADIATION FIELD USING A COMMERCIAL DIGITAL CAMERA

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Most of the quality assurance program of mega-voltage treatment machines requires authentication of compliance between light and radiation field. The authentication of compliance between light and radiation field is performed with a radiographic film, or with some new suggested ways as the use of radiography (CR system), photodiodes, self-developing films, electronic portal image devices (EPID) and expensive instruments for routine quality assurance of radiotherapy beams. We designed a simple QC test for authentication of compliance of the light and radiation field using a CCD Camera and radiographic cassette and we tested on linear accelerator of Elekta Synergy Platform. The part of radiographic cassette which is important for this work, is a plastic foil covered with phosphor, a fluorescent material. This foil allowed us to visualize radiation field. On the basis of three photographs, photo of square 10 cm x 10 cm, photo of light field and photo of radiation field, we analyze authentication of compliance between light and radiation field. Program for analyzing the compliance between light and radiation field is the function programmed in MATLAB. This function based on the first image transformation, transforms the other two, and compare and evaluate compliance between light and radiation field. For verification of the measurement we used radiographic film. Thanks to good resolution of CCD we were able to measure compliance between light and radiation field in order of magnitude 0.3 mm.

This simple procedure is very easy to perform, does not require material costs, saves time and there is no need to develop the film.

INVESTIGATION OF DAILY SET-UP ERRORS DURING CONFORMAL RADIATION THERAPY OF PELVIS

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Purpose: To evaluate patient set-up errors in conformal radiotherapy treatment of pelvic tumors and calculate planning treatment volume margin (PTV) to accommodate for the patient set-up error. PTV should ensure that clinical target volume (CTV), volume which must be adequately treated to achieve cure, receives prescribed dose [1].

Methods and materials: Data from 20 patients who underwent radiotherapy in pelvic region were used to study bony anatomy displacements relative to the isocentre. A total of 161 EPIs were acquired. We define isocentre set-up error displacement as the difference between measured position of bony anatomy defined by EPI and reference position defined by digitally reconstructed radiograph (DRR). The mismatch result, i.e. set-up deviation μ, is a deviation combining both random and systematic component. For the set up errors analysis we determined systematic and random SD in three directions (caudal cranial CC, medial lateral ML and anterior posterior AP). PTV margins calculated according to ICRU [1], Stroom [2] and Van Herk [3] models.

Results: The systematic and random set-up errors were calculated from initial /offline deviations and offline/online deviations evaluated from electronic portal images. The population systematic errors Σ in the CC, ML and AP projections of portal images were 2.2 mm, 2.6 mm and 2.2 for initial/offline evaluation, respectively. The population of systematic errors Σ in the CC, ML and AP projections of portal images was 0.8 mm, 0.7 mm and 0.8 for offline/online evaluation, respectively. The population random errors σ in the corresponding directions were 3.7 mm, 3.3 mm and 3.3 mm for initial/offline evaluation, and 1.3 mm, 0.9 mm and 1.7 mm for offline/online evaluation. PTV margins calculated according to ICRU, Stroom and Van Herk models ranged from 4 mm to 8.8 mm for initial/offline evaluations and 2.1 mm to 3.3 for offline/online evaluation.

Conclusion: We found that serial portal imaging and everyday online corrections enabled reduction and control of systematic error, making reduction of PTV margin possible.

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RADIATION EFFECTS IN ATOMIC AND MOLECULAR CRYOCRYSTALS

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In spite of detailed investigation of electronic excitations in atomic and molecular cryocrystals the properties and dynamics of charge states, accumulation of uncompensated charge in the samples remained almost unexplored. Our group developed special techniques for investigation of charge states in cryocrystals [1]. It was applied to rare gas solids and solid nitrogen. The correlated in real time measurements of spectrally resolved thermally stimulated luminescence, exoelectron emission, and the desorption yield were performed in combination with cathodoluminescence.

Condensed noble gases as well as solid nitrogen are used as detectors of ionizing radiation and moderators. Interest in research of solid nitrogen is associated with the prospect of its application as a high energy-density material. Investigation of radiation effects in solid nitrogen and rare gas solids is of high interest for astrophysics [2].

We achieved ultrahigh density of charge centers - 10^{15}-10^{16} cm^{-3} in cryocrystals under irradiation with an electron beam. The charge distribution was found to be inhomogeneous. We have shown that excess electrons are localized near the surface of the sample and positively charged centers are on the boundary between the sample and the substrate. The thermally stimulated exoelectron emission from solid nitrogen was detected. A new unusual phenomenon was observed - low temperature “post-desorption” from pre-irradiated solid nitrogen. Its mechanism is suggested and proved experimentally.

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THE VARIATION OF HOUNSFIELD UNITS ON SCANNING PARAMETERS AND INFLUENCE ON TREATMENT PLANNING RESULT

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Purpose/Objective. Since CT scanning of radiotherapy patients is done by different RTTs, with different daily routine, the influence of different scanning protocols (tube voltage, tube current, position in relation to the center of the table) were evaluated, and applied to real patient plans.

Materials/Methods. The CIRS 062M phantom was used. The scanning parameters were: U= 140 kV, 120 kV, 100 kV, 80 kV and 70 kV. The tube current used were: I= 20 mA, 35 mA, 60 mA, and 80 mA. The phantom was scanned with following parameters: tube voltage was kept constant, while the tube current was changing. Then the tube current was kept constant, while tube voltage was changing. Finally, the phantom was positioned off the axis of a patient table of CT simulator, and scanned in constant tube current (35 mA), while changing the tube voltage.

Conversion curves were generated, and applied to existing patient plans, and results evaluated.

Results. The highest dependence of CT to ED conversion curve is on the tube voltage. The difference was observed mostly in the high density material, such as bone and dense bone. The voltage decrease of 20 kV gives the difference between 10% and 20% (not linear) in the value of HU for the same dense material, such as different types of bones. None of difference is seen on titanium inserts, no matter what conditions were, they remain always close to 3070 HU.

The dependence on tube current was negligible.

The dependence on the off axis position of a phantom results in difference of 5% - 10% on reconstructed of HU values imported in TPS.

The overall difference on tube voltage changes, which introduced largest deviation in HU values (up to 20%), as seen on treatment plan for head and neck cases, is actually very little. The difference is a fraction of one monitor unit, and actually does not change the treatment plan.

Conclusion. The changes in the tube current during CT scanning does not imply any difference in conversion curve, and therefore to treatment planning. The tube voltage changes drastically the conversion curve, and therefore the fixed voltage should be used for treatment planning. This should be also measured on a phantom, to verify how much the calculation algorithm with reconstruction of a CT, gives difference to measurement on linac.

The strict instruction was given to all RTTs to keep the scanning protocol always the same. The work previously done on verification of calculation, defined 140 kV as the best tube voltage with respect to measurements, and it is kept constant in clinical practice.

MATTER IN EXTREME CONDITIONS

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The theory, which currently best describes the creation of the Universe, is called the Big Bang theory. To create conditions which ruled one billionth of a second after the Big Bang, it is necessary to heat and compact the nuclear matter. By varying the beam energy one may, within certain limits, map the phase diagram matter in extreme conditions when the particles collide at high energies, it leads to the conversion of particle collision participants in a much heavier particle. This creates a little Big bang in the laboratory. If the energy density is large enough, after a collision occurs the formation of quark gluon plasma. At the beginning the plasma is in equilibrium condition. It can achieve equilibrium through secondary collisions. After further expansion and cooling the system is hadronized again. Further expansion leads to free flow through the freeze-out. In the dense nuclear medium collective phenomena occurs such as increased production of strangeness, damping, Armoni and bulk motion of particles. In nuclear medium comes to individual collision of quarks which also hadronize. Using simulation package Pythia we analyzed the reaction system that results in individual collisions of quarks and antiquarks, and emergence of collective phenomena.

Key words: extreme conditions, quark gluon plasma, production of strange particle, suppression of charmonium, collective motion, radial flow, directed flow, elliptic flow

PRODUCTION CROSS SECTIONS FOR DIAGNOSTIC AND THERAPEUTIC RADIOISOTOPES USING SMALL FACILITIES

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Progress in technology made using of small accelerators (usually cyclotrons) a feasible way for the production of medical radioisotopes, even for hospitals and institutes in modest-budget countries (see e.g. [1]).

Sharp fluctuations in angular distributions, typical for direct reactions, are not so important for calculations of the yields. Therefore, simple statistical model is the preferred choice. When the (incident) energy is above some 10 or 15 MeV (so-called "baby cyclotrons" give usually 18 MeV, and a bit larger machines range above 20 MeV), the presence of pre-equilibrium mechanism cannot be ignored.

We applied the pre-equilibrium (exciton) model, which includes compound nucleus equilibrium emission as its organic part, to calculations of cross sections of several reactions yielding diagnostic or therapeutic isotopes, namely 18F, 61Cu, 65Ga, 111In and 123I [2-6] and we have been successful in finding some novel possible ways to produce these isotopes. These suggested ways are either cheaper or they decrease the presence of unwanted dangerous "parasitic" isotopes. To keep with the progress of knowledge, new developments of the model are being continuously incorporated. In parallel to the calculations, we have me3asured these reactions.

Our paper gives an overview of basic ideas of our model calculations and it presents some of our results, both experimental and theoretical.

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RADIATION PROTECTION

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OCCUPATIONAL EXPOSURE TO IONISING RADIATION AT A COPPER MILL

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The Copper Mill Sevojno produces various copper and copper alloy products for utilization in different industry sectors. Technological process of copper rolling from blocks to strips consists of cold and hot rolling. For the control of copper strip thickness radio-isotope strip thickness gauges are installed. These gauges are widely used for contactless measurement of the metallic or non-metallic strip thickness. At the Copper Mill Sevojno, radio-isotope strip thickness gauges are with radio-isotope ^{90}Sr. The gauges are placed on the machines for cold rolling of copper and brass strips, named rolling mills. The employees that operate on these rolling mills are exposed to gamma radiation and are under legislation dosimetric control. The results of dosimetric monitoring of rolling mills workers are presented here. The doses, in terms of personal dose equivalent, Hp(10), are reported quarterly, as those workers are categorized as "B" group workers occupationally exposed to ionizing radiation. Measurements are done with thermoluminescent system that consists of Harshaw 6600 Plus automatic reader and thermoluminescent dosimeters for whole body TLD-100 (LiF:Mg,Ti). Annual doses are given for all four groups of monitored twenty-one persons for three-year period. The results show that maximal measured personal annual dose is less than recommended annual dose limit of 20 mSv.

RADIATION LEVELS AT CARRYING OUT THE REFURBISHMENT OF THE BULGARIAN RESEARCH REACTOR IRT 2000

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The paper presents a summary of the main steps in carrying out the refurbishment of the research reactor IRT in Sofia. It was a 2 MW pool type light water cooled and moderated reactor which after the final shutdown was defueled and brought to a state of safe enclosure. During the reactor operation period of 28 years there were no major modifications, no significant incidents or accidents and no events with a hazardous impact on the staff, public or environment and the reactor has been shut down under normal circumstances. According to a decision of the Bulgarian Government it undergoes a reconstruction into a low-power reactor. In this regard during the period 2008 - 2014 within the IRT-Sofia took place a number of activities with potential for radiation hazard such as shipping of the spent nuclear fuel, dismantling of the reactor internals and replacement of aged reactor equipment, categorization, sorting and packaging for temporary storage of dismantled equipment and the radioactive waste generated during the dismantling activities. The applicability of existing proven dismantling technologies has been identified together with some additional features for the dismantling. Additionally, a work schedule and an estimation of the collective radiation dose for the preparation and implementation of dismantling and associated activities have been established. One of the basic goals during the partial dismantling activities is the assessment of the possible sources of irradiation of the personnel when carrying out the dismantling of reactor equipment as well as providing the admissible work conditions – devices, personal means of protection, measuring appliances for overall dosimetry control, personnel conduct, instructions, etc., so that the obtained doses are in the permissible limits determined by the basic norms of radiation protection and the internal regulations for work with sources of ionizing radiation. Extensive radiological characterization was completed to provide the necessary information on the technical conditions and the amount of radioactive materials. The report gives information on the organization and management of the activities and outlines some key technical aspects of the dismantling and removal of the contaminated/activated components. Also, the experience gained during this project is highlighted, particularly with a view to the selection of dismantling methods and methods for the separation of radioactive waste from material to be cleared. The radiation measurements and site monitoring prior, for the period of all the activities and at present supplied comprehensive evidence that the work has been accomplished safe without radiation consequences for environment.

RESEARCH STAND FOR TESTING CONCRETE SHIELDING

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Lately few new concrete constructions become unexpected failures (reactors and accelerators). For this reason concrete as shielding and bearing material is widely reconsidered in view of its parameters. A design of research stand for testing concrete shielding is presented. Studies of of new concrete mixes are needed especially in the era of nuclear power development (two unexpected shutdowns of reactors and continuation of Polish Nuclear Energy Programme). This stand is designed in order to examine and emerge the best concrete mix for the construction of the first Polish nuclear power plant. The examination of those concrete shielding will be performed in the room at the outlet horizontal channel H2 at nuclear reactor MARIA (National Centre for Nuclear Research - NCBJ, Poland). This place simulates real condition in which the concrete shielding will appear when produced for power plant. During design process it was taken into consideration that nobody can get in to the research room during reactor operating time (because of radiation level) - only remote movement of concrete slabs is allowed; position control and configuration setting of the slabs are from the adjacent control room ensuring the safety of the operators.

The stand will be composed of: the cast iron frame on the rails, that allows the whole construction to move along the beam; detector (recombination chamber), cased by a shield preventing detection of particles dispersed; linear guide system (consisting of 14 linear rails intended to move 14 slabs) that allows changing the configuration of the concrete slabs that is insertion and removal of them from the reactor beam; and optional concrete block between the detector and linear guide system if the 14 concrete slabs would not give proper characteristics.

Each slab will have dimensions of 420x420x50 mm and will be made of high density concrete (about 4 g/cm^3/), which make single slab weight of about 35 kg. The whole construction was specially designed to hold equipment with 14 single slabs an extra concrete block doubling thickness of the tested shielding and detector shielded with concrete. (total carrying capacity t more than 1 ton).

RADIATION EXPOSURE WITH AIRBORNE DISCHARGE FROM EUROPEAN NUCLEAR POWER PLANTS

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In this investigation, we demonstrate results of airborne discharge analysis from vent stacks of European nuclear power plants. The main purpose of this investigation is to range radionuclides according to effective dose. In this case, authors consider only normal conditions of radionuclides discharge from nuclear power plant into the atmosphere. Nomenclature information of discharging radionuclides was obtained from the official website of Radiation Commission of the European Union.

The effective dose is assessed on the basis of discharging information from nuclear power plants with different types of reactors. The results of effective dose estimation from different types of reactors demonstrated:

- average value of effective dose to airbone discharge from Pressurised Water Reactor was $2.1 \cdot 10^{-8}$ Sv/year at a distance up to 500 m from the discharge source;

- average value of effective dose to airbone discharge from Advanced Gas-cooled Reactor was $4.3 \cdot 10^{-8}$ Sv/year at a distance up to 500 m from the discharge source;

- average value of effective dose to airbone discharge from Light Water Graphite Reactor was $2.0 \cdot 10^{-8}$ Sv/year at a distance up to 500 m from the discharge source.

Also, a list was formed from the radionuclides controlled at half of the nuclear power plants of the European Union at least. This list includes 36 radionuclides.

This estimation of effective dose allows to determine the list of radionuclides, which make up 99% of the dose for simulated conditions of population radiation exposure. Model conditions of public exposure are the same for each nuclear power plant. Such conditions include the main factors affecting the dose: sex and age structure of population, food cart, weather data and characteristics of terrain.

The obtained results can be revised by considering conditions of public radiation exposure formation for specific conditions of nuclear power stations location.

SAMPLE THICKNESS AND COMPOSITION EFFECT ON THE ABSORBED DOSE THROUGH SOME MATERIALS

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In order to protect healthy organs (tissues) located near tumor, radiotherapy centers are using linear accelerators equipped with multi-leaf collimators (MLC) in the fight against cancer.

In this paper we present an experimental study regarding the effect of the sample thickness and composition on the absorbed dose through some moldable materials that could be used as absorbent shields with applications in radiotherapy and radioprotection, when subjected to electron beams of various energy values (ranging from 6 to 15 MeV).

The samples have been obtained at West University of Timisoara by combining moldable silicon with different micrometric particles (aluminum or copper), and tested in the High Energy Radiotherapy Center from Timisoara.

The experimental results show that the absorbed dose through tested samples is between 30% and 95%, depending on the electron beam energy, sample thickness and sample composition.

These preliminary results suggest that the analyzed materials can be used as absorbers in different applications in radiotherapy and radioprotection.

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Keywords: absorbed dose, absorbers, radiotherapy, electron beams, shield

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ASSESSMENT OF DOSE RECEIVED BY ORGAN IN LUMBOSACRAL EXAMINATION

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This study was performed in Khartoum teaching hospital in period of January to June 2014. This study performed to assess the effective dose (ED) received in lumbosacral radiographic examination and to analyze effective dose distributions among radiological departments under study. The study was performed in Khartoum teaching hospital, covering two x-ray units and a sample of 50 patients. The following parameters were recorded age, weight, height, body mass index (BMI) derived from weight (kg) and (height (m)) and exposure factors. The dose was measured for lumbosacral x-rays examination. For effective dose calculation, the entrance surface dose (ESD) values were estimated from the x-ray tube output parameters for Lumbosacral Spine AP and lateral examinations. The ED values were then calculated from the obtained ESD values using IAEA calculation methods. Effective doses were then calculated from energy imparted using ED conversion factors proposed by IAEA. The results of ED values calculated showed that patient exposure were within the normal range of exposure. The mean ED values calculated were 2.49 $\pm$0.03 and 5.60 $\pm$ 0.22 for Lumbosacral Spine AP and lateral examinations, respectively.

APPLICATION OF PROCESS MAPPING FOR RADIATION SAFETY CONTROL

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As the domestic use of radiations increase in many institutions and industries, radiation safety control becomes increasingly complex. The number of persons required for radiation safety control has been decreased in spite of the increase in the number of facilities and radiation workers. The most important principle of radiation protection is to keep all does as low as reasonably achievable while still allowing the beneficial use of ionizing radiation. In addition, the objective of radiation safety control is to ensure radiation safety by limiting the probability of stochastic effects below the acceptable ALARA levels as well as preventing detrimental deterministic effects attributed to radiation exposure to personnel who handle the radiation and/or radioactive materials in the process of works and/or operation of nuclear facilities. The purpose of this research is to study the business analysis and process mapping for the radiation safety control from diversified and varied radiation sources and facilities. The managed organization of radiation safety and safety risk factors were analyzed. Protection objects and requirements for medical, industrial, research, and other radiation facilities were analyzed. The analyses were conducted, and the flow of individual radiation working process was ordered. Fourteen process maps of the radiation safety control were illustrated, based on each individual task analysis. This study will reduce errors and failures in the development of radiation safety control. This work was supported by the Nuclear Safety Research Program through the Korea Radiation Safety Foundation (KORSAFe), granted financial resource from the Nuclear Safety and Security Commission (NSSC), Republic of Korea (No. 2011-0031069)

CALCULATION OF DOSE RECEIVED BY ORGAN IN CERVICAL VERTEBRAE (C/S) EXAMINATION

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Reference dose levels provide a framework to reduce doses variability and aid in the optimization of radiation protection. This study performed to assess the effective dose (ED) received in Cervical Vertebrae radiographic examination and to analyze effective dose distributions among radiological departments under study. The study was performed in Khartoum teaching hospital, covering two x-ray units and a sample of 50 patients. The following parameters were recorded age, weight, height, body mass index (BMI) derived from weight (kg) and (height (m)) and exposure factors. The dose was measured for Cervical Vertebrae x-rays examination. For effective dose calculation, the entrance surface dose (ESD) values were estimated from the x-ray tube output parameters for Cervical Vertebrae AP and lateral examinations. The ED values were then calculated from the obtained ESD values using IAEA calculation methods. Effective doses were then calculated from energy imparted using ED conversion factors proposed by IAEA. The results of ED values calculated showed that patient exposure were within the normal range of exposure. The mean ED values calculated were 1.89 $\pm$0.02 and 2.15 $\pm$ 0.11 mGy for Cervical Vertebrae AP and lateral examinations, respectively. Further studies are recommended with more number of patients and using more two modalities for comparison.

RADIOLOGICAL CONSEQUENCE OF GASEOUS TRITIUM LIGHT SOURCE

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Gaseous tritium light source (GTLS) is a sealed glass tube internally coated with a phosphor and filled with tritium gas. The GTLS is widely used for luminescent items, including timepieces, compasses, fishing floats, telephone dials, and key rings. About 850 TBq of GTLS is imported annually in Korea. The products with GTLS are handled by workers for product manufacture and used by members of the public. The workers and the public lack knowledge in radiation protection. Therefore, it is concern of radiation exposure form the consumer products. The objective of this study was to assess radiological consequences of the GTLS by estimating radiation dose under various scenarios. Radiation doses were estimated for use of watch and potential incident scenarios. Radiation doses to skin and eye lens were calculated for the use of watch. The incident scenarios included breakage and fire during storage and accident during transport. The incident scenarios were categorized into public use, industrial use, and military use. For each incident scenario, intake of tritium was estimated and radiation dose was calculated based on ICRP human respiratory tract model. For the public use, radiation doses for all the scenarios were below 1 mSv in spite of conservative dose estimation. Therefore, it was considered that radiological consequences of breakage or fire of a single product is not significant. For industrial and military uses, dose estimations exceeded the annual dose limit to the general public for the most scenarios. Dose estimations were higher if many products were stored and damaged together. Therefore, It is necessary to establish safety control standards of consumer products containing radioactive substances. Many dose influencing factors contributed radiation doses. The safety control standards should be established considering the factors. This study showed that radiological consequences from any incident scenarios of a consumer product containing tritium below exemption level were not significant. If plenty of products or GTLSs are involved, the radiological consequences might be significant. Therefore, it is necessary to establish safety control standards of consumer products containing radioactive substances such as limits of total storage activity, standards for storage volume and ventilation, limits of total transport activity, use of transport container, standards for transport vehicles, etc.

THE EFFECTIVENESS OF RADIATION DAMAGE REDUCTION IN MICE BY LASER LIGHT DEPENDING ON THE TIME INTERVAL BETWEEN EXPOSURES

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The experiments we conducted earlier on the action of 650 nm laser radiation, as well as the combined irradiation with laser radiation and gamma - rays ^{60}Co of C57BL/6 mice showed that the red spectral region laser radiation can be used to improve the recovery of hematogenesis after their exposure to ionizing radiation. The method of the laser radiation protection of biological objects also contributes to an increase in the viability of mice, prevents the damages of skin, and also increases the mitotic activity of mice bone marrow cells. In these experiments, the time interval between exposures of ionizing and laser radiation should not exceed 30 minutes. From a practical point of view, the definition of the time interval during which the laser irradiation has the potential to reduce the radiation damages in mice is of great interest. To do this we conducted experiments with young mice CD1. The mice were irradiated at the Medical-Technical Complex of the Laboratory of Nuclear Problems of the Joint Institute for Nuclear Research. First the mice were exposed to gamma - radiation (whole body irradiation), then after 2 hours or 24 hours they were irradiated with laser radiation. When mice were irradiated with laser radiation they were placed, one by one, into a special bench. Only the furry back of each mouse and not the whole body was irradiated with laser radiation (dose 1mJ/cm^2). The area of the enlarged beam in the irradiation point was » 5.3cm^2 (approximately, 1/3 of the surface of the back).

The results of these studies have shown that the use of laser irradiation to reduce radiation damage in mice is effective 24 hours after exposure to ionizing radiation at a dose of 5 Gy which leads to the bone-marrow clinical form of the acute radiation sickness (ARS).

In the case of the lethal dose of ionizing radiation 7 Gy (the transitional clinical form of the ARS) the increase in life expectancy of mice is observed using laser radiation both 2 and 24 hours after exposure to gamma- radiation, but the effectiveness of the laser by using 2 hours after the ionizing radiation is significantly more efficient.

STUDY OF L-TYROSINE AND PYRIDINECARBOXALDEHYDES DERIVED SCHIFF BASE COPPER COMPLEXES AS POTENTIAL RADIOPROTECTIVE AGENTS

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Introduction. The increased use of ionizing radiation in various aspects of human life has necessitated development of an effective and non-toxic radioprotector to safeguard against harmful effects of radiation exposures. Many natural and synthetic chemicals have been investigated in the recent past for their efficacy to protect against radiation-induced damage in biological systems. However, the inherent toxicity of some of the synthetic agents at the effective radio-protective concentration warranted further search for safer and more effective radio-protectors. Efforts to find non-toxic radioprotectors have revealed strong radioprotective potential of essential metalloelement chelates. Many small molecular mass Cu organic complexes have been reported as chemical models of superoxide dismutase enabling them to prevent the accumulation of toxic metabolic products, promote biochemical, cellular, and tissue repair processes required for recovery from radiation injury including survival of lethally irradiated mice and rats. The biological activity of the metallocomplex depends not only on the metal ion, but also the ligand coordinated to the metal. Schiff bases are considered as very important class of organic ligands. Pyridinecarboxaldehydes (isomers bear the carboxaldehyde group at 2-, 3- or 4-position with regard to the nitrogen of pyridine ring) are useful precursors for complex forming Schiff bases because they may have similar physiological effect with pyridoxal-amino acid systems, which are significant in many metabolic reactions intermediated with amino acid and pyridoxal.

Aim of the Study. The present study was designed to investigate the radioprotective activity of copper complexes with Schiff Bases derived from isomeric 2-, 3-, and 4-pyridinecarboxaldehydes and L-tyrosine aromatic amino acid (Cu.2-Tyr, Cu.3-Tyr, and Cu.4-Tyr, correspondingly) and ascertain the role of the aldehyde group location in manifestation of radioprotective effect.

Materials and methods. Experiments were performed in white pubescent male rats subcutaneously or orally treated with metallocomplexes at 10 mg/kg or 40 mg/kg dose 1 hour or 24 hours before X-ray irradiation at 650 R dose level ($LD_{50/30}$ for untreated control irradiated rats). In 30 days after the exposure the indices of the average life-span of animals and their survival were determined.

Results and Discussion. At all the applied schemes of animals preventive treatment Cu.2-Tyr failed to manifest radioprotection, while Cu.3-Tyr and Cu.4-Tyr demonstrated expressed radioprotective activity. Animal survival achieved 100% in groups either orally or subcutaneously obtained Cu.3-Tyr at both considered doses 1 hour before irradiation, as well as at subcutaneous treatment with 10 mg/kg Cu.3-Tyr 24 hours prior to exposure. The same results were obtained in case of oral and subcutaneous administration of 40 mg/kg Cu.4-Tyr to rats 1 hour before irradiation facilitating animal survival up to 90%-100%.

Efficient radioprotective properties exhibited by copper organic complexes mainly might be related to their SOD- and Catalase-mimetic activities, as well as their respective support of endogenous non-enzymatic antioxidant defense system.

Conclusion. Cu.3-Tyr and Cu.4-Tyr can be considered potent radioprotectors equally effective both at oral and subcutaneous treatment prior to radiation exposure. Apparently, the position of carboxaldehyde group with regard to nitrogen of pyridine ring is of great importance for manifestation of radioprotective activity of studied Schiff Base copper complexes.

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ASSESSMENT OF RADIOLOGICAL IMPACT TO THE ENVIRONMENT CAUSED BY PRODUCTION OF RADIOPHARMACEUTICALS IN BRAZIL

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Currently, there are eight cyclotrons with radiopharmacy associated in regular operation in Brazil. The production of radiopharmaceuticals such as FDG-18, C-11-PIB or F-choline leads to the formation of radioactive gaseous effluents, presumably small, that are released to the environment. According to some authors "the characterization and estimation of the hazard generated by large scale production of these radiopharmaceuticals is still poor".

In order to assess their radiological impact to the environment, concentrations and doses were calculated using the code CROM which implements IAEA recommended generic models (SRS19). Real emission rates reported by the operators to the Brazilian regulatory body were used in the estimations.

Radioactive gaseous effluents of F-18 originated in the production of FDG and F-choline were considered. The release is produced in a Brazilian public research institution, 6 km away from the city center in a slightly populated area. The considered cyclotron is a PET Trace 8 of 16.5 MeV energy, manufactured by General Eletric Health Care. It is an unshielded accelerator with radiopharmacy associated that comprises a double hot cell.

Annual averages of parameters such as emission rate (Bq/s), wind velocity (m/s), wind frequency, wind stability class, height of the vent stack (m), distance of the interest point from the emission point (m) and occupancy factor were estimated in order to calculate the doses and concentrations. Were possible, real measured data in 2012 were used.

The results, calculated at 100 m from emission point, were 05 Bq/m^3 for the concentration of F-18 in the air, 6 μSv/year for external dose, 2 μSv/year for inhalation dose and 8 μSv/year for total dose.

The calculated values showed that the radiological impact from the releases is very low and, as previewed, within the limits established by the Brazilian regulatory body. It is important to observe that, although these doses are very low, the control of the releases is necessary taking into account the trend for growth of both: productions of new radiopharmaceuticals and the number of facilities.

RADIOACTIVE DUST RELEASE FROM THE NEW SAFE CONFINEMENT AT CHERNOBYL

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The Shelter encasing the 1986 destroyed unit 4 of the Chernobyl NPP still remains a dangerous nuclear facility. Inside the Shelter remained about 96 % of the irradiated nuclear fuel inventory of the reactor before the accident, i.e. 180 t of Uranium of total radioactivity 7x1017 Bq a remarkable amount of which exists as radioactive fuel dust. The radiological situation caused by the spent fuel inside the Shelter and especially the properties and spatial distribution of radioactive dust were investigated and compiled in a comprehensive data base in the frame of the German-French Initiative Sarcophagus Project ruled by GRS. Currently the New Safe Confinement (NCS) to cover the Shelter and thus to protect the environment from radioactive releases is under construction. Nevertheless the NCS arch with its huge dimensions of 250 m base and 100 m height is expect not to fit totally dense with the old Shelter building so that a remaining portion of the radioactive fuel dust will be able to escape through leaks and cracks towards the environment. The NSC is being constructed in two phases. The first phase will include all procedures of commissioning and the second phase envisages operation of 100 years. During operation it is planned to dismantle first the unstable Shelter structures and later all other Shelter structures. Both stages of work will inevitably be accompanied by rise of existing and production of additional new dust. The purpose of the present project is the development, verification and application of a three dimensional thermodynamic computer model describing the airborne dust circulation inside the NSC depending on the dust properties, the geometric conditions as well climatic conditions caused also by outside parameters as e.g. temperature, humidity, air pressure etc. Finally the dust release towards the environment through leaks of estimated several tens of square meters, the airborne dust dispersion in the atmosphere and subsequent radiological consequences will be calculated. The results will be evaluated with the NOVARKA consortium currently erecting the NSC as well with the operator of the NSC with the aim to reduce the radiation exposure.

ASSESSMENT OF OCCUPATIONAL DOSE IN FLUOROSCOPY PROCEDURES WHEN INDIVIDUAL MONITORING IS NOT UTILIZED

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The use of x-rays for diagnostic or interventional procedures has increased in recent years. Fluoroscopy unit are of particular concern because of potential for causing relatively high exposures to workers and patients. Working in a fluoroscopy room requires that workers stand near the x-ray source (both the x-ray tube itself and the patient, as a source of scattered x rays). These procedures may led to increased radiation exposure of radiologists and other staff members. This study derives whole body radiation doses and doses to the eye in fluoroscopy rooms , based on measurements that allow for estimates of occupational doses when personal dosimeters have not been used. Four geometrical configurations were considered : overcouch x-ray tube with and without table mounted lead rubber curtains in place, undercouch x-ray tube with horizontal x-ray beam and undercouch x-ray tube with vertical x-ray beam. Scatter radiation dose rate was measured using a calibrated dosimeter in terms of operational dosimetric quantity H*(10) , in the presence of the water phantom 25 cm x 25 cm x 15 cm as a scattering medium. The dose rate measurements was performed in steps of 20 cm from 40 to 200 cm from the floor in vertical direction and from 20 to 100 cm from patient table side in horizontal direction. These result were used for assessment of weighted surface dose, i.e. surface dose at position of a particular organ contribution to the effective dose, as this quantity could be used as a conservative estimation of the effective dose. The position of organs was deduced from the MIRD5 mathematical phantom. Information on typical exposure parameters was taken from clinical practice (average:95 kV, 3 mA, 10 min of fluorospy time and 6 exposures/examination of 82 mAs each) and was further used to assess effective dose and eye dose for radiologist and radiographer performing a fluoroscopy procedure. Different arrangements of personal protective tools were considered, as aprons of 0.25 mm, 0.35 mm and 0.5 mm lead equivalence and combination of lead apron and collar shielding of 0.25 mm lead equivalence. Estimated effective dose was in the range from less than 1 to 63 μSv per procedure for radiologist, and from less than 1 to 26 μSv per procedure for radiographer, depending on the geometrical configuration and level of personal protection. Corresponding unprotected eye doses were estimated to be in the range 31 – 2800 μSv per procedure for radiologist and 20-770 μSv for radiographer. The highest exposures are associated with overcouch tube geometry and absence of table mounted protective tools. The presented results allowed for realistic estimations of the occupational whole body dose and dose to the eyes from the workload of the staff members and from the level of use of radiation protection tools when personal dosimeters have not been regularly used.

FRAGMENTED EXOGENOUS DNA SHOWS LENGTH-DEPENDENT RADIOPROTECTIVE EFFECT IN RATS AFTER LETHAL EXPOSURE TO GAMMA-RAYS

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Objectives: The exogenous DNA could participate in a wide range of physiological and pathophysiological processes including bystander signaling during response to ionizing radiation (IR), inflammatory signaling, formation of neutrophil extracellular traps, carcinogenesis, etc. In 2007, it was shown that preparations of syngeneic and xenogeneic DNA could protect mice from death after lethal exposure to IR. However, no data are available about this effect in other animal models. The aim of our study was to characterize survival curves in rats exposed to IR at lethal dose with or without treatment with preparations of DNA of different degree of fragmentation.

Methods: All experiments were conducted under approval of local ethics committee in concordance with international guidance of animal handling. The male and female rats were kept in groups of 5-6 animals/cage in standard conditions of vivarium for at least 2 months before and after experiment. 12 month old rats were exposed to total body irradiation with gamma-rays at dose of 9 Gy (0.64 Gy/min, 137Cs) in cages i.e. without moving or mixing animals from different cages. During 5 min after exposure, animals were injected (i.p.) with 1 mg DNA of low (3000-23000 bp) and high (500-3000 bp) degree of fragmentation. Control group received injections of PBS. All events during period of 60 days after exposure were collected daily. The DNA was isolated from rat spleen by conventional method with CTAB (OD260/280=1.62-1.92), sonicated, dissolved in PBS (1 mg/ml) and aseptically filtered (0.2 um).

Results: The exposure of rats to IR at dose of 9 Gy caused death of animals in a sex-dependent manner. The first phase of death (4-13 day) by "gut scenario" was strongly pronounced in females: the median survival (m.s.) in males was 31 day and in females 10.5 days but the overall survival rate (s.r.) at 60 days was better in females (5 of 30 in comparison to 2 of 35 in males). The treatment with DNA of low fragmentation caused no effect on the first phase of death but intensified loss of animals during intermediate and final phase of death by "bone marrow scenario" both in males (m.s. 26 days, s.r. 3 of 35) and females (m.s. 11 days, s.r. 2 of 33). In contrast, the treatment with DNA of low fragmentation increased median survival in female rats up to 16 days (14.5 in control group) and survival rate on 56 day up to 10 of 30 (8 of 30 in control group).

Conclusions: We demonstrated that treatment with DNA of high degree of fragmentation could enhance survival in rats exposed to lethal dose of IR. In contrast, treatment with DNA of low fragmentation intensified losses in exposed male and female rats. These data demonstrate that radioprotective effect of exogenous DNA depends on degree of fragmentation. The death by "gut scenario" accounted more than 50 % of losses. Thus, the model could be optimized in order to achieve better evaluation of the dose of IR to assess the palliative effect on bone marrow protection.

AIR KERMA TO $H_p(3)$ CONVERSION COEFFICIENTS FOR EXPOSURE OF THE HUMAN EYE LENS TO THE SELECTED STANDARD X-RAY BEAM QUALITIES

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International Commission on Radiological Protection (ICRP) has decreased the annual dose limit for the eye lens from 150 mSv down to 20 mSv for occupational exposures. With this, the radiation protection and monitoring the dose to the eye lens have become an attractive research areas focused on the development of new types of dosimeters, new calibration procedures and application of the developed dosimetry in real workplace situations. The operational quantity Hp (3) has been defined for eye lens dosimetry, while cylindrical phantom approximating the shape of a head was suggested for calibration purposes. The aim of the work was to provide a set of conversion coefficients that could contribute to improving the overall quality of eye lens dose assessment procedures in workplace situation involving exposure to x-rays. The work investigated the eye dose to air kerma conversion coefficients, Hp(3)/Ka (in Sv/Gy), based on Monte Carlo simulations using a standard beam qualities and suitable cylindrical phantom. Monte Carlo code MCNP5/X was used to compute the conversion coefficients. The geometrical model is based on the PMMA water filled cylindrical phantom of 20 cm diameter and 20 cm height. An aligned and expanded field of photons collides with the entire phantom. The source was modeled as a square parallel beam of 20 x 20 cm^2 . The center of the scoring volume was positioned on the mid-plane at a depth of 3 mm. The thickness along the radius is 0.2 mm and a height of 2 cm around the axial midplane. The calculation was performed for the zero angulation. The tally used to score the kerma was 'F6' with 1-keV energy cut-off for photons. Beam qualities used for calculation of the conversion factors Hp(3)/Ka were narrow standard series on photon reference radiation defined in the International Organization for Standardization (ISO) publication ISO 4037. For zero angulations, the conversion factors Hp(3,00)/Ka were: 0.86 for N-40, 1.13 for N-60, 1.37 for N-80, 1.46 for N-100, 1.46 for N-120 and 1.44 for N-150 beam quality. The conversion factors Hp(3)/Ka provided in this work are related to standard beam qualities readily available in the calibration laboratories and are suitable for application in numerous workplace situations in medicine and industry. The provided conversion coefficients could be applied in calibration procedures utilized in calibration laboratories and thus, could contribute to the implementation and accuracy of the dosimetry measurements for the eye lens exposure.

ASSESSMENT OF AMBIENT GAMMA DOSE RATES IN TRANSYLVANIA REGION BY TL METHOD: PRELIMINARY RESULTS

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Thermoluminescent dosimeters based on LiF doped with Mg, Cu and P have been applied for measuring radiation doses in different fields such as clinical usage (diagnostic procedures, radiotherapy, interventional cardiology), space studies and environmental radioactivity with interest in natural gamma background measurements. Natural radioactivity varies from one location to another over the world with some areas where the level is significantly higher than the average; hence it is necessary to assess the right value for annual total radiation dose. For this purpose, alongside with the goal of computing accurate effective doses of exposure for the population, mapping terrestrial γ-dose rates has been performed in many countries around the world. In 2000, the Romanian National Commission for Nuclear Activities Control has limited public dose to 1 mSv/year above the natural background according to the Basic Safety Standards and ICRP 60 recommendations. Therefore, more sensitive dosimeters with lower detection limit are required in order to comply with this new public dose limit and LiF: Mg, Cu, P is capable to measure such low doses. This thermoluminescent material is attractive for assessment of low radiation doses due to its dosimetric characteristics such as ultra-high sensitivity, long-term information storage, easy handling, simple readout, good reproducibility, negligible fading, good linearity (1 μGy - 10 Gy) and tissue equivalence. The current study aims to obtain gamma dose rates for Transylvania region with the ultimate goal of achieving a high resolution map of gamma dose rates for this area. In order to fulfill this purpose, almost 450 ultrasensitive LiF: Mg, Cu, P dosimeters (code MCP-N and MCP-7 produced by TLD Poland) were used, in the form of 4.5 mm diameter and 0.9 mm thickness pellets. The dosimeters have been placed in 127 different locations from Cluj and Alba County between April 2013 and November 2014, by dividing the territory in cells of 10X10 km, thus covering about 127.000 km^2. The exposure time ranged from 3 weeks to 4 months. The values obtained for the environmental gamma dose rates ranged from 56 ±4 to 150 ±7 nGy/h, with an average value of 91 ±2 nGy/h, being in agreement with the 2008 UNSCEAR Report. The present study presents preliminary results for Transylvania region having the main goal to obtain a high resolution map of gamma dose rates. Performing this kind of measurements is one of the obligations of our country as a European Union member state.

CHARACTERIZATION OF SCATTERED RADIATION IN DENTAL CONE BEAM COMPUTED TOMOGRAPHY

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Dental cone beam computed tomography (CBCT) is an emerging imaging modality that requires special radiation protection considerations owing that CBCTs are capable of producing fairly substantial levels of scattered radiation when compared with previous dental radiology equipment. Furthermore, different models produce significantly different levels of radiation. In this work, results of scatter dose measurements CBCT and particular model of CBCT Scanora 3Dx Soredex. In CBCT, the amount of scattered radiation per scan depends on a number of factors. The dose distribution may not be uniform in all directions around the CBCT equipment. Dose rate measurement in terms of ambient dose equivalent H*(10) was performed using calibrated pressurized ionizing chambers (451-P, Fluke Biomedical, Cleveland, OH, USA) and following set up: CT head phantom of diameter 16 cm was used as scattering medium, phantom was position in the isocenter of the x-ray unit, at height of 140 cm from the floor and dose rate meter was positioned at distance 100 cm from isocentre at height 140 cm from the floor. Measurement points were arranged circularly, in 9 points (40 degrees shifts) around x-ray unit. Scattered radiation levels were presented in terms of integral dose per exposure in units nSv and normalized to unit patient dose in terms of dose area product (DAP) in unit mGycm2.

The range of scatter dose values was 0.1-5 μSv per scan, taking into account different scan protocols and angulations. For comparison, regulatory dose limit for workers is 20 mSv/y and for public it is 1 mSv/y. A person would need to spend time during approximately 200 scans at distance 1 m from the isocenter to receive the dose od 1 mSv, taking into account the worst case scenario. For all protocols and angulations the observed correlation varies from good to moderate, indicating that DAP value available on the console can be used for assessment of scatter dose levels. The scatter produced by dental CBCT has been demonstrated to be higher than that of conventional (intra-oral and panoramic) dental radiology techniques. Owing that the maximum amount of scatter per scan that can be produced by different models of CBCT covered a wide range from 4.1 μSv to 46.8 μSv, the results obtained in this survey are in the lower range of these values.

Scattered dose levels in the vicinity of CBCT are in close relation to the radiological protection requirements. The obtained scatter doses can be used to determine the amount of shielding that is necessary for particular facility, depending on the actual design. Obtained relationship between scattered dose per scan and DAP per scan for different protocols can be used for estimation of scattered dose levels if survey meter is not available, having in mind that DAP value is readily available from CBCT unit.

EXTERNAL DOSE ASSESSMENT OF DESIGN BASIS ACCIDENTS AT A NUCLEAR POWER PLANT BASED ON ICRP 103 DOSIMETRIC SETTING

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In the International Commission on Radiological Protection (ICRP) 2007 recommendations, ICRP adopted reference male and female computational phantoms (ICRP 110) for forthcoming updates of organ dose coefficients of both internal and external radiation sources. In early stage of nuclear power plant accident, the major exposure radiation source terms are noble gases. For assessment of external doses due to noble gases, the dose coefficients prescribed in FRG 12 & 13 have been widely used. The objectives of this study are to calculate the effective dose rate conversion factors, equivalent dose rate conversion factors and exposure doses of radioactive noble gases for the cases of air submersion with the nuclear decay data (ICRP 107) and the ICRP 103 adult reference phantoms. Effective dose rate conversion factors for most of noble gases in this study are about 90 % to 135 % difference for FGR12 & 13 data except a few nuclides. The assumption to calculate exposure doses, the TID-14844 radiation source terms was used, the assessment distance from reactor core was 560m and atmospheric dispersion factors were calculated with USNRC RG 1.145 methodology. Finally, the assessment doses by newly made DCFs were compared to that of using previous DCFs in FGR12 & 13.

WEB-APPLICATION "FAR EAST RADIOLOGICAL SAFETY"

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This paper describes user interface and the functionality of the “Far East Radiological Safety” web-application. This application is intended for use by the specialists of Far Eastern Federal University (FEFU) in order to solve radiation monitoring (RM) task as well as to get background information by different categories, for example by radiation hazardous objects. We’ve given the review of the primary capabilities of the application, such as: objects cartographic layout, RM data representation in graphical mode, object “summary” realization, base and extended object search modes.

RADIATION PROTECTION AND MANAGEMENT OF IRRADIATED WORKERS

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No other radiation accident thus far has been as serious as the one at Chernobyl, but scores of other radiation accidents have occurred, some of which have caused fatalities. Even in the absence of accidents, mortality from cancer and other diseases has been increased among radiation workers in the past. Today even the smallest doses are presumed to pose a potential risk of injury. In view of the large number of workers at risk, recognition, treatment and prevention of radiation injury command an important place in occupational medicine. To minimize the radiation exposure of workers without unduly sacrificing their efficiency requires careful design of the workplace and work procedures, through training, and supervision of workers, implementation of a well-conceived radiation protection program, and systematic health physics oversight and monitoring. Also needed are careful provisions for dealing with radiation accidents, emergencies, and other contingencies; systematic recording and updating of each worker's exposures; thorough labeling of all radiation sources and exposure fields; appropriate interlocks to guard against inadvertent irradiation; and various other precautionary measures.

In any workplace where employees may be exposed accidentally to radiation or radioactive material, plans for coping with such contingencies should be made in advance. Such plans require delineation of lines of authority for managing accidents, knowledge in the workplace of local health care facilities that are capable of evaluating and treating radiation accident victims, plans for transporting radioactive victims, and an understanding by the workers of the hazards of radiation. In caring for a radiation accident victim, good medical judgment and first aid should come first. Even if the worker has been heavily irradiated or contaminated, he or she must be evaluated also for other forms of injury, such as mechanical trauma, burns and smoke inhalation. To guard against self-contamination, those handing or examining the victim should wear gloves, masks and other protective clothing. Our paper presents general principles to be observed in every radiation protection program and management of the irradiated workers.

Key words: Ionizing radiation, workplace, protection, management

A RISK FACTOR FOR LUNG CANCER DUE TO RADON AND EXCESS LIFETIME CANCER RISK DUE TO TERRESTRIAL RADIATION - COASTAL AREA OF MONTENEGRO

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In order to establish baselines for further research on the role of radioactivity in initiating lung cancer, coupling the data on indoor radon concentrations obtained from earlier work with the data on ^{226}Ra, ^{232}Th (i.e., ^{228}Ac), ^{40}K and ^{137}Cs activity concentration in uncultivated soils, the risk factor for lung cancer due to radon and excess lifetime cancer risk due to terrestrial radiation – outdoor, were evaluated and compared for the Coastal area of Montenegro. An analysis of lung cancers diagnosed and treated in Montenegro in 2009 (using data from the Special hospital for lung diseases, and a book of decisions of the Oncology Consilium for all lung cancer diseased), showed that 23.3 % were from the Coast, with the incidence rate of 38.2 per hundred thousand (Ulcinj, Kotor and Herceg Novi had higher incidence rate than the country average – 33 per hundred thousand). Annual indoor radon concentrations were measured previously in 107 homes (Ulcinj – 19, Bar – 27, Budva – 17, Tivat – 6, Kotor – 6, Herceg Novi – 32) and using those results (and estimated exposure to radon daughters in the range from 0.006 to 0.61 WLM/y, with an average of 0.1 WLM/y), the risk factor due to radon is estimated to be in the range from 0.02 to 2.13 %. By measuring soil from 10 locations on the Coast (Ulcinj, Bar, Sutomore, Petrovac, Budva, Jaz, Tivat, Kotor, Risan, Herceg Novi), the external terrestrial gamma absorbed dose rate due to ^{226}Ra, ^{232}Th/^{228}Ac, ^{40}K and ^{137}Cs (showing the range: 11-216, 18.3-107, 276-646, 1.9-85.5 Bq/kg, respectively) were calculated (in the range from 28.1 to 195 nGy/h, with an average of 64 nGy/h), as well as corresponding annual effective dose rate (in the range from 34.5 to 239 μSv/y, with an average of 78.5 μSv/y), resulting in an excess lifetime cancer risk (with lifetime expectancy taken as 70 years) in the range from $0.12 \cdot 10^{-3}$ to $0.84 \cdot 10^{-3}$. Additionally, direct measurements of outdoor gamma dose rates were carried out on the measuring points and showed the range from 20 to 120 nGy/h, with an average of 43 nGy/h (annual effective: the range from 24.5 to 147 μSv/y, an average – 52.7 μSv/y), and corresponding excess lifetime cancer risk in the range from $0.09 \cdot 10^{-3}$ to $0.52 \cdot 10^{-3}$. Thus, the risk factor for lung cancer due to indoor radon exposure at the Coast of Montenegro (an average of 0.35 %, i.e., 0.0035) is significantly higher than excess cancer risk due to terrestrial radiation outdoor (an average of $0.27 \cdot 10^{-3}$ – from laboratory measurements, and $0.18 \cdot 10^{-3}$ – from direct dose rate measurements at the selected locations).

MONTE CARLO STUDY ON PHOTON-NEUTRON COUPLED TRANSPORT IN A SHIELDING BARRIER OF LAMINATED STRUCTURE OF BORATED POLYETHYLENE WITH LEAD IN A MEDICAL ACCELERATOR ROOM

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A medical accelerator operating with high energy photon beam produces a significant yield of photoneutron and, therefore, requires shielding neutrons in addition to photons. Laminating structure of borated polyethylene (BPE) of low-Z element with a heavy material such as lead is generally considered as an adequate shield. Shielding performance is characterized by photon-neutron coupled transport in a laminated structure. Our previous study showed that shielding characteristics are highly dependent into configurations of BPE and lead in a laminating structure. It was also noted that optimization of laminating structure is not only governed by an energy spectrum of photon and neutron but also the ratio of absolute fluence of neutron with that of photon prior to a shielding barrier. Furthermore, many studies showed that a magnitude of particle fluence and an energy spectrum are sensitive to geometrical structure of a medical accelerator room. In this context, understanding the basic characteristics of photon-neutron coupled transport is very important for optimization of shielding design. In this study, we examine how the photon-neutron coupled transport in terms of slowing down and attenuation is influenced by an energy spectrum and relative ratio of photon with that of neutron. Considering the monoenergetic beam of photon and neutron respectively, Monte Carlo simulation is conducted to estimate fluences of photon and neutron before and after a shielding barrier of BPE-lead laminating structure using the transport code of MCNPX. For an individual energy of photon and neutron respectively, a coupled matrix of absolute fluence of photon and neutron in front of a shielding barrier was studied. The Monte Carlo simulation results from the study on sensitivity to an energy spectrum as wells as relative ratio of fluence give the production and absorption of both neutron and photon, respectively. The results are expected to provide a guideline to decision making for design optimization of shielding photons and neutrons simultaneously in a medical accelerator room.

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RADIATION PROTECTION ASPECTS RELEVANT TO RADIOLOGICAL TERRORISM

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The paper discusses some basic aspects related to the protection of people against the danger resulting from a radiological weapon or the so-called dirty bomb used for terrorist or other malevolent actions. The properties of radioactive material applied for this purpose and the quantification of the potential exposure received by affected persons, the prevention measures against and consequences of radiological attack as well as appropriate arrangements aimed at minimizing its impact are described. In addition, an overview of global initiatives addressing the fight against international terrorism is also presented.

SCATTERED X-RAY ENERGY SPECTRA AT THE HEIGHT OF THE OPERATORS HEAD - FIRST RESULTS

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Introduction: In 2012, the International Commission on Radiological Protection has recommended a reduction of the dose limits to the lens of the eyes for occupational exposure. Recent studies showed that in interventional rooms is possible to reach these limits especially without using protective equipment. The aim of this study is to calculate scattered energy spectra distribution in front of the head of medical staff.

Materials and Methods: The in-house developed Monte Carlo-based computer simulation code was used to design computational phantoms (patient and operator), the geometry of irradiation as well as to simulate the photon transport through the designed system. The computational phantoms were designed by simple geometrical primitives. Elemental compositions of the tissues for all the phantoms as well as their dimensions were adapted from ICRP 110. The initial spectra from seven different tube voltages, four different filtrations were calculated according to the IPEM Report 78. Incident exposure was set to all data processing and visualizations were realized with Matlab 8.1.

Results: The scattered radiation distribution for 7 different tube voltage, 4 different filtrations of the X-Ray unit and 2 positions according to X-Ray unit to the examiner, typical for clinical conditions was recorded.

Discussion: The radiation fields in practice are complex and the defining a scattered energy distribution in practice is difficult task. At the other hand knowledge of the energy distribution is important for radiation protection to medical staff.

ARMIR: THE SYSTEM FOR ESTIMATION OF RADIOLOGICAL RISK FROM OCCUPATIONAL EXPOSURE

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At present more than 90% of the personnel of the State Corporation ROSATOM monitored for individual radiation exposure have reports on radiation risks assessed with computed system ARMIR. For several years average value of the risk in the Russian nuclear industry does not exceed 0.00008. As of today radiation dose received by the nuclear workers corresponds to a permissible levels of health risks. The percentage of the workers in the high risk group (risk value is above 0.001) is 1.25%. The most part of high risk group are old stagers.

ESTIMATING LIFETIME RISK OF CANCER ASSOCIATED WITH MULTIPLE CT SCANS

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Multiple CT scans are often done on the same patient resulting in an increased risk of cancer. Prior publications have estimated risks on a population basis and often using effective dose. Simply adding the risks from single scans does not correctly account for the survival function. The estimated magnitude of attributable risk fraction (ARF) for possible development of radiation-induced cancer points to the necessity for strong clinical justification when ordering multiple CT scans.

Multiple CT scans begin performed on the same patient over a period of time is commonplace. The organ doses associated with multiple CT scans are in the range where statistically significant increases in a number of types of cancer have been shown in atomic bomb survivors. In medical practice one must weigh the risk and benefits from a procedure and sometimes present this information to the patient. Quantitative estimation of the benefits from a CT scan is very difficult but qualitatively the benefits are apparent. Quantitative estimation of radiation risks is possible and a number of methods have been used. Use of effective dose is inappropriate for estimation of individual risk and for assessment of a subsequent cancer in a given individual. Our present work indicates that simply adding risks from multiple CT scans rather than taking into account age at exposure and the survival function also can result in aberrations in terms of estimating risk for an individual patient.

NON-TARGETED EFFECTS OF FACTORS FROM BLOOD SERUMS OF CHERNOBYL POPULATIONS

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The purpose of this work was to study the bystander effects, induced *in vivo* - in blood of populations, irradiated by the Chernobyl accident (Chernobyl liquidators, people working and living on contaminated by radionuclides territories of Belarus). Effects of bystander factors induced in vivo in blood of people affected by the Chernobyl accident are of particular interest. For the first time such studies were performed by Dr. I. Emerit in 1990, when it was shown that blood sera from liquidators of the Chernobyl accident or residents of areas contaminated by radionuclides contained an increased level of bystander factors. In Emerit studies own lymphocytes of serum donors were used as a test-system. In the present study, a new method has been developed, which allows evaluation of the effects of bystander factors from sera of different groups of populations on immortalized culture of human keratinocytes. This method has serious advantages as compared to that which was used earlier: used cells are not previously irradiated and could be cultivated for a longer period, they are more sensitive as compared to human peripheral blood lymphocytes, and experiments could be easily repeated, allowing simple comparison and interpretation of the obtained results. Using this method, we evaluated the level of damaging bystander factors in blood of areas irradiated by the Chernobyl accident. Affected population groups included liquidators of the Chernobyl accident and people living and working in areas of Gomel region contaminated by radionuclides. The analysis has shown that bystander factors persist in Chernobyl liquidator blood samples for more than 20 years since irradiation. The data suggest that blood sera contain bystander factors, which are able to induce micronuclei and decrease metabolic activity of HPV-G cells. These factors could be neutralized by antioxidant substances. The discovery of the nature of such factors will facilitate better understanding of radiation damage mechanisms. Knowledge of these mechanisms is increasingly important for cancer radiation therapy -for using special correcting coefficients taking into consideration effects of bystander factors. The ability to neutralize and modify these factors may help to decrease significantly the effects of whole body radiation exposure.

THE ASSESSMENT OF ^{137}Cs AND ^{90}Sr CONTENTS IN THE DIET OF CHILDREN AND YOUTH IN DIFFERENT AGE GROUPS IN POLAND

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Caesium-137 and strontium-90 have the greatest impact on the radioactivity level caused by artificial radionuclides in the environment, thus also in food products. Ingestion is one of the main pathways for the intake of radioisotopes into organism. To estimate the intake of ^{137}Cs and ^{90}Sr isotopes with food their contents in daily meals were determined for children of several age groups from 8-9 months to 17 years old. The research covered the period from year 2007 to 2009. To assess the impact of milk consumption on the intake of isotopes by small children (1-3 years) the study was carried out in parallel for a standard and for a milk-free diet. In addition to daily meals, products which have a great impact on the level of radio-isotopes in a daily diet were analyzed: milk, meat and milk for infants' nutrition. Sampling of daily meals was carried out in two orphanages. The study was performed by means of gamma spectroscopy and radiochemical techniques. The ^{137}Cs content depends on the composition of meals and - in this sense - also on the group age: (a) 0.06 - 0.08 Bq/d for children up to 1 year old; (b) 0.24 - 1.30 Bq/d for children 1-6 years old and 0.32-1.10 Bq/d for the group 7-17 years old. The measured ^{90}Sr was 0,03 Bq/d, 0.06-0.10 Bq/d and 0.07 - 0.13 Bq/d for the three groups, respectively. Eventually, the annual intake of the isotopes and effective dose were assessed. The effective dose due to the consumption of^{90}Sr and ^{137}Cs with meals did not exceed 5 mSv for all surveyed age groups.

ASSESSMENT OF THE EXTREMITY DOSE DURING THE EXPOSURE BY AN IRIDUM-192 SOURCE USING A CLOSE-HAND PHANTOM

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Industrial radiography is one of the most high risk radiation practices due to working with high activity radiation sources. Inadvertent handling the sources by hands is one of the frequent incidents in this job. Consequently the local parts of hands may highly be exposed to the source. So an accurate assessment of extremity local dose would assist the medical doctors to do appropriate treatments preventing the injury expansion in the area.

In this research, a tissue equivalent phantom was designed to simulate a close-hand position when one may take or displace the source by hands.

The local doses were measured by implanted TLDs within the phantom at different distances from the sources.

The results showed that the measured doses are in accordance with that of the analytical calculations methods at some test points within the phantom. So the phantom can be used for extremity hand dose measurements particularly at the points next to the source.

EFFECTS OF IONIZING RADIATION AND THE PROTECTION OF PEOPLE IN TERMS OF RADIOLOGICAL CONTAMINATION

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Radioactive elements and ionizing radiation are present in all the universe and planet Earth as well. From its beginning until today, life on Earth has constantly been exposed to the effects of radiation from natural and artificial sources. Ionizing radiation is widely used in industry and medicine and can present a significant health hazard. It causes microscopic damage to living tissue, which can result in skin burns and radiation sickness at high exposures, and statistically elevated risks of cancer at low exposures. Radiation may directly influence the molecule in some biological system through energy transfer when the molecule is ionized (or excited), or indirectly, through the energy transfer from another ionized molecule. Indirect effect of the radiation is of a particular significance for biological systems. It is known that proteins have the largest number of roles in an organism, and they are, in chemical terms, amino acid polymers, and the part most sensitive to radiation is amino group. Living environment represents a space in which a large number of different people live, and its preservation represents the preservation in terms of radiation and R contamination, as well. In this paper, bio-effects of ionizing radiation have been considered in detail and measures of radiological protection in the system of eco-safety have been suggested. The biological effects of ionizing radiation had been studied and documented within few years after the discovery of X-rays and further information has consequently been available from longitudinal studies on population affected by atomic bomb. Both are directly related to a known dose of radiation and have a dose threshold and their severity is dose related. The effects on the fetus are both somatic and genetic and the most radiosensitive period is 8-17 week of gestation. The safety of radiographic imaging of gonads and in pregnancy is discussed with reference to doses delivered in common radiological studies.

THE FUNCTIONAL COMPOSITES OBTAINED BY USING CARBON NANO-MATERIALS

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Development of TV-, radio-, mobile-, sat communication, navigation and radiolocation systems is resulted in increase of electric-magnetic radiation (EMR). So the problem of electric-magnetic ecology in great cities became more sharp due territorial concentration of such radiation sources.

The carbon composite was developed, which gives radio-protective properties to constructive materials (concrete, decorative break, gyps-cardboard and also to some heat- and sound-insulating materials), in order to protect inhabitant rooms against EMR by reducing EM levels to permissible sanitary values.
Nano-carbon in the composition comes into the matrix's micro-pores and structural channels and forms there nano-sized in cross section of the elements and macro-sized in length electric-conductive net. In this case, EMR causes quantum effects in the composite, as well as a number of energy transmit levels, which ensure wide-band EMR absorption. Adding graphite in the composition creates EMR diffusion centers and leads to forming of Relay's diffusion structures and different sized zones. As result, the material's working frequency range increases and also EMR mitigation due increase of the reflection coefficient. The EMR reflection/absorption coefficients' ratio can be changed by percentage of carbon and graphite in the composite.

The radio-protective materials with different filler fillers and relevant functions were obtained. The radio-absorbing fillers and coats on base of carbon components (carbon composition, carbon fibers and nano-pipes) are use for protection against UHF range EMR. These filler and coating materials were used for technologies to manufacture radio-protective constructive and decorative materials, radio-absorbing filler materials on base of paper, cloth, carbon fiber, foam-glass- or polystyrene pellets, radio-protective foam-glass, etc.

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RADIATION RISK OF CANCER AMONG NUCLEAR POWER PLANT WORKERS

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Today the radiation exposures almost are in the rage of low doses. This is referring to the exposure in the professional sphere. In cases of radiation with relatively low doses, only stochastic effects are probable. Individuals, working in nuclear industry are exposed to continuous radiation with low doses and low dose rate.

Objectives and Methodology: To estimate the probability of causation of cancer and go before occupational radiation exposure among workers in nuclear industry in Bulgaria. The method of the Probability of Causation provides possibility to determine the causative connection between the occupational exposure and the consequent radiation-dependant cancer. The probability for such a connection depends on the duration of the employment period in an ionizing radiation environment, as well as on the cumulative dose for that period, age and sex of the employee and the latent period for the corresponding localization.

Results: An analysis of the probability for a causative connection with the radiation was carried out on 77 workers in Nuclear Power Plant who have individual dosimetric card in the period 1986 - 2008. Cases with cancer of the digestive tract (21%), breast cancer (15%) and lung cancer (10%) are prevailing. Out of all analyzed workers 66% are male and 34% female. With 69 out of 77 workers the probability for their occupational radiation to be the reason for the cancer is zero. There is a probability that the additional exposure to radiation could be the reason for carcinogenic illnesses in 8 employees. The probability of occupational exposure to be the cause for the cancer is between 1% and 6%.

Conclusion: The present study does not find out a causative connection between cancer and a previous occupational radiation received through normal work.

OPTIMIZATION OF OCCUPATIONAL EXPOSURE DURING FIRST OPERATIONS WITH F-18 IN CUBA

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The Republic of Cuba gets ready for the work with Positron Emission Tomography (PET) and the main radionuclide used for this is F-18. It is required to import this radioactive material for the quality control of dose calibrators in hospitals that will have PET. The occupational dose assessment is executed as a part of documentation for request the authorization to the Nuclear Regulatory Body with software Microshield version 5.0.3 and its maximum dose rate is determined in contact with the type A package and the value of the index of transport. Once received the solution with F-18, is executed the radiological surveillance of the operations of preparation of the calibration solutions and the quality control of 3 dose calibrator properly. Electronic Dosemeters model Fisher Scientific EPD Mk2+ from United Kingdom is used for the control of the effective doses. Measures are introduced to optimize the occupational exposure among are using the hot cell with 20 cm of Pb for the measurement of the initial activity of F-18 and the determination of the characteristics of the first safety barrier, the organization of the work among 4 workers, the employment of a peristaltic pump and of means of distancing of the source. It is concluded that the effective doses are less than 80 μSv and also of the minimal detection limit for TLD in Cuba (100 μSv per month). Staff received only the 10 percent of the estimated equivalent dose to hands. Preparation of the reference sources in solution and weighing and dosage of pycnometers have the biggest contribution to workers exposures.

WHEN SCIENCE MEETS THE ART, AND HUMAN AWARENESS MEETS THE RESPONSIBILITY

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In this paper we discuss how science and technology products, such as Internet of Things are radically shaping the human relationships and engagement to the nuclear disasters monitoring and shifting the responsibility from government to citizens. Developing strong awareness of hazard effects, and giving the tools to citizens, the radiation monitoring become more personalized and self-directed, self-motivated, changing the passive observation into active participation. As starting reference we used the case of Safecast which was possible due to efforts of tinkering hobbyists, like the members of the Tokyo Hacker space, who designed the way to feed information that was critical onto the Internet in real-time. It emerged from human choreography where science meets the art, and human awareness meets the responsibility. Using donated Geiger counters and connecting them with Arduino development boards, an open source electronics prototyping platform, they were able to do that. Using platforms like Cosmo (formerly Pachube), which connects people to devices, applications and the Internet of Things, it was easy to aggregate all the data in one easily accessible place, which sparked visualizations like Haiyan Zhangs which uses the information available and presents them in easily understandable form, giving meaning to the measurements gathered in Japan. This paper explores the impact of connected objects on future of radiation monitoring. We give brief review and own view how interplay of social situatedness and connectedness, together with movable lab on chips, including signal acquisition and visualization of the world, data collection and aggregation, and presentation in an understandable way, are at the heart of the Internet of Things which dramatically changed the social response and relation to the nuclear disasters.

THEORETICAL EVALUATION OF THE BIOLOGICAL SHIELDING SUFFICIENCY FOR THE 1.7 MV PELLETRON NEC PARTICLE ACCELERATOR AT THE GHANA ATOMIC ENERGY COMMISSION

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Theoretical evaluation of the biological shielding sufficiency provided for the 1.7MV Pelletron NEC Particle Accelerator Research Centre of the Ghana Atomic Energy Commission (GAEC) has been done. Using the Beer Lambert law, attenuation of radiation dose outside the walls of the facility was made for protons of energy 1.7MeV. Simulation of charged particle-matter interactions leading to bremsstrahlung radiation using Monte Carlo code (MCNP5) have been carried out. The Neutron Activation Analysis (NAA)analysis revealed that the elemental constituents of the ordinary concrete of density 2.3g/cm3 used for the construction of the walls included Na, Al, and Ca. Background radiation levels within and outside the facility was measured with the aid of a Sodium Iodide (NaI) identifinder and a Rados detector so as to have a practical reference datum. The weekly background radiation measurements yielded an average dose rate value of 0.05μSv/hr from recorded value range of 0.01μSv/hr to 0.07μSv/hr for an eight month period. Modeling and simulation of charged particle-matter interactions at different beam energies using Monte Carlo code (MCNP5) have yielded the dose rate of 1.58E-07uSv/hr outside the 22.86cm (9.0 inch) thick wall of the accelerator facility. The calculated value comparing with that of NCRP 151.Hence, it is concluded that the shielding provided for the accelerator is sufficient. Practical evaluation will need to be carried out to confirm the theoretical findings.

QUANTIFIABLE TECHNICAL ASPECTS OF A QUALITY MANAGEMENT SYSTEM FOR TL PERSONAL DOSIMETRY SERVICES

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The National Radiation Protection Department (NRPD) is the regulatory body for supervision of all personal dosimetry service providers via the national TLD laboratory in Iran.

This paper describes the technical activities realized by the NRPD to the national personal TL dosimetry laboratory for the implementation of a quality management system (QMS). The object is to achieve compliance with the requirements of ISO/IEC 17025 and accreditation for testing measurements of the physical and operational quantities of radiation dose.

ONSITE INSPECTION OF SPENT FUEL ASSEMBLIES - A MAJOR CONCERN IN RADIATION PROTECTION AND INTEGRITY OF NUCLEAR POWER PLANTS

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Higher safety and reliability are a pair of major aspects in the operation of Nuclear Power Plants (NPP). Increased burn-up rates related to meet power requirements result in higher neutron fluences that imply greater radiation damage of NPPs core and structural materials. During reactor operation, fuel assembly materials are the primary metallic components that experience higher neutron fluences, temperatures and mechanical stress. Further these materials undergo geometry changes or damage caused by parameters in the core. Fuel rods change their shape by the combination of swelling, creep, growth and bow. But the whole fuel assembly changes its geometry, too. This is influenced by parameters in the reactor core, e.g. radiation, coolant flow, temperature, water chemistry, etc. The coolant flow through the reactor core in combination with reactor internals and design of fuel assemblies can cause vibrations of fuel rods. This can lead to fretting damage and consequently to fission products release to the coolant. Bowing of fuel assemblies can lead to incomplete rod insertion for example. This can affect the NPP safety, functional reliability as well as economics. The potential fuel damages in light water reactors are prevented by the introduction of new procedures and programs of the fuel behavior monitoring refer to as post-irradiation inspections or pool-side inspections. Such inspections are performed onsite, in spent fuel pools during NPP outage to identify the geometric instabilities and to recommend for the structure updates. Fuel inspections also help to reduce radiation situation of the coolant because they enable to find leaking fuel rods that can be removed from the fuel assembly, to find a foreign object stuck in a fuel assembly or to determine the corrosion situation in the reactor core that is in relation with water chemistry.

In this paper, we discuss about the photogrammetry technique used for poolside inspections of fuel assemblies from NPP Temelín, a VVER-1000 reactor. Furthermore, findings from the fuel inspections will be presented that have an impact in the performance of the fuel assemblies and safety of NPP.

POSSIBLE ROLE OF PHOSPHOLIPASE A2 AND MITOCHONDRIA IN THE MECHANISM OF IONIZING RADIATION-INDUCED OXIDATIVE STRESS

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Ionizing radiation alters mitochondrial functions, increases mitochondrial oxidative stress, and induces apoptotic cell death. Exposure to ionizing radiation is known to result in an increase in ROS generation and damage to important biomolecules, such as nucleic acids, proteins and membrane lipids. The lipid peroxidation leads to disturbances of the membrane structure and lipid packing that can disrupt the barrier function of membranes and be an important co-factor in the organism's damage from ionizing radiation. As it is known, one of the enzymes responsible for the maintenance of membrane integrity and metabolism of fatty acids is phospholipase A2. It was found that the absence of the gene of secretory phospholipase A2 (PLA-IIA) from mice C57BL/6 accompanied with an increase in resistance to radiation. Thus, it can be assumed that the inhibition of phospholipase A2 would result in an increase in survival rate of organisms exposed to ionizing radiation. Therefore, in the present work the effects of inhibitors of secretory phospholipase A2 (YM-26734) and cytosolic phospholipase A2 (AACOCF3) on the survival of mice Kv:SHK after the exposure of ionizing radiation at a dose of 7Gy were studied. It was shown that the intraperitoneal injection of AACOCF3 and YM-26734 in a dose of 1 mg/kg animal body weight resulted in an increase in survival rate of mice exposed to ionizing radiation (by 50% and 30% respectively). The calculation of blood cell count also showed that the phospholipase A2 inhibitors partially prevent leucopenia of mice exposed to radiation. In parallel, we studied parameters of mitochondrial bioenergetics of mice exposed to ionizing radiation at a dose of 6Gy. It was found that liver mitochondria of the irradiated animals after 3 days of radiation exposure revealed decreased respiration rates (V2, V3, V4, VDNP), reduced respiratory control ratio (from 3.1 to 2.6) and decreased ADP/O parameter (from 2.8 to 2.5), compared with the control group of animals. Furthermore, the Ca2+ capacity of liver mitochondria of the irradiated mice was reduced by 1.5 times compared to control group. Possible mechanisms of protective action of phospholipase A2 inhibitors have been discussed. This work was supported by grants from the Government of the Russian Federation (project No. 14.Z50.31.0028) and RFBR (project No. 15-04-03081-a).

DETERMINATION OF ABSORBED DOSE RADIATION QUALITY NEAR EYE PHANTOM IRRADIATED WITH THERAPEUTIC PROTON BEAM USING A RING-SHAPED RECOMBINATION CHAMBER

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Recombination methods were applied for determination of stray radiation doses and quality factors close to the eye phantom irradiated with two therapeutic proton beams. The main contributors to the out-of-field doses were neutrons and scattered protons. An innovative recombination chamber has been used. The chamber is ring-shaped, so that the proton beam can be directed trough the empty center of the ring and the outer part of the chamber registers only the signal from secondary particles and radiation background. There is an option to place an eye phantom inside the ring, in order to simulate the realistic conditions of therapeutic irradiation. In that case the chamber simulates the area surrounding the eye. During the measurements, the chamber is placed on the therapeutic chair with the axis along the direction of the therapeutic beam. The eye phantom should be fixed in therapeutic position. The chamber body and electrodes are ring-shaped so the beam may be directed through the empty center of the ring. The ionization of the filling gas is caused by secondary or scattered radiation and can be related to the dose absorbed in the tissues close to the irradiated target volume. The chamber also allows for determination of recombination index of radiation quality at small distances from phantoms of eye. Measurements were performed in the Institute of Nuclear Physics (IFJ PAN) in Krakow at the cyclotron AIC 144 and at the Proteus-235 isochronous cyclotron.

THE NUCLEAR POWER PLANTS' NEW METHODOLOGY FOR UNIVERSAL VULNERABILITY ASSESSMENT OF TERRORISM THREATS AND NATURAL DISASTERS ANALYSES AND PREDICTIONS

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National emergency systems in the past, based on our in-depth analysis and assessments, explicitly did not include vulnerability assessments of the critical nuclear infrastructure as an important part of a comprehensive preparedness framework. After the huge terrorist attack on 11.09.2001, decision makers became aware that critical nuclear infrastructure could also be an attractive target to terrorism, with the purpose of using the physical and radioactive properties of the nuclear material to cause mass casualties, property damage, and detrimental economic and/or environmental impacts.

To assure safe nuclear facilities operation and national security, the necessity to evaluate critical nuclear infrastructure vulnerability to threats like human errors, terrorist attacks and natural disasters, as well as preparation of emergency response plans with estimation of optimised costs, are of vital importance.

In the article presented new universal methodology and solution methods for nuclear power plants and other radiation objects vulnerability assessment can help the overall national energy sector to identify and understand the terrorist and natural disaster threats to and vulnerabilities of its critical infrastructure. In the world first developed new mathematical formula for quantitative vulnerability assessment estimations is also presented. Furthermore, adopted methodology could help national regulators and agencies to develop and implement a vulnerability awareness and education programs for their critical assets to enhance the security and a safe operation of the entire energy infrastructure.

The new methods presented in the article can also assist nuclear power plants to develop, validate, and disseminate assessment and surveys of new efficient countermeasures. Consequently, concise description of developed new quantitative methods and adapted new methodology for nuclear regulatory vulnerability assessment of nuclear power plants are presented.

An important new additional original contribution is use of new formula for quantitative vulnerability assessment estimations for three different nuclear power plants from which one power plant is Fukushima in Japan. Particularly important is the use of new methodology for the qualitative and quantitative "case study" assessment of the vulnerability of nuclear power plant in Fukushima to natural disaster which has occurred.

By all this new methodology and solution methods the regulatory bodies could importantly improve radiation protection in their countries.

DNA DAMAGE UNDER THE COMBINED EXPOSURE OF MOUSE BLOOD LEUKOCYTES TO ORANGE-RED AND ULTRAVIOLET RADIATION

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The negative effects of sunlight on biological systems are mainly caused by ultraviolet (UV) radiation. UV-C (100-280 nm) is fully absorbed by the stratospheric ozone layer, but unabsorbed UV-B (5%) and UV-A (95%) can induce cellular DNA damage by various mechanisms. To protect against the damaging effects of UV radiation, implementing an innovative "useful sun" strategy, special nanoluminofors are developed which convert the UV component of solar radiation into the bio-stimulating orange-red light, in contrast to the conventional "safe sun" strategy, in which the UV component is absorbed or screened. The aim of the work was to assess the damaging effects of UV-A and UV-B radiation on the cellular DNA and a protection potential of orange-red light against DNA damage, and clarify the mechanisms of protective effects.

The experiments were performed using the whole blood leukocytes of male random-bred white Kv:SHK mice. The cells immobilized in agarose slides were exposed to different light at a room temperature or treated with hydrogen peroxide at 37oC for 10 min. Mercury lamp DRSH250-3 with different filters was used for the exposure. An additional orange-red component was formed by nanoluminofor containing screen with the excitation spectrum in UV and blue light and maximal luminescence at 625 nm. DNA damage in mouse whole blood leukocytes was assessed using an alkaline comet assay by the percentage of DNA in the comet tail (TDNA%).

We have found that TDNA% was about 18.5 ±0.8% when the cells were exposed to the total radiation from the used lamp at a dose of about 6 J/cm2. Upon irradiation of the cells using a polycarbonate filter (390-700 nm) at even higher doses, DNA damage was not observed (0.24 ±0.08%). The exposure of cells using different filters at an equivalent dose of 1.8 J/cm2 induced DNA damage in leukocytes of about 19.1 ±1.7% (290-390 nm), 1.3 ±0.2% (330-390 nm), 19.4 ±1.2% (313 ±20 nm), and 22.7 ±1.8% (280-330 nm), respectively. These results are indicative of the DNA damage mainly caused by UV-B (280-320 nm). The use of nanoluminofor containing screens (with active and inactivated luminofor) showed that the exposure with active luminofor induced protective effect, the DNA damage was reduced on the average by 30%. Recently, we have found that the exposure of water solutions to orange-red light led to production of reactive oxygen species (ROS) at nanomolar concentrations, which can be mediators of the protective effect. We revealed that the pre-incubation of the cells in the presence of exogenous hydrogen peroxide at concentrations of 300-500 nM resulted in a reduction of DNA damage induced by UV-B on the average by 25-30%. Thus, the mechanisms of the protective effect are associated with the induction of adaptive response by nanomolar concentrations of ROS induced by the orange-red light.

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STUDY ON OCCUPATIONAL EXPOSURE IN INDUSTRIAL RADIOGRAPHY PRACTICE

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Revision of the basic standards for the health protection of workers and the general public against the dangers of ionizing radiation elaborated by IAEA and by the Community under Article 2 (b) of the Euratom Treaty is based on the recommendations of the ICRP publication 103.

The revised recommendations contain no essential changes of radiological protection policy, but help to clarify the application of the protection system for all the various exposure situations which occur and therefore improve protection standards.

One of the main amendments to the revised Directive, caused by the ICRP recommendations, consists in changing the dose limits. Whole body dose limit was set at 20 mSv / year, with flexibility to consider the 5-year average.

According to the new approach, occupational exposure in planned exposure situations is controlled under constraint optimization procedures associated with the source and using procedures similar to prescriptive dose limits for "practice".

The aim of this study is to review the occupational exposure doses recorded in industrial radiography practice undertaken at fixed facilities and on site before the entry into force of the revised standards. One of the main scopes of this paper is to provide information on doses for comparison and to give an indication of whether the techniques were optimized in terms of doses and to discuss about the categorization of the industrial radiography workers.

The assessment was performed based on the doses recorded in 6 Romanian companies from 1978 to July 2013 for 144 persons operating X-ray machines, including accelerators and gamma installations (192 Ir and 60 Co; λ=5,5TBq). Approximately 54% of the recorded doses are below the minimum detectable level and 28% of operators received less than 1mSv/year. The staff involved in the practice received whole body doses ranging from 0.1 to 9 mSv/year. It can be noted that the highest annual exposure received as a result of routine operations over the period is below the annual limit of 20mSv.

TESTING POSSIBILITIES OF PERSONAL RADIATION AND CHEMICAL PROTECTIVE CLOTHING

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Protective properties of radiation and chemical personal protective clothing are studied at the National Institute for Nuclear, Chemical and Biological Protection. Radiation shielding protective clothing (RSPC) are prior tested via a narrow collimated beam of X- and gamma rays originated from 133Ba, 241Am, 137Cs, 60Co, 152Eu point radioactive sources. X-rays or gamma rays attenuation in tested materials is then determined.

Properties of shielding garments in dispersed ionizing rays environment are tested in radioactive aerosol atmosphere, developed in hermetic 'Radon-Aerosol Chamber' (RAC), where short-term radionuclides (e.g. 140La,24Na, 99mTc, 222Rn together with its decay products) are used for preparation of aerosol atmosphere. In case of222Rn, the radionuclide is injected into the RAC, where its decay particles deposit on subsequently injected non-radioactive aerosol. As regards the other radionuclides, the radioactive aerosol is formed by evaporation of corresponding radioactive salt solution, releasing from an aerosol generator, and then it is injected into the RAC. A mannequin placed inside the RAC is equipped with the tested RSPC together with thermo-luminescent dosimeters (TLDs). The TLDs are positioned on the RSPC surface and under it. Absorbed dose decrease, measured by the corresponding groups of TLDs, determines protective efficiency of tested RSPCs.

A supplementary testing method for whole body protective suits against radioactive contamination is determination of radionuclide decontamination efficiency after controlled radioactive contamination. This method is mostly realised by determination of surface radionuclide activity before and after decontamination procedure.

Penetration through leaks of chemical protective clothing together with other personal protective equipment (masks/respirators, gloves and protective shoes) is frequently tested. A person or mannequin is placed inside hermetic 'Toxicological Chamber' (TC) with atmosphere of selected chemical compound, such as benzoyl chloride, chlorine gas or sulphur mustard. Testing person is dressed in specially impregnated underwear and the tested protective clothing. Colour changes caused by reaction between tested compound and impregnated underwear visualise the points of untightness of the protective suit and/or its single parts. In case of chlorine used as testing gas, quantitative determination of the colour changes can be perform by means of digitalised colorimetric system.

Physiological stress of users induced by wearing of radiation and/or chemical protective suits can be tested in specially designed 'Climatic Test Chamber' (CTC). The tested person acclimatisation under different thermal, air flow and humidity conditions may also be carried out. Physiological stress of persons can be investigated under various combinations of protective clothing. They can be dressed in underwear together with chemical protective suit or radiation shielding protection clothing, or combination of both.

PUBLIC EXPOSURE IN BOUNDARY AREAS OF IRAN - PRELIMINARY RESULTS

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Introduction: A continuous monitoring in boundary areas of a country is one way to indicate the level of public exposure of inhabitants as well as possible released radioactive materials from the neighboring countries.

Materials and Methods: The background radiation was assessed at the meteorological stations of 12 boundary cities as well as Tehran (Capital) which are shown in Fig. 1 using TLDs. The measurements were carried out at 4 semi-annual time intervals from the beginning of January 2010 to the end of December 2011.

Results: The bi-annual average of monthly ambient dose equivalents was measured less than 40 μSv/month for the located cities at the sea level to more than 55 μSv/month which are on higher elevation. There is one exception for Ramsar which is a coastal city but shows a higher background radiation as a high elevation city. This is probably due to the presence of radium or radon progenies in the air or soil of that high level natural radiation area

Conclusion: Annual public external exposure is obtained 0.83 mSv/y which is less than the corresponding total value of 0.9 mSv/y reported by UNSCEAR.

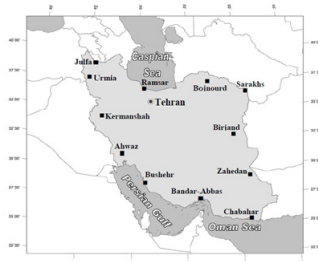

Fig. 1 Location of the selected boundary cities in ambient gamma dose measurements.

Table 1: The measured monthly average of background gamma dose in semi-annual time intervals in boundary areas of Iran.

City	Geographical coordinates (city center)	Mean elevation (m) (above sea level)	Monthly average of background gamma dose in semi-annual time intervals (nSv/month)				Monthly average of background gamma dose 2010-2011 (nSv/month)
			Jan-Jun 2010	Jul-Dec 2010	Jan-Jun 2011	Jul-Dec 2011	
Urmia	37°,33,19"N 45°,04,21"E	1330	47.5 ± 2.6	56.0 ± 1.9	67.9 ± 4.9	90.9 ± 0.7	**65.58** ± 18.84
Julfa	38°,56,75"N 45°,37,51"E	710	47.1 ± 1.8	47.7 ± 1.8	65.3 ± 2.2	79.6 ± 1.4	**59.90** ± 15.62
Ramsar	36°,54,11"N 50°,39,30"E	10	42.2 ± 3.1	45.4 ± 1.1	63.1 ± 1.3	80.7 ± 1.2	**57.83** ± 17.81
Bojnourd	37°,28,30"N 57°,20,00"E	1070	42.1 ± 3.4	41.7 ± 0.3	64.8 ± 3.6	82.2 ± 0.3	**57.68** ± 19.61
Sarakhs	36°,32,42"N 61°,09,28"E	270	47.6 ± 0.9	40.2 ± 1.4	59.3 ± 1.1	79.3 ± 1.0	**56.58** ± 17.09
Birjand	32°,52,00"N 59°,12,00"E	1450	46.7 ± 1.9	45.4 ± 1.8	61.6 ± 2.3	74.3 ± 2.5	**56.98** ± 13.70
Zahedan	29°,29,47"N 60°,51,46"E	1350	46.0 ± 1.3	52.5 ± 1.6	64.9 ± 2.7	77.5 ± 1.4	**60.20** ± 13.95
Chabahar	25°,17,31"N 60°,38,35"E	10	30.6 ± 1.3	32.7 ± 1.0	50.2 ± 0.4	46.7 ± 1.2	**40.03** ± 9.87
Bandar-Abbas	27°,11,00"N 56°,16,00"E	10	29.2 ± 0.5	28.1 ± 1.4	46.6 ± 2.6	43.3 ± 1.7	**36.78** ± 9.55
Bushehr	28°,58,00"N 50°,50,00"E	10	28.1 ± 0.5	38.6 ± 0.7	47.6 ± 0.8	44.7 ± 0.6	**39.73** ± 8.63
Ahwas	31°,19,13"N 48°,40,09"E	15	27.9 ± 1.4	27.4 ± 2.3	37.8 ± 2.0	37.9 ± 1.4	**32.73** ± 5.90
Kermanshah	34°,18,51"N 49°,03,54"E	1350	40.9 ± 2.3	41.2 ± 0.6	70.3 ± 1.7	69.8 ± 0.7	**55.53** ± 16.78
Tehran (Capital)	35°,41,46"N 51°,25,23"E	1367	60.5 ± 2.9	55.5 ± 2.9	75.7 ± 2.7	84.7 ± 1.2	**69.08** ± 13.50

PUBLIC PERCEPTION OF IONISING RADIATION / STUDIES ON MENTAL MODELS OF RADIATION IN POLAND

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The studies on mental models of understanding ionizing radiation in Poland were conducted within the frames of EURATOM project "Enhancing education, training and communication processes for informed behaviours and decision-making related to ionizing radiation risks" (EAGLE). Supporting material for investigation of public perception of ionizing radiation was a questionnaire composed of questions about the structure of matter, concept of ionising radiation, its sources, effects, risks and possible means of protection. The answers of selected group of 16 respondents were supported by individual drawings that expressed the idea of the structure of matter, atom, images of radiation and interaction of IR with matter. The questionnaire ended with questions about Fukushima accident, its impact on the level of knowledge and perception of IR, as well as responsibility of decision-makers. The role of media in dissemination of the knowledge and information in emergency cases was evaluated.

The studies revealed that the knowledge about ionizing radiation in society is rather low and superficial. It is insufficient to understand the phenomena associated with IR like interaction with human organism during medical procedures, diagnostics and therapy. Although people accept the methods offered by nuclear medicine their acceptance is based on the trust to the doctors, but not understanding the phenomena connected with IR. The most of respondents accept nuclear power and benefits associated with nuclear energy. The greatest concerns are related to accidents in NPPs; however the phenomena that occur during failure of the plant are not well understandable. The opinions concerning information sources are different; though most of respondents think that decisions to apply IR or construct the future NPP should be taken by experts and governmental bodies. In opinion of respondents the role of public should be marginal; the society ought to be consulted and should warn against the hazards. The role of mass-media is important, but sometimes not completely clear; the media inform, but very often the information is not professional and reported facts are exaggerated. The knowledge and positive attitudes towards the IR depends on the age; it is independent on place of living, gender and education. The survey conducted in Poland is part of a wider activity carried out by EAGLE consortium, whose aim is to find gaps, differences, misunderstandings and misconceptions between public and professionals from European countries.

Acknowledgements

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INSURANCE AGAINST RADIATION EMERGENCY RISKS IN THE RUSSIAN FEDERATION: PAST, PRESENT AND FUTURE

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As shown by the experience of major disasters (wild fires and floods) in the Russian Federation, insurance companies do not fully compensate the public for damage caused by such disasters because of a low insurance coverage among the general population. Eventually, public authorities have to undertake both disaster relief and compensate for losses suffered by the affected people. A compulsory insurance against the risk of disaster could reduce the burden on the regional and federal budgets. However, as of now, Russia has no laws requiring that people living in disaster-prone areas should insure their lives, health and property against the risk of such disasters.

Radiation emergency is an emergency accompanied with signs of radiation accident or contamination, regardless of its cause. Insurance is the only available form of financial guarantee of compensation for nuclear (radiation) damage. The current Russian legislation does not require compulsory insurance of individuals against the risk of radiation emergencies.

In 2014, the Russian Emergencies Ministry drafted guidelines on providing insurance coverage for the population against radiation emergencies. The guidelines contain recommendations to:

- insurance services for contracts of compulsory insurance of civil liability of nuclear facility operators before the third parties for the risk of radiation emergency;
- insurance services for contracts of voluntary insurance of individuals against the risk of radiation emergency;
- insurance services for contracts of compulsory insurance of physical persons against the risk of radiation emergency.

The draft contains the following key recommendations for contracts of compulsory insurance of individuals against the risks of radiation emergencies:

1) guidance for prediction of damage due to a radiation emergency;

2) guidance for determining the limit of insurance compensation per claim under a contract of compulsory insurance:

- for damage resulting from the death of each victim;
- for damage resulting from personal injury;
- for damage to property of each affected person, except for damage due to abnormal life conditions;
- for damage caused by deterioration of the life conditions of each affected individual.

A record of radiation emergencies is kept by the Emercom of Russia National Emergency Management Center as part of the record of all natural and man-made disasters that occurred in the Russian Federation. Although the statistics of radiation emergencies shows a rather optimistic picture, the proposed compulsory insurance against the risks of radiation emergencies in the Russian Federation would prevent unforeseen expenditures related to compensation for damages due to nuclear accidents and would be an important factor of disaster relief.

CONSIDERATIONS OF THE HORIZONTAL FUEL CHANNEL AND REFERENCE PLANS FOR INSTALLATION INTO THE CALANDRIA OF CANDU 6 NUCLEAR REACTOR

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The aim of this study is to identify the fuel channel components and the reference plans based on which is made the installation into calandria of CANDU 6 nuclear reactor.

The CANDU 6 is a 740 MW pressure tube reactor designed by Atomic Energy of Canada Limited (AECL) to provide safe and reliable nuclear power. It is an evolution of the previous CANDU reactor, and it is designed to be licensable internationally by ensuring its compliance with the latest Canadian nuclear regulations and the fundamental safety principles of the International Atomic Energy Agency (IAEA) Safety Standards.

The CANDU reactor design is based on the experience derived from preceding CANDU reactors and virtually every design feature of the latest CANDU reactor is identical to, or it is an evolutionary improvement of, an earlier proven design.

The design of the CANDU fuel channel is accordingly the result of continuing intensive engineering development of its major components.

The reactor assembly of the CANDU 6 nuclear reactor consists of the horizontal, cylindrical, low-pressure calandria and the end-shield assembly. This enclosed assembly contains the heavy water moderator, the 380 fuel channels assemblies and the reactivity mechanisms.

The fuel channels are one of the major distinguishing features of a CANDU reactor and their reliability is crucial to the performance of the reactor. Each fuel channel consists of four major components: the pressure tube, the calandria tube, the annulus spacers and the end fittings. Fuel bundles are enclosed in the fuel channels that pass through the calandria and the end-shield assembly.

The fuel channel is designed to ensure a radiation exposure protection of workers and public, during the reactor operation.

The fuel channels are assembled and installed into the calandria vessel at the reactor site following installation of the calandria.

The fuel channel assembly is made according with the specific requirements of reference planes definition, reference planes measurements, tools and equipments, installation procedures and the quality assurance program.

Defining reference plans, measurements reported to reference plans and installation procedures to a new fuel channel in the calandria CANDU nuclear reactor comply the requirements described in the AECL (Atomic Energy of Canada Limited) specified documents.

SCHEMATIC REPRESENTATION OF THE HORIZONTAL FUEL CHANNEL ASSEMBLY MAIN STEPS INTO THE CALANDRIA OF CANDU 6 NUCLEAR REACTOR

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The scope of this paper is to obtain the needed information on main steps necessary to assembly the fuel channel into calandria of CANDU 6 nuclear reactor.

The CANDU fuel channel is essentially the same in all CANDU reactors and it is considered a fundamental building block in the CANDU system and their reliability is crucial to the reactor performance.

The fuel channels have a high importance for the operation of CANDU nuclear reactors because they allow new refueling while operating at full capacity.

The reactor assembly consists of a hollow cylindrical structure called the calandria assembly, fuel channels and control mechanisms of reactivity.

The 380 fuel channels are composed of pressure tubes, made of zirconium-niobium alloy, located inside the calandria tubes, with two end fittings mounted, that are connected by the pipes network of the cooling supply feeders.

Each CANDU fuel channel consists of four major components: the pressure tube, the calandria tube, the annulus spacers and the end fittings.

The install operations to a new fuel channel must comply with the described requirements from the specified documents by AECL. The main installation operations are the roll expansion of the pressure tube ends into the two end fittings, the welding of the end fittings to the bellows and the installation of the positioning assemblies. The following installation and inspection of all 380 channels, the feeder pipes of the cooling system are connected to the end fittings.

After each operation, the resulting information must be recorded in the specific registration and verification documents of each component and each operation.

The registration documents, the check documents and the related reports of the fuel channel installation are part of the processes records of the assembly history of the nuclear reactor. All these documents and reports will be archived in order to take anytime a sequential picture of each fuel channel.

The radiological safety analyses are made by certified experts for assessment of radiation exposure of workers and public.

CONSIDERATIONS OF DECOMMISSIONING OF THE HORIZONTAL FUEL CHANNELS OF CALANDRIA'S CANDU 6 NUCLEAR REACTOR

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Based on the knowledge referring to assembly the fuel channel into calandria of CANDU 6 nuclear reactor, the purpose of this study is to achieve possible method for decommissioning of the horizontal fuel channels of calandria vessel.

As long as nuclear power plants are reaching their end of lifecycle, the decommissioning of these installations has become one of the 21st century's great challenges. Every project may be managed differently, depending on the country, development policies, financial considerations, and the availability of qualified engineers or specialized companies to handle such projects.

The main objective of decommissioning is to place a facility into such a condition that there is no unacceptable risk from the decommissioned facility to public health and safety of the environment.

The overall decommissioning strategy is to deliver a timely, cost-effective program while maintaining high standards of safety, security and environmental radiation protection. If facilities are not decommissioned, they could degrade and potentially present an environmental radiological hazard in the future. Simply abandoning or leaving a facility after ceasing operations is not considered to be an acceptable alternative to decommissioning.

The decommissioning activities performed are administrative and technical, and include the preparation, endorsement and approval of documents, obtaining permits and authorizations, providing financial resources, decontamination, dismantling, demolition, controlled removal of equipments, components, conventional or hazardous waste demonstrating the fulfillment of the radiological conditional or unconditional release of the facility and the ground included in the decommissioning project.

The Nuclear decommissioning consists in a planning phase and the implementation of all procedures and operations.

The decommissioning of fuel channels represents one of the last operation which is performed in the nuclear power decommissioning and it is the most important operation in the nuclear reactor dismantling.

The radiological safety analyses should be made by certified experts for protection assessment to radiation exposure of workers in time of fuel channel dismantling.

The dismantling of fuel channels represents the final phase of nuclear facility decommissioning and refers to the technical operations taken to extract the components from inside of the nuclear reactor channel. It is a complex process and requires activities such as disassembly decommissioning device, locking/unlocking the channel closure and the shield plug, pressure tube cutting, extracting of each component from the channel, as well as radioactive waste management.

The dismantling operation stages of the fuel channel components should be repeated for each of all 380 channels of the reactor, starting from the front of calandria side and continuing with the rear side.

The final aim of decommissioning is to recover the geographic site to its original condition.

RESEARCHES FOR THE DEVELOPMENT OF A DEVICE FOR THE DECOMMISSIONING OF THE HORIZONTAL FUEL CHANNELS IN THECANDU 6 NUCLEAR REACTOR

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The objective of this paper is to present a possible solution for the designing of a device for the decommissioning of the horizontal fuel channels in the CANDU 6 nuclear reactor.

The decommissioning activities are dismantling, demolition, controlled removal of equipment, components, conventional or hazardous waste (radioactive, toxic) in compliance with the international basic safety standards on radiation protection.

One as the most important operation in the final phase of the nuclear reactor dismantling is the decommissioning of fuel channels.

For the fuel channels decommissioning should be taken into account the detailed description of the fuel channel and its components, the installation documents history, adequate radiological criteria for decommissioning guidance, safety and environmental impact assessment, including radiological and non-radiological analysis of the risks that can occur for workers, public and environment, the description of the proposed program for decommissioning the fuel channel and its components, the description of the quality assurance program and of the monitoring program, the equipments and methods used to verify the compliance with the decommissioning criteria, the planning of performing the final radiological assessment at the end of the fuel channel decommissioning. These will include also, a description of the proposed radiation protection procedures to be used during decommissioning.

The dismantling of the fuel channel is performed by one device which shall provide radiation protection during the stages of decommissioning, ensuring radiation protection of the workers. The device shall be designed according to the radiation protection procedures.

The decommissioning device assembly of the fuel channel components is composed of the device itself and moving platform support for coupling of the selected channel to be dismantled. The fuel channel decommissioning device is an autonomous device designed for dismantling and extraction of the channel closure plug and shield plug, extraction of the end fitting, cutting and extraction of the pressure tube.

The fuel channel decommissioning device consists of following major components: coupling and locking fuel channel module, assembly valve for access to the fuel channel, storage tubes assembly for extracted components, handling elements assembly, cutting and extraction device and housing device.

The design of the device and platform support is achieved according to the particular features of the fuel channel components to be dismantled in the program of nuclear reactor decommissioning according to all the safety aspects and environmental protection during the activities, resulting from the decommissioning plan developed.

RESEARCHES FOR THE DEVELOPMENT OF A CUTTING AND EXTRACTING DEVICE FOR THE DECOMMISSIONING OF THE HORIZONTAL FUEL CHANNELS IN THE CANDU 6 NUCLEAR REACTOR

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This paper present a constructive solution proposed by the authors in order to achieve of a cutting and extracting device for the decommissioning of the horizontal fuel channels in the CANDU 6 nuclear reactor.

One of the most important part of the decommissioning device is the Cutting and Extraction Device (CED) which perform the dismantling, cutting and extraction of the fuel channel components. This flexible and modular device is designed to work inside the fuel channel.

The main operations performed by the Cutting and Extraction Device (CED) are dismantling and extraction of the channel closure plug and shield plug, cutting and extraction of the pressure tube.

The Cutting and Extraction Device (CED) consists of following modules: guiding-fixing module, traction modules, cutting module, guiding-extracting module and articulated elements for modules connecting. The guiding-fixing module is equipped with elastic guiding rollers and fixing claws in working position, the traction modules are provided with variable pitch rollers for allowing travel speed change through the fuel channel. The cutting module is positioned in the middle of the device and it is equipped with three roll knives for pressure tube cutting, having a system for cutting place video surveillance and Â pyrometers for cutting place monitoring temperature.

The operations performed by the Cutting and Extraction Device (CED) of fuel channel are as follows: unblock and extract the channel closure plug, unblock and extract the channel shield plug, block and cut the middle of the pressure tube, block and cut the end of the pressure tube, block and extract the half of pressure tube.

The Cutting and Extraction Device (CED) is fully automated, connected by wires to a Programmable Logic Controller (PLC) and controlled from a Human Machine Interface (HMI).

The design of the Cutting and Extraction Device (CED) shall be achieved according to the particular features of the fuel channel components to be dismantled and to ensure radiation protection of workers.

SPECIFIC PSYCHOLOGICAL FEATURES OF RESIDENTS IN AREAS OF POSSIBLE RADIATION EMERGENCIES

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Individuals of different sex, age, education and occupation tend to assess their radiation risk differently. However, getting information about actual radiation emergencies causes a significant psychological stress and sharply increases anxiety in all population groups, which can be explained by the specifics of the public perception of radiation risk.

Based on this fact, it has been hypothesized that living close a nuclear power station (in the areas of possible radiological emergency) has a significant impact on the psychological condition of the residents.

Two groups of subjects were recruited for a study: an experimental group (people living near a nuclear power station) and a control one (people living at least 300 km from the nuclear power station). Both groups had similar general characteristics:

age: 18 to 40;

gender composition: 30% males, 70% females;

education: higher;

other characteristics: urban economically active population.

A comparative study of the two groups based on the survey results suggested the following conclusions:

- susceptibility to stress in the experimental group was lower than in control;
- neurotization level in the experimental group was higher than in control. This points to increased emotional excitability, which results in negative emotions (anxiety, tension, restlessness, confusion, irritability);
- a comparative analysis of the two groups in terms of mental condition showed higher anxiety and frustration, lower aggression, and rigidity of people in the experimental group as compared with the controls.
- mental stress was found in all respondents in the experimental group;
- anxiety level in the experimental group was higher than in the control group.

The performed analyses demonstrated that living near a nuclear power plant had a negative impact on the psychological condition of the residents. Noteworthy is that before the diagnostic survey as little as 15% of the respondents in the experimental group answered that living near a nuclear power plant affected their psychological condition, whereas the other 85% of them denied any effect.

This means that a comprehensive psychoprophylactics is necessary to improve the psychological state of residents in areas of possible radiation emergencies, even if the respondents' subjective feelings do not show the need for such corrective actions.

The results of the study can be used in:

- psychological counseling of people living in areas of possible radiation emergencies;
- planning comprehensive psychoprophylactics aimed at improving the psychological state of those living in areas of possible radiation emergencies;
- planning rescue and other emergency response activities in areas of possible radiation emergencies.

KINETICS OF COBALT-60 ADSORPTION REMOVAL FROM LIQUID RADIOACTIVE WASTE USING A POLY(ACRYLIC ACID) HYDROGEL

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Kinetics of cobalt-60 adsorption removal from liquid radioactive waste using a poly(acrylic acid) hydrogel Co-60 with half-life ($t_{1/2}$ = 5.27 y) commonly occurs (with the shorter-lived isotopes Co-57 and Co-58) in liquid effluent discharged from nuclear power and waste reprocessing plants [1]. Enormous amounts of low-level liquid radioactive wastes are being produced as a result of operation, repair and disposal at those facilities [2]. The adsorption technologies using different adsorbents such as: zeolites, bentonite, ion exchangers, sepiolite, lignocellulosic and hydrogels, may be used for removal radioactive ions very successfully [3].

The aim of this work is to investigate the kinetics of isothermal adsorption of cobalt ions from an aqueous solution onto poly(acrylic acid) (PAA) hydrogel. The PAA hydrogel was synthesized by the procedure described in our previous work [4]. The kinetics of Co^{2+} adsorption was carried by the batch method.

The concentration of Co^{2+} remaining in supernatant was determined by measuring the absorbance at 625 nm. The determination of Co^{2+} ions as Co-(thiocyanate) was carried out by using the method of spectrophotometry [5]. The UV-Visible spectrometer (Cintra 10e, GBC Scientific equipment) was used.

The isothermal adsorption kinetics curves were recorded at temperature range from 298 K to 315 K.

By using Friedman's iso-conversional method [6] was established that the kinetics of Co^{2+} adsorption was a kinetical's elementary process. The model fitting method [7] confirmed that the kinetics of Co^{2+} adsorption could described by theoretical kinetic model of three-dimensional diffusion (D3): $[1-(1-a)^{1/3}]^2=kt$.

Based on the found changes in the adsorptions constant rates with temperature, by applying the Arrhenius equation, the values of adsorptions kinetics parameters were calculated (E_a = 41 ± 4 kJ mol-1 and $t \ln [A/min^{-1}]$= 12 ± 2). A probable mechanism of Co^{2+} adsorption from water solution onto PAA hydrogel was postulated.

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HISTORICAL PROGRAM FOR MANAGEMENT OF RADIOACTIVE WASTE IN BULGARIA

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In 2004 a state enterprise for management of radioactive waste (SERAW) was founded. According to regulatory requirements SERAW has to develop a special program for the management of historical radioactive waste including spent high activity radiation sources (SHARS) by beginning of 2006.

The need for the program emerged from the large amounts of historical wastes accumulated in many sites all over the country during the political and economical changes in Bulgaria in 1990-ies. A lot of spent and disused sources became orphan or vulnerable. The ownership, the activity and the staff of the sites with radiation sources had been changed several times in few years. Reliable information and records for the sources were not available. Some sites' owners and users were even unaware of the presence of sources at the sites. The major owners of historical wastes were research institutes, industrial facilities, hospitals, military bases, Uranium mining and milling faculties. Due to the security reasons in the past part of these sites stayed outside of regulatory control. No inventory of sources had been kept or maintained. No financial provisions for the management of radioactive wastes had been made.

The program has elaborated the approach for search, identification, characterization and qualification in situ and acceptance by SERAW of historical wastes. The special program has found the ways to secure the technical and financial resources for the consolidation of legacy radioactive waste to the Novi Khan Repository in a long term schedule. The principle "Polluter Pays" was introduced in Bulgaria by the Act on the Safe Use of Nuclear Energy in 2002. It took a few years for the waste generators to get accustomed to this principle and begin planning financial resources to address the proper transfer and disposal of radioactive waste and disused sources.

This program is vital to ensure that a proper management pathway is provided for disused sources and waste throughout Bulgaria. The identification and consolidation of SHARS are considered of highest priority in the special program. The total activity of more than 20 PBq have been secured by consolidation of SHARS at the Novi Khan repository of SERAW. The special program has been supported by Bulgarian Nuclear Regulatory Agency, IAEA and Defense Nuclear Nonproliferation's Radiological Security Program (DNN RSP), DOE - USA. In 2015 the removal of SHARS from the sites of the Institute for Nuclear Research and Nuclear Energy and Military Medical Academy is foreseen.

RELATIONSHIPS BETWEEN BONE TREATMENT CONDITIONS AND CO^{2+} SORPTION CAPACITIES

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60Co is an important radionuclide in spent nuclear fuel and radioactive wastes related with nuclear reactors and fuel reprocessing plants. It is a neutron activation product of cobalt present in various components of nuclear reactors (steel alloys). Due to beta and gamma radiation, this isotope exhibit high impact onto environment and living organisms. Sorption processes on hydroxyapatite (Ca10(PO4)6(OH)2) can be successfully applied for the purification of water containing Co2+ ions. Bio-apatite materials, derived from animal bones, were found to be cost-effective alternatives for synthetic hydroxyapatite powders. However, organic phase removal is an essential treatment step for the production of effective sorbents with high specific surface area. In this study, dependence between bovine bone treatment conditions and Co2+ sorption was investigated. Eight sorbents were previously prepared using fractional factorial design, by simultaneous variations of five process variables between two levels: factor A-the type of the chemical reagent (H2O2 or NaOH), factor B-reagent concentration (0.1 mol/L or 2 mol/L), factor C-reaction temperature (200C or 600C), factor D-contact time (1h or 3h) and factor E-sample annealing (without or at 4000C). At this point, amounts of Co2+ sorbed by these materials were considered as system responses, and the treatment factors significant for sorption efficiency were selected using statistical analysis. Sorption experiments were conducted by mixing each sorbent with Co(NO3)2 solutions (initial concentrations of Co2+: 10-4, 5 ·10-4 and 5 ·10-3 mol/L; initial pH 5), at solid/liquid ratio of 1:200 for 24 h. The results showed that the impact of factor treatment was different for different starting concentrations of Co2+. All bone sorbents were found to be similarly effective considering the lowest initial Co2+ content (10-4 mol/L), while differences in sorption capacities have become noticeable for higher investigated initial Co2+ concentrations. Consequently, no statistically important relations could be established between treatment conditions and Co2+sorption for lower levels of contamination, whereas thermal treatment at 4000C was the only statistically significant factor influencing sorption from the most concentrated solution (5 ·10-3 mol/L). Depending on initial Co2+ concentration, various factors had statistically significant effect on equilibrium pH values, whereas no relation was found between bone treatment conditions and the amounts of Ca2+ released during the sorption. Based on the obtained results, possible mechanisms of Co2+ sorption were discussed. For the production of high capacity Co2+ sorbent, variation of chemical factors in wide ranges was less effective than thermal treatment of bovine bones.

THE RECOVERY OF BORON BY USING MEMBRANE TECHNOLOGIES - THE REVIEW

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Boron in the form of boric acid plays an important role in the field of nuclear energy. The presence of this element in the first circuit of the coolant in PWR nuclear reactors allows control of reactivity, especially during start-up and shut-down operations. During operation of the reactor the concentration of boron is changed as the fuel is used up and becomes less reactive. In the form of borosilicate, as control rods, boron is used in emergency shut-down systems. Stable isotope of boron - 10B, which constitutes 19.9% of natural boron, possesses high cross-section for absorption of thermal neutrons and thus compensates for changes in core reactivity temperature-related effects and regulates reactor power. To change the reactor reactivity using boric acid, it is necessary to bleed of some amount of coolant or inject boric acid into cooling water. The cooling reactor water must be of high purity; required quality of water is achieved in water make-up systems that allow providing sufficiently low concentration of chemical impurities

The problem to solve is the separation of boron from activation and corrosion products. There are many methods that allow its separation such as: reverse osmosis, electrodialysis and ion exchange. However, these methods have some drawbacks, such as unsatisfactory selectivity and high energy demand. The alternative to these processes may be a micellar-enhanced ultrafiltration.

The study presents a concept of micellar-enhanced ultrafiltration applied for the simultaneous recovery of boric acid and elimination of radionuclides contained within water of the primary cooling circuit of PWR reactor.

RADIOBIOLOGY

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STATE OF PERIPHERAL BLOOD OF FISH IN WATER BODIES WITHIN THE CHERNOBYL EXCLUSION ZONE

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During 2008-2013 we studied the peripheral blood of fish inhabiting the most radioactive contaminated water bodies of the Ukrainian sector of the Chernobyl Exclusion Zone (ChEZ) - Glubokoye Lake, Azbuchin Lake, Yanovsky Backwater and cooling pond of the Chernobyl NPP. We analyzed the leukograms and rate of erythrocyte morphological abnormalities: deformation of nucleus and cell membrane, nucleus and cytoplasm vacuolization, pyknosis and lysis of cells, forming of microcytes, schistocytes and double-nucleus cells as well as micronuclei. The common perch (Perca fluviatilis), the roach (Rutilus rutilus), the common rudd (Scardinius erythropthalmus) and the crucian carp (Carassius carassius) were the main species of our studies. The obtained results were compared with published data, as well as with material sampled from water bodies at the Kiev region area with background levels of radioactive contamination. Analysis of leukograms and erythrocyte morphological abnormalities in peripheral blood of fish under conditions of radiation dose rate in range of 30-330 μGy h-1showed that fish from the most contaminated water bodies characterised by decrease of the part of lymphocytes, whose function is to realize the immunological reactions. At that the increase in the number of granulocytic elements - neutrophils and pseudoeosinophils, executing a phagocytic function and involving to allergic and autoallergic reactions was observed. Also it is determined a low content of neutrophils by increasing of monocytes, which are the active blood phagocytes absorbing decay product of cells and tissues. Thus increasing the number of these cells in blood of fish indicates the implementation of protective mechanisms to enhance the protective functions of the organism. The rate of erythrocyte micronuclei in peripheral blood of fish form water bodies within the ChEZ registered in range of 0.06-1.41‰, and double-nucleus erythrocytes - 0.04-0.33‰ with highest rates in fish of Glubokoye Lake. Micronuclei and double-nuclei cells in the blood of the control fish have not been detected. Rate of erythrocyte nuclei abnormalities as invaginations and ramification recorded at the following levels: 4.7-14.0‰ in the cooling pond of the Chernobyl NPP; 6.4-29.0‰ in Yanovsky Backwater; 17.3-29.1‰ in Azbuchin Lake and 7.1-15.0‰ in the Glubokoye Lake. The highest rate of erythrocyte nuclei abnormalities registered in blood of the pike from Yanovsky Backwater and Azbuchin Lake. In control water bodies the rate of invaginations and ramification in erythrocyte nuclei did not exceed 0.5‰. According to the literature data the atypical form of nucleus of healthy red blood cells in fish occurs with rate 0.4‰ and increase the rate of the nucleus membrane invaginations evaluated as degenerative changes of erythrocytes resulting from the negative impact of environmental factors on the fish organism. The total level of morphological abnormalities of red blood cells for pray fish in 4-12 times and for predatory fish in 7-15 times higher than the similar parameters in water bodies with background levels of radioactive contamination and with dose rates in range 0.06-0.12 μGy h-1.

DROSOPHILA GENE EXPRESSION ALTERATIONS AFTER INFLUENCE OF POLLUTANTS (DIOXIN, TOLUENE, FORMALDEHYDE) AND LOW DOSE OF GAMMA-IRRADIATION

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General and specific effects of molecular genetic responses to adverse environmental factors are not well understood. This study examines genome-wide gene expression profiles of Drosophila melanogaster in response to ionizing radiation, formaldehyde, toluene, and 2,3,7,8-tetrachlorodibenzo-p-dioxin. We performed RNA-seq analysis on 25,415 transcripts to measure the change in gene expression in males and females separately. An analysis of the genes unique to each treatment yielded a list of genes as a gene expression signature. In the case of radiation exposure, both sexes exhibited a reproducible increase in their expression of the transcription factors sugarbabe and tramtrack. The influence of dioxin up-regulated metabolic genes, such as anachronism, CG16727, and several genes with unknown function was considered. Toluene activated a gene involved in the response to the toxins, Cyp12d1-p; the transcription factor Fer3's gene; the metabolic genes CG2065, CG30427, and CG34447; and the genes Spn28Da and Spn3, which are responsible for reproduction and immunity. All significantly differentially expressed genes, including those shared among the stressors, can be divided into gene groups using Gene Ontology Biological Process identifiers. These gene groups are related to defense response, biological regulation, the cell cycle, metabolic process, and circadian rhythms. KEGG molecular pathway analysis revealed alteration of the Notch signaling pathway, TGF-beta signaling pathway, proteasome, basal transcription factors, nucleotide excision repair, Jak-STAT signaling pathway, circadian rhythm, Hippo signaling pathway, mTOR signaling pathway, ribosome, mismatch repair, RNA polymerase, mRNA surveillance pathway, Hedgehog signaling pathway, and DNA replication genes. Females and, to a lesser extent, males actively metabolize xenobiotics by the action of cytochrome P450 when under the influence of dioxin and toluene. Finally, in this work we obtained gene expression signatures pollutants (dioxin, toluene), low dose of gamma-irradiation and common molecular pathways for different kind of stressors.

The study was supported by grant of President of Russia MD-1090.2014 and grant of RFBR N 14-04-01596.

XpG GENE AS THE MARKER OF INDIVIDUAL SUSCEPTIBILITY OF HUMAN GENOME TO AN INCREASED CONCENTRATION OF RADON

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Estimating the biomedical long-term effect of small doses of ionizing radiation is a complicated issue that affects not only radiobiology but also social and economic spheres. It has been reported that > 60% of the ionizing radiation a person receives every year can be caused by natural sources of radiation, and more than 50% of this radiation can be due to radon and the products of its disintegration. A correlation between radon and the frequency of lung cancer has been confirmed in recent years by extensive epidemiological research.

One of the most actual problems of modern science is the searching of some molecular-genetic markers that can be as indicators of the individual sensitivity of human body to radon and its decay products.

As a result of the long-term monitoring was performed in 2007-2012 years, we have found that children living in the boarding-school in the Tashtagol city (Kemerovo Region, Russia) are exposed to the influence of the excessive doses of radon (> 200 Bq/m3).

For the assessment of the level of cytogenetic damages we have used the following methods: micronucleus assay in exfoliated cells, cytokinesis-block micronucleus assay in peripheral blood, and analysis of chromosome aberrations (CAs) in peripheral blood.

The DNA extraction was performed by standard phenol-chloroform method.

For the determination of allelic variant of the potential marker genes we have used the allele-specific end-point PCR using the reagent kit produced in the Lytech Company (Moscow, Russia).

We have discovered that the XpG gene Asp1104His polymorphism is associated with an increasing of some cytogenetic markers, registered in all three cytogenetic tests performed in this study.

The His/His genotype was associated with the increased frequency such cytogenetic markers as binucleated lymphocytes with micronucleus (MN) (0.8 ± 0.11% in comparison with Asp/Asp and Asp/His genotypes – 0.56 ± 0.09% and 0.69 ± 0.21%, respectively) and single chromosome fragments (5.09 ± 0.53% in comparison with 3.78 ± 0.29% and 4.42 ± 0.29%). These indicate that the carriers of His/His genotype are characterized by the increased level of genetic damages.

The frequency of protrusions of “bubble” type registered using micronucleus assay in exfoliated cells was lower by carriers of His/His genotype too. Such type of protrusions is a result of the elimination from cell DNA-reparation complexes, so we may suppose that the His/His genotype is associated with the insufficient activity of DNA repair under an influence of radon and its decay products.

We have discovered, that the XpG gene Asp1104His polymorphism is a marker gene for the assessment of individual susceptibility of human organism to radon and its decay products, and the His/His genotype of this gene is associated with the increased genome susceptibility.

EFFECT OF LOW-DOSE GAMMA RADIATION ON THE *DROSOPHILA MELANOGASTER* LIFESPAN

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Ionizing radiation in low doses has a wide range of biological effects from benefit (adaptive response, hormesis) to harmful (hypersensitivity, genetic instability).

Previously, we found that the effect of radiation-induced hormesis on Drosophila melanogaster lifespan may be mediated by FOXO, SIRT1, JNK, ATM, ATR and p53 genes, as well as genes of heat shock proteins hsp22, hsp67, hsp70, hsp83 and heat shock factor hsf. The analyzing of gene expression using RNA-sequencing data showed that ionizing radiation in a dose of 20 cGy induces transcriptional activation of genes associated with longevity (Sugarbabe), but reduces the expression level of genes associated with aging (Keap1, Hormone receptor-like in 38, Relish, CG6188, Peptidoglycan recognition protein LB).

Based on these data, we assumed that changes in gene expression may be the primary mechanism of effects of radiation-induced hormesis on lifespan. In the present study, we observed the dose-dependent effects of gamma irradiation in low-doses (5, 10, 20 and 40 cGy) on Drosophila melanogaster lifespan and compare these effects with the results of quantitative real-time PCR.

The possible mechanisms of radiation-induced effects on the lifespan and the role of alteration of genes expression in these effects will be discussed.

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EFFECT OF GAMMA RADIATION ON MORPHOLOGICAL TRAITS OF BARLEY PLANTS

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The effect of gamma rays was investigated on: plant height, main ear length, last internodes' size, number of grains per spike, numbers of productive tillers per plant, morphological variation.

Dry seeds of Sonor, Galactic, and Unirea barley cultivars were irradiated by 100, 150, and 250 Gy doses of gamma rays (Co^{60}). The irradiated seeds were planted in the field conditions to grow M_0-M_2 progeny and donor plants of explants for *in vitro* culture. The studied barley regenerants were obtained from immature embryos - derived calluses via somatic embryogenesis and organogenesis. Gamma rays influenced the mean values of morphological characters for evaluated genotypes in dependence of genotype, studied traits, doses of radiation, and studied generation.

The analysis of variance of barley plants showed that the genotype has a strong impact on variability of morphological traits (2,9 to 49,9 %) which means that variation of studied characters mostly depends on genetic factors. Gamma rays significantly ($P \leq 0,01$) induced the variations of plant height, last internodes' size, and number of kernels per spike (1,3% to 14,6 %).

Different morphological variations were observed:

· characteristics of leaves (shape, size, and color)

· characteristics of stems (shape, internodes' length, and wall thickness)

· characteristics of inflorescence (branching, shape of the lemma.)

Gamma radiation (100 Gy and 250 Gy doses) generated two barley mutant forms including two with aberrant spike morphology (622,623 forms in R1-R2 generation; cv. Unirea) and hooded mutants which represents mutant that exhibit altered awn development (M1-M3, cv. Sonor). Rate of plants that have inherited these changes in subsequent generations was 42% - 100%.

This research demonstrates that gamma rays (100 - 250 Gy) are useful tools to produce morphological variation in barley plants *in vivo* and *in vitro* conditions.

EVALUATION OF THE USEFULNESS OF PREMATURE CHROMOSOME CONDENSATION ASSAY IN RAPID RETROSPECTIVE BIOLOGICAL DOSIMETRY

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Conventional chromosome aberration analysis, as well as cytokinesis-blocked micronucleus assay, does not provide an accurate high-dose estimation for rapid biological dosimetry or in medical treatment management. Due to mitotic delay, poor mitotic index and disappearance of lymphocytes from peripheral blood circulation, individual radiosensitivity prediction is less effective. Therefore, there is a need to establish reliable methods, which allow analysis of biological effects after high-dose exposure i.e., particle radiotherapy. Premature Chromosome Condensation (PCC) has become an important method in high-dose biodosimetry and a promising treatment modality to cancer patients.

The aim of study was to evaluate the usefulness of drug-induced PCC assay in rapid retrospective biological dosimetry.

Drug-induced PCC assay was performed on human peripheral blood lymphocytes (HPBL) after in vitro exposure to 250 keV of X-ray radiation and to therapeutic proton radiation of 60 MeV from Proteus C-235 cyclotron in the dose range: 5.0-20.0 Gy separately. Cells were cultured for two days with PHA. Than to achieve premature condensation, calyculin A was added. After Giemsa staining, chromosome spreads were analysed via microscope. The dose effect curves were derived from 3 parameters: PCC index, PCC rings and PCC fragments.

The results indicated adequate dose estimates in the whole high-dose range for both studied types of radiation. Moreover, the chemically induced premature chromosome condensation technique might be potentially used in radiosensitivity prediction, when it comes to low and high LET radiation exposure. The PCC assay gives a new possibility to further improve individual radiotherapy.

These investigations were carried out as a part of an extended examination of the 60 MeV proton beam from AIC-144 isochronous cyclotron and IBA Proteus C-235 cyclotron, at IFJ PAN by cytogenetic and molecular methods and were partially supported by grant DEC-2013/09/D/NZ7/00324 from the National Science Centre, Poland.

DNA REPAIR AND AOPOTOSIS RELATED GENE EXPRESSIONS IN LOW-DOSE AND LOW-DOSE-RATE GAMMA-IRRADIATED MOUSE THYMUS ORGINATED LYMPHOMA CELL

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Purpose: To determine the biological effects of low-dose and low-dose-rate gamma-irradiation on mouse thymus originated lymphoma cells (EL4), we investigated the expression of gene related to DNA repair and apoptosis.

Materials and Methods: EL4 cells were exposed to dose of 155 mGy with low-dose-rate (Cs-137, 23 mGy/h, for 24h) and high-dose-rate gamma-radiation (Cs-137, 204 mGy/min). We analyzed cell proliferation by trypan blue staining, apoptosis by flow cytometry with the apoptosis ELISA kit, gene expression by real-time PCR, and protein levels.

Results: No difference was observed in the gene expression of DNA repair proteins between non- and low-dose-rate gamma-irradiated or between non- and low-dose gamma-irradiated cells. Gene expression of Trf and Trfc increased with low-dose-rate gamma-irradiation. Apoptosis increased in the low-dose-rate gamma-irradiated EL4 cells, but cell number did not differ between non- and low-dose or low-dose-rate gamma-irradiated EL4 cells. In concordance with apoptosis rate, mdm2 expression was suppressed, while p53, p21, Bax, and PARP expression was activated. Similarly, low-dose gamma-irradiation down-regulated mdm2 but up-regulated p53, p21, and Bax expression. Phospho-p53 and cleaved caspase 3 expression was up-regulated in the low-dose-rate gamma-irradiated cells.

Conclusions: Low-dose-rate radiation activated iron transported and apoptosis in EL4 lymphoma cells. We also identified DNA repair and apoptosis related genes in low-dose and low-dose-rate gamma-irradiated mouse thymus originated lymphoma cells.

ASSESSMENT OF RADIATION RESPONSE BY TISSUE-SPECIFIC gH2AX FORMATION AND ELIMINATION AFTER X-IRRADIATION

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Purpose: DNA double-strand breaks (DSBs) are the most dangerous lesions in eukaryotic cells. Unrepairable, they can cause cell death or carcinogenesis. One of the earliest responses to DSBs, caused by ionizing radiation (IR)chemicals, is the phosphorylation of the core variant histone H2AX at 139-serine in megabase chromatin domains around DSB sites with formation of discrete nuclear gH2AX foci. Maximal inductions of gH2AX for cultivated human cells were noted 30-60 min after IR.

Assuming that gH2AX is slowly eliminated, and kinetics of elimination correlates with the kinetics of DSB rejoining, we try to use different methodological approaches for examination of dynamics of gH2AX formation and elimination in Syrian hamster' (heart, brain and liver) and mouse' (heart, brain, kidney and liver) organs after IR.

Methods and materials: We perform 3 to 5 independent whole-body irradiation of ±20 g C57Bl/6 males mice and ±150 g males of Syrian hamsters using RUM-17 X-ray machine (200 kV, 13 mA, 0.5-mm copper-aluminum filter). Dynamics of gH2AX formation and elimination was studied by Western blotting (WB) and immunohistochemistry (IHC) using antibodies to gH2AX at different time points after irradiation.

Results: Profound increase in number of gH2AX-positive cells in hamsters' tissues was noted 1 h after IR (5 Gy). 24 h after exposure, the percentage of gH2AX-positive cells was compared to control only in liver, while the number of gH2AX-positive cells in brain was 3 times higher than in non-irradiated hamsters, and the highest level of gH2AX persistence was seen in heart, the latter one was more than 4.5 times higher than in controls. WB showed that gH2AX induction in mouse heart at 1, 3 and 5 h after IR at 3 Gy were lower than in brain, and significantly lower than in kidney and liver. IHC analysis showed that unirradiated tissues (heart, brain, liver) had 2-5% gH2AX-positive cells.

Conclusion: Significant variations between differentiated mammalian tissues in the initial H2AX phosphorylation rate as well as in the rate of gH2AX elimination after X-irradiation should be take into account in the analysis of radiation responses.

HEALTH ASSAY OF MEDICAL PERSONNEL FROM A RADIOTHERAPY UNIT

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Occupational exposure to ionizing radiation induces specific effects and might initiate co-morbidities.

The study aimed to assess in a nine years follow-up tissues and organ reactions in 29 subjects at risk from a radiotherapy unit with a mean exposure of 14.21±1.49 years to gamma-rays and other 6.65±1.29 to X-rays. The subjects underwent specific exams – clinical and hematological and non specific tests-cytogenetic (micronuclei - MN- in blood peripheral lymphocytes and oral exfoliated cells), cellular stress and oxidative markers (whole blood superoxide dismutase activity - SOD, serum lipoperoxides - Lpox).

Peripheral blood MN tests were assessed every three years, showing at first double numerical changes compared with the latest tests accompanied mainly by nucleus damages in epithelial cells and numerical abnormalities, possibly due to inhomogeneous exposure and as an adaptive first response to a recent radiation exposure. The enhanced SOD activity and Lpox revealed the imbalance in antioxidant protection induced by chronic radiations exposure. Specific tissues effects were detected in the eye lens (fine opacities at one subject after 18 years of exposure) and skin papillose/allergic dermatitis. For non targeted effects we account for cardiovascular diseases (arterial hypertension), respiratory and renal pathologies.

Health workers from radiotherapy units develop early and late cells and tissues reactions with low incidence due to highly education and training in respect to radiation protection rules.

COMPARISON OF CHROMOSOME ABERRATIONS OUTCOME IN CANCER PATIENTS WITH DIFFERENT TUMOR LOCALIZATIONS UNDERGONE MEGAVOLT THERAPY ON LINEAR ACCELERATOR

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The investigation of the cytogenetic effects in peripheral blood lymphocytes of cancer patients is an important task in the development of radiobiological basis of radiotherapy. In order to estimate the risk to health resulting from medical irradiation, it is necessary to evaluate the mechanisms of fractionated partial-body radiation action at chromosomal level.

Chromosome and chromatid type aberrations were analyzed in lymphocytes of 27 radiotherapy patients divided on three groups depending on tumour localization: with uterine body cancer, with lung cancer and with head and neck cancer. Blood sampling was performed before treatment, at the middle and at the end of megavolt radiation therapy course on linear accelerator. Lymphocytes were cultivated by conventional technique, and FPG-staining control of cell division was applied.

The excess of chromosomal damage before treatment over spontaneous level was shown in all groups of patients, regardless on tumour localization. The different character of chromosome and chromatid type aberrations accumulation in groups of patients with various tumour localizations was found. The monotonic increase of the level of chromosome type aberrations from the beginning to the end of treatment in all groups of patients was demonstrated, however, its pace was different depending on tumor localization. Thus at the middle of radiotherapy course the ratio of unstable chromosome type aberrations mean levels was 1: 0.77: 0.51 for groups with uterine cancer, with lung cancer and with head and neck cancers, and at the end of the course - 1: 0.86: 0.68 respectively. The distribution of the dicentrics among cells was found to be over-dispersed according to Poisson statistic both at the middle and at the end of radiotherapy course in all groups. The frequency of chromatid type aberrations significantly increased during radiotherapy only in the group with lung cancer. The correct assessment of the impact of megavolt therapy on normal cells at the chromosomal level will be discussed.

HPRT MUTANT INDUCTION IN V79 CELLS OVER TIME AFTER EXPOSURE TO RADIATION OF DIFFERENT LET

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Mutation induction in the HPRT gene of V79 Chinese hamster cells was studied after exposure to ionizing radiation of different linear energy transfer (LET) values in the range of 50-153 keV/µm. The dependence of the HPRT mutant fraction on expression time was measured after exposure to doses of 0.5, 1, and 2 Gy.

It was found that the mutant fraction increased with expression time, reached a maximum, and fell down to the initial levels. After approximately 30 – 40 days (60 – 80 cell generations), the mutant fraction returned to the levels typical for spontaneous mutants. The position of this maximum depended on the LET value of the used heavy ions. With increasing LET, the maximum shifted towards longer expression times. For example, the mutant fraction maximum was observed 7 – 14 days after 18O irradiation with LET ~ 116 keV/µm; however, 20Ne irradiation with LET ~ 153 keV/µm caused the peak to shift to 20 – 26 days after exposure. No clear relation with the dose was observed.

The mutant fraction values at different expression times were also compared with chromosomal aberration analysis results. Samples with mitotic chromosomes were prepared as metaphase spreads. The first results did not reveal any clear correlation between the number of mutants and the yield of chromosomal aberrations in remote descendants of irradiation-induced subclones.

PSYCHOPHYSIOLOGICAL PROGNOSIS OF MULTIFOCAL ATHEROSCLEROSIS OF THE PATIENT WHO TRANSFERRED ACUTE RADIATION SICKNESS OF THE I DEGREE OF SEVERITY

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B.A.I., 1940 year of birth, did the work of the chief of shift plant of thermal automatics and measurements (PTAM) of the 4th unit of Chernobyl NPP in April 1986. April 1986, at the age of 45, suffered ARS I degree of severity from uniform gamma-beta radiation. The total dose to the body, according to electro-paramagnetic resonance (EPR) of tooth enamel from 2001, was 0,77+-0,25 Gr., on neutrophil - 1,2 Gr., in the culture of cells – 0,7 Gr. Since the 30-day treatment of ARS I degree of B.A.I. in dynamics started being formed and progress, the so-called, multifocal atherosclerosis (MFA). As the main manifestations of the adverse forecast served not only crisis courses of a hypertensive illness, episodes of the sharp heart failure (HF), rhythm and conductivity violation, myocardial infarction (MI) recurrence (2002, 2004, 2011), but also development of failures in not coronary arterial pools (stenosed atherosclerosis of carotids, occlusion of the right internal carotid, cerebrovascular illness, obliterating atherosclerosis of the bottom extremities). B.A.I. during the first inspection 16.05.1986 and at supervision within 25 years in dynamics (2001,2002,2009,2010) the aspiration to look in favorable light was a leading resistant tendency when testing, showing in answers strict observance even insignificant rules and social norms (L=71,6 scale), subdepressive and disturbing-depressive tendencies (scale 2 D-71,2, 9Ma-50,0 T-points, F1 = 5,1-7,7,-8,1 walls). Registration of B.A.I. of the changes overstepping the bounds of population norm, in the form of an affective rigidity (scale of 6 Pa = 71,0), psychasthenia (a scale of 7 Pt = 71,8) and original thinking (scale of 8 Sch = 68,8), along with the indicators of characterizing a neurological triad (scales 1 Hs, 2 D, 3 Hy), indicate violation not only neurologic, but also psychological adaptation, subdepressive and disturbing and depressive tendencies, caused by weight of all-somatic and psychosomatic pathology. The subdepressive and disturbing-depressive syndrome in B.A.I. was independent risk factor of development of multifocal atherosclerosis.

ACTIVATION OF CELLULAR DEFENSE MECHANISMS REDUCING THE DNA DOUBLE-STRAND BREAKS AMOUNT AND REACTIVE OXYGEN SPECIES PRODUCTION IN PRIMARY HUMAN DERMAL FIBROBLASTS UNDER CONTINUOUS LOW DOSE-RATE X-RAY RADIATION EXPOSURE

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There is a considerable controversy as to whether DNA damage induced by low doses and low dose rates of ionizing radiation is treated by cellular defense mechanisms in ways similar to that induced at high doses and high dose rates, and what downstream delayed effects may be caused by low doses compared to moderate and high doses. This constitutes the major challenge for the linear no-threshold model currently used for radiological risk estimates. Among the various DNA lesions induced by ionizing radiation, DNA double strand breaks (DSBs) are considered the most important due to their potential to cause cell death, mutagenesis and carcinogenesis. The goal of this study was to study of the DSBs formation and repair in primary human dermal fibroblasts under continuous (up to 6 hours) exposure to X-ray radiation at a dose-rate of 4 mGy/min. The immunocytochemical analysis of the phosphorylated H2AX histone (γH 2AX) and RAD51 foci was performed to estimate the cellular DNA DSBs formation and their repair pathway. γH2AX is a marker for DNA DSBs, while RAD51 plays a major role in homologous recombination of DNA during DSB repair. The apoptotic cell frequency and production of reactive oxygen species (ROS) were also evaluated. It was shown that under continuous low dose-rate X-ray radiation exposure the γH2AX foci number increases linearly up to a dose of 480 mGy (2 hour exposure time), reaches “plateau” at doses ranged from 480 to 960 mGy and after it slightly decreases at doses of 1200 and 1440 mGy (irradiation time - 5 and 6 hours, accordingly). The dose-response curve obtained shows the result of two simultaneously occurring processes in cells exposed at a low dose-rate: DSBs induction and their repair. In fact, mammalian cells use two major pathways to repair DNA DSBs, which are non-homologous end joining (fast) and homologous recombination (slow). The RAD51 foci number increases with dose/exposure time increase and reaches maximum at doses of 1200 and 1440 mGy. There were no changes in the apoptotic cell frequency during 6 hour exposure at this dose-rate; however, the results of the ROS production measurements showed that changes in the ROS production rate are associated with the γH2AX foci number in these cells. The effects observed at a low dose-rate irradiation could be explained based on the suggested inducibility of the DNA repair or antioxidant systems once the threshold for signaling has been reached. These results provide further support for non-linearity in the biological effects of low dose-rate irradiation. This work was supported by the Russian Foundation for Basic Research, grant no. 12-04-01733-a.

THE EFFECT OF IRRADIATION ON THE INFLAMMATORY PHENOTYPE OF BRAIN PERICYTES

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Introduction: Chronic inflammatory reactions affecting the brain microvasculature are factors contributing to radiation-induced neurotoxicity. Pericytes are main components of the brain microvascular region, having pleiotropic functions. Apart of regulating the integrity and normal homeostasis of the blood-brain barrier they play important role in brain inflammation also. The objective of our study was to investigate radiation effects on the inflammatory phenotype of murine brain pericytes.

Methods: Ten-day old C57Bl/6 mice were irradiated locally on their head with doses of 0.1, 0.5 and 2 Gy at the age of 10 days after birth. At several time-points after irradiation the level of cell-surface inflammatory markers (CD68, TLR4, CD11b, CD4) and intracellular cytokine levels (IL-1beta, IL-6, IL-12 and TNF-alpha) were measured in pericytes. Similar investigations are ongoing in 10-week old animals. In order to determine the interaction between irradiation and a pre-existing inflammation, experimental autoimmune encephalomyelitis was induced in SJL mice, and irradiation was performed when inflammatory reactions were evident. The same phenotypical markers were investigated as above.

Results: Persisting pericyte activation, reflected by CD11b and MHCII upregulation developed in the young C57Bl6 mice 6 months after irradiation. If inflammation was induced in SJL mice, this manifested at pericyte level by increased CD68, TLR4 and CD11b expression. In contrast to C57Bl/6 mice, in the SJL mice with no brain inflammation irradiation did not lead to pericyte activation. Moreover, if irradiation was performed on an inflamed brain it reduced the expression of the studied inflammatory markers with the exception of MHCII. Cytokine expression profiles are under evaluation.

Conclusions: Age, genetic background and a pre-existing inflammation might influence radiation-induced changes in inflammatory phenotype of pericytes.

ASSESSMENT OF ENVIRONMENTAL QUALITY IN VICINITY OF UNDERGROUND NUCLEAR EXPLOSION SITES ON THE TERRITORY OF WESTERN YAKUTIA BY DEVELOPMENTAL INSTABILITY PARAMETERS OF ANIMALS AND PLANTS

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The research was carried out in vicinity of two underground nuclear explosions (UNE) on the territory of Western Yakutia that were followed by unplanned radioactivity releases. We used fluctuating asymmetry (FA) value to assess developmental stability deviations. FA is small-scale nondirectional deviations from ideal symmetrical state that result from random developmental errors over the course of ontogeny. Normally their level is minor but it increases under any unfavorable influence affecting the developing organism.

The objects of our study were the dwarf birch (Betula exilis) and red vole (Clethrionomys rutilus). Asymmetry level of the birch leaf was assessed by four traits of the lamina venation. With the red vole we used 10 traits describing the location of cranial foramina.

For the control we used a site two km far from the UNE Crystall, where γ-background was 4-6 microroentgen per hour (μR/h); this also was where one of the lowest FA levels in the dwarf birch (0.040) was registered.

In vicinity of the UNE Kraton-3 the samples were collected on different distances from the radioactivity release point. FA values of the dwarf birch in all the points were higher than in the control and varied between 0.041 and 0.050. Note that virtually no difference in FA value was found between the plants from the sites with the background of 20 to 120 μR/h.

Background of 160-190 μR/h was registered on small patches within the general area with the background of 80-130 μR/h. On these patches FA value was 0.050, the difference from the control site being statistically significant ($p < 0.05$ by Student's t-test). The difference from the samples with the background of 20-120 μR/h was also substantial but not statistically significant.

In vicinity of UNE Crystall γ-background level generally did not exceed 5-15 μR/h, only on certain patches it reached as high as 50 μR/h. Levels of developmental stability deviations in the dwarf birch there were lower than in vicinity of UNE Kraton-3 and came to 0.037-0.042.

The occurrence of asymmetry manifestations (OAM) in the red vole within the taiga zone normally is 0.25-0.35, but in the sparse taiga zone this parameter is higher, which is supposedly explained by the influence of unfavorable abiotic factors.

In vicinity of the studied UNEs the FA level in the red vole was 0.42-043, while on the distance of 250 m from the edge of the "dead forest" it was 0.37, and on the distance of 1-2 km it was 0.36. The differences between the control and contaminated territories did not reach statistically significant levels.

Thus, developmental instability parameters of plants and animals indicate some deterioration of living conditions in vicinity of UNEs Kraton-3 and Crystal. On the whole, positive dependence of these parameters' values on the γ-background was noted, and the increase in their levels was most pronounced where the background was higher than 150 μR/h.

ESTABLISHING A RESEARCH PARTNERSHIP WITHIN THE EURATOM RADIATION PROTECTION PROGRAMME OF HORIZON 2020: THE OPERRA CONSORTIUM

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The European Commission provides funding for collaborative research within EURATOM through competitive calls for research proposals. In Horizon 2020 the research objectives of radiation protection are defined by research platforms (MELODI for low dose risk, ALLIANCE for radioecology, NERIS for accident management, EURADOS for dosimetry, as well as a new platform for medical applications). Many European research institutions are already members of these platforms and work together to develop a strategic research agenda (SRA) and a roadmap for its implementation.

There will be calls for proposals released at regular intervals with the scope and size of the projects defined by the road map. The Commission notes that there has been only modest participation of laboratories from outside the main radiation research centres. This is a fundamental problem with far-reaching consequences for dissemination of knowledge, creating a sustainable European research competence and for bringing new ideas and opportunities into radiation research.

One perceived barrier to participation is the complexity of the different organizations, platforms and programmes. A second is the lack of opportunity to join experienced researchers in proposals for research consortia. A third barrier is the lack of experience in participating in EU-funded research projects, which present unique scientific and administrative challenges to new partners.

The OPERRA consortium (coordinator Jean-Rene Jourdain, IRSN, France) has as one of its tasks the promotion of participation of new member states in EURATOM research. One key activity will be workshops to bring together interested researchers from eligible countries with experienced EURATOM project participants for an exchange of information. Information on OPERRA is available from the project website (http://www.melodi-online.eu/operra.html).

The Helmholtz Zentum München will hold workshops in 2015 to provide participants with the skills and knowledge needed to participate in future projects, and at the same time we will assist in making contacts with both the EURATOM platforms and leading researchers.

If you are interested we request that you notify us of your interest in participating at the following address:

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MAIN ASPECTS OF RADIATION STERILIZATION OF MARTIAN LANDERS ELEMENTS

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Due to COSPAR severe requirements to permissible microbiological contamination of Martian Landers elements as well as complexity of their chemical composition and structure the exposure of such elements to antimicrobial treatment (sterilization) at their integration requires application of a wide set of methods: chemical, ultraviolet, radiation. The analysis of all the applicable methods of treatment for cleaning of elements’ surfaces and inner contents from microbiota showed that the most important, predictable and controllable method is radiation processing (of the elements which don’t change their properties after effective treatment). The experience of ionizing radiation application for sterilization of products in medicine as well as in “Mars-96” and MML (the set of mini-meteorological landers on Mars) projects shows that, depending on initial microbial contamination of lander elements, the required absorbed dose can be within the range 12 Ã· 35 kGr.

We are currently expected to use radiation treatment of the Descent Module structural elements in a joint Russian-European project "ExoMars-2018".

The important phase of establishing of the effective condition of each structure element treatment is experimental verification of real microbiological contamination in terms of S/C integration, contamination maximum decrease using another cleaning procedures (mechanical, chemical, ultraviolet) and determination of radiation resistance of spore microorganisms typical for the manufactures of space technology assembling. Proceeding from three parameters (irregularity of radiation absorption in a concrete element, its initial microbial contamination and resistance of microorganisms to the effect of radiation) the condition of the packed object sterilization is chosen, the condition that prevents secondary contamination, ensures given reliability of the treatment without final experimental microbiological verification only by simple control of the absorbed dose at critical points.

All the process phases (from the choice of treatment conditions to provision of the procedure safety) are strictly regulated by Russian standards.

NOS-INHIBITOR ENHANCES THE ANTITUMOR EFFICACY OF RADIATION THERAPY

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Activation of a NO/cGMP-pathway is the general link in development of angiogenic action of numerous proangiogenic factors. In this regard inhibition of NO-synthase (NOS) activity may cause nonspecific angiostatic effect in tumors and enhance the antitumor effect of radiation, like known antiangiogenic substances. So we studied the antitumor and antimetastatic effects of NOS-inhibitor and γ-irradiation in there separated and combined application. MATERIALS AND METHODS. Isothiourea derivative named NS23 was used as NOS-inhibitor. This substance is synthesized in the laboratory of radiation pharmacology Medical Radiology Research Centre of Hertsen FMRC MH RF. Mice used in the present study were a part of conventional colony of male F1 hybrids (CBA x C57Bl) maintained on a standard laboratory diet with water ad libitum. Lewis lung carcinoma(LLC) was used as a model of tumor growth. In the 7th day after LLC transplantation mice were exposed to 5 Gy g-radiation of 60Co. The irradiation beam was focused on the posterior leg where LLC was transplanted. Mice were treated with NOS-inhibitor from day 7 to 20 after LLC transplantation, injection dose was 60 mg/kg i/p. In a case of combined application NS23 was injected after irradiation. Dynamics of tumor growth were estimated every 3-4 days. After 21 days anesthetized animals were brought out of experiment and the amount of pulmonary metastasizes were calculated. RESULTS. Irradiation was effective in delaying tumor growth compared to control nonirradiated tumors and within a week after beginning of the treatment duration of tumor growth delay was 1,8-2 days. Since this moment and till the end of the experiment index of tumor growth was 65-75%. Irradiation also caused reliable suppression of metastasizing - inhibition index was 45-60%. Treatment with NS23 caused the same effect - duration of tumor growth delay was 2-2,5 days, index of tumor growth was 55-70%, metastasizing inhibition index was 30-45%. Combined treatment with irradiation and NS23 caused an increase of antitumor effect. In a week after beginning of the treatment duration of tumor growth delay was 2,8-3,2 days, index of tumor growth was 40-55%, metastasizing inhibition index was 60-70%. CONCLUSION. NOS-inhibitor NS23 has an ability to suppress growth and metastasizing of tumors and to enhance the efficiency of radiation therapy.

CELLULAR RESPONSES MEDIATED BY RADIATION-INDUCED P53 LEVEL

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Activation of p53 pathway by ionizing radiation arrests cells at G1 or G2 checkpoint of cell cycle, or terminates cell division. The rate of apoptosis and autophagy is variable with different p53 status after IR treatment. MCF-7 and HeLa cells were used to study the cellular responses to IR. Cell cycle was analyzed with flow cytometry, and cell senescence was evaluated by staining of SA β-gal activity. Cellular levels of proteins related to the cell cycle and apoptosis were checked by western blotting. To check autophagy, the development of acidic vesicular organelles (AVOs) was evaluated by staining with acridine orange and autophagosome-incorporated LC3-II protein expression was evaluated. Caspase-3 activity was measured as a marker for apoptotic cell death. The expression of p53 increased in a dose-dependent manner in both cells. After irradiation, MCF-7 cells showed a bigger increase in p21 expression than HeLa cells. Cell cycle analysis indicated a significant accumulation in G2/M phase in the MCF-7 exposed to IR. Induction of p21 and G2 arrest by IR hampered apoptosis in MCF-7 cells. Instead the irradiated MCF-7 cells displayed cellular senescence. HeLa cells did not show a drastic increase in apoptosis-related proteins 24 h post-irradiation. Cellular senescence was not detected in HeLa cells exposed to IR. Instead, autophagy was detected by detected AVOs and increased LC3-II protein expression in HeLa cells at 24 h post-irradiation. Autophagy in HeLa cells can result in cell survival. This study identified that IR-induced cell fates were determined through p53-dependent activation of p21, which resulted in senescence of MCF-7 cells and autophagy of HeLa cells. This result is of great importance in understanding the process of cell's fate decision.

Keywords: ionizing radiation, p53, cell cycle arrest, senescence, autophagy, apoptosis

CHROMOSOME ABERRATION ELIMINATION AND DOSE EVALUATION IN REMOTE PERIODS AFTER DIFFERENT RADIATION ACCIDENTS

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The persons suffered in the accident at the Chernobyl nuclear power plant were observed into the Clinic of Burnasyan FMBC for more than 25 years after irradiation. The repeated cytogenetic researches of peripheral blood lymphocyte cultures were included in the plan of these checkups to study patterns of chromosome aberration elimination and the development of approaches to retrospective dose evaluation using the classical method of chromosome painting. However, this radiation incident was not the first, as he was not and the last. Survived victims of accidental exposure in various other situations periodically (with varying degrees of frequency) were admitted to the our hospital in the remote periods for examination and treatment regarding various diseases, allowing to produce dynamic monitoring of their chromosome damage levels. In total repeated cytogenetic analysis of lymphocytes was carried out among representatives of the following groups of victims: 1. 4 persons after gamma-irradiation (4 accidents, the frequency of blood sampling varied from 1 to 10), 2. 14 persons after gamma-beta-irradiation (5 accidents, the frequency of blood sampling varied from 1 to 6) and 3. 6 persons after gamma-neuron irradiation (5 accidents, the frequency of blood sampling varied from 1 to 5). The results of physical calculations, studies of the EPR signal in tooth enamel, hematological and cytogenetic data were used (in various combinations) as the initial dose estimates. We emphasize that cytogenetic dose estimations could be absent unlike the Chernobyl contingent. Most cultures of peripheral blood lymphocytes of these patients was studied, or in terms that are close to the end of the observations for Chernobyl patients, or in a much later time after irradiation (from 17 to 51 years). Thus as a whole these patients exposed to gamma, gamma-beta- and gamma-neutron irradiation were examined repeatedly in more remote terms after irradiation than Chernobyl patients. The relationships for retrospective dose estimations were obtained after the cytogenetic analysis using the classical method of chromosome staining in the long terms after the Chernobyl accident with the help of special computer program. Use of these relationships for the same object of patients from other radiation accidents showed the following. Retrospective evaluation of doses of considered contingent by the multiple regression equation including computer restored dose evaluation and time after irradiation generally gives poor results as there is a clear exit of many points outside the 95%-confidence intervals for individual values in the direction of higher dose evaluations. The application of multiple regression equation which includes computer restored dose evaluation and frequency of atypical chromosomes in the remote terms after irradiation produced better results as obtained esitimations of doses were situated within the 95%-confidence interval for individual values for the most part of patients.

TRACKING ENTERIC VIRUSES INACTIVATION BY GAMMA IRRADIATION

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Viruses are a major cause of human water and foodborne diseases. Especially important are a variety of nonenveloped human and animal enteric pathogenic viruses. This type of viruses primarily infect the intestinal tract through ingestion of sewage contaminated water or food. Enteric viruses, like norovirus (NoV) and adenovirus (AdV), can enter the environment through the discharge of waste materials from infected individuals and contaminate drinking and recreational waters or fresh food products, and be transmitted back to susceptible individuals to continue the cycle of infection. The stability of these viruses and their presence in waters and food may cause serious implications on public health. In this scenario gamma irradiation could be an important technology to achieve elimination of viral pathogens.

The main goal of this study was to investigate the inactivation of murine norovirus type 1 (MNV-1), as a NoV surrogate, and human adenovirus type 5 (AdV-5) by gamma irradiation. Six different substrates – PBS (phosphate buffer saline), demineralized water, tap water, FBS (fetal bovine serum) and aqueous solutions of 10% and 50% FBS, were inoculated with MNV-1 and AdV-5 and irradiated in a (60)Co source at several doses (from 1 to 10 kGy, approximately). The inactivation of viral particles was tested by plaque assay using Raw 264.7 and A549 cells. The D10 values (dose required to reduce the virus by 90%) were estimated for each virus and substrate. Degradation of AdV genome by gamma irradiation was evaluated by PCR technics.

A reduction on MNV and AdV titers of 4 log10 PFU/ml (99.99% inactivation efficiency) was achieved after irradiation at 3 kGy on PBS, tap and pure water suspensions. However, MNV and AdV were approximately 3 times more resistance to gamma irradiation when irradiated in FBS suspensions, and even at a dose of 10 kGy it was detected the presence of viral particles in an infective state. The observed D10 values ranged between 0.76 kGy (pure water) and 3.22 kGy (10% FBS) for MNV; and between 0.87 kGy (PBS) and 2.94 kGy (FBS) for AdV. PCR results also showed an important influence of the matrix constitution on the viral DNA degradation by ionizing irradiation. In FBS suspensions, gamma irradiation (at doses up to 10kGy) seems to have no effect on the viral genome viability. However on PBS, tap and pure water solutions a dose of at least 3 kGy is sufficient to cause a clear damage on AdV genomic DNA. The virucidal effect of gamma rays seems to be impaired by scavengers in highly protein substrates that could hijack free oxygen radicals.

These results show that inactivation of MNV-1 and AdV-5 by gamma radiation strongly depends on the substrate where the viruses are inoculated. The study of the MNV-1 and AdV-5 behavior in different substrates could open new insights on the inactivation mechanism caused by gamma irradiation. This work may well introduce new concepts on the utility of nuclear technology as an effective tool to guarantee the reduction or elimination of viral pathogens.

ASSESSMENT OF PATIENTS' IN-TAKEN DOSES IN DENTAL RADIOLOGY

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Introduction. Dental radiology is the most frequent diagnose method using radiation sources, representing 25 per cent of the total medical exposures in the EU. On the other hand, dental radiology represents some 90% of the practice in the private health system, and the number of laboratories increased rapidly after 2000, a fact that lead to a growth in the number of population exposures as the dentists require a high number of exposures. The organs highly exposed to ionizing radiation, in the case of dental radiology, are the brain, the thyroid, and the salivary glands. A special attention must be paid to the quality of the obtained images, as these are frequently of a low quality due to the difficulty in positioning the radiological film inside the mouth, as compared to the panoramic radiography. The latter offers an overall review of the maxillary, showing a radiological image of one or both dental arches and the surrounding bone structures, but requires a special device. Nevertheless, it is recommended only in certain cases, for extended pathological processes, but it cannot replace the standard dental radiography, as it does not offer detailed information and does not highlight early changes. The effective in-taken dose for one panoramic image can equal the dose for taking four intra-oral images.

Material and method. The aim of this study was to compare the dose values obtained both from the intra-oral dental radiology and from the panoramic one versus the quality of the radiological image, as well as the frequency of radiological investigations and their distribution on age groups. There have been under scrutiny five dental offices for the intra-oral radiology, and five for the panoramic one.

Results. The frequency of the radiological investigations shows that the number of medical exposures in intra-oral radiology is three times higher than in panoramic radiology. As far as the age group is concerned, that between 16 and 40 was the most exposed. At the same time, the results show that there is a great variety of doses depending on the equipment, on the technique, and the measures applied to ensure the quality. The doses varied in intra-oral radiology between 0.68 and 1.15 mGy/procedure (the average effective dose value being of 0.009 ±0.004mSv), and between 0.6883-1.027dGyxcm2 (the average value of the effective dose being 0.101 ±0.051mSv) for the panoramic one.

Conclusions. Although the in-taken individual doses and the implied risks are quite small, the specialists consider that there are too many extended examinations, a fact which leads to the multiplication of the in-taken doses by the patients by six times and even more.

THE EFFECT OF RADIOCHEMOTHERAPY ON THE PHENOTYPE OF REGULATORY T CELLS AND MYELOID-DERIVED SUPPRESSOR CELLS IN COLORECTAL CANCER PATIENTS

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Introduction: The primary objective of radiotherapy is to eliminate tumor cells sparing the surrounding normal tissue as much as possible. However, radiotherapy can impact the antitumor immune response as well. The interaction between radiotherapy and the immune system is complex, with some components of the antitumor immune response being enhanced, others being repressed by radiation. Differences in the immunological profile of the tumors contribute to the inter-individual variations in radiotherapy-induced responses. Regulatory T cells (Treg) and myeloid-derived suppressor cells (MDSC) have key roles in the induction of an immune suppressive phenotype in cancer patients during tumor progression. The radiotherapy could influence the pool and phenotype of these cells, which could serve as markers of prognosis and therapy response. The objective of our work was to identify immunological markers with possible prognostic value in estimating therapeutic response.

Methods: We analyzed the pool and phenotype of Tregs and MDSCs from blood samples of patients with colorectal cancer collected before and after treatment. Peripheral blood mononuclear cells (PBMC) were isolated and the expression of a panel of Treg and MDCS markers was analyzed by flow cytometry.

Results and conclusions: Our preliminary results show that the level of MDSC was moderately increased while that of CD4+ T cells was lower in cancer patients compared to the control group but therapy did not influence the level of these cells. The fraction of Tregs increased after treatment indicating that these cells were more radioresistant than other lymphocytes subpopulations. There was an increased proliferation rate of the Foxp3- CD4+ cells in cancer patients which further intensified after therapy. However, the proliferation rate of Foxp3+CD4+ Treg cells returned to the control level after treatment. The level of CD39+ Tregs with an ATPase activity decreased after treatment, but the fraction of CTLA4+ Tregs increased. This indicates that radiochemotherapy modified the suppressing phenotype of Tregs. On one hand their direct effector T cell suppressing and apoptosis inducing effect was reduced. On the other hand the increased CTLA4 expression points to an inhibition of the effector T cell activation capacity of the dendritic cells. Phenotypical characterization of Tregs might help identifying that patient category which is the most sensible to CTLA4 blockade therapy.

RADIOBIOLOGICAL EFFECTS IN SMALL RODENTS - CONSTANT INHABITANTS OF CNPP RADIATION-POLLUTED REGION

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Complex radiological research (including in-field and laboratory ones) of small rodents - constant inhabitants of CNPP radiation-contaminated region were made. Trapping of animals performed in areas with uneven distribution of radiation fields.

Species composition of the small rodents was studied using karyotyping and morphological characteristics. It is shown that the most representative type of CNPP region is red vole (Clethrionomys glareolus). In γ-β-spectrometric studies, the levels of accumulation and specific activity of 137Cs and 90Sr in the body of animals were conducted. Radioactive contamination of the animals varied widely from 200 to 1450 Bq/g 137Cs, 100-1700 Bq/g 90Sr. Individuals with abnormally high content of radionuclides were also observed. Absorbed radiation doses originating from Chernobyl radiation factor were calculated. A comparative analysis of cytogenetic, morphophysiological and hematologic parameters of animals from contaminated and background areas was made.

In experimental animals the frequency of mononuclear cells with MN was in 8 - 13 times higher than the spontaneous level; also cells with a large number of MN per cell were observed. These changes indicate a violation of cytogenetic homeostasis.

Hematological studies have established that the concentration of leukocytes and erythrocytes in animals from contaminated areas were not statistically different from the control group. Nevertheless were observed qualitative changes in the hematopoietic system: impaired maturation of cells, the formation of foci of hematopoiesis in the spleen and liver. In the spleen of animals with a high content of incorporated radionuclides registered an erythroid precursor cells.

Analysis of morphophysiological parameters showed that mass indexes of the internal organs of animals from the Chernobyl exclusion zone are different from control levels. Changes of morphological parameters testify to stress in the physiological state of the body irradiated animals. The set of these results and the literature data indicates complex adaptative processes in populations of animals within the zone of radioactive contamination.

THE EFFICIENCY OF DIFFERENT ADSORBENTS IN AIM OF BROILERS PROTECTION IN CASE OF ALIMENTARY INTOXICATION WITH URANIUM

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The aim of present study was to investigate the protective effect of organobentonite, organozeolite and sepiolite in case of alimentary intoxication with uranium in broilers. The broilers were contaminated during 7 days with 25 mg/uranyl nitrate per day (UN). Three different adsorbents (organobentonite, organozeolite and sepiolite) were given via gastric tube immediately after contamination with UN. The efficiency of protection in kidney, liver, and brain were on average 61% for organozeolite and 60% for organobentonite and sepiolite. The histopathological changes were observed in group 1 where broilers did not receive any adsorbents, in the form of necrosis of intestinal villi, oedema and cytoplasmic vacuolation of hepatocytes, and dystrophic changes in the kidney tubules epithelium. In groups 2,3 and 4 where the broilers received adsorbents immediately after the UN contamination, no histopathological lesions were observed, as in broilers which received only adsorbents without UN contamination (groups 5,6,7).

NON-CODING RNAS AS POTENTIAL BIOMARKERS OF RADIATION RESPONSE

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The past five years has seen an explosion in knowledge of the structure and function of the human genome, forcing a paradigm shift in the way we look at the information encoded in our DNA. It now turns out that 90% of the genome is actively transcribed into RNA in a regulated manner and a number of different functional classes of non-coding RNA transcripts (ex. microRNAs and long non-coding RNAs) are recognized. Thousands of non-coding ribonucleic acids (ncRNAs) are electronically classified yet remain functionally unresolved. Irradiation responsive ncRNAs were identified from microarray expression profiling with single assay verification. Experimental assessment included in-situ hybridization, neighbouring gene alterations along with lentiviral knockdown and promoter activity determination.

Furthermore, we established the 2D and 3D cultures of tumour and normal human cell lines with different sensitivity to the ionizing radiation in order to monitor intra- and extracellular changes in the ncRNA profile following the radiation with low and medium doses (from 0.2 Gy to 2 Gy) at different time points (4 hours to 72 hours after irradiation). Three-dimensional (3D) microtissues are widely accepted as being more physiologically relevant than conventional 2D monolayer cell cultures, and can therefore help generate more predictive data. Validation of the phenotypic screen using 3D microtissues was performed by exposure to ionizing radiation, miRNA overexpression / knock-down (ex. miR-21, miR-221) and treatment with a panel of selected chemotherapeutic compounds. Expression changes of specific ncRNAs in combination with irradiation decelerated growth, as proven by measuring the area of the cell spheroids after treatment. Of ten analysed chemotherapeutics, ex. vinblastine was the most effective compound, with docetaxel and doxorubicine being less effective in combination with radiation using breast cancer 3D microtissues. The compound treatment in combination with irradiation is changing the shape of ncRNA response using different cell types, classifying them in radiation resistant and sensitive groups. The basic cellular response after treatment is going to be followed for differential ncRNA expression changes and correlated with blood plasma samples from specifically designed cohorts.

Dark.Risk consortium will prepare the way to use SRTCC (Serbian Registry of Tinaea Capitis Children) biomaterials to evaluate the potential of the non-coding genome to deliver information on disease outcome and association with radiation. As the effects of low doses of radiation are still uncertain a series of biomarkers are needed to distinguish between radiation-associated and radiation-independent cases (ie. biomarkers of causality).

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SINGLE LOW DOSE X-RAY EXPOSURE-INDUCED BLOOD BRAIN BARRIER DAMAGE IN MICE

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Background:

High-dose radiation-induced blood-brain barrier breakdown contributes to acute radiation toxicity syndrome and delayed brain injury, but there are few data on the effects of low dose cranial irradiation. Our goal was to measure blood-brain barrier changes after low (0.1 Gy), moderate (2 Gy) and high (10 Gy) dose irradiation under in vivo.

Methods:

Cranial irradiation was performed on 10-days old and 10-weeks old mice. Blood-brain barrier permeability for Evans blue, body weight and number of peripheral mononuclear and circulating endothelial progenitor cells were evaluated 1, 4 and 26 weeks postirradiation, by FACS immunostaining. Endothelial senescence was determined by senescence associated ß-galactosidase staining. Repair of double strand DNA breaks was followed by histone H2AX γ-chain phosphorylation immunostaining.

Results:

Extravasation of Evans blue increased in cerebrum and cerebellum in adult mice 1 week and in infant mice 4 weeks postirradiation. Head irradiation with 10 Gy decreased body weight. The number of circulating endothelial progenitor cells in blood was decreased 1 day postirradiation. The number of brain endothelial and glial cells decreased from third day of postirradiation and senescence in endothelial cells increased at 2 and 10 Gy. Low dose irradiation induced double strand DNA breaks but repair was complete by 24 h.

Conclusion:

Not only high but low and moderate doses of cranial irradiation increase permeability of cerebral vessels in mice, but this effect is reversible by 6 months. In-vitro experiments suggest that irradiation decreases cell number and causes senescence in brain endothelial cells.

SOME ASPECTS OF RADIATION-INDUCED APOPTOSIS

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Genetically-determined cell death (apoptosis) is a fundamental biological process. Apoptosis is universally required for normal development and firmly established in the etiology, pathogenesis and treatment of many diseases (cancer, autoimmune, neurodegenerative and others).

The aim of our study was to investigate the biochemical regulation of apoptosis in immunocompetent cells upon X-ray irradiation (1.0 and 7.78 Gy). According to modern concepts the ionizing radiation activates some major apoptotic pathways: receptor-mediated (extrinsic), lysosomal-mediated, and pathway associated with the mitochondria and the nucleus (intrinsic). Te intrinsic pathway is characterized by utilization of mitochondria to propel cell death through its membrane permeabilization and releasing some proapoptotic proteins such as AIF. As a result AIF is translocated to the nucleus to facilitate DNA fragmentation. Our investigations using Western blotting demonstrated a dose-dependent reduction of AIF (67 kDa) in rat thymocytes after X-ray exposure (30 minutes and 3 hours postirradiation). These data were accompanied by enhancing of calpain activity (calcium -dependent cysteine protease) which cleaves and induces AIF translocation under IR injury (our results). The activation of calpain also contributes to release of lysosomal protease cathepsin B into cytosol by causing lysosomal membrane permeabilization (LMP). This process is followed by the increase of cathepsin B activity after X-ray exposure (1.0 and 7.78 Gy). The LMP is favored also by ROS-induced lipid peroxidation, and we've demonstrated the disturbance of oxidative homeostasis due to the ROS overproduction and deficiency in the antioxidant system in thymocytes after X-ray exposure. The injection of inosine (under commercial name "riboxine") before X-ray treatment leads to decrease radiation-mediated processes intensity and modulation of radiation-induced apoptosis pathways.

RESPONSE OF MARINE MICROORGANISMS TO LOW-DOSE RADIOACTIVE EXPOSURE

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Recent years have seen a change in the approach in ecological studies: biota in toto is considered now as a target of toxic impact, with the human included as a part of biota and integrated into the biosphere by a multiplicity of functional interrelations. As microorganisms are basic and numerous part of biosphere, their physiological indices are useful for monitoring the state of the biosphere on the whole.

The study summarizes effects of alpha- and beta- emitting radionuclides on marine microorganisms under conditions of low-dose irradiation. Luminous marine bacteria were chosen as an example of these microorganisms since they are known to be sensitive to toxic compounds. Bioluminescent intensity was used here as main testing physiological parameter of the bacteria. Non-linear dose-effect response of the bacteria to the chronic radioactive exposure was demonstrated. Three successive stages in the bioluminescent response to Am-241 and H-3 were found under conditions of low-dose irradiation: (1) absence of effects, (2) activation, and (3) inhibition. They were interpreted in terms of bacterial response to stress factor as stress recognition, adaptive response/syndrome, and suppression of physiological function (i.e. radiation toxicity), respectively. The effects were attributed to radiation hormesis phenomenon. In Am-241 aquatic solutions, an increase of peroxide concentration and oxidation rates were demonstrated. The results reveal a biological role of reactive oxygen species generated in water solutions as secondary products of radioactive decay.

The study is aimed at understanding effects of low-dose radiation on marine microorganisms, suggests an approach to evaluation of non-toxic and toxic stages under conditions of chronic radiation exposure. The time when bioluminescent intensity reverses from activation to inhibition can be considered as a beginning of a toxic stage.

The results demonstrate the advantages of luminous marine bacteria for monitoring the microorganism's response under conditions of low-dose irradiation. Additionally, the advanced experience in effects of exogenous compounds on luminous bacteria suggests that the bacteria is a convenient object to study physico-chemical mechanisms of toxic and hormetic effects of the radionuclides. Bioluminescence of bacteria can be considered as a simple model process for understanding activation and inhibition of physiological functions of higher organisms.

THE USE OF RADIOSENSITIZING Fe_3O_4/TiO_2 NANOCONJUGATES IN NEUROBLASTOMA CELL LINES

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We examined the subcellular distributions of different surface functionalized formulations of nanocomposites prepared as iron oxide core titanium dioxide shell (Fe_3O_4/TiO_2) particles, as well as their capacity to increase radiation sensitivity of neuroblastoma cell lines. Rationale for the expected radiosensitization effect was that (1) nanoparticles activated by photons of any energy greater than the band-gap of the material produce reactive oxygen species on particle surface; (2) presence of nanoparticles in cells alters cell cycle dynamics (and hence radiation response) of cells. Among the nanoparticle surface coatings tested were two types of small molecules: metaiodobenzylguanidine (MIBG) and 3,4-dihydroxyphenylacetic acid (DOPAC), and an epidermal growth factor (EGF) mimicking peptide (so called B-loop peptide (DOPAC-MYIEALDKYAC-COOH)). Nanoparticle presence in different subcellular compartments was evaluated with cryo X-ray fluorescence microscopy of frozen hydrated cells treated with nanocomposites. We also evaluated the toxicity of these nanoconjugates in several neuroblastoma cell lines using MTS assays. With regard to subcellular localization, we found that free MIBG localizes throughout the cytoplasm of neuroblastoma cells, including mitochondria. On the other hand, distribution of nanoconjugates coated with MIBG shows similarities with distributions of both nanocomposites alone and MIBG alone. Distribution of DOPAC coated nanoconjugates was characterized by presence of large aggregates in cytoplasm. Nanoconjugates with B-loop peptide could be found in cytoplasm and nuclei both. Nevertheless, with regard to radiosensitization, DOPAC covered nanoconjugates showed the best activity. Neither DOPAC nor MIBG showed any additive effect with ionizing radiation, while MIBG coated nanoparticles with or without addition of the B-loop peptide caused some radiosensitization in neuroblastoma cell lines. Use of radiolabeled MIBG may be expected to lead to nanoconstruct activation similarly to external beam irradiation. Therefore, radioactive MIBG decorated nanoconstructs can be expected to have very localized toxicity.

MICRO RNA RESPONSES TO HIGH AND LOW DOSE RATES OF RADIATION

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Historical radiobiological animal archives provide samples and data from hundreds of thousands of animals irradiated under controlled conditions. Our laboratory has collected such samples and used them to investigate micro RNA (miR) expression in spleen samples from animals that have lived out their "natural" lifespan after irradiation. Irradiation regimens included: single, 24, 60, 90, 120, or 300 fractions or daily (22h long) exposures to gamma rays (dose rates 0.001 to 27.285 cGy/min; total doses from 21.57 to 1840 cGy) or neutrons (dose rates 0.002 to 1.884 cGy/min; total doses from 0.94 to 37.68 cGy). Archival spleen samples were analyzed for miR expression using a limited, custom made 40 micro RNA (miR) array. Several types of comparisons were done (1) healthy mice (non-irradiated or irradiated) vs. mice with developed spleen disease (regardless of irradiation status); (2) untreated mice (either in healthy or sick) vs. mice previously exposed to ionizing radiation.

For comparisons of spleen miRs from animals with spleen disease vs. healthy spleens two miRs were found to be differentially expressed. Neither was previously reported to be associated with spleen cancers. Micro RNA mmu-miR-714 is uniquely expressed in mice (without a human equivalent). In vascular smooth muscle cell increased expression of mmu-miR-714 is believed to lead to calcification. This miR is elevated in kidney and plasma after ischemia-reperfusion injury. Micro RNA miR574-5p is present both in mice and humans. Elevated expression of miR574-5p is associated with lung cancer, esophageal squamous cell carcinoma and thyroid cancer. Moreover, in a mouse colorectal cancer model suppression of miR-574-5p reduced tumor growth (and was found negatively correlated with the expression of Quaking but positively correlated with the expression of beta catenin).

Several miRs were found to be associated with certain groups of irradiation treatments. For example, miR503 was found to be significantly higher in spleens of sick non-irradiated vs. sick irradiated mice. Overexpression of this miR is associated with decreased drug resistance (drug resistance reversal) in human hepatocellular carcinoma.

In summary, this type of animal archive investigation can be expected to point out to new miR-irradiation associations.

INFLAMMATORY-TYPE RESPONSE OF TISSUE RESIDENT MACROPHAGES COULD UNDERLIE DELAYED NON-TARGETED RADIATION EFFECTS

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Objectives: The machinery of early signaling events and biochemical alterations in tissues induced by ionizing radiation (IR) have been well characterized (Ross B Mikkelson and Wardman 2003). Less is known about the delayed effects of exposure to IR named “non-targeted effects” (Morgan 2003). A number of observations support the idea that exposure to clinically relevant doses of IR induces inflammatory-type response, accompanied by macrophage activation in irradiated tissues (Wright 2010). We propose that cell-mediated overproduction of reactive oxygen/nitrogen species (ROS/RNS) serves as the mechanistic link between primary events in exposed tissues and pathogenesis of non-targeted effects. The aim of this work was to evaluate oxidative metabolism in tissue resident phagocytes (peritoneal cavity and bone marrow) in rats two month after exposure to IR at dose of 0.5-4 Gy and to assess alterations in redox state of the serum.

Methods: The maturate male Wistar rats were sacrificed at 61 and 78 days after whole body exposure to γ-irradiation at dose of 0.5, 1, 2 and 4 Gy (0,93 Gy/min, 137Cs). The resident peritoneal cells (RPMs) were collected by lavage with 12 ml of complete media (DMEM, 1% antibiotic/antimicotic cocktail, 5 % FBS, heparin 10 U/ml). Bone marrow cells (BMCs) were isolated from thighbone with 7 ml of complete media, filtered via mesh of 80 um and diluted to match RPMs concentration. Common metabolic activity of cells was evaluated with MTT. The spontaneous and PMA-stimulated luminol-enhanced luminescence and XTT reduction were used to characterize ROS production. The spontaneous and LPS-stimulated accumulation of nitrite in 24 hr culture media served as a surrogate marker of RNS production. Total antioxidant capacity (TAOC) of serum was evaluated with AAPH and expressed in uM of Trolox. Serum lipid peroxidation level was expressed as a serum TBARs concentration.

Results: The obtained results demonstrated that increased ROS and RNS production in cells after exposure to IR was dose-dependent but not monotonic. The highest levels of spontaneous RNS production in RPMs and BMCs were identified two month after exposure to IR at dose of 1 Gy and reached 130 and 205 % of control for RPMs and BMCs respectively. Functional response to LPS stimulation was inhibited while response to PMA was enhanced. Increased levels of ROS/RNS production correlated with decreased TOAC and elevated levels of TBARs.

Conclusions: The observed effects had an inflammatory-type response and manifested mostly in a narrow range of absorbed doses of ionizing radiation. Dose-response relationships at selected time points, had a mainly nonlinear character, since their appearance depended on complex interaction of regeneration processes in the organism and nonspecific responses to toxic effects of IR exposure. The observed increase in ROS/RNS production, accompanied by para-inflammatory metabolic shift, could underlie delayed non-targeted radiation effects.

ROLE OF PULMONARY PROGENITOR CELLS IN REPARATION AND REGENERATION OF IRRADIATED LUNG TISSUE

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Intrinsic variations in the development of lung injury among patients undergoing radiotherapy (RT) for tumors in the thoracic region suggest that one or more genes influence the development and severity of radiation pneumonitis and/or fibrosis. Murine strain differences in pulmonary response to radiation may offer a novel method to extract the specific mechanisms that participate in the pathogenesis of radiation injury. The purpose of this study was to interrogate the role of pulmonary progenitor cells in the repair and regeneration of lung tissue following thoracic irradiation. Age and sex-matched C57L/J and C57BL/6J mice were exposed to a single dose of 15 Gy X-rays (1.25 Gy min-1; HVL~1 mm Cu) delivered to the whole thorax (WTLI) with lead shielding of the head, abdomen, and forelimbs. Lung tissue was harvested on day 1, 3 and 7 and weeks 2, 4, and 6 post-radiation. Changes in epithelialization, pulmonary progenitor cell populations, and inflammatory markers/signaling pathways were evaluated by electron microscopy, flow cytometry, real-time PCR, Western blot, and confocal microscopy. Results demonstrate damage to bronchial epithelial cells can be observed as early as 24 h after WTLI in C57L/J mice but not in C57BL/6J mice suggesting the increased radiosensitivity of this strain may be in part due to loss of a bronchial epithelial progenitor cell population. In vitro studies are being performed to compare the inherent radiosensitivity of primary pulmonary multipotent and/or progenitor cells isolated from C57L/J and C57BL/6J mice. Strain-specific genetic differences in early responses to radiation, such as propensity toward epithelial injury, the speed of mucosal repair, and the type, intensity, and efficacy of immune responses, may facilitate development of pneumonitis and/or fibrosis. Acknowledgements: This study was supported by the National Institutes of Health Grant number U01-AI-107361 (PI: Vujaskovic Z).

ADAPTATION MECHANISMS OF DANDELION (*TARAXACUM OFFICINALE* S.L.) AND PLANTAIN (*PLANTAGO MAJOR* L.) FROM RADIOACTIVE CONTAMINATION AND HEAVY METAL POLLUTION ECOSYSTEMS

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The adaptation ways of biota to anthropogenic impacts are diverse. These mechanisms have universal and specific components due to the nature of active factor and biological characteristics of the species. We studied populations of dandelion (*Taraxacum officinale* s.l.) and plantain (*Plantago major* L.), that long time grows under radioactive contamination (East-Ural Radioactive Trace - EURT) and chemical pollution (Nizhny Tagil Metallurgical Combine - NTMC). Background samples grew out of any contaminations. Used allozyme analysis evaluated the genetic structure of background and impact populations. The quality of plant seed progeny characterized in terms of viability, mutability, metal and radiosensitivity.

The dandelion seed viability (PP generation) was reduced in a similar manner in EURT and NTMC areas. Background samples were resistant to provocative exposure (R) and sensitive to heavy metals (HM). The impact populations had non-specific responses to “usual” and “new” factor. The individual variability of dandelion metal- and radioresistance (F1 generation) found that seed progeny from EURT has high viability, but had latent damages that led to high sensitivity to additional man-made influences. The high seed viability combined with increased resistance after additional R and TM were in the F1 generation seeds from NTMC area. The significant differences in the responses to “usual” or “new” factors, i.e. pre-adaptation effect, have been not found in samples from impact areas.

The quality and quantity of allozyme structure was differed in all dandelion populations. The clonal diversity was unique. The genesis of each of them had individual: the different plants was set-founders, whose descendants are genetically modified, reproduced, more or less successfully mastering the territory, subject to selection by the action of natural and anthropogenic factors. The common feature of populations experiencing chemical or radiation stress can be increased genetic variability as compared to background samples and, as consequence, decrease of clonal diversity.

The survival rate of seedlings plantain (PP generation) from chemical contamination samples was lower than in EURT and background populations. However, the seed samples from EURT and background areas were sensible to R. The descendants of plants from the NTMC area were stable, it is indicating about high adaptive capacity of these plants. The seedlings with modified form of true leaves have encountered in the chemical contamination area, seedlings with root necrosis were absent. The seedlings with root necrosis were increased in the EURT, and remained minimal in NTMC areas after R. Therefore high proportion of latent damage was in plants from radioactive area.

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PRELIMINARY STUDIES OF RADIOBIOLOGICAL EXPERIMENTS WITH LASER ACCELERATED PARTICLE BEAMS

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Introduction: The laser-driven particle acceleration provides beams with different properties compared to conventional acceleration techniques. Their special characteristics offer further challenge in radiation dosimetry, radiobiology and radiotherapy. The aim of our study is to develop suitable dosimetry systems applicable for the special properties of laser-driven particle beams and the theoretical preparation of our future radio-biological experiments.

Materials and Methods: ELI-ALPS offers laser-accelerated electron and ion-beams with unique parameters (broad energy range, ultra-short pulses, high dose-rate). Furthermore, the beams' energy can reach values appropriate for experimental radiobiology and medical use, and could be operated in energy an intensity modulated mode. For radiobiological research we plan to use an integrated, modular, multipurpose irradiation end-station, with a sophisticated beam monitoring and dosimetric system, to meet various radiobiological research requirements. This device will offers an accurate control and verification of delivered radiation dose and will include other diagnostic possibilities. The beam line will be a gamma, electron and ion beam which can be mono- or plurienergetic. For accurate dosimetric measurements we are developing a standardized calibration protocol based on absolute dosimetry measurements (ionization chamber, water or graphite calorimeter, Faraday cup is taking into account). For microdosimetry measurements we are developing on several suitable dosimetry devices, like silicon based microdosimetry devices, ion-counting nanodosimeters and high resolution, diffusion free gel dosimeters. In this development phase we intensively use the Geant4-DNA toolkit for microdosimetric study of our biological model systems (cell culture, Zebrafish embryos and rats) and FLUKA (or combination of them) for device development. The main objective in this stage is the demonstration of feasibility of our biological model systems, to understand the main physical and biological processes of our biological models and to estimate their outcomes.

Results and Conclusions: In our systematic studies on existing dosimetry solutions we define the suitable method for ELI-ALPS radiobiological experiments. Particular attention is paid to microdosimetric and nanodosimetric solutions. We implemented a conceptual design of our dosimetric systems to ensure the accuracy and precision needed for planed radiobiological experiments. The main achievement in this stage is to demonstrate the feasibility of the proposed dosimetry-biological model systems. Regarding the specific properties of the beams offered in ELI-ALPS, a thorough examination of the different methods is needed.

IRIF CLUSTER FORMATION AND STRUCTURE IN HUMAN FIBROBLASTS AFTER IRRADIATION WITH BORON IONS AND γ-RAYS

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Low-linear energy transfer (LET) radiation induces mainly isolated DNA lesions which are generally repaired efficiently. With increasing the LET value, damage complexity increases and clustered DNA double-strand breaks (DSBs) are formed. These complex DNA lesions are more difficult to repair than isolated ones or in some cases are irreparable.

In this study, we have compared the formation of ionizing radiation-induced foci (IRIF) clusters and their structure in human fibroblasts irradiated with 1 Gy of 60Co γ-rays (LET ≈ 0.3 keV/μm) and accelerated 11B ions (LET = 137 keV/μm, E = 8.4 MeV/u), using immunostaining for DNA DSB response proteins γH2AX and 53BP1. Sample irradiation with 11B ions was done in two geometries: perpendicular to the beam direction to study the kinetics of γH2AX/53BP1 foci formation, and at a small angle (10°) between the beam direction and cell monolayer to analyze the foci distribution along the particle trajectories. High-resolution confocal microscopy and 3D reconstruction of cell nuclei allowed us to analyze in detail the structure of clustered γH2AX/53BP1 foci.

The obtained data show differences in the kinetics of γH2AX/53BP1 foci formation and elimination in cells irradiated with γ-rays and 11B ions. Under the action of accelerated boron ions, the number of γH2AX/53BP1 foci decreases slower than for γ-irradiation. Within 4 h after γ-irradiation, most of the foci are eliminated, whereas the elimination of ~80 % of the foci is achieved 24 h after 11B ion irradiation. A detailed analysis of foci cluster structure demonstrates that the complexity of the 11B ion-induced clusters is higher and more variable. In the cells irradiated with 11B ions, more than 80% of the foci form clusters comprising several individual foci in mutual contact, whereas only ~ 30% of the foci were identified as clusters after γ-irradiation. It is observed that the fraction of more complex clusters increases with post-irradiation time. The increasing multiplicity of γH2AX/53BP1 clusters probably reflects the irreparability of the highly complex clusters. Also, a dose dependence of γH2AX/53BP1 foci formation 1 h after 11B ions irradiation was obtained.

SECOND PRIMARIES AFTER HDR ^{252}Cf OR ^{60}Co BRACHYTHERAPY COMBINED WITH EBRT FOR CARCINOMAS OF CERVIX OR CORPUS UTERI

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Background. It's well known the carcinogenetic action of the neutron irradiation. The quantity of second primaries in the adult women population with gynaecologic cancer after medical use of ^{252}Cf neutron irradiation is still unknown.

Materials and methods. ^{252}Cf neutron brachytherapy was introduced into world clinical practice at the 1980. Starting 1990 to 2000 year period the HDR ^{252}Cf brachytherapy combined with ^{60}Co distant gamma irradiation was used for radiation therapy of the 605 pts with cervix or corpus uteri carcinomas in Lithuania. At the same time 538 pts with these tumours received external and/or intracavitary radiation by the use of the ^{60}Co photon sources. All patients have had no chemotherapy.

Results. The check-out time was 1 October 2014 and it was agreed the latent period for second primaries 2 yr. after completing radiation therapy. Overall 87 second primaries were observed (7.8 %):48 in ^{252}Cf group (7.9 %) and 39 in ^{60}Co group (7.2 %).

The distribution of second primaries according quantity of received dose of radiation (Kleinerman RA et al., 1995) is shown in table.

Table. Observed numbers of second primaries according received dose of radiation.

	^{252}Cf group (605 pts)	^{60}Co group (538 pts)
Heavily irradiated sites	17	10
Moderately irradiated sites	7	7
Lightly irradiated sites	21	15
Hematologic site	3	7
Overall	48	39

Conclusions. The detailed analysis of the obtained results should be presented during poster presentation.

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Kleinerman RA, Boice JD, Storm HH et al. Second primary cancer after treatment of cervical cancer. Cancer. 1995; 76, Nr.3: 442-452.

DEVELOPMENT OF ANIMAL MODELS FOR TESTING NEW THERAPEUTIC STRATEGIES TO MITIGATE AND/OR TREAT MULTIORGAN INJURY AND IMPROVE SURVIVAL FOLLOWING LETHAL RADIATION EXPOSURE

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As the number of countries interested in developing peaceful nuclear technology rises, there is a growing risk for a nuclear accident or for weapons-grade materials to be diverted for non-peaceful purposes. As such, it is critical to rapidly develop new strategies to mitigate and/or treat the acute and delayed radiation syndromes (ARS/DEARE). In a radiation accident or attack, the environment will be ill-defined as a result of body position, random shielding, variable distances from the source and/or radiation intensity in the fall-out field. These factors will result in unilateral, non-uniform, and heterogeneous exposures. The objective of this study was to develop a "real world" murine model of total body irradiation (TBI) with 2.5-5% bone marrow (BM) shielding that progresses through each of the acute and delayed radiation syndromes for the purpose of studying the mechanisms of multiorgan injury and to screen radiation countermeasures. Adult C57L/J mice were exposed to a single dose of 9 to 16 Gy TBI with 2.5 or 5% BM shielding. Animals were followed for major morbidity/mortality for up to 160 days post-exposure. The primary endpoint was survival. Secondary endpoints include complete blood count with differential, platelet count, and histologic evaluation of gastrointestinal, lung, heart, and spleen tissue. 5% BM shielding shifted the lethal dose for 50% of the animals at 30 days from 11.8 Gy to 13.0 Gy. Acutely spleen weights were significantly reduced in the BM2.5 compared to BM5, which recovered by the end of the study suggesting early immunosuppression. This was consistent with reduced platelet and WBC counts in the first several days to weeks post-TBI/BMx. Histologic evaluation of tissue is ongoing. Timed analysis to evaluate the progression of ARS/DEARE and organ interactions is being performed. In summary, the TBI/BMx model recapitulates the progression through each of the organ specific sequelae associated with acute radiation exposure, namely the acute and delayed hematopoietic and gastrointestinal syndromes and lung injury. This model allows for screening of various polypharmacy approaches to determine the appropriate medical management for victims exposed to supratherapeutic radiation doses to significantly reduce morbidity/mortality.

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FEATURE OF THE STOCHASTIC EFFECTS OF PARTICIPANTS IN DIMINISHING OF THE CHERNOBYL DISASTER CONSEQUENCES

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870 patients – participants in diminishing of the consequences of the Chernobyl nuclear accident (PDCCNA) were investigated clinical, immunological, citogenetic and oncology. The clinical investigation indicates the prevalence of large polymorphism of nervous, heart-vascular and gastric-intestinal system, which was accompanied by circulatory disorder of the vegetative nervous system. The aberrations of T- lymphocyte μs immunofenotype and tendency to T-/cell immunity insufficiency have been revealed with monoclonal antibodies to cd19+, cd3+, cd4+, cd8+, cdHLA DR+ and cd16+. Citogenetic research of the lymphocyte cultures of peripheral blood revealed the high level of genomic, chromosomal and chromatid type aberration. The structure of tumors has the appropriate profile, but not identical with the mun. Chisinau populations for the same period.

Key words: Chernobyl Nuclear Accident, ionizing radiation, malign tumors.

SODIUM COPPER CHLOROPHYLLIN: A POTENTIAL RADIOPROTECTIVE CANDIDATE

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Chlorophyllin (CHL) is a derivate of natural plant pigment chlorophyll which is used in food production as a food dye. It has also shown several beneficial effects on different experimental models which makes it interesting molecule to study for its radiomodulating properties.

The aim of this study was to evaluate potential radioprotective properties of CHL on human peripheral blood lymphocytes (HPBLs), which are reliable target cells, from the aspect of cyto- and genotoxicity. Two different approaches were investigated. The whole blood samples that were pre-treated with 10, 50 and 100 μg/mL of CHL for 2 h at 37 °C, and blood samples treated immediately before gamma irradiation with the same range of CHL concentrations. Using 60Co as a source of γ-radiation, total absorbed dose of all irradiated blood samples was 5 Gy.

After HPBLs isolation and vital staining using ethidium bromide/acridine orange dye, viable cells were stained in green while dead cells were stained in red which was analysed using fluorescence microscope. The cell viability did not change either for samples treated with all concentrations of CHL, or for irradiated samples pre-treated and treated with CHL. On the other hand, using comet assay we have managed to detect changes in genome damage. Results were presented as tail moment (TM) that incorporates two comet assay parameters: tail length that represents distance that broken fragments of DNA managed to migrate, and tail intensity that reflects the percentage of DNA in the comets' tail. There was no difference in TM for CHL treated samples alone compared to corresponding negative control. Expectedly, γ-radiation managed to induce significant DNA damage what was observed in higher TM (0.09 ±0.01 vs. 1.97 ±0.16 for pre-treated vehicle control samples, and 0.12 ±0.02 vs.2.33 ±0.20 for treated vehicle control samples). The presence of CHL in blood samples during γ-radiation resulted in dose-dependent significant decrease in TM for both pre-treated and treated samples compared to irradiated samples. At the highest CHL concentration (100 μg/mL) TM dropped to 1.20 ±0.15 for pre-treated samples and 1.51 ±0.15 for treated samples.

Taken together, CHL showed potential radioprotective properties which are especially valuable due to lack of its toxicity. Further investigations are needed in order to determine its protective capacity compared to known radioprotectors, and molecular mechanisms of action.

DYNAMICS OF GROWTH PROCESSES OF THE COMMON REED'S SEED FROM WATER BODIES IN THE CHERNOBYL EXCLUSION ZONE AFTER ADDITIONAL IRRADIATION

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Research of biological indexes of non-human biota in conditions of long-term ionizing radiation impact is an important radiobiological and radioecological issue nowadays. Investigation of adaptation response of higher plants communities and their sensitivity to the long-term ionizing radiation impact on the basis of single individual's biological effects contribute to the concept of radioecological complex monitoring system. Ionizing radiation effects for aquatic vascular plants are investigated incompletely, however these plants are a significant link of radionuclides transfer and bioaccumulation.

The common reed (Phragmites australis) is a typical species living within fresh and brackish waters. Biological effects during seeds germination, are the most convenient to be investigated, because of high sensitivity to ionizing radiation impact at this stage.

Total absorbed dose rate received from environment and accumulated radionuclides, was calculated for parent plants according to techniques (Strand et al., 2003) and varied in range 0.03-12.0 μGy hour-1. Seed progeny material was sampled in the Chernobyl accident exclusion zone - from Glyboke Lake, cooling pond of the Chernobyl NPP, and Verbne Lake nearby Kyiv city area. To investigate the radiation adaptation potential, seed material was additionally exposed to acute 25, 75 and 175 Gy X-ray of 30 Gy min-1 dose rate. Seed germination experiment started at 2.5 hours after additional irradiation.

Reliable linear dynamics of roots and leafs growth in contrast to exponential one in case of acute irradiated seed progeny, was determined. Reliability index varied from 0.89 up to 0.99. High variation coefficient C (18.7, 25.3), defined for roots and leafs of acute irradiated seed progeny from Verbne Lake, characterizes wide range of this index in comparison with additional acute radiation (up to 19.3). Inverse correlation between acute irradiation dose and linear indexes of leafs and roots growth was determined - from -0.80 up to -0.99. Two-factor analysis of "long-term irradiation" and "acute irradiation" showed reliable influence of both factors on growth reaction of the common reed's seed progeny for $P = 0.05$ and $P = 0.01$ confidence levels. Dose-effect curves of investigated indexes, showed high radioresistance of the common reed's seed progeny from the least radionuclide contaminated water body - Verbne Lake (0.03 μGy hour-1). Controversially, in case of the most contaminated Glyboke Lake (up to 12.0 μGy hour-1) high radiosensitivity was detected.

Thus, vitality indexes of the higher plants seed progeny, by the example of the common reed, may be considered when investigation of higher plants radiosensitivity, adaptation potential of single plants and their communities in conditions of radioactive contamination of water bodies.

DIFFERENTIAL REACTION OF NORMAL AND MALIGNANT CELLS TO GENOTOXIC EFFECT OF X-RAY RADIATION AND EXOGENOUS NITRIC OXIDE

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Introduction. According to data of the International Agency for Research on Cancer (IARC), a primary cause of human cancers is environmental pollution, especially – air pollution. Exogenous factors cause 75-80% of all cancer incidents. Moreover, the chemical carcinogens are responsible for the occurrence of 80-90% of all human malignant tumors.

One of the main environmental air pollutants worldwide are nitrogen oxides (NO). Anthropogenic pollution of environment with radionuclides, as well as expanding of X-ray use and radiographic methods in medical research have led to increased external and internal exposure of humans to ionizing radiation.

Data of literature on the impact of prolonged (chronic) combined treatment with environmental factors of low intensity, in particular NO and LDIR on the development of genetic instability and as a result increase of cancer risk are mainly absent.

We investigated the dynamics of DNA breaks formation in cells with low (PBL), intermediate (BMC) and high (solid tumor Guerin carcinoma (GC) cells) proliferative activity.

The aim of this study was to investigate the reaction of normally proliferating and malignant cells to genotoxic effect of widespread environmental factors - exogenous nitric oxides and ionizing radiation.

Methods: The animals were treated with NO (125 mg/cm3) and low dose ionizing radiation (10*0.1 Gy). Genotoxicity was assessed in vivo in rats normally proliferating peripheral blood lymphocytes, bone marrow cells and malignant cells of Guerin carcinoma. DNA damages were assessed by alkaline single-cell gel electrophoresis.

Results: Exogenous nitric oxides as well as irradiation caused significant increase of DNA damage in all types of investigated cells. The genotoxic effect correlated with rate of cell proliferation and increased in the order: peripheral blood lymphocytes < bone marrow cells < Guerin carcinoma cells. The greatest genotoxic effect was registered in the most actively proliferating Guerin carcinoma cells on terminal phase of tumor growth in rats exposed to NO and low dose ionizing radiation.

Conclusions: Long-term exposure to common environmental factors (exogenous nitric oxides and ionizing radiation) capable to induce DNA damage in different cells. Severity of the genotoxic effect depends on rate of cell proliferation and nature of impacting factors. NO caused more significant DNA damage than low dose ionizing radiation but the highest level of DNA damage was observed after their joint action. Obtained results confirm the real threat of cancer risk increase under combined action of common environmental factors of different nature.

EXPERIMENTAL ESTIMATION OF ANTITUMOR EFFICIENCY OF CULTIVATED FUNGI BASIDIOMYCETES

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Effect of environmental factors having adverse effects on public health can be reduced by using natural biologically active substances (e.g., medical fungi), which are capable of correcting metabolism, in irradiated organism as well. Medical fungi are known to have a number of advantages, since, when used by human, they provide a set of organism-related compounds.

This paper presents experimental estimation of cultivated Basidiomycetes (Hericium erinaceusbiomass and Shizophillum commune) aqueous extracts antineoplastic efficiency for Af-line mice. Mice with transplantable Ehrlich's ascite carcinoma were kept intact on the territory of Polesie Radiation and Ecological Reserve (PRER).

Shizophillum commune (250 mg/kg) efficiency was assessed for males, part of them receiving fungi extract both 40 days prior to being inoculated with tumor cells and during the rest of the research; while the rest of the mice were receiving water.

Influence of aqueous extracts of Hericium erinaceus and Shizophillum (both were introduced in equivalent doses) on antineoplastic resistance was studied for F1 mice progeny, whose parents were kept in PRER for two months. Obtained in the vivarium, F1 progeny was receiving fungi extract during 10 days prior to being inoculated and during the rest of the research.

Tumor mass growth rate was reduced in the case of intact mice receiving Shizophillum communeaqueous extract. On the 16th day after the tumor inoculation, the average tumor mass for the group with preventive Shizophillum commune treatment was 32% less than that for the group that did not receive treatment. The survival rate was as high as 33% for mice receiving preventive fungi extract treatment.

Thus, increased antineoplastic resistance was established for the exposed in PRER mice progeny that received aqueous extracts of Hericium erinaceus and Shizophillum. Treatment with Hericium erinaceus andShizophillum reduce Ehrlich's ascite carcinoma growth rate by 38% and 55%, respectively.

The studied kinds of cultivated Basidiomycetes possess antineoplastic and radiation-resistance properties. These fungi can be considered for development of prophylactic drugs as an additional component in comprehensive treatment of oncological diseases, and to stabilize state of an oncological patient.

THE ACTIVATION OF N-METHYL-D-ASPARTATE RECEPTOR AND CORRELATION WITH RADIATION-INDUCED GUT INJURIES

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Heavy-ion therapy is effective treatment for cancer because it is possible to focus the peak of charged particle beam on the cancer-affected area, whereas the beam can cause damage to the surrounding normal tissues and its damage limits the radiation dose or area for cancer therapy. The intestinal crypt stem cells in gut have a high radiosensitivity, it is dose-dependently reduced by heavy-ion irradiation. Radiation-induced gut injuries are most potent threat to radiotherapy for abdominal cancer. Therefore, radioprotective agents for gut may contribute to more effective and less harmful heavy ion therapy. N-methyl-D-aspartate receptor (NMDA-R) is one of excitatory amino acid receptors and NMDA-R antagonist has been reported to prevent the radiation-induced injuries in the central nervous system. We determined that radiotracer of 2-14C-thymidine is useful for predicting radiation- induced gut injuries, in term of crypt repopulation and early diagnosis of cell death. We assume that the peripheral NMDA-R activation is a possible cause of injury to normal tissues after irradiation. We examined the 2-14C-thymidine accumulation in gut after irradiated with carbon-ion until 84 hrs. Mice were given whole body irradiation with carbon-ion (290 MeV/u, 6cm-SOBP, 20keV/μm). 2-14C-thymidine accumulation in gut significantly decreased 4 hrs after irradiated with 9 Gy . At 12 hrs after irradiation, accumulation of 2-14C- thymidine decreased with an increase of carbon-ion doses. On the other hand, 2-14C-thymidine accumulation not showed dose dependence at 84 hrs after irradiation. However, the dose dependence was obtained when 2-14C-thymidine accumulation was corrected by blood flow. The regional blood flow marker 14C- labeled N-isopropyl-p-iodoamphetamine (IMP) in gut markedly increased after 9-18 Gy irradiation. The results of the present study are first demonstration that the 2-14C- thymidine uptake in vivo could be an appropriate marker for early gut response to irradiation and correction by blood flow is essential for the evaluation by 2-14C-thymidine. The radioprotective effects of MK-801, a noncompetitive NMDA-R antagonist, on gut were confirmed by the crypt survival assay. The tritium-labeled 3H-MK801 was used as a marker for NMDAR activation and injected into C3H female mice intravenously. Gut accumulation of 3H-MK801 after whole body irradiation of carbon ion. The significant increase of 3H-MK801 accumulation in gut show that intestinal NMDA-R are most activated at 24 hrs after 3-9 Gy carbon ion irradiation. This study may evaluate the effect of carbon-ion radiotherapy against cancer by PET (Positron emission tomography) diagnosis and it would be possible to inhibit radiation-induced gut injuries by NMDA-R antagonists until 24 hrs after carbon ion exposure.

THE HSP90 INHIBITOR GELDANAMYCIN ACCELERATES THE REPAIR OF RADIATION-INDUCED DNA DOUBLE STRAND BREAKS IN HUMAN LYMPHOCYTES

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DNA-PKCS (DNA-dependent protein kinase, catalytic subunit) is a key enzyme in the non-homologous end joining (NHEJ) pathway, a predominant double-strand breaks (DSB) repair pathway in mammalian cells. Heat shock protein 90 (Hsp90) is a highly conserved molecular chaperone, involved in the folding, assembly, stabilization and activation of several hundreds of proteins, referred to as Hsp90 "clients". DNA-PKCS plays essential role among the Hsp90 clients as it has been shown that the kinase can phosphorylate the molecular chaperone and modify its cytoprotective activity in response to DNA breaks. Thus, Hsp90 has been identified as both chaperone and substrate of DNA-PKCS.

Geldanamycin (GA), a natural benzoquinone, can inhibit Hsp90 and affect the function of DNA damage response proteins including DNA-PKCS. We analyzed the impact of Hsp90 inhibition on the DNA-damage response in human peripheral blood mononuclear cells (PBMC) exposed to ionizing radiation and found that GA accelerated the repair of radiation-induced DSB. Data provides evidence for GA-induced activation of DNA-PKCS and a significant role of the DNA-PKCS/Hsp90α regulatory interactions in the repair of the toxic DSB by NHEJ pathway. Thus, the Hsp90 inhibitor GA has been found to exert radioprotection on human lymphocytes constituting the majority of PBMC.

ST2 PROTEIN AS A NOVEL BIOMARKER FOR AN INCREASED RISK OF CARDIOVASCULAR DISEASE IN INDIVIDUALS OCCUPATIONALLY EXPOSED TO LOW-DOSE RADIATION

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Cells are secreting numerous proteins into blood plasma as a response to various stimuli. The secreted proteins can be highly informative of cellular states at real time and at given conditions which makes them potential biomarkers of a particular importance and value for diagnosis, prognosis, risk stratification and therapeutic monitoring. Therefore identification of accessible, sufficient and reliable protein markers which reflect and mark various stages of disease development is of particular importance for relating chronic toxic exposures including radiation exposure to health outcomes.

The soluble form of the ST2 receptor protein (sST2) is secreted into blood plasma and has been identified as an emerging prognostic marker in patients with cardiovascular disease. Interleukin-33 (IL-33), a cytokine and transcriptional factor is a ligand of ST2, involved in the signalling between cardiomyocytes and cardiac fibroblasts during mechanical overload. sST2, playing a role of "decoy receptor", can bind and sequester IL-33, thus preventing the transmembrane IL-33/ST2 signalling and blocking the protection of myocardium.

This pilot study aims to answer the question whether sST2 protein can represent a marker for potential use in epidemiological studies monitoring the risk of developing cardiovascular disease in subjects, occupationally exposed to low-dose ionizing radiation. For the purpose, sST2 levels in the blood plasma of 45 occupationally exposed to radiation individuals from the "Kozloduy" NPP in Bulgaria and of 24 healthy individuals representing an external control group were analysed. Significantly higher number of occupationally exposed workers with elevated levels of sST2, exceeding the clinical threshold of 35 ng/ml, has been found in comparison with the control group. Association of sST2 levels with the total antioxidant status (TAS) of the blood plasma has also been observed. This may link increased cardiovascular risk with radiation-induced oxidative stress predisposing to endothelial dysfunction and cardiovascular injury.

The main limitation of our study is the relatively small number of subjects and the study should be considered a pilot one; it needs extension and continuation as a prospective study. To the best of our knowledge, this study is the first one to reveal a relationship between sST2 as a perspective marker of cardiovascular disease and low-dose irradiation and may represent an important initial step towards an easy and reliable method for estimation of cardiovascular risks related to occupational radiation exposure.

THE PROTECTIVE EFFECT OF ALPHA-LIPOIC ACID FOR RADIATION-INDUCED FIBROSIS IN BALB/C MICE

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Radiation-induced fibrosis (RIF) in skin and soft tissue, which is characterized by excessive accumulation of extracellular matrix and the proliferation of fibroblasts, is one of the most common late complications of RT. Clinical significance of RIF is very important about radiation oncology field, but there is no effective treatment method or drug. α-lipoic acid (α-LA), a metabolic thiol antioxidant, inhibits TNF-α-induced NF-κB activation and acts as a direct free-radical scavenger. In this study, we investigated that α-LA has potential value as a novel RIF-protective agent.

To examine the key mechanism of radiation-induced fibrosis, male BALB/c mice were used for the RIF mice model and the right hind limb of each mouse received two weekly radiation doses of 22 Gy using linear accelerator. After irradiation, each group was daily treated with saline (control group) or α-Lipoic acid (600 mg/kg/day) orally administered for 14 weeks. The protective effect of α-LA in a mouse model was tested using the leg-contracture assay. In addition, the expression of fibrosis-related genes was analyzed by western blot, qPCR and immunohistochemistry. The p300/CBP activity was measured by histone acetyltransferase assay kit after irradiation, and the complex dynamics of p65, acetyl-p65 and p300 on PAI-1 genes were tested by using chromatin immunoprecipitation assay.

As a result, the expression level of collagen protein was increased and leg contracture was decreased in the RIF mice model. However, α-LA-treated RIF tissues was reversed collagen expression and leg contracture. α-LA also suppressed the expression of pro-fibrotic genes via TGF-b1 activation after irradiation, in vivo and in vitro, and directly inhibited the up-regulation of TGF-b1-mediated p300/CBP activity. Furthermore, those up-regulation of TGF-b1 mediated p65 acetylation and α-LA antagonized p65 acetylation in dose-dependent manner. Finally, α-LA suppresses NF-kB activity through antagonizing the hyperacetylation of p65 in radiation-induced fibrosis.

In conclusion, we found that α-LA inhibits the expression of pro-fibrotic markers by inhibiting NF-κB activation during radiation-induced fibrosis and prevents RIF in mice through the inhibition of TGF-β1-mediated histone acetyltransferases (HAT) activation by radiation.

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THE INTERACTION OF TRITIUM WITH SOME TYPES OF AQUATIC PLANTS: ELODEA CANADENSIS AND LEMNA MINOR

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According to the results of the present work the following conclusions are made:

1. The experiments on the tritium accumulation by the aqueous plants under study, namely, by Elodea canadensis and Lemna show the maximum radionuclide decrease to occur after the first day of the experiment. The maximum tritium absorption by the aqueous plants amounts to ~60 % from the introduced amount.

2. With the chronic influence of tritium in the form of HTO on the young elodea shoots the transformation of HTO into OBT occurs, as a result of the experiments on the tritium accumulation by elodea the tritium content in the form of OBT increased from 3 to 15 % from the total amount of the isolated radionuclide.

3. The maximum portion of tritium in the form of OBT was found in the course of the experiments carried out at ~25°C and the light regime – 6/18 (day/night). In this case the OBT portion in the plant biomass is 35 % from the total tritium content.

4. Upon the introduction of tritium the number of rosettes in the lemna at the end of the experiment was 8, with only 6 ones in the controls. Under the influence of tritium on the lemna fronds the increase of the frond area was found to increase by 38 % in comparison with the control in the case of using the water from the Yenisei River as the medium and by 20 % when using the distilled water.

IMPACT OF MEDIUM NUTRITION ON THE SHAPE OF BACTERIA SURVIVAL CURVE AND RBE OF α-PARTICLES

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The aim of this work was to analyze the effect of medium nutrition on alpha particles RBE and the shape of the survival curves of bacteria E. coli B/r. A standard bacterial medium and a medium comprising 6% malt extract were applied as the media to cultivate cells before irradiation. Cells were cultured at 37oC for 18 hours, while they reached the stationary growth phase. After that a cell probe (suspension) was split into two portions, one of which was irradiated with different doses of gamma radiation and the other one with different doses of alpha particles. In the latter case, the cells were irradiated in a Sparsely ionizing radiation (γ-rays of 60Co, LET=0.2 keV/μm, 22 Gy/min) and densely ionizing radiation (α-particles of 239Pu, LET = 120 keV/μm) were used to expose cells. A macrocolonies method was used to determine the cell survival. The control and irradiated cells were plated in petri dishes on standard bacterial substratum and incubated at 37°C for 20 hours. Control cells were subjected to the above operations, eliminate exposure. Each experiment was repeated 5-7 times.

The results of experiments can be summarized as follows. The dependence of cell responses on the quality of radiation as well as on the cultivation conditions was demonstrated. It was shown that the cultivation of bacteria on a medium comprising malt led to the transformation of survival curve form from the exponential to sigmoidal shape. As a result, the RBE of α-particles varies from 1 to 1–10 when medium conditions were changed from the standard bacterial substratum to the substratum with 6% malt extract. The observed bacteria responses to the action of sparsely and densely ionizing radiation were interpreted from the point of the dependence of cell recovery on medium nutrition.

DESIGN AND CHARACTERIZATION OF A DESK-TOP LASER PLASMA X-RAY SOURCE FOR RADIOBIOLOGY STUDIES

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During the past several years, soft X-ray irradiation systems are mainly based on X-ray tubes (electron beam interacting with a solid target), synchrotrons, free-electron lasers, hot plasmas - both discharge and laser-produced, among others. Currently, biological effects of low-energy X-rays are studied using, mainly, monochromatized synchrotron radiation [1,2]. The synchrotrons, although, state of the art facilities for cutting-edge experiments, offer limited accessibility, have high running and maintenance costs. A new desk-top laser produced X-ray source based on gas puff target dedicated for radiobiology studies has been developed. The source is based on a double-stream gas puff target, irradiated with the focused beam of a commercial Nd:YAG laser. The source has been optimized to get a maximum photon emission from LPP in the X-ray water window spectral wavelength range from 2.3 nm (i.e., an absorption edge of oxygen) to 4.4 nm (i.e., an absorption edge of carbon) (from 540 to 280 eV in photon energies) by using argon gas-puff target and spectral filtering by free-standing thin foils. A potential advantage of this source is the possibility to irradiate biological samples under different conditions (either in He/air or in vacuum). The source delivers nanosecond pulses of soft X-rays at a flux of about 4.2x103 photon/(m2 pulse) on a sample placed inside the vacuum chamber and about 7.5x102 photon/(m2 pulse) on a sample located outside the chamber. The source design, radiation output characterization measurements and initial irradiation experiments will be discussed. The source can be useful in addressing observations related to biomolecular, cellular and organisms sensitivity to pulsed radiation in the water window spectral range.

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HYPERMETHYLATION IN HUMAN BLOOD LEUKOCYTES AS A RESULT OF RADIATION EXPOSURE OF THE BODY

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Methylation-sensitive PCR assay was used to analyze promoter methylation of p16/CDKN2A, p14/ARF, RASSF1Aand GSTP1 genes in blood leukocytes from 208 unirradiated volunteers and 124 irradiated subjects (83 Chernobyl Nuclear Power Plant liquidators, 21 nuclear specialists, 20 residents of territories with radioactive contamination, 4 persons evacuated in 1986 from the zone of Chernobyl NPP). The age of unirradiated and irradiated subjects at the time of examination was 19 to 78 years and 36 to 77 years, respectively. Besides, 74 non-exposed offsprings (2.5 – 49 years) born from irradiated parents were examined. As a whole, a frequency of individuals with promoter methylation of at least one of the analyzed genes in exposed group is significantly higher compared to the control group ($p = 3,9 \cdot 10^{-7}$). No significant differences were found in the frequency of children born to irradiated and unirradiated (control group) parents with the revealed promoter hypermethylation of studied genes (power of the test is about 90%). On this account, upon further analysis, the offsprings of irradiated individuals were assigned to the control group. The frequency of hypermethylation cases of RASSF1A and p14/ARF gene promoters increases with age both in exposed group and in the control group. In contrast, frequency of individuals with abnormal methylation of p16/CDKN2A and GSTP1 genes significantly higher in exposed group than in control group for both age categories. The correlation of exposure fact with methylation of the RASSF1A and p14 genes disappear at a fixed age ($r = 0,011$; $p = 0,825$ and $r = 0,032$; $p = 0,523$, respectively), but it is significant for genes p16 and GSTP1 ($r = 0,186$; $p = 1,7 \times 10^{-4}$ and $r = 0,182$; $p = 2,4 \times 10^{-4}$, respectively). On the contrary, when the status of the exposure is fixed, the correlation of hypermethylation with age disappear for p16 and GSTP1 genes ($r = 0,059$; $p = 0,238$ and $r = 0,010$; $p = 0,844$, respectively). Thus differential role of age and radiation exposure factor in the hypermethylation of various genes was identified.

A MULTIGENERATIONAL STUDY OF SUBCHRONIC GAMMA IRRADIATION EFFECTS IN THE ZEBRAFISH MODEL

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The zebrafish model offers many practical benefits such as optical transparency of embryos, which allows visualization of the development of major organ systems within 48 hours post fertilization (hpf). Alarge number of zebrafish can be maintained in a small space and paired mating can produce hundreds of embryos at a time. External embryogenesis allows experimentation without parental sacrifice and the generation intervallasts4-5 months. Furthermore, zebrafish and humans share 70% of the genes. A high throughput screening (HTS) assay for assessing developmental neurotoxicity (DNT) in zebrafish is available. The aim of this study was to assess the most relevant adverse outcomes from external exposure to gamma radiation during two subsequent generations and to establish a gametogenesis, and a gametogenesis and embryogenesis gamma irradiated line of zebrafish.

Two groups of 32male and 32 female adult zebrafish (F0) were exposed to 60Co gamma radiation at nominal1 dose rates of 10 mGy/hand 40 mGy/h for a period of 27 days. Crossing exposed males and exposed females produced significantly lower numbers of embryoscompared to non-exposed controls.F1 embryos from F0 irradiated at nominal 10mGy/h and40 mGy/h showed 20% and 100% mortality, respectively. The mortality at nominal 40 mGy/h occurred during the gastrulation stage corresponding to 8 hours post fertilization (hpf). Demographic scoring in F1conducted at 28, 48, 54, 60 and72 hpf showed that the exposed groups hatched earlier than the non-exposed controls (48-72 hpf). Significantly higher numbers of deformities were also found in exposed embryos compared to controls. Behavioral changes were observed using the Zebrabox and validated with Viewpoint software (View Point Life Sciences Inc, Lyon, France).Global gene expression and epigenetic changes analyses such as histone methylation/acetylation and DNA methylation in the offspring will be finished within June.

[1] Actual measured ranges for the absorbed dose rate to water from the deepest to the most shallow areas accessible to zebrafish were[4.5 - 8.9 mGy/h]and [35 - 69 mGy/h].

EVALUATION OF EFFICACY GAMMA IRRADIATION ON INACTIVATION OF *SALMONELLA SPP.* INOCULATED ON BLACK PEPPER AND SESAME

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Vegetable food is an important vehicle for bacterial, viral and protozoal infections and in particular spices may represent a risk to public health. During the last decade of the 20th century, food-borne infections and intoxications due to spices have increased in several European countries. The main cause is the increased consumption of ready-to-eat foods (RTE) and the increased use of spices in these foods both at the industrial and domestic level. The use of ionizing radiation on food has been widely accepted and is now legally recognized in many countries as a safe and effective method for improving food safety at a maximum dose of 10 kGy.

The aim of this work has been to test the effect of gamma irradiation treatment on destroying Salmonella spp. on Black Pepper and Sesame frequently used on RTE food. Black pepper and sesame were previously irradiated at 25 kGy to remove the background microflora and than inoculated with Salmonella Montevideo; the samples inoculated were irradiated at 1, 3 and 5 kGy and the log number of surviving Colony Forming Units (CFU) per gram in irradiated samples (log cfu/g) was determined. The contamination by Salmonella spp. gradually decreases with an increasing radiation dose; 3 kGy is sufficient to determine a reduction of 3-4 log cfu/g, whereas 5 kGy a reduction of 6 log cfu/g ; the values obtained in sesame were lower respect to black pepper.

The obtained results suggest that irradiation treatment can improve the microbial quality of spices and reduce the risk of food-borne infections and intoxications due to Salmonella spp.

THE EFFECT OF GAMMA-RAY IRRADIATION ON SHIGA TOXIN-PRODUCING *ESCHERICHIA COLI* IN GROUND MEAT

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In recent years, Shiga Toxin-producing *Escherichia coli* (STEC) have rapidly emerged as one of the major threat to food safety. The main symptom of STEC infections is hemorrhagic colitis, but also hemolytic uremic syndrome and other potentially lethal complications may arise. According to ECDC, an increasing trend in the number of illness cases has been reported in the European Union, with approximately 4000 cases confirmed in 2010. In particular, beef and other meat products are the most commonly reported vehicles in outbreaks, as cattle is the primary reservoir of these pathogens. Despite all the intervention strategies employed, beef processing industry is still unable to avoid contamination. In this context irradiation could represent an innovative solution, eliminating food pathogens and extending the shelf-life of the products. This study's major objectives were: to evaluate the survival of *Escherichia coli* O157 (one of the most virulent serotype among STEC) in inoculated ground meat, and to assess any difference in radiation resistance among a non-pathogen *E. coli* strain (ATCC 25922) and *E. coli* O157 (ATCC 35150). Ground beef was hence inoculated with ca. 4.0 log cfu/g, and afterwards subjected to irradiation at 0.15, 0.25, 0.35 and 0.5 kGy. Results shows that irradiation has significantly reduced the microbial populations, both E. coli, and E. coli O157, causing a decrease proportional to the increasing treatment dose. In particular, a dose of 0.25 kGy reduced the initial contaminations by about 1.7 and 1.8 log cfu/g respectively, therefore nearly halving the count of microorganisms. The dose of 0.50 kGy instead proved to be sufficient to entirely remove the contaminations, with both the counts being under detectable values. Furthermore the two investigated strains showed no significant difference in radiation resistance in all the examined radiation treatments.

Irradiation therefore shows great potential in controlling STEC contaminations in beef carcasses. Since STEC are usually present at low levels, the radiation dose necessary to eliminate these pathogens would be under 1 kGy, thus preventing the formation of compounds that may alter the organoleptic quality.

RADIOCHEMISTRY

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RECENT ADVANCES IN THE PROPERTIES AND APPLICATIONS OF URANYL PEROXIDE CAGE CLUSTERS

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This presentation will be presented 10 years after our initial discovery of the first nanoscale uranyl peroxide cage cluster. Such clusters self-assemble in aqueous solution at room temperature spontaneously, and can be crystallized for structure characterization. To date, we have isolated 109 different types of cage clusters that contain as many as 124 uranyl ions, that include peroxide bridges, and that include a variety of other bridges such as hydroxyl, oxalate, phosphate, pyrophosphate, nitrate, phosphite, and transition metal polyhedra. We study the properties of these cage clusters in solution using small-angle X-ray scattering, dynamic and static light scattering, electrospray ionization mass spectrometry, etc. This presentation will evaluate the range of structures found, focusing on those that have not been reported in the literature, and the properties of these clusters in aqueous solution. I will emphasize formation of blackberry aggregates and their geometric parameters, as well as the optimization of conditions for usage of uranyl cage clusters in uranium purification and fuel reprocessing.

DETERMINATION OF ^{3}H AND ^{14}C IN GAS-AEROSOL DISCHARGES AND SURFACE AIR NEAR THE VICINITY OF KOZLODUY NUCLEAR POWER PLANT (BULGARIA)

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Methods for accurate assessment of ^{3}H and ^{14}C content in gaseous releases from ventilation stacks of Kozloduy Nuclear Power Plant (Bulgaria) were developed. Technique for correction of incomplete desorption of tritium from exposed silica gel was proposed. The distribution and the concentrations of both nuclides in various chemical forms were constantly monitored for a period of 1 year. The results for annual normalized gaseous discharges were assessed for the fifth unit at 173 GBq/(GW.a) for ^{3}H and 369 GBq/(GW.a) for ^{14}C, while for the sixth unit-^{3}H-98 GBq/(GW.a) and ^{14}C-289 GBq/(GW.a).

CHEMICAL STATE OF ^{210}PO IN LICHEN CETRARIA ISLANDICA

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Lichens have a capacity for concentrating higher levels of heavy metals and radionuclides (natural and artificial). Some lichens accumulate very high amounts of ^{210}Po - more than 700 Bq/kg d. w. [1]. However, it is still not clear the absorption mechanism of Po-210, localization of nuclide in the lichens thallus and association of Po-210 with lichen substances. In this paper we attempt to estimate the part of ^{210}Po cationic form in the thallus of Cetraria Islandica lichen and to reveal the relationship between the Po-210 and lichen polysaccharides.

Thallus of lichen was purchased in the pharmacy network. Before testing the samples were dried at 60°C to a constant weight and then homogenized.

The forms of ^{210}Po removed from the lichen thallus by selective extraction. It was used 3 different extraction methods. The first allows to select the lihenin with hot water. The second involves the selection of four different polysaccharide fractions, including water soluble polysaccharides, pectin and acid and neutral hemicelluloses. The third allows to extract adsorbed cations with Na2EDTA (20 mM) solution. Before extraction lichens samples were treated with distilled water at room temperature to remove dust particles.

The content of ^{210}Po in lichen and extracts was determined by alpha-spectroscopy method. The specific activity of polonium in the original sample was 190 Bq/kg d. w. In aqueous fractions were passed not more than 4% of ^{210}Po. The amount of ^{210}Po in fraction of lichenin was 7%. The fractions of water soluble polysaccharides and pectin contain 8.5% and 5% of polonium-210, respectively. The quantity of Po-210 in the fractions of hemicelluloses was less than 1 percent. The Na2EDTA solution extracts up to 25% of Po-210 for three times of the sample processing. The main amount of polonium remained in the insoluble residue.

According to these data, we can conclude that thallus of Cetraria Islandica lichen accumulates Po-210 as dust particles and as cations. The presence of ^{210}Po in fractions of polysaccharides may be due to mechanical capture of nuclide and requires further investigations.

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STABILIZATION OF PLUTONIUM(IV) + NEPTUNIUM(IV) AND PLUTONIUM(IV) + NEPTUNIUM(V) FOR THE SIMPLIFIED PLUTONIUM PURIFICATION CYCLE OF THE PUREX-PROCESS

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The RT-1 plant of FSUE PA «Mayak» facility provides reprocessing of VVER-440 spent nuclear fuel. The reprocessing is carried out with the use of the PUREX process. The process flowsheet includes the first (HA) cycle for extraction of U, Pu, Np from the SNF feed solution, the separate uranium purification cycle, and the Pu purification unit, which includes two extraction cycles, one for purification of Pu, and one for purification of Np. The solutions of Pu and Np, stripped of unwanted components and uranium FP's, are the product of the unit's operation.

Two new extraction flowsheets (omitting the specialized Np cycle) are being developed in order to reduce the volume of liquid waste, generated by Pu purification unit, and to simplify the layout of the plant. The new flowsheets are designed to provide the joint Np, Pu stripping to a single purified Pu flow (this demands the stabilization of Pu and Np in extractible tetravalent form), or the removal of Np to the raffinate flow (this demands stabilization of the non-extractible pentavalent Np). The feed nitric acid solution for the unit is produced by the Pu stripping operation on the first (HA) extraction cycle, and contains not only the valuable components, but some extractible FP's, oxidizing, reducing and chelating agents. Such composition promotes very complex catalyzed oxidation-reduction interactions, leading to the dynamic change of Pu and Np valence state.

This work is aimed on finding the conditions for stabilizing Pu and Np in desired valence state in these solutions. The influence of acidity, temperature, treated solutions holding time and other technology parameters on the Pu, Np valence were studied. The composition and order of introduction of proper oxidizing and reducing agents, needed to promote the desired element valence, was determined. The study of element valence form quantities were carried out with the use of UV-VIS spectrometry.

The results of the research allowed to provide the conditions for stabilizing of ~ 85% Pu(IV), 80% Np(IV) in feed solution, which is significant enough for joint extraction and stripping, and conditions for stabilizing of 85% Pu(IV) and ~74% Np(V) in feed solution, which enables Np removal to the raffinate. The final stabilization of Pu and Np in desired valence state takes place during the extraction process. The preparation of feed solutions for reprocessing is carried out with the salt free chemical agents, simplifying the further treatment of liquid radioactive waste of Pu purification unit.

DEVELOPMENT OF THE CHALMERS GROUPED ACTINIDE EXTRACTION PROCESS

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Currently, the primary research focus at Chalmers University of Technology within the field of partition and transmutation is in developing a Grouped ActiNide Extraction (GANEX) separation process. The basic concept of partition and transmutation is to separate the transuranic elements from the fission products in used nuclear fuel and then transmute them using a fast neutron spectrum. The principle of the GANEX process uses two cycles; the first to remove the uranium bulk is removed from the fuel dissolution liquor and the second (where GANEX extraction actually occurs) to extract the transuranic elements and remaining uranium together as a group thereby avoiding pure plutonium streams. The GANEX process previously developed at Chalmers combines the two extractants 6,6'-bis(5,6-dialkyl-[1,2,4-]triazin-3-yl)-2,2'-bipyridine (CyMe4-BTBP) and tri-butyl phosphate (TBP) in cyclohexanone. However, cyclohexanone has a low flash point (44 °C compared to kerosene (37-65 °C), for example) and it is somewhat soluble in the acidic aqueous phase. An attempt has therefore been made to replace cyclohexanone with phenyl trifluoromethyl sulfone (FS-13). FS-13 was developed for use in the UNiversal EXtraxtion (UNEX, extracts elements through ion-exchange) process as an alternative to highly polar nitrobenzene. FS-13 was considered as an alternative to cyclohexanone in the GANEX process, due to its stability for irradiation and acid, and its higher flash point (122 °C).

RADIONUCLIDES DISTRIBUTION AMONG ZOO-, PHYTO- PLANKTON AND BENTHOS IN ARTIFICIAL RESERVOIRS

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Reservoirs R-17 of MAYAK Production Association, Chelyabinsk region, Russia is used as intermediate level liquid radioactive wastes (ILLW) and reservoir R-4 is used as low level liquid radioactive wastes (LLLW). The water surface area of the R-17 is 0.13 km2. The reservoir R-4 is larger, and the water surface area is about 1.3 km2.

The aim of this study is to determine radionuclide distribution among zoo-, fito- plankton and benthos in reservoirs R-4 and R-17. As a result of field research 2013 at the reservoirs, the numbers of hydrobionts were collected: benthos (Chironomids (Chironomidae), Corixa (Hemiptera)), zoo- and phytoplankton. Plankton was divided by filtration system – filters with 100 μm were used for zooplankton and 0.45 μM for phytoplankton. All samples were analyzed by gamma spectrometry using HPGe detector Canberra GR 3818.

The ^{137}Cs radioactivity varies from 2,4 KBq/g to 149 KBq/g, ^{154}Eu (was found only in reservoir 17) — 249 Bq/g,^{241}Am — from 0,5 to 12 KBq/g. For phytoplankton (only for reservoir 4): ^{137}Cs radioactivity is 41 Bq/g, ^{241}Am —0,5 Bq/g. For zooplankton: ^{137}Cs varies from 22 Bq/g to 376 Bq/g, ^{154}Eu (was found only in reservoir 17) — 0,7 Bq/g, ^{241}Am — from 0,1 to 6,7 KBq/g. The Concentration Factors (CF = Bq/g bentos / Bq/g zooplankton) increased from 108 for ^{137}Cs in V-4 to 1930 for ^{241}Am in V-17. The Concentration Factors (CF = Bq/g zooplankton / Bq/g phitoplankton) is around 0,5 for all radionuclides from the both reservoirs.

To determine the radionuclide microdistribution in hydrobionts, the samples were analyzed by radiography using Imaging Plate (Cyclone Plus Storage Phosphor System, PerkinElmer) along with SEM-EDX technique. Integrated approach for the samples and standards (digital radiography) along with Alpha Track radiography and γ-spectroscopy of the preparation was used to estimate the contribution of the main nuclides in specific parts of samples. The data shows uneven distribution of radionuclides on the benthos bodies also showing many radioactive particles that stick to the hydrobionts surface.

THE STUDY OF KINETICS IN THE INTERACTION OF CARBOHYDRAZIDE WITH TC(VII) IONS IN PERCHLORIC ACID SOLUTION

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According to the references [1], carbohydrazide is an advanced chemical reducing agent for plutonium re-extraction used in spent nuclear fuel reprocessing. In this respect, it is necessary to study the interaction of this reducing agent with the other components of the of the solution for the Pu(IV) reduction re-extraction. The report [3] states that technetium (VII) interacts with carbohydrazide, and this interaction should be studied carefully to elaborate a feasible forecast of the behavior of technetium in the re-extraction system.

The spectrophotometry method has allowed to study the reduction rate of Tc(VII) ions interacting with carbohydrazide in the perchloric acid solution depending on the concentration of the system components and temperature.

All experiment data show that the reduction of Tc(VII) to Tc(IV) is a step process carried through formation of the intermediate valence state of technetium - Tc(V):

$Tc(VII) + CO(N_2H3)_2$ ®Tc(V) + reaction products (1)
$Tc(V) + CO(N_2H3)_2$ ®Tc(IV) + reaction products (2)

All experiment data prove that the Tc(VII) concentration reduction rate has a linear characteristic and can be determined by the first-order Tc rate equation. We have determined that as the concentration of perchloric acid and carbohydrazide increases, the reaction (1) rate constant rises proportionally. The measured rate constant values have been used for calculation of the orders of reaction in relation to the reducing agent and perchloric acid. The experiments show that the order of reaction (1) for perchloric acid within concentration limits of 1 to 3 mole per litre is 1 at 50 °C; as for the reducing agent, this value is 0.76 within the concentration limits of 0.1 to 0.3 mole per litre.

When studying the reaction (2) rate/solution components concentration correlation, we have determined the orders of reaction for each component: carbohydrazide - minus 1.48, perchloric acid - 2.65.

Range for studying the temperature effect: 20 to 50 °C. The relationship between the rate constant and temperature is regulated by the Arrhenius equation. The resulted values of energy of activation: for equation (1) - (62 ± 9) kJ/mole; for equation (2) - (83 ± 3) kJ/mole.

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RELEASE OF RADIONUCLIDES AND HEAVY METALS FROM URANIUM MINE WASTE AT A FORMER URANIUM MINE IN ENO, EASTERN FINLAND

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The Paukkajanvaara mining site in Eno started operation in 1959. The mine was a test site for assessing the feasibility of larger scale uranium extraction. The ore was milled and enriched on site but mining proved to be uneconomic, and so operations ceased in 1961. In the late 1970's the entrance of the mining shaft was sealed with a concrete slab and the area including tailings, waste-water ponds etc., was abandoned. The site was left untouched for nearly 30 years until Finnish Radiation and Nuclear Safety Authority initiated a review. Their results indicated that ambient radiation levels at the site had increased by 0.5 μSv/h as a direct result of the earlier mining operations. Rehabilitation was completed by 1994 after which the area was released for outdoor use without restrictions.

The aim of this study was to examine the potential for mobilisation of radionuclides and heavy metals from the mill tailings and the waste rock pile. The results indicate, that the presence of pyrite in the waste rock has led to the formation of acid mine drainage development and subsequent mobilization of iron, manganese, cobalt, copper, zinc, lead, radium and uranium from the waste rock pile. In the run-off sediment, the released metals are most probably co-precipitated with Fe and Mn oxy-hydroxides. When the stream floods in the spring time, a part of these metals are released back to the solution and emanate further in the stream. An increase in the metal concentration can be seen, when the stream has passed the mill tailings area. However, the results are not clear, whether the leaching of radionuclides and heavy metals originates also from the mill tailings repository or mainly from the waste rock pile. In the mill tailings samples, the isotopic ratios suggest the emanation of ^{226}Ra and ^{222}Rn. The vertical migration of Cr, Co, Zn, Cu, Pb, Mn, Fe, ^{226}Ra, U, Th was also detected.

The concentrations of Co, Zn, U, Pb, Cr, Fe, Mn in water sample at 14 m of depth at the Iso Hiislampi pond are elevated compared to the surface concentrations. Furthermore, at the surface sediment layers the concentrations Co, Zn, U, Cr, Fe, Mn, Pb (also ^{210}Pb) and ^{226}Ra are elevated. This indicates the adsorption of these elements to organic material in the pond water and finally their sedimentation at the bottom of the pond. Furthermore, the isotopic ratios of ^{226}Ra/^{238}U in the pond sediment samples suggest the vertical mobilization of uranium to the lower layers of the sediment.

CHEMISTRY OF RuO_4 IN THE CONTAINMENT OF NUCLEAR POWER PLANT

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During a severe nuclear accident several radiotoxic gaseous fission products will be released from the fuel. First noble gasses (^{135}Xe, ^{85}Kr) and volatile fission products (^{131}I, ^{137}Cs) will be released. Later semi volatile elements can be released from the fuel depending on oxidizing conditions. Among the semi-volatile fission products ruthenium is one of the main concerns. This is due to it's radio-toxicity (^{103}Ru, ^{106}Ru) and chemical properties of its volatile oxides. In the conditions expected during severe nuclear accident in the containment, the most relevant ruthenium gaseous specie is considered to be ruthenium tetroxide. Ruthenium tetroxide has a high affinity towards all the available surface materials leading to creation of ruthenium-rich deposits on the surfaces. This work was focused on affinity of ruthenium towards different surfaces in the containment and chemical identification of the created deposits. Additionally examination of gamma radiation effect on possible re-vaporization of these deposits was performed.

ADSORPTION OF SUPERHEAVY ELEMENT 113 SINGLE ATOMS ON GOLD AND QUARTZ SURFACES: A RELATIVISTIC DENSITY FUNCTIONAL STUDY

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Long-lived isotopes of superheavy elements (SHE) beyond Rf, i.e., with atomic number Z ≥ 104 can be produced via fusion reactions between heavy actinide targets and neutron-rich projectiles at a rate of only single atoms per minute (Z = 104) or per week (Z = 114). After successful chemical identification of copernicium (element 112) and flerovium (element 114) by the thermochromatography on gold technique, investigation of element 113 (E113) properties is of top interest. First experimental results on E113 chemistry were recently obtained in FLNR JINR (Dubna) [1]. Adsorption energy of E113 single atoms on gold surface were estimated using the cluster model. Its reliability was improved by monitoring charge distributions in the vicinity of the adsorption site and taking into account the effects of relaxation of the cluster compatible with its embedding into the crystal. The resulting adsorption energy estimates lie within the range 106 ±10 kJ/mol [2]. Calculations were performed within the two-component shape-consistent small-core pseudopotential model [3] and employed the non-collinear version of relativistic density functional theory (RDFT) to treat electronic correlations [4].

To evaluate the probability of E113OH molecules formation in the experiment described above, we performed a comparative study of E113OH and TlOH properties. We employed the combined approach involving scalar relativistic coupled cluster (CCSD(T)) calculations with the extapolation to the complete-basis-set limit and the evaluation of spin-dependent effects and zero-point energies at the RDFT level. The energetics of the simplest reactions M + H_2O → MOH + H (M = E113, Tl) was estimated. Both reactions are energetically unfavorable: ΔH_0 =128 kJ/mol for M = Tl and 267 kJ/mol for M = E113. The equilibrium distance E113–O in E113OH is 2.28 , the corresponding value for Tl is 2.15 . The complexes of E113 and Tl atoms with H_2O singe molecules (M–H_2O) are also weakly bounded and unstable.

We also present theoretical results on adsorption energies and equilibrium distances of the element 113 and Tl single atoms on SiO_2 (001) surface.

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SPIRAL FILTERING ELEMENT AS THE BASIS OF THE FILTRATION INSTALLATIONS FOR REMOVAL OF THE SOLID RADIOACTIVE IMPURITIES FROM GAS AND LIQUID PHASES

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The radiation resistance of the filter materials has great importance for removal of the solid radioactive impurities from gas and liquid phases. One of such materials, widely used in radiochemical industry, is cermet filter elements. But, this filtering material after carrying out of some cycles «filtration - regeneration » is irreversible stopped up by the solid phase and should be taken from devices and replaced, that leads to the formation of additional amounts of high level radioactive solid wastes. To overcome this problem with retention of high radiation resistance we developed the new spiral filtering element with variable surface for fine decontamination of gases and liquids from solid radioactive impurities. This spiral filtering element consists of a filtering partition, a cover, the union, a skeleton and spring. The filtering surface is produced from the corrosion-proof wire with a diameter from 0.6 up to 0.8 mm and represents a screw cylindrical spiral between of its coils with the special image carried out the filtering backlashes: their size can be from 3 up to 300 micron; diameter of a filtering partition - 16 mm; its length - up to 370 mm. From one end the filtering partition closes by cover, and another end has the union with external groove M16x1.5. The coaxisility of coils is provided with a skeleton. Sixty spiral filters make 1 m2 of a filtering surface. Dimensional diameter and length of spiral filter make according to 25 mm and 415 mm. Spiral filter are established vertically by unions upwards or downwards.

The spiral filtering elements provide for a complete reduction of the filtering properties of the units after each cycle "filtration-regeneration", which is currently not feasible in filters of other types (metal ceramics, fabrics, cardboard etc.). Main advantages of new spiral filtering element are high reclaiming qualities in comparison with standard filtering.

A COMPARATIVE STUDY OF THE SORPTION OF URANIUM(VI) ON RAW AND MODIFIED DIATOMITE SAMPLES FROM KAZAKHSTAN

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Uranium is one of the most hazardous heavy metals due to its high toxicity as well as its radioactivity and, U(VI), one chemical homolog of long-lived lanthanides and actinides in subsurface environments, has attracted intense interest in multidisciplinary study [Chen et al., 2013; Sprynskyy et al., 2010]. In nuclear fuel cycle processes, such as extraction, conversion, enrichment, fabrication and reprocessing, it is inevitable that radioactive U(VI) ions are dispersed into the natural environment. The free radioactive U(VI) ions can directly damage biological organization or produce reactive species that can subsequently react with bio-molecular when human inhales them into body [Sun et al., 2012]. For example, cancers, including lung cancer, bone cancer, female breast cancer, skin cancer and thyroid cancer, are observed in humans after exposure to radioactive contamination or ionizing radiation. For the sake of public health and environmental pollution, it is necessary to eliminate U(VI) ions from contaminated groundwater and aqueous solutions.

Numerous adsorbents have been tested for their potential application to remove hazardous metal ions from wastewater. Among them, natural and modified diatomite is a promising adsorbent for the removal of hazardous metal ions in high efficiency and low cost because of its unique combination of physical and chemical properties. As a low-cost and readily available mineral diatomite is a fossil assemblage of diatom shells and its characteristic of macro/mesoporous structure has excellent thermal and mechanical stabilities (Yuan et al., 2010).

In this work, we investigated and compared the sorption properties of U(VI) on raw and modified diatomite using hydrochloric acid solution, under various solution chemistry conditions such as U(VI) initial concentration, pH of solution, contact time and temperature. The raw diatomite samples were collected from Mugadjar deposit in Aktubinsk, Kazakhstan. The characteristics of the diatomite samples were tested by several methods such as SEM, XRD, FTIR and TGA/DTA. Various sorption isotherm models like, Langmuir, Freundlich and Dubinin-Radushkevich have been carried out for the adsorbents. Thermodynamic parameters, such as Gibb's free energy, entropy and enthalpy of sorption process, have been calculated. Furthermore, the Lagergren first-order and pseudo-second-order models were used to describe the kinetic data. The all experimental results of this study propose that natural, cheap and effective adsorbent diatomite (raw and modified) can be successfully used for U(VI) removal from geological, mining or radioactive wastes.

FLOW-THROUGH BIOREACTOR WITH BACTERIA FROM EXTREME HABITATS FOR LLRW DENITRATION IN FSUE "RADON"

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Liquid radioactive wastes are multicomponent systems consisting of various macro-components like nitrate solutions (with the concentration of nitrate ions up to 300 g/L), sulfate ions, extractants, solvents, detergents and as well of microcomponents - uranium series radionuclides, fission products (cesium, strontium, technetium, ruthenium, etc.), tritium and corrosion products. The special problem in the implementation of the core technologies of conditioning and long-term storage of radioactive waste is the presence of huge amounts of nitrate.

The aim of this work is the use of haloalkaliphilic denitrifying bacteria at the stage of waste denitration prior to cementation. Biological denitrification is tied to respiration process where nitrate ions are reduced to nitrogen through a series of intermediates.

Here we used the microorganisms separated from extreme habitats: ecosystems contaminated with radioactive waste (Radwaste repository "Severniy") and alkaline lakes of Kulunda steppe, with a total salt content of up to 300 g / l and pH 9 -11.

We used radwastes models, based on the data of FSUE "RADON" analytical laboratory. The concentration of nitrates varied from 4 to 100 g/l, sulfates up to 2 g/l, bicarbonate HCO_3^- up to 10 g/l with pH 9-10. Laboratory designed biofilters with different types of cultivation (in static and flow-through conditions) were used. Source of carbon and electron donors for cell respiration was sucrose in 1:1 proportion to nitrate ions. We analyzed the solutions on supply and outlet of flow-through biofilter points for nitrate, nitrite and COD parameters in a 1 per 10 min discrete mode.

After cultivation under the static conditions (batch mode) we have detected that the concentration of nitrate ions decreased by factor 2 to 5. During the cultivation in the flow-through biofilter system the rate and degree of nitrate consumption has been significantly increased by formation of a surface biofilm on an inert carrier providing higher specific surface.

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LABORATORY UNIT FOR ORGANIC RADIOACTIVE WASTES BIODEGRADATION TESTS

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Series of methods have been currently developed and successfully used for the removal of different hydrophobic organic wastes contaminating the environment. Some methods include wastes' oxidation to carbon dioxide. Such oxidation process may occur in two ways - due to exposure to high temperatures in air or to enzyme systems of microorganisms under aerobic conditions in bioreactors. The purpose of this work is development and testing laboratory facility for bio-oxidation of organic radioactive waste (waste vacuum and transformer oils, liquid scintillation cocktails, extractants and solvents). The unit has a 50 L cylindrical flask equipped with a hydrothermostatic shell, drain tap and a hole for air supply. Air is supplied by an air pump through a hose. Magnetic stirrer provides with effective additional stirring if needed.

The biological oxidation of the organic components is carried by bacteria under the following conditions: temperature 27,10C, pH 7.0, organic components contents - up to 10%, aeration rate - 4.1 ml / s. The process completes within about 7 days.

Consumption data for soluble organic waste components (acetates, oxalates, EDTA, vacuum oils, TBP and used scintillation cocktails including contaminated ones) are derived. When the unit is used in a batch mode, the soluble organic constituents successfully biodegrade during 4-5 days at the inlet concentration, total 4 g / l (5000 mg O2 / l). Hydrophobic active ingredients were also consumed by bacteria within 7 days to some stationary level. During this time, the microorganisms consumes up to 10.7 g per 100 ml of water of pure organic component (20 to 75% of the organic phase, depending on the ratio of the aqueous-organic mixture).

Waste pump oil VM-4 was subjected to biodegradation in a semi-continuous mode. In this case, once per 7 days during a month, 70-80% of aqueous phase with microorganisms was poured off from reactor; then a fresh sterile medium was added. So the microorganisms continued to evolve in the reactor, using the rest of the oil as carbon source. Such mode significantly increased the oil consumption due to the continually growing cells. The analogous tests were carried with scintillation cocktail waste contaminated with radionuclides. It has demonstrated effective consumption of the organic phase despite its medium level radioactivity (up to 106 Bq/l). Furthermore, the microbial biomass displayed sorption activity towards transuranium metals having provided additional purification/decontamination of aqueous phase.

DECONTAMINATION OF RADIOACTIVE CONCRETE

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A great amount of uranium-contaminated (U-contaminated) concrete waste has been generated from the uranium conversion plant at KAERI. Thus its volume reduction is required for a reduction of the disposal. A practical decontamination process for U-contaminated concrete has been developed in this study. U-contaminated concrete pieces have to be decontaminated to below 1.0 Bq/g for the self-disposal of natural uranium.

The concrete waste is divided into three groups: one is a mortar block with epoxy generated from the floor surface of a laboratory and its radioactivity is high, another is a concrete block from the floor except the surface, having a lower radioactivity, and the other is a brick from the wall of a laboratory.

The color of the wall brick surface contaminated with high concentration of uranium was changed to yellow or brown. The colored surface was removed by a chisel in a glove box, and the radioactivity of the brick was then measured. The removal and measurement works were iterated until the radioactivity of the remaining block reached less than 1 Bq/g.

The mortar blocks coated with epoxy are directly burned for 15 minutes to remove the epoxy and binder. After burning, the removal of the surface and the measurement of the radioactivity were performed using the same decontamination method as for the bricks. Concrete blocks without epoxy are crushed to less than 30 mm in size, and the concrete pieces then are sifted with a 1 mm pore-sized sieve. Concrete pieces larger than 1 mm are consecutively washed using a ball mill in the order of clear recycle solution (around pH 1.0) and 1.0 M of fresh nitric acid. When the washed concrete pieces are washed with a small amount of tap water, the radioactivity of the concrete particles above 1 mm in size generally reached below 1.0 Bq/g. Concrete powder smaller than 1 mm and the murky solutions produced from the ball mill are put together into a rotary washing machine. The powder is washed in pH 0.5-1.0 nitric acid solution for 6 hours. After removal of the supernatant, the remaining solution was centrifuged. The radioactivity of the dried solid was measured. If it was higher than 1 Bq/g, we used electrokinetic equipment for the further continuous washing. Concrete powder reached 1 Bq/g within 10 days by the electokinetic equipment.

The supernatant produced from the washing process was adjusted to near pH 9 by adding CaO in order to precipitate the uranium. The precipitate was filtered using a filter pressure with a 25 μm pore size, and will be disposed of at a radioactive waste repository. In order to recycle this filtrate, sulfuric acid was added into filtrate to form a $CaSO_4$ precipitate.

LEVELS OF ^{210}Po AND ^{210}Pb ACTIVITY IN URINE SAMPLES OF INHABITANTS OF GDAŃSK (NORTHERN POLAND)

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The urine samples were collected from volunteers from Gdańsk, Gdynia and Sopot agglomeration. The ^{210}Pb and^{210}Po activity levels in the urine samples were next examined to determine whether and how they are related to cigarette smoking, age, diet and sex. The obtained results indicated that ^{210}Po and ^{210}Pb concentrations were variable within each group of volunteers. The study shows that the amount of ^{210}Po and ^{210}Pb are incorporated into the human body and slightly dependent upon the life mode including diet habits, smoking habits, sex, and age. The activities of ^{210}Po and ^{210}Pb in urine are widely disparate, slightly higher activity values are listed among females than males and were 4.13±0.44 mBq d^{-1} and 6.17±0.86 mBq d^{-1} for ^{210}Po and 3.35±0.42 mBq d^{-1} and 4.93±0.57 mBq d^{-1} for ^{210}Pb. The higher values of ^{210}Po and ^{210}Pb activities were observed in the age group of 24 to 45 years (4.37±0.49 mBq d^{-1} and 6.70±0.95 mBq d^{-1} respectively) than in the other analyzed classes. Relatively small differences were observed among people with different dietary habits: the smaller activity was observed for people, who eat less than once fish per week, the higher among people who eat once or more fish per week (3.72±0.33 mBq d^{-1} and 3.95±0.75 mBq d^{-1} for ^{210}Po; 5.56±0.44 mBq d^{-1} and 5.87±1.59 mBq d^{-1} for ^{210}Pb). Higher values of the ^{210}Po and ^{210}Pb activity were found in the group of vegetarians (the class of people who exclude flesh of any other animal from diet) (4.52±0.72 mBq d^{-1} and 7.43±1.70 mBq d^{-1}respectively) than for meat consumers group (3.47±0.31 mBq d^{-1} and 5.00±0.39 mBq d^{-1} respectively).

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NEW CONCEPT OF ATOMS IN COMPOUNDS: EFFECTIVE ATOMIC STATES OF TRANSURANIUM ELEMENTS IN HIGHER OXIDES

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The translation of the results of first principle based electronic structure calculations on molecules or solids containing transuranium elements into chemical terms (oxidation states, effective configurations of atoms or ions) can greatly facilitate the analysis of physical and chemical properties of complex systems by invoking chemical expertise and intuition. The new definition of effective states of heavy atoms in compounds (AiC) recently proposed in Ref.[1] seems to be particularly well suited for this purpose. Based on the analysis of the behaviour of one-electron density matrices (DM) of a molecule in the vicinity of a heavy nucleus, it is by construction compatible with popular techniques used to determine effective atomic states from experimentally measured chemical shifts in X-ray, Moessbauer, or nuclear quadrupole resonance spectra, hyperfine structure etc). It is readily adapted for the use within the relativistic pseudopotential approximation which provides a robust base for accurate and reliable description of electronic structures of actinide compounds. Finally, it is equally applicable within wave function-based and density functional theories; in the latter case, the lack of wave functions and global density matrices does not block its use since in the vicinity of nuclei Kohn-Sham independent-particle DM should reasonably fit the true one due to the local domination of strong nuclear field over electron-electron correlations.

In the present work we apply the new approach to determine the effective states of transuranium (An) atoms / ions, An = Pu through Bk, in the molecules of An - oxygen compounds containing three or more oxygens per each actinide atom. The electronic structure calculations were performed within the shape-consistent small-core relativistic pseudopotential model using the two-component non-collinear DFT. The results are analyzed together with bond orders and oxidation states derived from equilibrium structures, force fields, Bader atomic charges and integrals of magnetisation densities over Bader atomic areas in a way similar to that described in Ref. [2]. Correlations between Bader charges and sums of effective atomic occupancies, the dependencies of effective configurations on oxidation states and actinide atomic number are discussed.

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FLOW-THROUGH BIOREACTOR FOR THE DECONTAMINATION OF LRW FROM URANYL AND PERTECHNETATE-IONS

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Liquid radioactive wastes (LRW) proper and effective reduction followed with its conversion to solid phases is a very important and problematic item in the radioactive waste management. Nowadays because of the large volumes of LRW one of the processing modes is LRW decontamination. Most of decontamination techniques are based on physical-chemistry processes (ion exchange, liquid extracting and so on). Microbial - metal interaction has been studied intensively as well and the mechanisms of metal and radionuclide interaction were thoroughly described. To date, considerable information on biotechnological methods for purification of solutions containing uranium, strontium, cesium and iodine (Macaskie, 1991) are accumulated and considered as cost and environmentally effective.

Ability to enzymatic reduction of hexavalent uranium has been found in a number of sulfate and iron-reducers. Some mesophilic bacteria could not only reduce, but also to obtain energy for growth (Geobacter, Shewanella, Desulfotomaculum) (Lovley, 1993; Pietzsch, Babel, 2003), while others were only able to reduce uranium (Desulfovibrio). Also, technetium red-ox reactions were detected in biological systems and have been shown to be responsible for Tc immobilization.

The aim of this study is to develop technique, based on biological processes for cleaning LRW solutions from uranyl and pertechnetate anions.

Previously, for purification (detoxification) of low-radioactive LRW the model laboratory system based on immobilized cells of sulfate-reducing bacteria was developed and tested. The system operated in flow providing complete removal of sodium pertechnetate (50 mM) at flow rate of 16 ml/h under neutral pH conditions. The use of immobilized cells of bacteria for biotechnological solutions has several advantages compared with the slurry. The cells attached to the carrier aren't washed out with passing through solution. It has a longer lifetime in the system and higher resistance to environmental stress (Lloyd J.R. et al, 1999).

In the presented investigation, we use the haloalkaliphilic and sulphate-reducing bacteria for reduction of technetium and uranium under alkaline and neutral conditions. The bacteria of genus Halomonas were tested and were able to reduce oxyanions under different conditions (Shapovalova A.A. et al, 2008). Our experiments show that in case of mixture of anions (nitrate, senate and vanadate), consecutive reduction occurs, nitrate being reduced firstly, than selenate was the following and, at last, vanadate is reduced in accordance with their oxidation potentials and the enzimatic availability.

The designed laboratory system is planned to be tested for simultaneous reduction of uranium and technetium at the "Radon".

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RADIATION CHEMISTRY OF THE EPR DOSIMETER LITHIUM FORMATE MONOHYDRATE

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Lithium formate monohydrate, HCOO- Li+ H2O (LiFo) has been successfully used as a sensitive radiation dosimeter monitored by Electron Paramagnetic Resonance (EPR) spectroscopy. The dosimetric sensitivity of LiFo is several times higher than that of the common EPR-dosimeter alanine and displays a linear dose-response relationship (0.2–1000 Gy) at 295 K. In addition to being more tissue-equivalent than alanine, these properties make LiFo more suitable for the low doses used in radiotherapy.1

The main radical formed after irradiation at 295 K, responsible for the dosimetric EPR signal, is the $CO_2^{\cdot-}$ radical. However, its stability depends on the storage environment of the dosimeters such as temperature, humidity and light exposure. For LiFo to become well established as a dosimeter it is also essential to understand its radiation chemistry. In general, ionizing radiation produces various primary radicals which transform into (more) stable species along multi-step pathways. These reactions are highly dependent on the thermal energy of the system. Of particular interest, therefore, are the chemical and electronic structures of the initially formed (shallowly trapped) radicals as well as the more deeply trapped end-products.

Single crystals of LiFo were X-irradiated and studied at temperatures between 6 and 295 K, using Electron Magnetic Resonance spectroscopic techniques. Quantum chemical calculations using periodic boundary conditions were made to characterize (structurally and electronically) the radicals identified at various irradiation temperatures, as well as species formed following thermal annealing the shallowly trapped species.

The radicals trapped after irradiation at 6 K are mainly the $CO_2^{\cdot-}$ radical and a one-electron reduction product $HCOOH^{\cdot-}$, which has become protonated on oxygen by proton transfer from neighboring water. Upon warming, this latter radical partly transforms into a different geometrical conformation in which the O-H bond is significantly bent out of the O-C-O plane. These three radicals are also the main radical species formed after irradiation at intermediate low temperatures (77 K). When warming the crystals to higher temperatures (up to 295 K) both reduction products decay, leaving mainly the $CO_2^{\cdot-}$ radical which seemed stable during the warming.

After irradiation at room temperature two (minority) radicals are stabilized in addition to the $CO_2^{\cdot-}$ radical. These were tentatively identified as the $CO^{\cdot-}$ radical and the dimerization product $-O_2C\times O\times\cdot CH\times O-$. When the crystals are stored at 295 K and at ambient environments, the $CO_2^{\cdot-}$ radical slowly decays and the EPR spectra (after months) become dominated by these minority radicals. Work is in progress by several research groups to establish measures promoting the stability of the $CO_2^{\cdot-}$ radical.

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RADIONUCLIDE EXTRACTION FROM AQUEOUS SOLUTIONS BY IONIC LIQUIDS

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Ionic liquids (ILs) are salts with a low melting point (below 100 °C) and they are composed of completely dissociated large ions. ILs have many advantages and they are of growing interest in the field of green chemistry. Some of the unique properties of the most widely studied ILs include the large liquid temperature range, high thermal stability, electrical conductivity, and tunable physical properties.1 Especially the extraction of uranium by using ILs is of enduring interest in the literature as it may also be relevant to spent fuel reprocessing.5,6

The presented work is part of a project dealing with purification processes for drinking water. The aim of our work was the extraction of Uranium, Pb-210 and Po-210 from aqueous solutions with an IL. Furthermore, a successful back-extraction of the radionuclides from the IL is desirable in order to be able to re-use the IL for several times. Investigations in our laboratory demonstrated that extraction of uranium from water is possible with [A336][TS],2,3 tricaprylmethylammonium thiosalicylate, as well as from maltol-based ILs, namely [A336][Mal] (tricaprylmethylammonium maltolate) and [C101][Mal] (tetradecyltrihexylphosphonium maltolate).4 The ILs under investigation now are [A336][HNBA] and [A336][Ant] (trioctylmethylammonium 2-hydroxy-5-nitrobenzoate and anthranilate, respectively), as well as [PR4][HNBA] and [PR4][Ant] (trihexyltetradecylphosphonium 2-hydroxy-5-nitrobenzoate and anthranilate, respectively).

Investigations were performed with artificial water samples: uranyl nitrate solution with known uranium concentration was added to about 10 mL of distilled water, then NaOH was added in order to set a specific pH-value. The resulting uranium content is 27.7 µg U nat. (or 683 mBq) in 10 ml corresponding to a uranium concentration of 2.8 mg/L. This solution is then mixed with the respective ILs. After centrifugation the phases were separated and the aqueous phase was analysed by liquid scintillation counting (LSC) to ensure that the uranium was removed. For Pb-210 and Po-210 the added activities to the aqueous phase was about 500 mBq. Afterwards 0.05M HNO 3 was used for back extraction of the radionuclides from the organic phase.

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INFLUENCE OF THE SEPARATION PARAMETERS APPLIED IN CHEMICAL IMPURITIES DETERMINATION

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2-fluoro-2-deoxy-D-glucose (FDG) and 2-chloro-2-deoxy-D-glucose (ClDG) are chemical impurities found in the 2-[18F]fluoro-2-deoxy-D-glucose products. Limits for the presence of ClDG and FDG have been set by the European Pharmacopoeia (Ph.Eur 8.0, 2014). It is necessary to determine accurate, reliable and efficient way the concentration level of the impurities because these impurities can have toxic effect (Hung,2002).

The objective of this work was to discriminate the best separation column of FDG and ClDG amongst different columns. Chromatographic settings such as composition and flow rate of the mobile phase and column temperature were the independent variables used in the optimization process. The original values recommended by the producer were the starting point of the parametric search, while the associated performance of the system was the bench-test..

Retention time (TR) and peak resolution (RS) were calculated in order to compare the separation performance, based on the type of the stationary phase.

The HPLC method with PAD detection for simultaneous measurement and quantification of FDG and ClDG was optimized and validated. The method was reproducible as the relative standard deviation of the peak area was less than 5%.

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FIRST PRINCIPLE BASED MODELING AND INTERPRETATION OF CHEMICAL EXPERIMENTS ON SUPERHEAVY ELEMENT IDENTIFICATION

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Our latest advances in studies of actinide and superheavy element (SHE) chemistry using the shape-consistent two-component small-core relativistic pseudopotential (RPP) method and two-component relativistic density functional theory (2c-RDFT) are summarized. The features of these elements due to large relativistic effects are emphasized. The RPP model leaving for explicit correlation treatment both valence and subvalence (outercore) electrons accounts for the finite nuclear size and incorporates relativistic effects (including the bulk of Breit interactions), providing a good basis for attaining optimal accuracy/cost ratio in the cases of large and strongly interfering relativistic and correlation effects intrinsic for the heavy-atom compounds. The RPP/2c-RDFT approach allows one to solve the outercore-valence many-electron problem with moderate computational expenses while using practically exhaustive basis sets optimized for the case of large differences between nl(j=l+1/2) and nl(j=l-1/2) one-electron states.

Because of the exceptional role of thermochromatography on gold in the experiments on the “chemical” identification of SHE with atomic numbers $Z \geq 112$, main attention was paid to the description of the SHE - gold interactions. Adsorption energies of SHE on gold surface were estimated using the cluster model. Its reliability was improved by monitoring the charge distributions in the vicinity of the adsorption site taking account of the effects of relaxation of the cluster compatible with its embedding into the crystal. In some cases the results differ significantly from those of previous theoretical studies.

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IMPORTANT PROGNOSTIC FACTORS FOR THE LONG-TERM SURVIVAL IN NON-SMALL CELL LUNG CANCER PATIENTS TREATED WITH COMBINATION OF CHEMOTHERAPY AND CONFORMAL RADIOTHERAPY

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According to the literature, performance status, stage-tumor dimension and nodal status, weight loss, were the most important prognostic factors for survival in patients with locally advanced non-small cell lung cancer. To evaluate the treatment results and prognostic variables in our patients, study of 85 patients was randomly assigned to one of the two treatment arms. In the sequential arm, 45 patients had previously received sequential chemotherapy with 4 cycles of and etoposide followed by conformal radiotherapy (RT). In the second concurrent group, 40 patients received concomitant chemotherapy of cisplatine and etoposide and conformal RT, followed by two cycles of consolidation chemotherapy of carboplatine and etoposide. We described all phases of the conformal three dimensional (3-D) RT.

From October 2005 to April 2008, 85 patients were enrolled. Eight patients were not eligible, seven had stage IV and one patient had pleural effusion. They were all initially considered to have stage IIIB disease. The median survival was 13 months for the patients in the sequential arm and 19 months for those in the concurrent treatment arm. The differences were statistically significant (log-rank test p=0.0039). The disease-free survival was 9 months in the sequential arm and 16 months in the concurrent treatment group. The differences were statistically significant (log-rank test p=0.0023).

We found that the following prognostic factors significantly influenced the survival in lung cancer patients treated with conservative method:

-age	$p<0.05$
- performance status	$p<0.001$
- weight loss	$p<0.001$
- tumor dimension	$p<0.05$
- nodal involvement	$p<0.05$

Conclusions: Given the higher toxicity in the concurrent-consolidation schedule, it should be reserved for patients younger than 70 years, having good performance status and minimal weight loss. Also we highly recommend precisely define the stage of disease and the prognostic factors in lung cancer patients for giving better treatment.

IN VITRO EVALUATION OF PROMISING NOVEL BRAIN AGENTS: BIOQUIN-HMPAO (BH) AND PLGA ENCAPSULATED BH (BH-PLGA) NANOCAPSULES

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Investigation of novel brain imaging agents assessing the blood-brain barrier (BBB) has attracted much interest due to the limited number of brain imaging agents. Scans using conventional imaging techniques and nuclear medicine brain imaging techniques are not specific yet. Previously, we sought to elucidate the diagnosis of Alzheimer's Disease (AD) by designing amyloid probes that could be used to measure amyloid plaques in brain noninvasively by single photon emission computed tomography (SPECT). For this purpose; previously novel radiolabeled agents, 99mTc-Bioquin-HMPAO (99mTc-BH) and poly(lactic-co-glycolic acid) (PLGA) encapsulated BH nanocapsules (BH-PLGA NCs) which overcome the impositions of BBB were synthesized and AD diagnosis potentials were investigated.

In current study, brain cancer imaging potential of ^{99m}Tc-BH and ^{99m}Tc-BH-PLGA NCs were investigated utilizing in vitro cell culture methods. With this aim, BH and BH-PLGA NCs were radiolabeled with ^{99m}Tc and quality control studies were performed utilizing solvent extaction (SE) and chromatographic [Thin Layer Radio Chromatograpy (TLRC) and High Performance Liquid Radio Chromatography (HPLRC)] methods. Stability and lipophilicity studies of radiolabeled agents (^{99m}Tc-BH and ^{99m}Tc-BH-PLGA NCs) were performed. Cyctotoxicity studies of HMPAO and BH compounds were carried out on different cancer cell lines (DAOY, U87-MG and A549). Furthermore; incorporation studies of radiolabeled agents were assessed on DAOY, U87-MG and A549 cells.

The radiolabeling yield and the radiochemical purity (RCP) of ^{99m}Tc-BH and ^{99m}Tc-BH-PLGA NCs were over 95 %. Stability of the complexes was appropriate for imaging period. Maximum incorporation ratios were obtained for ^{99m}Tc labeled BH-PLGA NCs. It's observed that there is a noteworthy potential of previously synthesized compounds on brain cancer cells.

TECHNETIUM SULFIDE FORMATION KINETICS AND SIZE SPECIATION FOR ENVIRONMENTAL MOBILITY CONTROL

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Sulfur is an element of high environmental importance, especially in view of behavior of a number of metals. Tc – S system is not an exclusion in this respect. The sulfur, its different compounds and their derivatives, present minerals and rocks, are being leached by dissolution or microbiological transformation into natural waters, which drastically affect the environmental transportation routes of Tc. For the better understanding of the Tc behavior in the different natural environments we need quantitative data for the composition and properties of Tc sulfide species that could be formed. The determination of the free Tc species concentration by separation of ionic Tc from colloid-bound Tc with 5 kD membrane gave evidence on the Tc_3S_{10+x} formation similar to that observed in [1, 2]. We carried out size separation in course of the reaction of Tc(VII) and its analogue Re(VII) with sulfide and followed it with size speciation of particles formed in the solution by SAXS at specialized small angle diffractometer SAXSess (Anton Paar (Austia), CuK (1.54 A), transmission analyses after collimation correction mode, sealed glass capillaries, registration with ImagingPlate). Based on log(I) = f(s2) plots, $s = 4\pi\sin(\Theta)/\lambda$) for the aged samples two types of species were observed in Re sulfide colloidal solution by SAXS. Small particles were monodisperse and quite isotropic with Rg = 0.31 – 0.45 nm. Large particles were disc shaped with 40 nm in diameter and 5 nm height. Based on the similarity of chemical behavior we suggest similarity in composition of technetium and rhenium species obtained in the identical conditions. When higher than 0.06M Na2S, further grouth of Tc and Re sulfide particles occurred for □ ≥ 150 h. For [Na2S] ≤ 0.04 M, the M_3S_{10} was reoxidized by present air to Tc(VII) within 175-200 hours thus being resolubilized. The determination of the free Tc and Re species concentration by separation of ionic from colloid-bound Tc and Re with 5 kD memebrane gave evidence on the M_3S_{10} nanosulfide formation similarly to that observed in [1]. The equation for the Tc sulfide solubility based on these figures was evaluated enabling the prediction of Tc mobility in sufide conaining environments.

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POLONIUM ^{210}Po IN SWEAT AND NAIL SAMPLES OF GDAŃSK AGGLOMERATION VOLUNTEERS

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The death in London of the former secret service agent Alexander Livtinenko on 23 November 2006 generally attracted the attention of the public to the rather unknown radionuclide ^{210}Po. This paper presents the results of the determination of polonium isotopes in samples of sweat and nails. Analyzed samples were taken from Gdańsk agglomeration volunteers (northern Poland). Samples of nails and sweat were collected from people practicing about three hours a day in the gym. The volunteers were subdivided in classes of males and females, cigarette smokers and non-smokers and life-style differences were taken into account. 17 people had been participated in this study. This is the first study, to our knowledge, which has reported the ^{210}Po level difference in sweat and nails samples depending on the factors mentioned above. Further investigations ought to be carried out in other countries in order to verify this issue. The results show that the all obtained results of ^{210}Pb concentration in sweat and nails samples present a ^{210}Po concentration lower than 30 mBq day^{-1} that is the minimum reporting level established by HPA (UK) for urine of the general population. ^{210}Po levels in normal human body may differ from one person to another depending upon the mode life as diet habits, origin of drinking water, residence place which effects radon exposure rate and also smoking habits. The method used in this study presents a high accuracy, reproducibility and sensitivity.

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RADIO-GREEN CHEMISTRY OR GREEN RADIOCHEMISTRY?

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The mandate of green chemistry is to reduce the requirement of chemicals in any chemical processes. For almost a decade we are trying to use greener and environmentally benign reagents in radiochemical separation studies. In fact for the first time we have punched green chemistry with accelerator-based radiochemistry. We have proposed alternative routes for production of clinically important radionuclides and developed method of separation using various green reagents like room temperature ionic liquids (RTIL), polyethylene glycols, poly-vinyl pyrolidone, etc., contrary to our experiments in the last decade of twentieth century. We have found sometime the classical chemistry is highly relevant to green chemistry approach. The RTILs are non-volatile, non-flammable and non-toxic and therefore a replacement of the volatile organic solvents. Aqueous Biphasic System (ABS) is also a landmark and is well celebrated in the field of green chemistry as both the phases are aqueous in nature. PEG based aqueous biphasic system has been employed successfully in separation of various no-carrier-added (nca) radionuclides from the corresponding bulk target materials from our laboratory. These are the separation of nca ^{209,210}At from $Pb(NO_3)_2$, nca ^{93m}Mo from Y target, nca ^{199,200}Tl, ^{199,200}Pb, ^{197}Hg from Au target, nca ^{183}Re from Ta target, and separation of trace amount of long lived ^{152,154}Eu from ^{134}Cs radionuclides. Speciation and partitioning behavior of Cr(III) and Cr(IV), Hg(I), Hg(II) and methyl mercury were investigated using PEG based aqueous biphasic system.

Green chemistry principles in radiochemical separation processes are now-a-days followed by many other researchers all over the world. These works have been categorized by the authors mainly under two nomenclature, “Green Radiochemistry” or “Radio- Green Chemistry”. This is the high time to fix on one terminology. It can be initiated even from the platform of RAD15.

STUDY OF THE REACTION MECHANISM OCCURRING DURING MICROPLASMA ACTIVATION OF AQUEOUS SOLUTIONS OF ORGANIC SUBSTANCES

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Objective. The objective of the work is to study the mechanism of physical and chemical processes occurring in reactors under the action of pulsed electrical discharges with iron and aluminum load using aqueous solutions of organic substances.

Material and Methods. The experimental setup consists of a reactor volume of 1.5 L and power source. The reactor was made of a dielectric material. At the bottom of the reactor filled with aluminum or iron granules. Selection of different granules determined electrochemically active metal in an aqueous medium. The two external electrodes immersed in the metal loading was applied pulse voltage amplitude of 500 V with a pulse repetition rate of 300 s-1 and duration of 15 ms. The maximum discharge current was 250A. Pulse energy 0.5 J / pulse. The colored aqueous solutions of organic substances with well-studied properties: methylene blue, furacilin and eosin. Selected organic substances can demonstrate the possibility of chemical reactions such as oxidation-reduction, and adsorption.

Treatment of aluminum or iron pellets electrical discharges in the solutions leads to the formation of a homogeneous suspension. The concentration of solids in the suspensions depends on the time of the metal processing load. The suspensions is centrifuged in a centrifuge slurry «Allegra 64R» firm «Beckman-Coulter» US at 20.000 rpm for the separation of the solid phase and the solution

Absorbance of the solution was measured at the maximum of the absorption bands of the instrument ApelPD-303UV, the company «ApelCo., LTD», Japan. For methylene blue, it is at a wavelength of 590 nm to 440 nm at furcilina and eosin is at 490 nm.

Results. The paper presents the results of a study of the mechanism of chemical reactions at developing microplasma activation of aqueous solutions of organic compounds with aluminum and iron downloads. Selected organic matters allow to show the flow of redox reactions, degradation of organic compounds and their adsorption. Methylene blue solution on the conditions for the development and location of redox reactions in the systems is "electrode-metal loading-aqueous-electric discharge." The role of the metal electrodes and loading in the development and maintenance of redox reactions is in these systems. Furacilin irreversibly oxidized in reactions effectively changes its properties when in contact with iron loading than with aluminum. This is due to rupture of the furan ring due to high local temperatures and the accumulation of OH-ions. It is also associated with the formation of insoluble compounds with variable valency of metals, and removing from the solution as precipitate. On the example of the solution of eosin demonstrated flow adsorption processes for forming metal hydroxide corresponding electrode material and loading.

Conclusions.

1. It is shown that the main processes in the reactors are redox reactions. Efficacy of redox reactions is dependent on the material load.
2. It is found that methylene blue is involved in redox reactions.
3. It is shown that furacilin simultaneous occurrence of two processes such as the destruction due to high local temperatures and the formation of insoluble compounds with heavy metal ions
4. Flow adsorption processes are shown in eosin solution. The effectiveness of which is determined by the surface charge of the oxidized products of erosion.

THIN SOLID FILM EXTRACTION PRECONCENTRATION AND DETERMINATION OF URANIUM CONTENT IN PHOSPHATE FERTILIZERS BY ALPHA-SPECTROMETRY

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Alpha-spectrometry is known to be one of the most widely used techniques for Uranium determination in the environmental samples . Due to the very low content of Uranium in these samples, a complex chemical procedure such as isolation and preconcentration is often required to obtain a reliable data about the analysis .

Tri-n-octyl phosphine oxide (TOPO), Polyvinylchloride (PVC), and cyclohexanone were used for stock polymer solution preparation. Aliquots of the solutions were pipetted directly to the polished stainless steel discs (d = 20 mm) and cyclohexanone was evaporated while heating under infrared lamp. Such a procedure of film preparation appeared to be more simple and reliable, than that described in [71]. The low surface tension of the solution enabled the formation of qualitative thin layer uniformly spread over the disc surface.

The aim of this investigation is to evaluate uranium content in the Libyan phosphate Fertilizers for, at least, two reasons: firstly, upgrading the phosphate quality by removing the uranium content in order to reduce the radioactivity in the fertilizer products. The results of this study shows that the uranium concentration in phosphate fertilizers is relatively low (less than 100 ppm).

STUDY PATTERNS OF EXPOSURE TO IONIZING RADIATION ON THE STABILITY OF COLLOIDAL SOLUTIONS OF IRON

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Objective. The purpose of this paper is to study the effect of a pulsed electron radiation on the coagulation stability of the iron colloidal solutions. The stated purpose of the work is conditioned by the problems related to the practical use of the electron beams for cleaning the wastewater. The ionizing radiation of the electron beam has a simultaneous impact on the organoleptic, chemical and biological properties of the water, besides all kinds of microorganisms (bacteria, viruses) are damaged. The main advantage of this method in comparison with the conventional wastewater treatment methods is the complete rejection of the reagents, that is, a reagentless technique. Using the radiation method in a combination with the ozonation or aeration results in a deep cleaning and decontamination of the water and provides the maximum permissible concentration (MPC) at the European standard level. We used the TEA-500 pulse electron accelerator as a radiation source, which is located in the Institute of High Technology Physics of Tomsk Polytechnic University.

Material and Methods. The parameters of the accelerator: the accelerating voltage pulse duration at halfheight is 60 ns, the amplitude of the accelerating voltage is (400÷500) kV, the energy of the formed electron beam is up to 200 J. The dosimetry of the TEA-500 electron accelerator was performed by the KNO3-based chemical dosimeter with the value of the radiation-chemical yield of nitrite-ions equal to 1.6 ions per 100 eV of the absorbed energy. The model solution containing iron and silicon ions and humic substances was used as a solution used to investigate the stability of iron colloids under the action of the pulse electron radiation. The efficiency of the radiation action on the colloidal solution was estimated by the variation in the iron concentration in the solution after the filtration on the filter "a blue ribbon". The filter is chosen by its disability to sustain the particles of the dispersion phase in the model colloidal solution before the beginning of the coagulation process. The concentration of iron in the solution was determined using the ICP-OES plasma optical emission spectrometer produced by the Varian company.

Results. It is shown that in the case of the positive charge of the colloidal particle the eaq- interacts with the dispersed phase with a high rate In this case, the value of $\alpha < 1$ and α is the coefficient, which is a part of the equation of coagulation rate constant $k=(1/\alpha-1)/C_0 \cdot t_к$,. If $\alpha < 1$, the micelle catalyzes the interaction process. In the case of the negative charge on the surface of the colloidal particle, the value of $\alpha > 1$, that is the micelle inhibits the process. The value of the ξ-potential was determined for the examined model solution, which is 38 mV and characterizes the charge of the surface of the dispersed phase. The negative value of the ξ-potential must block the interaction of eaq- with the micelle nucleus, which plays the role of the electron acceptor in the considered case. However, there is the interaction, since the performed experiments show the decrease in the stability of the colloidal system. Therefore, we should consider such an important factor in the studied process as diffusion. According to the literature data, eaq- penetration into the reaction volume of the micelle is accompanied with the interaction, whose reason is the transfer of the electron from the hydrate trap, where it is located, through the double layer of the micelle to the electron acceptor. The calculations performed for the studied colloidal system considering the radiation-chemical yield of eaq- and the absorbed dose, which are given below show that the concentration of the hydrated electrons is comparable with the concentration of the colloidal particles and is 3*10-5 mole for eaq- and 0.1*10-5 for the colloidal particles. However, the decrease in the iron ions concentration in the solution from 6.32 to 3.64 mg/l show that the efficiency of the interaction could be higher, but the negative value of the ξ – potential decreases the efficiency of the interaction of eaq- with the dispersed phase.

Conclusions

1. The effect of the pulse electron radiation on the stability of the colloidal solutions is studied. It is shown that there is the variation in the chemical composition of the wastewater and formation of the sedimentation within the range of the absorbed doses 0.2-2.5 Mrad that indicates the efficiency of the ionizing radiation effect on the studied system.
2. The mechanism of the interaction of the radiation, whose base is the reaction of the interaction of the hydrated electron with the dispersed phase, is offered. The suggested mechanism can be also implemented under radiation of the true wastewater.

RADIOLYTIC DECOMPOSITION OF ENVIRONMENTALLY PERSISTENT PERFLUORINATED SURFACTANTS WITH THE USE OF IONIZING RADIATION

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Perfluorinated surfactants (PFSs), in which in alkyl chains all hydrogen atoms are substituted with fluorines, are industrially produced since 1950-ties. Their particular properties such as high surface tension activity and outstanding chemical are main reasons of broad applications. They include impregnation of paper and textiles, application as components of a fire fighting foams and lubricants. Wide interest in their environmental role since beginning of 2000-ties resulted from discovery of a common global presence of those anthropogenic compounds, mostly perfluorinated sulfonates and carboxylates, in human and animal organisms, and in the environment, even in the most remote places. It resulted in wide development of analytical methods of their determination, as well as toxicological studies.

The extraordinary chemical stability of PFSs results in insufficient efficiency of their removal for wastes, surface waters, and raw and drinking water sources by conventional treatment processes. This implies increasing interest in search of new treatment technologies. They include both methods based on reductive dehalogenation (employing e.g. sub-critical elemental iron reduction or UV-iodide photolysis), as well as advance oxidation processes (AOPs). The pulse radiolysis measurements indicated, that reactions of perfluorinated octanoic acid (PFOA) or perfluorinated octanesulfonic acid (PFOS) with ·OH radical and hydrated electron eaq- exhibit similar kinetics. Then this implies a possibility of favorable application for this purpose of gamma or accelerated electron beam, where as a result of water radiolysis strong reactants - oxidizing ·OH radicals and reducing hydrated electrons and hydrogen radicals are formed. The rate constants for radical reactions with PFOA and PFOS are 2-3 orders of magnitude lower compared to reactions of other common environmental organic pollutants. This confirms high chemical resistance of examined PFSs.

The yield of defluorination was determined using ion-chromatography with conductivity detection. Studies on radiolytic decomposition of PFCs were carried out in aqueous solutions with initial concentrations 1 mg/L by gamma and EB irradiation, which gives different dose-rate conditions. Irradiation was carried out both in oxidative and reductive conditions. The products of decomposition in function of absorbed dose are fluoride and PFSc with shorter alkyl chains, than irradiated species.

INFLUENCE OF URANYL NITRATE ON THE THERMAL STABILITY OF THE EXTRACTANT MIXTURES WITH NITRIC ACID

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UN is an important intermediate product either in production of NF, or in the processing of SNF. Technological operations using UN can be divided into two groups - the isolation of UN at the stage of extraction remaking and high temperature operations of converting UN to uranium oxides. In the first case, in mixtures with the extractant, nitric acid presents besides UN, the temperature does not exceed 70°C and the main potential danger is inflammation of vapor-air mixtures when heating extractant above the flash temperature.

In the second case, the solutions of UN are evaporated to the melt state at temperatures 120-140°C [1] and melt thermally decomposes to oxides of uranium at 160-200°C. Also the methods of UN denitration using chemical reagents (e.g. formic acid) at temperatures above 500°C are being developed. At present, relatively low-temperature denitration method (up to 100°C) with the use of hydrazine hydrate is proposed.

The thermal stability of extractant mixtures with UN has been studied very superficially, and the arising the uncontrolled exothermal reactions have not been studied at all. There is absolutely no information concerning the influence of the extractant radiolysis and thermolysis products on the thermal stability of these mixtures. Meanwhile, as has been found for mixtures of extractant with nitric acid, radiolysis has negative effect on thermal stability of these compounds. Present transition to new types of fuel with high burnup causes increasing radiation exposure on extractant, which can lead to a corresponding increase of both steam-air and condensed mixtures explosiveness. The same trend may occur for mixtures of extractant with UN.

The main objects of this study are mixtures of 30% TBF solution in a hydrocarbon diluent with uranyl nitrate, in some kind imitating the mixtures, which for various reasons may occur during nitric acid solutions evaporation, obtaining the melt of UN and its denitration. As for extractants, 30% solutions of TBP in perspective diluent – Isopar-M and (for comparison) - the solutions of TBP in n-dodecane or the diluent “DL-3” mainly were used. Experiments were provided with either "fresh" extractants or degraded, i.e. exposed to radiation in the presence of UN.

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EXTRACTION OF RARE EARTH ELEMENTS FROM MONAZITE AND PHOSPHOGYPSUM AND THEIR SEPARATION FROM URANIUM-238, THORIUM-232 AND RADIUM-226, USING SUPERCRITICAL CARBON DIOXIDE CONTAINING TBP AND D2EHPA

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For the first time, supercritical fluid extraction (SCFE) using TBP, D2EHPA and their adducts with HNO_3 used for extraction of rare earth elements (REE), Th and U of monazite concentrate (MC) and phosphogypsym (PhG). In the case of MC extraction of REE and their separation from Th and U using SCFE become possible after sintering MC with Na_2CO_3 in the presence of coal by microwave (MW) radiation and converting phophate of REE, Th and U, contained in the MC, in their oxides (MCS). It was established that under SCFE the adducts TBP and D2EHPA with HNO_3 recovered up to 50% of REE from solid MCS. Th and U from MCS are not extracted, however, after dissolving the residue of MCS in a mixture of 4M HCl with 0,05M HF, which is a solid solution of CeO_2 oxides Th and U, can be quantitatively extracted by using SCFE with D2EHPA and thereby separated from the remainder of REE, which is ramaining in solution. For the separation of radium from Th, U and REE from hydrochloric acid solution prepared by dissoving the precipitate of MCS was used sorbent DGA with TODGA groups (N,N,N',N'-tetraoktildiglikolamida). Conditions of quantitative extraction of REE, Th and U by SCFE from PhG were determined. The scheme of complex processing of MC and PhG to extract REE and their separation from Th and U have been proposed.

RESEARCH ON DEPENDENCE OF PU (IV) TRANSITION COMPLETENESS INTO THE ORGANIC PHASE WHILE ITS EXTRACTION WITH 30% TBP SOLUTION IN ISOPAR-M ON THE TYPE AND DOSE OF IRRADIATION IN THE CYCLIC MODE CONDITIONS

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In the course of the nuclear industry development, extraction technology using tributyl phosphate in inert diluent (PUREX-process) has found the most wide application. Due to the increasing fuel burnup and changing of its chemical composition, research on the radiation effects on TBP and its solutions in a hydrocarbon diluents is actual for avoiding technological accidents.

The first series of experiments include the cyclical exposure of 30% TBP - Isopar-M system and is aimed at the definition of radiolysis products and production of irradiated extractant, used for Pu extraction from its nitric acid solution. To irradiate samples the linear accelerator UELV-10-10-C70 was used. Accelerated electron beam was scanned along the vertical axis of the 200 ml cylindrical glass cell (5.5 cm in diameter), equipped with a hydraulic lock and mounted on a rotating carousel table. 4 mole/l HNO_3 was used as the hardening liquid. Radiolysis products were defined by IR spectroscopy with Fourier transform and gas chromatography. In the second series of experiments the effect of accelerated electrons impact on ^{239}Pu extraction from 4 mole/l nitric acid by 30% solution of TBP in isoparaffin diluent Isopar-M in the cyclic mode of using the extractant was determined. A third series was carried out in a semicontinuous-semicyclic mode. Extractant was exposed to proper alpha radiation of plutonium-239. During 2 and 3 series of experiments, after each stage the distribution coefficient of plutonium between the organic and aqueous phases, the density and viscosity of the organic solution and (after each contact) speed of phase delaminateon were defined. In all three series 0.5 mole/l sodium bicarbonate solution we used as a recovery agent.

Slowdown of delamination of emulsions during alpha-radiolysis of extractant was found to be of much greater extent than under electron irradiation; especially sharply it was shown on the stage of the soda recovery. The reason for this - high track density of alpha particles, which promotes the second order reactions (recombination, etc.), causing the formation of heavy, bulky combinations of TBP and diluent fragments, as well as mixed adducts. This is evidenced by the gray jelly tuber-shaped products formation (at a dose of 97 kGy), settling in aqueous phase; their removing on phase separation cause an increase of phases delamination rate (after the next contact) by a factor of 70.

Distribution coefficient of plutonium is slightly dependent on the irradiation dose, falling in the investigated range equally under either electronic or alpha-irradiation, mainly due to the radiolytic decomposition of HNO_3. Compensation of its losses on the next solvent saturation with acid returns distribution coefficient to its previous level. Radiation decomposition of TBP at doses up to 500 kGy occurs only by 8-10%, and has therefore miserable effect on the solvent capacity.

Regeneration of the extractant, irradiated with electrons, using the solution with less (to reduce the salinity phase) sodium bicarbonate concentration (0.5 mole/l, instead of 1 mole/l in the previous study) satisfyingly washes emulsifiers of the radiolytic origin within 11 cycles (up to a dose of 360 kGy).

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PLANT PIGMENTS INTERACTION WITH UV-LIGHT: *IN VIVO* AND *IN VITRO* APPROACH

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Sunlight, a basic life source on planet Earth, contains more than 90% of visible light (VIS) in its spectrum, while few percents (from 5-8%, depending on geographic latitude and atmospheric altitude) belongs to ultraviolet (UV) radiation. Depletion of the ozone layer recorded in the past few decades led to significant increase of the most energetic fraction in the natural light spectrum, UV-B radiation (320-400 nm), up to 1.5%. Together with already present UV-A fraction (320-400 nm), UV-B represents most damaging part of UV-radiation that can, in shorter and/or longer periods, initiate a lot of very harmful processes in the whole biosphere, affecting plants, animals and humans; the consequences are registered on sub-cellular levels, inside tissues and organs, as well as in whole organisms . These processes – especially in the long terms – may lead to a numerous pathological states, precursor of various diseases, including different types of cancer. The involving mechanisms usually involve Reactive Oxygen Species (ROS) - which is a direct impact of UV-irradiation effect in vitro as well as in vivo - including free radicals. Some of ROS-mediated processes have a global character, like photosynthesis, DNA replication (nucleotide bases are excellent UV-absorbers !) or lipid peroxidation.

There are a lot of UV-targets in plants and the plants pigments are among the most prominent ones. They have very important functions, like photosynthetic pigments, chlorophylls and carotenoids, performing crucial functions within unique photosynthesis process: absorption of sunlight and its distribution to reaction centers of photosynthetic apparatus. Therefore their interaction with UV-A & UV-B is inevitable; as numerous photosynthetic studies show their functioning is seriously affected in vivo, though the structures mainly stay intact due to available regulation mechanisms in plants activated under extreme environmental conditions (like high light intensity). On the other hand, the other plant pigments – not involved in photosynthesis - like flavonoids, have been synthesized inside plants as a part of plants response against increasing presence of UV-fraction in sunlight spectrum, because of their efficient UV- absorptivity. Flavonoids interactions with UV radiation are also very complex and not well known.

Therefore, to get more light on the inherent interactions of plant pigments with UV radiation, in vitro studies are necessary, first in solutions as the simplest possible systems from molecular organization point of view. These studies provide initial data necessary as a base to understand more complex interactions and mechanisms in vivo, in much more constrained environment with a lot of influential variables.

THE IMMEDIATE RESULTS OF THE COMBINED TREATMENT OF LOCAL RECURRENCE OF RECTAL CANCER

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Objective: To increase the effectiveness of radiation therapy (RT) of local recurrence of rectal cancer (MRRPK) by setting the preferred modes and dynamic medium dose fractionation irradiation MRRPK, assessing immediate outcomes, identifying the frequency and severity of early radiation reactions during radiation therapy.

The study included 60 patients with a diagnosis of "local recurrence of rectal cancer." The median age was 67 years. Terms of recurrence after surgical treatment averaged 20 months. The histological structure of the tumor was presented adenocarcinoma in 57 (95%) patients. Radiation therapy (RT) was carried out in medium or dynamic fractionation. Chemotherapy used pelleted 5-fluorouracil.

In group 1 (20 patients) received palliative radiotherapy course with a fractional dose of 3 Gy to 42 Gy SOD (SDeq 51 Gy). In group 2 (20 patients) underwent a course of radiotherapy using dynamic dose fractionation: fractional dose - 4, 3 and 2 Gy to 51 Gy SDeq. In the third group (20 patients) underwent combined treatment using dynamic dose fractionation: fractional dose - 4, 3 and 2 Gy to 56 Gy SDeq and chemotherapy - Xeloda or ftorafur. In group 1 complete regression was achieved in 1 patient, partial regression - 15, stabilization - at 3, progression - at 1, that is clinical effect was observed in 19 of 20 patients. In group 2, complete regression of the tumor was diagnosed in 3 patients, partial regression - 17, therefore, 100% of patients had received clinical effect. According to follow-up, 5 patients in this group were subsequently. In the third group of complete regression of the tumor was diagnosed in 7 patients, partial regression - 13, ie, 100% of patients had received clinical effect. According to follow-up, 7 patients in this group were subsequently operated. Among the radiation reaction in group 1 nausea 1 tbsp. was observed in 3 patients, radiation Recto 1-2 degree - 15, radiation epithelitis 1-2 degree - 4 patients; in group 2, nausea 1 degree - At 7, radiation Recto 1-2 degree - At 7, radiation epithelitis 1-2 degree - In 6 patients and 6 reactions were observed; in the third group of nausea 1st. was observed in 7 patients, radiation Recto 1-2 degree - At 9, radiation epithelitis 1-2 degree - At 8 and 3 patients reactions were observed.

Thus, when irradiated in the dynamic fractionation showed less pronounced dose response as beam during treatment, and after. Increasing the total dose with the addition radiomodification increases the frequency of complete responses with acceptable toxicity. As a result of treatment in all patients achieved a significant reduction in pain, relief of bleeding.

Keywords: recurrence of rectal cancer, radiation therapy, dynamic fractionation.

NATURAL RADIOACTIVITY ASSOCIATED WITH DISSOLVEDRN-222 AND RA-226 IN A COAL MINING AREA IN SOUTHERN BRAZIL

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Coal is an important source of non-renewable energy and can be associated with radioactive elements. In Figueira city, Paraná state, it was recorded high uranium activity near the coal mine that supplies the thermoelectric power plant. In this context, the radon activities (Rn-222, produced from the Ra-226 decay in the U-238 natural decay series) were evaluated in groundwater, river water and effluents (produced from the acid mine drainage generation in the coal reject dumps) samples. The samples were collected in August 2013 and analyzed at LABIDRO (Laboratory of Isotope and Hydrochemistry), UNESP, city of Rio Claro, Brazil, using a alpha spectrometer (AlphaGuard), being the mean radon activity calculated in five cycles of 10 minutes. There was no radon concentration above 100 Bq/L, the critic value according to the World Health Organization. The average radon activity concentration in groundwater (10.39 Bq/L) was higher than in surface water (0. 96 Bq/L) and the drainage (3.50 Bq/L), possibly due to the accumulation of uranium and radium in the aquifer layers that favors the radon trapping. The lower value in the river waters can indicate dilution and the intermediate value in the effluents may indicate radon absorption in the coal particles of the reject dumps. The results also indicate that the radon activities in the effluents increase with the sample acidification, possibly due to the higher radium leaching and the subsequent radon transport to the drainage flow. The water samples of Laranjinha River, which supplies the city, and Ribeirão das Pedras, its tributary that receives the mining effluent, exhibited higher pH values upstream the mine, reflecting the acid mine drainage discharge. The radionuclides transport indicates the importance of monitoring their activity concentration in natural waters due to the risks that the radioactivity can represent to the human health.

INVESTIGATION OF SEDIMENT ACCUMULATION IN THE NORTHERN PART OF DANUBE DELTA (ROMANIA)

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This study relies on the determination of some physical parameters, ages and sedimentation rates of two northern Danube Delta lakes, namely Matita and Merhei. These two lakes are situated between the Chilia (in the north) and the Sulina branches (in the south) of the Danube, both having areas in the range of 500-1000 ha, the anthropic factor being present through the numerous manmade channels, which are continuously widened. Three sediment cores were taken from the Matita Lake and four from the Merhei Lake. Porosity, water content and bulk density was calculated. The total carbon content and the attenuation coefficient were measured for the subsampled cores (one subsample being 1-2 cm). Porosity, Physical parameters and total carbon content have a general decreasing, while the bulk density shows a slight increasing with the depth. The ages and sedimentation rates of the sediment layers were measured using the Pb-210 radionuclide: the total lead content being measured through of the alpha particle emitting Po-210 radionuclide and the in situ lead content being measured using Ra-226. The sediment cores have been dated on average until 1990, the total lead content being in the range of 8-80 Bq/kg, with an in situ Pb-210 level of 14±6 Bq/kg. The sedimentation rates show the presence of major floods in 1980, 1996, 2006 and 2013, having sedimentation rates of 1.20 ± 0.15 g/cm2y and 1.11 ± 0.10 cm/y, 1.98 ± 0.23 g/cm2y and 1.96 ± 0.20 cm/y, 1.29 ± 0.16 g/cm2y and 1.83 ± 0.19 cm/y and 6.56 ± 0.71 g/cm2y and 1.52 ± 0.18 cm/y respectively.

This study is part of the PNII-RU-TE-2012-3-0351 project.

IN VIVO EVALUATION OF RADIOIODINATED NATURAL LAWSONE AS A TERANOSTIC AGENT

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Curative plants had potential role at wars, wounds and treatment of diseases in history. Henna (Lawsonia inermis) is one of these plants and it used to treat a lot of diseases and illness for a long time from ayurvedic medicine to modern medicine. The using of Henna leaves is very popular for cosmetic as well as medicine in many countries. Henna leaves contain lots of different compounds and lawsone (LW) is the main one which is main compound of henna is orange and hydrophilic. Antibacterial, antifungal, antioxidant and anticoagulant properties of LW are well known from literature.

In current study, extraction with bidistillated water of henna leaves was performed and LW was isolated by using High Performance Liquid Chromatography (HPLC) system. LW was iodinated with inactive iodine (127I) by using stochiometrically equivalent amount of LW, potassium iodide and oxidizing agent iodogen. The product (127I-LW) was analyzed with HPLC method. Molecular structures of both LW and 127I-LW were evaluated by Nuclear Magnetic Resonance (NMR) method. LW was radiolabeled with 131I radionuclide to determinate the potential as a theranostic agent for ceveral cancer types by utilizing iodogen method. Quality control of radiolabeling was evaluated by Thin Layer Radio Chromatography (TLRC) and High Performance Liquid Radiochromatography (HPLRC). The yield of radiolabeling of LW (131I-LW) was calculated as 92.70 ±4.312 % (n=10). The stability of131I-LW was calculated at 30, 60, 90, 120, 180, 240 and 1,440 min. by using TLRC method. Determination of the partition coefficient (logP) of 131I-LW was performed for lipophilicity. In vivo biological activity of 131I-LW was investigated by biodistribution study which was performed by using healthy female and male Balb/C mice. Blood was taken and tissues of interest were excised. All tissues were weighed and counted for radioactivity with Cd(Te) detector. As a result, radioactivity ratios per gram (% ID/g) were calculated for each tissue. ID/g % values of 131I-LW versus time graphs are plotted.

In vivo biological activity studies conducted in this work show that 131I-LW may be proposed for uterus, breast, ovary and prostate tissues as a teranostic agent. Further studies with tumor bearing animal models, cytotoxicity and cell culture experiments need to be performed to make a definite claim.

Keywords: lawsone, 131I, radioiodination, cell culture

SORPTION OF SELECTED RADIONUCLIDES FROM LIQUID RADIOACTIVE WASTES BY ALGINATE BEADS

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Introduction. Radioactive waste-waters that contain radioactive metal ions, e.g. Cs(I), Sr(II), Eu(III) and/or Am(III) are dangerous for people and for the environment. There are several methods to remove them from the waste waters. Sometimes, several of these methods are combined to form so called hybrid method, e.g. complexation with ultrafiltration. Alternative method of eliminating the radioactive metals from waste-water is sorption by low cost natural materials of the biological origin. Among its major advantages over conventional treatment are: low cost, easy regeneration of biosorbent and possibility of metal recovery [1,2].

Experimental Methods. In presented studies, sorption of Cs(I), Sr(II), Eu(III) and Am(III) on different alginate sorbents was studied as a function of contact time, initial pH of aqueous solution and mass of the sorbent and concentration of the radionuclide, respectively. An attempt to revitalize of the Cs(I)-, Sr(II)-, Eu(III)- and Am(III)-loaded sorbents was done by shaking the material at room temperature with different types of desorbing agents.

Results and Discussion. Decontamination Factor - the ratio of specific activity before and after decontamination [3] has been found to be above 85 % for Sr(II), Am(III) as well as for Eu (III) and for Cs(I) is slightly lower.

Thermogravimetric analyzes of the materials show that selected sorbents obtained in our laboratory decompose at only ca. 200 oC. This means that energy necessary to reduce the mass of the solid wastes obtained in the course of decontamination of liquid aqueous radioactive wastes may be relatively low, what decreases cost of the process.

Conclusions. Laboratory obtained beads of calcium alginate characterize high Decontamination Factor (DF) and decompose at relatively low temperatures.

Keywords: sorption, radionuclides, calcium alginate.

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THE EFFECTIVENESS OF COVALENTLY BONDED PHENYLENE FILMS ONTO MILD STEEL AS A CORROSION BARRIER TOWARD THE PROTONS

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Although industrial metals posses very good mechanical stability, major problem is their vulnerability toward the corrosion. The chemical modification of surfaces is an important tool that resolves some of the problems concerning these phenomena, furthermore it allows not only modification of surface properties but also functionalization. Despite the fact that there are many classes of chemical compounds that are able to achieve the task of spontaneous surface modification (thiols, silanes, phosphonic acids, diazonium salts, etc), not all these molecules are prone to the formation of covalently bonded films. Additionally, in general, except the diazonium salts, these molecules are surface specific.

In the first step, we examined the possibility of the covalent attachment of the phenyl groups by electrochemical reduction of: a) ”in situ” formed benzenediazonium chloride in acidic media and b) the reduction of the synthesized benzenediazonium tetrafluoroborate in organic media (ACN). In the first case the formation of the ”in situ” diazonium salt was monitored by UV-VIS and ATR-IR (diamond crystal) spectroscopy. In order to gain insight about the quality of the grafted films (thickness or pin hole defects), this process was done in different potential ranges and the information was obtained through the measurement of the inhibition efficiency by the potenciodynamic measurements. The grafted film in organic media gave the best results acting more efficiently as a barrier to protons than the film grafted from the ”in situ” generated diazonium salt.

PROTECTION OF MILD STEEL FROM CORROSION IN MINERAL ACID MEDIA BY THE USE OF MIXED INHIBITORS: 4-AMINOBENZOIC ACID AND SOME AMINO THIAZOLE DERIVATIVES

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Owing to the fact that aggressive acid solutions are used extensively for industrial purposes, inhibitors are generally used to decrease the corrosion effect on metallic materials. Commonly the inhibition of corrosion of mild steel by mineral acids is more effective by using different organic compounds containing nitrogen, sulfur and oxygen atoms. The responsible inhibition mechanism reflected by those molecules is their ability to form physically or chemically adsorbed film on the metal surface, acting as a barrier to protons - thus decreasing the corrosion rate of the metal.

The corrosion inhibition of mild steel in 0.1 M hydrochloric acid and phosphoric acid solutions by 4-aminobenzoic acid (4-ABA) and different molar ratios of 2-Amino-4,5-dimethylthiazole hydrochloride (A) and 2-amino-5-bromothiazole monohydrobromide (B) was studied using electrochemical (potentiodynamic) measurements. These measurements show that the inhibition efficiency obtained by these compounds increased by increasing their concentration. The remarkable inhibition efficiency was found when 4-aminobenzoic acid was used as inhibitor in the concentration of 5*10-3 M in 0.1M HCl as corrosion media, giving a 96.5 % inhibition efficiency. Furthermore, by the use of different molar ratios of 4-ABA and thiazole derivatives (A and B) interesting insight about the surface coverage of these molecules was obtained.

THE THEORETICAL (DFT/B3LYP) AND EXPERIMENTAL STUDY OF THE EFFECT OF PYRIDINE/THIAZOLE DERIVATIVES ON THE CORROSION BEHAVIOR OF MILD STEEL IN PERCHLORIC ACID AS A CORROSION MEDIA

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The usage of inhibitors is a well recognized method for the protection of the metals from the corrosion. The reflection of the inhibiting behavior is property of many heterocyclic compounds containing nitrogen, sulfur, phosphorus and oxygen atoms. The investigation of the relation between the corrosion inhibition efficiency and structural properties of inhibitor molecules have been taken by many experimental techniques and theoretical methods. The most promising/accurate one is the DFT. In this study, the electrochemical methods were used to evaluate the corrosion of mild steel in 0.1 M perchloric acid media. As the inhibitors were used the pyridine molecule and two thiazole derivatives: 2-amino-4,5-dimethylthiazole (A1) and 2-amino-5-bromothiazole (A2). The evaluation of inhibition properties was done for two series: a) when the corrosion media contains only one type of the corresponding molecules and b) and in the presence of two molecules in molar ratios: 0, 0.2, 0.4, 0.6 and 1.0. The first case serves to obtain data of the maximum surface coverage and in the second case the collected date shed light on the important questions such as: can one type of the molecule desorbs the other one, at what extent this phenomena takes place and does the use of the mixed inhibitor type has synergistic effect regarding the inhibition efficiency toward the protection of iron from corrosion. The calculated theoretical parameters are in good correlation with the experimentally obtained data.

PRODUCTION OF ^{103}Pd VIA (N,ALPHA)-REACTION AND ITS SEPARATION BY SPONTANEOUS ELECTRODEPOSITION

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Objective. ^{103}Pd is a radionuclide used in brachytherapy sources for the treatment of prostate cancers, ocular tumors and is also a candidate for intravascular brachytherapy [1]. Generally, it is produced in cyclotron. Until 2002, more than 10 cyclotrons have been installed in the USA with the exclusive aim to produce ^{103}Pd [2]**.** Recently a permanent breast seed implant (PBSI) technique has been developed as a new form of adjuvant radiation therapy for early stage breast cancer and the use of ^{103}Pd as PBSI has been found safe [3].

^{103}Pd is generally produced either in a cyclotron by proton or deuteron irradiation of rhodium or silver via the^{103}Rh(p,n)^{103}Pd, ^{103}Rh(d,2n)^{103}Pd or ^{nat}Ag(p,x)^{103}Pd reaction or with neutron irradiation in a nuclear reactor via the ^{102}Pd(n,g)^{103}Pd reaction. The (n,g) reaction is not very useful since the achievable specific activity is rather low. Production feasibility studies via ^{106}Cd (n,a) ^{103}Pd process and its separation by spontaneous electrodeposition were pursued and reported in this work.

Material and Methods. 20 mg of the natural cadmium foil was irradiated at a fast neutron flux density of 7.5 x 10^{13} $cm^{-2}s^{-1}$ for a period of 12 hours for the production of ^{103}Pd via the (n,a)-reaction. Thereafter, ^{103}Pd was separated by spontaneous electrodeposition using three-chambered cell**.** The deposited radioactive palladium was removed by dipping the platinum electrode in nitric acid.

Results. Production feasibility studies showed that at a fast flux neutron density of 7.5x10^{13} $cm^2s^{-1}$and an irradiation time of 120 h, using 100% enriched ^{106}Cd target 340 MBq of no-carrier-added ^{103}Pd per batch can be produced. The method is thus suitable for medium-scale production of this radionuclide. The separation factor achieved was reasonable (1.3x10^6). The process is not sensitive to Cd $(NO_3)_2$ and HNO_3 concentrations. Deposition velocity (4.119±0.353).10^{-2} min^{-1} and deposition constant 0.1211 $cm.min^{-1}$ were calculated and from the temperature dependence of the deposition velocity constants, the activation energy (0.1155±0.3169 eV) was also determined. The thermodynamic spontaneity can be satisfied at different concentrations of Pd^{2+} ions. The process was found to be irreversible giving a highly pure yield of carrier-free ^{109}Pd and/or ^{103}Pd.

Conclusions. Production method of ^{103}Pd via ^{106}Cd (n,a) ^{103}Pd is suitable for medium-scale production of the said radionuclide. The method of spontaneous electrodeposition for the separation of ^{103}Pd is an attractive technique. This technique needs no external electromotive force. The process was found very simple and needs little manipulation and amenable to automation and remote processing.

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THE RADIOLYSIS OF GLYCERALDEHYDE ADSORBED ONTO MINERAL SURFACES

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Many theories have been proposed to explain the origin of chirality, but accurate physicochemical processes remain controversial. Recently, a number of these theories have been re-examined experimentally. It is reasonable to consider the participation of heterogeneous catalysts in the prevalence of one enantiomer. In addition, these systems represent a plausible geochemical scenario for possible glyceraldehyde chiral separation. To this end, we studied the role of certain surfaces like calcite, some clays and silicates as deterministic mechanisms to induce chirality, which involves the interaction of racemic glyceraldehyde with these minerals when exposed to a high-radiation field. Also, in chemical evolution, the study of chemical stability under the environmental conditions that existed on primitive Earth and that may exist in extraterrestrial environments is very important; for this reason, this research is also focused to analyze the effect of high radiation and mineral surfaces in the survival of racemic glyceraldehyde.

The experimental part was divided into two groups: Adsorption of racemic glyceraldehyde in different mineral surfaces, and the study of the stability of the glyceraldehyde in high-radiation fields, as well as whether it remained free or was adsorbed in mineral surfaces.

The analytical tools used in this study involved UV spectroscopy, high-performance liquid chromatography (HPLC) and liquid chromatography-mass spectrometry. To study the stability in high-radiation fields, racemic glyceraldehyde solutions (0.1 mol.L-1, oxygen-free) were irradiated in a Co-60 gamma source, with doses up to 8.2 kGy. The results show that this compound is very labile under irradiation and forms a yet-unidentified compound that has a higher absorption in UV, accompanied by a hypochromic shift in peak absorption at 251 nm. This shift increases with irradiation dose. A possible preliminary explanation is that this maximum corresponds to the dihydroxyacetone tautomeric form of glyceraldehyde that polymerizes under these conditions. Experiments conducted with minerals, like Na-Montmorillonite, a type of Smectite clay, produced similar results.

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ACETIC ACID DECOMPOSITION, THE ROLE OF RADIATION AND TEMPERATURE IN THE STABILITY OF ORGANICS ON PRIMITIVE EARTH

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Chemical evolution refers to the processes that preceded the emergence of life on Earth, which means all of the chemical reactions that allowed the complication of molecules and the shift from inorganic to organic molecules. In this scenario, it is very important to consider the environment in which chemical reactions took place. All of the models that try to explain this transition consider energy as a fundamental element and among proposed energy sources are ionizing radiation and thermal energy. One of the major premises of chemical evolution states that important organic compounds for modern life forms were fundamental when life emerged. Carboxylic acids are essentials molecules for living beings; they participate as intermediates in metabolic pathways, particularly the Krebs cycle; carboxylic acids are also precursors of more complex molecules (as fatty acids), and their formation has been reported in numerous prebiotic experiments. In this research, the decomposition of acetic acid has been studied when exposed to thermal and radiation energy sources in order to explain its probable presence in the prebiotic scenario. Acetic acid is relatively labile and decomposed resulting in the formation of more complex molecules such as malonic acid, succinic acid, tricarballylic acid and other polyxcarboxylic acids, which have been detected at 10 kGy. The analysis was performed by gas chromatography and gas chromatography attached to a mass detector.

GAMMA-IRRADIATION: AN ALTERNATIVE METHOD TO ANCHOR ORGANOSILANE ON SILICA SURFACE

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Hybrid materials are an important new family of amorphous solids in which organic and inorganic constituents are enclosed in a unique composite material. Silica is the ubiquitous inorganic platform used in systems designed for catalysis, separation, filtration, sensing, optoelectronics and environmental technology. The versatility of the silica is due to bulk silica properties as morphology, particle size, shape and porosity jointly to the number of surface silanol groups that are the active groups in the grafting process.

The incorporation of single or multiple organic functional groups onto inorganic supports leads to hybrid organic-inorganic materials with tailored physicochemical properties.

Generally, the surface modification of pre-formed inorganic materials is obtained through vapor-phase deposition or solution methods. The vapor phase process is generally performed at high temperature, limiting the silanizing agents to those which have sufficient vapor pressure and high thermal stability. In solution methods, the grafting reaction is mediated by physisorbed water in a hydrolysis step of the haloalkylsilane. Several physico-chemical phenomena are to be taken into account in the solution approach, namely the affinity of the reactant silane towards silica relative to the solvent, silica hydration, and accessibility of the surface reactive sites as grafting progresses.

It is well-known that gamma-irradiation exerts complex effects both on silica. Radiation damage imparted to silica by gamma-rays includes oxygen vacancies formed through knock-on processes, trapping of a hole at oxygen-deficient centers and transformation of pre-existing Si-H, Si-OH, Si-X centers. In short, both paramagnetic, and diamagnetic (cationic) defects are generated, which account for a higher propensity towards grafting of adsorbed molecules. Furthermore, radical species such as H·, [O], OH· and so forth are developed during irradiation. These may trigger further reactions of radical nature on adsorbed molecules on silica. Besides this silica-mediated effect, direct activation of organosilane by gamma-rays should generate Si and C radicals that can either be trapped by the solid support, or result in crosslinking reactions. As a result of the combined activation of the silica support and of organosilane by ionizing radiation, we expect to obtain an organically-modified silica surface.

The aim of the present work is to explore the possibility of obtaining organosilane-modified silica by gamma- irradiation. We study the silica grafting process using different alkoxy-propyl-silanes precursors with general formula $(CH_3CH_2O)_3Si\text{-}CH_2CH_2CH_2X$ where X = H, Cl, NH_2 .

We investigate the grafting efficiency of the gamma-irradiation processes and subsequently compare it with the efficiency of thermal grafting. The properties of gamma-grafted hybrid materials are investigated by ATR FT-IR analysis, elemental analysis and thermogravimetric analysis.

REACTIVITY OF SELECTED PRIMITIVE AMINO ACIDS INDUCED BY GAMMA-IRRADIATION IN ASTROCHEMICAL CONTEXT

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Amino acids found in meteorites are the result of reactions between small molecules, such as CO_2, CO, CH_3OH and NH_3 with H_2O of ice layers in solid dust particles (silicate grains). Due the action of different energy sources, mainly ultraviolet photons and cosmic rays, they generated radicals able to interact with each other, creating more complex organic molecules. As a result, the organics (i.e amino acids) were incorporated into silicate structures which preserved them from further cosmic rays and ultraviolet photons.

On the other hand, the presence of radioactive elements in meteoritic body, principally 40K, 232Th, 235U, 238U and 26Al, can play a role against the preservation of amino acids. In fact the radionuclide decay was the main cause of the amino acids degradation in astrochemical context.

According to Urey's works radioactive elements produced a total radiation of ≈14 MGy during the life of Solar System (4.6x109 years).

It is well known that a chiral molecule submitted to ionizing radiations can experience radioracemization, a transformation process leading to a reduction in optical activity as a consequence of two main events: firstly, the radiolysis of chiral molecules and their degradation into products without asymmetric centre; secondly, the inversion of chiral centre due to the high energy involved during irradiation.

We already carried out some studies regarding the amino acids capacity to survive at a dose of gamma radiations equivalent to 1.05x109 years of Solar System life, that is, 3.2 MGy. In the present work we analyze three amino acids (valine, isoleucine and leucine) irradiated in the solid state at 3.2 MGy, either without oxygen or humidity. These three amino acids are considered to be primitive amino acids, in other word amino acids formed at the first stages of Solar System life. The study was conducted to investigate the possibility for the amino acids to retain their initial signature at a such high level of radiation dose, and to examine how the lack of oxygen can influence the amino acids radioracemization. Besides using mass spectrometric techniques, we could identify some interesting degradation pathways carrying out to important products. These could be effectively considered as real precursors of more complex intermediates, very important from a biological point of view. At last, several gamma irradiation experiments were repeated on more complex systems where the selected amino acids were adsorbed into the cavities of a porous material.

USING TOTALLY-REFLECTED X-RAY RADIATION FOR COKE AND COAL CHEMICAL ANALYSIS

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The element composition is one of the most important properties of coke and coal. It helps to reveal the main quality metrics, such as heat capacity and ash content, predict contaminations in end product and realize whether extracting precious elements from waste products is economically expedient. The modern chemical methods of coal materials composition determination are rather complicated and require long sample pretreatment process.

In our work we suggested to use Total Reflection X-ray Fluorescence (TXRF) analysis as an express method of coal materials element composition determination. The goal of the work is the definition of optimal TXRF spectra registration conditions with minimal sample pretreatment cost. We optimized TXRF spectra acquisition conditions of three types of coal samples: petroleum coke, coal coke, coal and those artificial mixtures that simulate a range of samples with intermediate composition. The measurements were carried out with TXRF spectrometer S2 PICOFOX (Bruker Nano GmbH, Germany). Mo Kα (17,479 keV) radiation is used for X-ray fluorescence excitation. Acquisition time is equal 650 s. There are suggested to prepare sample aliquot as slurry from a few micrometer fine milled cokes in water phase with a presence of surface active substance (Triton X-100). It was found that optimal procedure to obtain slurry is to add 8-10 mg of milled (10-40 μm fine) coal sample to 100 μl 0,1% surfactant solution, mix it and then dilute mixture by 900 μl of deionized water. Optimal volume of droplet is found to be 3 μl. Taking into account the spectral interferences gallium is suggested to use as an internal standard element. The relative standard deviation of main elements concentration and visual estimation of homogeneity and quality of dry sample spots on reflector were the main criteria of optimization process described. There are two reflector types are used in experiments: acrylic and quartz. It was found that cheaper acrylic reflectors can be used to determine only the heavy elements ($Z > 23$) due to high level of secondary radiation scattering that cause high intensity of background signal. The determination of light elements (Al, Si, S, P, K, Ca, Ti, V) is only possible on quartz reflectors.

The result of optimization is achieving of relative deviation 3-10% level for coal and coal coke and 10-20% for more hydrophobic petroleum coke, which is typical for instrumental analysis methods. Lower limits of detection is 1-100 mg/kg for macroelements (Al, Si, P, S, Cl, K, Ca, Fe) and less then 2 mg/kg for microelements (Ti, V, Mn, Ni, Zn, Sr, Ba) and trace elements (Cu, Br, Rb, Pb).

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RADIOECOLOGY

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SEDIMENTATION RATES AND HEAVY METAL POLLUTION HISTORY IN MARINE SEDIMENTS FROM ALİAĞA BAY DERIVED FROM ^{210}Pb AND ^{137}Cs CHRONOLOGY

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Sediments register environmental changes, and accurate sediment dating provides a chronology of these changes. In particular, ^{210}Pb is the most common and reliable method during more than 5 decades, through dating of undisturbed sediment cores, to study ecosystem changes during the last 100 yr. Meanwhile, it is common practice to use ^{137}Cs as an independent age control to verify ^{210}Pb method.

Aliağa city, 50 km north of İzmir on the Aegean coastline of Turkey, includes many heavy industries such as Turkish Petroleum Refinery, Petrochemical Holding Company, ship- breaking facilities, phosphate fertiliser plant, paper factory, iron and steel plants and also two thermal power Plants. While the heavy metal of the pollution status of the Aliağa Bay was available for surface sediments in many recent publications, any information about the dating of undisturbed sediment cores lacking up to now. Hence, there is a need for a detailed study about the determination of sedimentation rates and heavy metal pollution history in the sediments from Aliağa Bay derived from ^{210}Pb and ^{137}Cs chronology.

The results have been provided a realistic picture of the environmental changes of the Aliağa Bay throughout the last 100 years and a reference database for the future studies.

Keywords: ^{210}Pb and ^{137}Cs chronology, sediments, heavy metal pollution, pollution history, Aliağa Bay/Turkey.

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THE ACCUMULATION OF ^{137}Cs AND ^{90}Sr IN THE CELL OF *NITELLOPSIS OBTUSA* ALGAE

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Cells of starry stonewort (Nitellopsis obtusa) algal are a classical object for study of the selective accumulation of ions. These cells are a convenient model for studying the biological effects of various toxins on a cellular level too. In the present study, we investigated the accumulation of ^{137}Cs and ^{90}Sr in compartments of the Nitellopsis obtusa cells. The effect of Sr^{2+}, Cs^{+} and Ca^{2+}, K^{+}, which are chemical analogues of ^{90}Sr and ^{137}Cs, to the bioelectric parameters of these algae were studied simultaneously.

The aim of this work was studying the penetration of ^{137}Cs and ^{90}Sr through regulating membrane barriers in the cells of starry stonewort (Nitellopsis obtusa). Cells of the algae were separated into the vacuolar sap, the protoplasm and the cell membrane. The central vacuole pronounced in these algae cells. The central vacuole surrounded by a cytoplasmic membrane – the tonoplast. The cytoplasm is around the vacuoles and surrounded by other cytoplasmic membrane – the plasmalemma and the cell wall. The accumulation coefficient (AC) served as a measure of the ability to accumulation of radionuclides in compartments of cells. AC is determined as the ratio of radionuclide concentration in compartments of cells (wet weight) and in the water.

Obtained data show the kinetics of the ^{137}Cs and ^{90}Sr accumulation in the cell membrane of Nitellopsis obtuse algae consists of two phases. The first is a fast nonlinear and lasts for hours. The second phase lasting several days is a slow and linear. The kinetics of accumulation of the studied radionuclides is mostly linear in the cytoplasm and the vacuolar sap.

^{137}Cs and ^{90}Sr are accumulated mainly in the cell membrane (75% to 92%) of these algae. The cell membrane as a cation exchanger regulates ion flow through the first cells diffusion barrier – its thick outer cytomembrane (the complex consisting of the cell wall and plasmalemma). Significantly smaller amounts of ^{137}Cs and ^{90}Sr enter into the cytoplasm than in the cytomembrane, 10-20% and 3-10%, respectively.

Greater intake of ^{137}Cs than ^{90}Sr from the cell membrane into the cytoplasm may be due to selective permeability of plasmalemma for K^{+} and ability of protoplasm to concentrate potassium ions, which's amount in plasmalemma is 1000 times more than in the environment. Apparently, the relatively weak penetration of 90Sr into the cytoplasm can be associated with a slow and very low level accumulation of Ca^{2+} in the cytoplasm of these algae. On average, 13-27% of ^{137}Cs and 12-21% of ^{90}Sr are transferred into the vacuole of charophytes cells through the tonoplast. Consequently, the inner cytoplasmic membrane appeared to be more permeable for the studied radionuclides than the outer cytoplasmic membrane.

Analysis of the accumulation levels of ^{137}Cs and ^{90}Sr in the compartments of the Nitellopsis obtusa cells show that is being the accumulation in the cell membrane as well as the active transport through outer and inner cytoplasmic membranes. Membrane potentials determined mainly by the gradient of the K^{+} ions are doing an important regulatory function in this process.

From the obtained data it results that cells of Nitellopsis obtusa algae can be a convenient radioecological model for the study of the accumulation of radionuclides in plants at the cellular level.

MAPPING OF THE GEOGENIC RADON POTENTIAL IN ÇINE REGION AS REPRESENTATIVE OF WEST ANATOLIA

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The geogenic radon potential is the essential parameter describing the subsurface as the main source for the indoor radon concentrations independent on the construction features of buildings. In general, uranium/ radium contents of soils, radon activity in soil gas and also radon emanation are all good geochemical indicators of radon risk. In the same lithology, noticeable differences in radon levels can occur independently of lithology (possibly caused pedological factors such as moisture content, permeability, particle size and etc.). The aim of the study is therefore mapping of the geological radon potential using by GIS on the basis of the interpretation of the geological, geochemical and pedological data and radiometric measurements including soil gas radon measurements for the Çine region as representative of West Anatolia lithology.

ESTIMATION OF THE TERRESTRIAL GAMMA RAY COMPONENT IN EUROPE

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Distributed over Europe, several thousand monitors continuously measure the ambient dose rate and transmit the data in almost real time to the European Commission. The original, and primary purpose, of the system is to warn against high radiation levels as consequence of radiological events such as reactor accidents. However, in the absence of such events the system generates large amounts of "background" data which could be used for additional purposes. One of them is a European map of the terrestrial gamma ray background.

Measured values of ambient dose rate consist of several components related to different physical effects. These include internal background of the monitor, cosmic rays, terrestrial gamma rays, cosmogenic and geogenic gamma emitters in the atmosphere and anthropogenic components such as fallout and, in the case of an event, airborne radioactivity. This presentation deals with a method to retrieve the terrestrial component from this mixture.

We discuss the different components and show how they can be estimated individually from physical laws and from external data. Then we show how the terrestrial component can be separated from the fluctuating time series of ambient dose rate. Next, we discuss problems of the estimation procedure which result from the heterogeneity of the network with regard to instrumentation and characteristics of the monitoring sites. Finally we give some results about the geographical distribution of terrestrial dose rates and physical factors that control it.

ORIGIN AND FALLOUT CONCENTRATIONS OF $^{238,239+240,241}$PU, ^{241}AM, ^{134,137}CS AND ^{90}SR IN SOILS FROM BULGARIA

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The origins of different artificial radionuclides found in soils from Northern and Southern Bulgaria was determined by measurements of their actual concentrations and respective ratios. On the basis of the measured mobility and concentrations of the investigated radionuclides in soils, it was estimated that after the Chernobyl accident the mean depositions of fresh ^{137}Cs were 3.0 ± 2.5 kBq/m2 for Northern Bulgaria and 15 ± 7 kBq/m2 for Southern Bulgaria. As a result of global fallout following atmospheric nuclear weapon tests in the 1950s, mean depositions (corrected to 1965) were calculated for Northern and Southern Bulgaria as follows: for ^{90}Sr-1.0 ± 0.5 and 2.3 ± 1.3 kBq/m2, ^{238}Pu-1.3 ± 0.8 and 2.8 ± 1.6 Bq/m2, $^{239+240}$Pu-15 ± 14 and 47 ± 38 Bq/m2, and ^{241}Pu-520 ± 200 and 760 ± 260 Bq/m2.

FRACTAL PROPERTIES OF THE SPATIAL DISTRIBUTION OF FUKUSHIMA FALLOUT

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The releases from Fukushima Daiichi NPP after the accident on 11 March 2011 triggered by a heavy earthquake and subsequent tsunami resulted in ground contamination whose level varies strongly geographically. In some areas contamination was high enough to necessitate long-term evacuation of the inhabitants. Similar to what has been observed after the Chernobyl accident in 1986, the deposition pattern is very patchy, as a result of the complexity of the controlling physical processes, i.e. release history and meteorological conditions.

We present an analysis of data of dose rate and estimated ^{134}Cs and ^{137}Cs deposition density acquired by the US-DOE through an airborne survey in April and May 2011, i.e. shortly after the accident (11 March) and the subsequent releases (until the first days of April). We analyse "patchiness" based on multi-fractal reasoning and local anomaly detection. If scaling properties of spatial structures can be discovered, this may be used to probabilistically estimate spatial structures below sampling resolution which is inevitably limited, in different ways, for both remote sensing and point sampling techniques.

RADIATION DAMAGES IN THE CRYSTALLINE ACTINIDE WASTE FORMS

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Nuclear power plants (NPPs) generate ≈12 % of total electricity in the world. The contribution of the NPPs in the world energy generation will likely to increase. The safe treatment with liquid high-level wastes (HLW) from spent nuclear fuel reprocessing is a crucial condition of sustainable nuclear fuel cycle development. The optimal method of the HLW treatment should include the reducing amounts of wastes required of long-term isolation from biosphere: minor An (Am, Cm) and REE separation from HLW, incorporation these elements into durable crystalline matrices and disposal in deep repositories (Laverov et al., 2008). Radiation resistance and low solubility in water are the most important requirements to the properties at selection of the suitable actinide waste forms. It is necessary to study the alteration of matrices properties due to α-decay of An to estimate their long-term behavior.

The goal of this research was to determine radiation resistance of the promising forms for actinides immobilization with pyrochlore and perovskite structures by their irradiation with 1 MeV Kr2+ or doping the phases with ^{244}Cm (T1/2=18 years). The quantitative parameters of radiation resistance are critical dose (Dc, displacements per atom, dpa) leading to amorphization and critical temperature (Tc) at which amorphization does not occurred with dose increasing. The influence of amorphization on matrices solubility in water is also investigated.

The samples were synthesized by cold pressing of powdered oxide mixtures with target composition and sintering at 1300-1500 C (5 h). Phase composition was determined by XRD method. Chemical compositions of phases in the ceramics were measured by scanning electron microscope with EDS. Ion irradiation and in-situ observations of structure transformation were performed at the Argonne National Laboratory (USA). Ceramics containing Nd as Cm imitator were produced before experiments with Cm-244 in NIIAR (Dimitrovgrad, Russia). Cm-doped samples were studied by X-ray diffraction method. Dc for all samples expect Zr-pyrochlore vary from 0.17 to 1.4 dpa, Tc from 210 to 650 C. Waste form with 10 wt.% of An-REE fraction will become amorphous for less than 500 years of storage. Due to high Tc the recovery of its structure will not occur at temperatures in geological repository (Yudintsev et al., 2014). The elements normalized leaching rate increases in 10-100 times after amorphization. Thus the low solubility of amorphous matrices in water will determine the safety of An immobilization.

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PLUTONIUM ^{241}Pu INFLOW WITH THE VISTULA AND THE ODRA RIVERS

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Most contamination studies have focused on alpha emitting plutonium isotopes so far. ^{241}Pu is less important in terms of its radiotoxicity than the α-emitting plutonium radionuclides ^{238,239,240}Pu but is quite significant because of its huge contribution to the whole plutonium fallout. Moreover beta-emitting ^{241}Pu (T1/2=14.35 years) decays to the long-living, highly radiotoxic alpha-emitting ^{241}Am (T1/2=432.2 years).

Significant amount of radionuclides are transported with rivers waters. The aim of the study was ^{241}Pu determination in the biggest Polish rivers (the Vistula and the Odra) and 3 Pomeranian rivers.

The research showed ^{241}Pu concentration depended on sampling season as well as the sampling site and the main source of ^{241}Pu was the global atmospheric fallout and the Chernobyl accident. The biggest ^{241}Pu inflow from the Vistula river was estimated for spring season while autumn season for the Odra river. Both rivers, and Pomeranian at a lesser extend, enrich the southern Baltic Sea inn 2.42 GBq of ^{241}Pu per year.

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THE SPATIAL DISTRIBUTION OF SOIL INVERTEBRATES ON THE GRASSLANDS WITH ENHANCED RADIOACTIVITY (VODNYJ, KOMI REPUBLIC, RUSSIA)

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Some populations of plants and animals exist and develop under constant effect of an enhanced radioactivity. The soil invertebrates are applicable objects for radioecological research. They have high species richness and diversity of ecological connections. They are sensitive to radioactivity effect because they can accumulate radionuclides from soil (Krivolutskij, 1994).

Researches were spent at the area with the impact of enhanced radioactivity. The study area is located near the Vodnyj settlement (63 °N 53 °E) and covers an area of 1300m. Contamination has been caused by storage of uranium mill tailings and radium production wastes. The spatial distribution of soil invertebrates at the impact plot 1 (20-25 mkGr/h) and background plot 2 (0.6 mkGr/h) was researched. 25 soil monoliths of size 5x5 cm (on Nematoda) and 10x10 cm (on other invertebrates) were sampled at the each square plot of size 20x20 m. After extraction of soil invertebrates the chemical analysis of soil monoliths was spent. The data analysis was spent by Statystica 6.0.

Nematoda of the plot 1 were presented by 32 genera with number 282 ±74 ind./100 cm3, Nematoda of the plot 2 were presented by 25 genera with number 212 ±43 ind./100 Cm3. The genera Diphterophora, Aphelenchus, Clarcus, Eudorylaimus, Anaplectus, Cephalobus, Tylenchorhynchus were abundant at the plot 1, the generaMesodorylaimus, Enchodelus, Eudorylaimus, Dorylaimoides, Rhabditis - at the plot 2. Oribatei had high number (17.7 ±7.5 thous. ind./m2) at the plot 1, Collembola had high number (11.5 ±1.9 thous. ind./m2) at plot 2. Number of Mesostigmata was low at the both plots (2.2 ±0.5 thous. ind./m2- plot 1, 4.8 ±1.2 thous. ind./m2 - plot 2). Collembola were presented by seven species at the plot 1 and 10 species at the plot 2. The species Parisotoma notabilis was dominant at the both plots. Also species Folsomia bisÐµtosa and Isotomiella minor were abundant at the plot 1, Isotomiella minor, Friesea mirabilis, Mesaphorura krausbaueri - at the plot 2. Large soil invertebrates were presented by 10 taxonomic groups. Thysanoptera (45 %) was dominant group at the plot 1, Lumbricidae (60 %) - at the plot 2. The average number of soil macrofauna was 846 ±100.2 ind./m2 at the plot 1 and 298 ±40.8 ind./m2 at the plot 2. Some distinctions at diversity and number of soil invertebrates were revealed at the impact and background plots. Different reactions of researched soil invertebrates were explained their biological features, especially different sensitivity to radioactivity. But the spatial distribution of any groups of soil invertebtrates did not determined variable distribution of radionuclides in the soil of the impact plot 1.

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EPIGENETICS CONTRIBUTION IN ADAPTATION OF MURINE RODENTS TO RADIOACTIVE ENVIRONMENT

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Problems of adaptation, heredity and microevolution of mammals exposed to ionizing radiation among several generations, are considered on an example of rodents occupying ecosystem in Ural which was contaminated with radionuclides for about 100 generations (nuclear disaster level 6 in 1957). Their initial population died from superlethal radiation 100-400 Gy. Decrement of the absorbed dose at the reproduction period to ~ 3 Gy gave an opportunity of permanent settlement. Currently, radiation is decreased to ~ 1 mGy/d. In 15-25 generations, viable association of small mammals was formed. Its important difference from the neighboring "pure" populations is the accumulation of ^{90}Sr in a bone and induction of radioadaptation - main microevolution event in a radioactive environment (Raushenbakh, Monastirsky, 1966; Il'enko, 1974; Lyubashevskiy, Starichenko, 2010). Radioadaptation results in viability under exposure to radiation doses even above 100 mGy/day (for example, in the first-second decade after the explosion), while the tolerance limit is at 1.0 mGy/d (ICRP Publication 108, 2008). Extent of adaptation of rodents considerably differs. Radioadaptation of an northern mole-vole (Ellobius talpinus Pallas, 1770) is perfect, that is without pathological deviations. But more than 70% of rodents have imperfect adaptation, accompanied with cytogenetic and hematopoietic damage, decreased immunity, etc. The northern mole vole complete isolation (migrants share <1%) and, on the contrary, continuous dilution of the adapted gene pool by migrants in other rodents (migrants share <10%) - is the reason for the differences in the extent of adaptation. The leading role of the hereditary nature of reactivity and pathology are testified through effects, which appearance require many generations, in particular, the specific frequency of phonetic characteristics and changes of the mandible shape (Vasil'eva et al., 2003; Bol'shakov et al., 2012). But distinction of haplotypes are not found at irradiated and control animals (Meeks et al., 2007, 2009; Modorov, Pozolotina, 2011). Immutability of genotypic pattern over 100 generations means, that a determinant in the formation of radioadaptation had not genetic, but epigenetic nature, which is consistent with the conclusions of phenetic research (Vasil'ev, 2005). Speed of processes is also characteristic and confirms epigenetics. Time of adaptation of northern mole-vole was limited to increase in radiation of its underground shelter. It borrowed no more, than 3 generations. Currently high correlation of intrafamily metabolism ^{90}Sr in northern mole-vole is observed. Intrafamily correlation accumulation ^{90}Sr also confirmed in experiments on mice linear (with the absence of interline differences). We believe that reversible epigenetic processes helped rodents to get rapid populational radioadaptation and a favorable forecast.

ESTIMATION OF EFFECTIVE DOSE IN INGESTION OF FOOD CROPS FOR ^{40}K

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Numerous studies have been conducted in order to determine the factor of transition of natural radionuclides for most important agricultural products. Several projects have been conducted by the International Atomic Energy Agency (IAEA) in order to determine the transition factor. These data are extensively applied in the models of radiological estimation. The natural radioactivity of the environment arises mainly from the original radionuclides, such as ^{40}K and the radionuclides from the series of ^{232}Th and ^{238}U and the products of their decay are considered the main cause of the internal radiation dose. Several studies have been conducted on the transition of the natural radionuclides from the soil to the plant in different regions of the world. For this reason, the goal of the current study was to estimate the effective dose that the human receives if he uses specific crops that are cultivated on previously analyzed soils. On the basis of the obtained specific activities of the soils and known TF for specific crops, specific activities in the crops have been calculated (Bq/kg). On the basis of such obtained activity for specific crops and the quantity of average ingestion of these crops in Macedonia, by using the dose coefficient e, the effective dose Def for adults is estimated. The selection of the crops is made because these crops are most commonly used in nutrition (most common crops in the nutrition).

The radiometric analysis of these samples was conducted by applying a γ-ray spectrometer with high purity germanium (HPGe), detector with 30% relative efficiency and energy resolution (FWHM) of 1.8 keV for 1.33 ÐœeV referential transition to ^{60}Co. The software used for obtaining data is Canberra software package Genie-2000.

From the very research one can perceive that the transport of ^{40}K from the soil to all types of plants is large, and at the same time it is the most important biological element required for normal functioning of plants. The highest level of 40K is found in the vegetables with mean value of 802,55 Bq/kg, while the level is lowest in root crops, 339,54 Bq/kg. The different lifestyle and the different food habits also contribute for differences in the estimation of the effective dose.

The total dose of ^{40}K from this research is 0.5497 mSv/year, which means that it is lower than the recommended dose which is 1 mSv/year. However, the total obtained estimated effective dose is lower than the recommended one which is 1 mSv/year.

These data can be the foundation for estimation of radioactive contamination risk for the population, which is received by ingestion of produced food. Before making final conclusions for the dangers of the exposure of the population to radioactive contamination, a more extended and more systematic examination of the field is required.

Key words: Radioactivity, soil, plant, transfer factor (TF)

RADIOECOLOGICAL CONSEQUENCES OF THE 50-YEAR OPERATION OF THE PLUTONIUM COMPLEX AT THE YENISEI RIVER

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The Yenisei is one of the largest rivers in the world. The Mining-and-Chemical Combine (MCC) of Rosatom, situated on the bank of the Yenisei, 60 km downstream of the city of Krasnoyarsk, consists of a reactor plant and a radiochemical plant. The MCC has been in operation for over 50 years, producing weapons-grade plutonium, and has contaminated the Yenisei floodplain with radionuclides. Annual expeditions of the Institute of Biophysics have revealed a number of facts suggesting that radionuclide concentrations in the Yenisei ecosystem are many times higher than their background levels. There are floodplain areas with abnormally high 137Cs levels in the soil and “hot” particles. Laboratory examination proved the reactor origin of those particles and made it possible to approximately date them. Sediment samples collected from the Yenisei River were found to contain layers with abnormally high levels of transuranics.

Aquatic plants are an important component of water ecosystems, which can accumulate high levels of radionuclides and, thus, can be used in biomonitoring and bioremediation. When the last MCC reactor was still in operation (before 2010), detailed analysis of radioactive contamination of aquatic plants of the Yenisei River revealed large-scale contamination of aquatic plants as far as 250km downstream of the Combine. Among macrophytes, the best accumulator of radionuclides is the aquatic moss Fontinalis antipiretica, followed by Potamogeton species and Elodea canadensis. The biomass of aquatic plants was also analyzed for heavy metals. Comparative analysis of the distribution of radionuclides and their stable isotopes as well as radionuclides and their analogs in the biomass of the Yenisei River macrophytes provided a better insight into major mechanisms of radionuclide accumulation. Cytogenetic investigations of submerged plants showed that at the MCC discharge site and downstream, the frequency of occurrence of chromosomal aberrations in ana-telophase and metaphase cells of plants was considerably higher than in the control area.

DOSE FORMATION AND BIOLOGICAL EFFECTS ON HELOPHYTE FROM THE CHERNOBYL EXCLUSION ZONE

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Long-term radioecological monitoring of water bodies in the Chernobyl Exclusion Zone (ChEZ) allowed collecting an extensive database of both the content of main dose-forming radionuclides in water, bottom sediments and macrophytes tissues, and variety radiobiological effects on plant organisms. Received data array permit to propose several hypotheses regarding the peculiarities of internal radiation dose (IRD) formation and caused biological effects on higher aquatic plants under long-term chronic exposure. Aerial-aquatic plants (helophytes) serve as a major barrier on radionuclide's transfer from contaminated territories to water. It is not a surprise that the registered radionuclide concentrations in vegetative helophytes vary widely. It has registered that over the last decade, a range of IRD into plants from ChEZ ponds varies within one or two decimal orders, regardless the post-accident time. For example, during 2006-2011 the IRD (μGy/h) on plants in one of the most radioactively contaminated pond of the ChEZ - Glubokoe Lake, varied: for the common reed Phragmites australis in range 0.17-4.2, for the bur-reed Sparganium erectum - 0.03- 0.48, for the bulrush Schoenoplectus lacustris - 0,03-1,3. Less variation - within one decimal order, has been marked through one vegetation period. For example, IRD (μGy/h) in plants of the same lake in 2012 varied: for reed from 1.05 (May-June) to 0.26 (November), the manna grass Glyceria maxima from 3.5 (June) to 0.75 (November). So, the IRD on helophytes is not the value of a steady decline after environment contamination. The additional superimposed effect of constantly varying IRD can modify both the intensity of the display and range of radiation effects. The following biological indexes were analysed: set of cytogenetic indexes - range and number of chromosomal aberrations, number of aberrations per aberrant cell in root meristems of 12 species of helophytes; for one of the referent species (the common reed) - panicles and seeds morphometric; set of reproductive indexes, set of indexes of seed vitality and abnormalities at earliest stages of ontogenesis. Biological effectiveness of IRD of long-term chronic exposure on wildlife referent species was calculated. The existence of "pseudo-safe" range of low doses based on the analysis of IRD bio-effectiveness under cytogenetic and seed vitality sets was revealed. Hormesis phenomenon at the level of seed vitality is accompanied by maximum level of sprout abnormalities and cytogenetic damages. Obtained field data of bio-effectiveness of long-term low-level chronic exposure on aquatic plants have a great importance for understanding the relationship between cytogenetic effects and reproductive ability. Presented data can be used both to model the expected biological effects on chronically irradiated non-human biota and for the calculation of the radiation risks to aquatic ecosystems.

NEPTUNIUM BEHAVIOR IN GNEISS ROCK MASSIVE ENVIRONMENT

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A great amount of radioactive wastes was accumulated during plutonium production and reprocessing of spent nuclear fuel. Isolation of radioactive wastes, especially of high level wastes containing long lived radionuclides, is the one of the actual challenges for fate of atomic energy. Current approach is to incorporate HLW in inert matrix and bury in deep geological repository designed in conception of multilevel safety system formed with both engineered (matrix, container etc.) and geological (rock massive) barriers. Area in gneiss rock was chosen as one of the probable lots for deep geological repository [1].

Neptunium is one of long lived radionuclides mobile in environment. It is redox sensitive radionuclide and can present in environment in different oxidation states. Since the most probable oxidation state of neptunium in the beginning of repository operation is (V) initial form of neptunium in all experiments was NpO_2^+.

Kinetics of neptunium uptake by gneiss and dolerite from the ground water were evaluated in oxic and anoxic environment at temperature 20 °C and 90 °C. All experiments were done for crushed or solid rock samples collected from the studied lot and modeling underground water. Speciation of sorbed neptunium and it's time and temperature depend changes were studied with modified Tessier's procedure of sequential extraction. It was shown that content of strongly bond fractions increases with time of contact. Rising temperature of contact slightly increases content of strongly bond fractions of sorbed neptunium and significant increase uptake with crushed rock.

Distribution of sorbed neptunium was studied by autoradiography. Single mineral grains with high concentration of sorbed neptunium were detected. In that neptunium oxidation state was studied by XPS. It was shown that at temperature 90 °C the most of sorbed neptunium is reduced to Np(IV) and exist as NpO_2 or $Np(OH)_4$ which are low soluble. Therefore elevated temperature will decrease mobility of neptunium in environment and in this case enhance radioecological safety of repository.

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BIOLOGICAL MONITORING OF THE ENVIRONMENT IN A VICINITY OF THE FAR-EASTERN CENTER FOR RADIOACTIVE WASTE TREATMENT

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Anthropogenic nuclear and industrial activities can substantially increase environmental exposure levels. Contamination of territories through human civil and military activities such as nuclear facilities operation, mining sites, nuclear weapon testing involves a complex impact so that there are a number of situations where a mixture of radionuclides is supplemented by other potentially hazardous substances. There is still a large lack of knowledge on actual hazard of such combined contamination for biota and human health.

This work was aimed at an estimation of impact from the Far-Eastern center on radioactive waste treatment (FEC) on the environment with techniques of biological monitoring. The FEC is located about 40 km of Vladivostok, Russia on the shores of the Sea of Japan, and it is considered as a potential source of radiation hazard. Two main technologies were used: bioindication of plant populations growing in the impacted environment, and a bioassay of underground waters collected from the site.

Sampling was done in May 2013. Soils for component analysis and plants of three species (five-finger, violet, white clover) were collected in five sites with dose rates ranging from 0.05 to 6.0 μSv/h. As indexes of the environmental well-being a fluctuating asymmetry of leaves and pollen fertility were used. Statistically significant increase in the index of fluctuating asymmetry in white clover was found in the site where external dose rate. In the same white clover population a rare morphological anomaly was found. Survey of reproduction index - pollen sterility, - showed an increasing of sterile pollen grains in violet plants along with external dose rate, while five-finger plants showed increased pollen sterility in the reference site.

In waters sampled from controlling wells at the territory of the FEC chemical components analysis as well as radionuclides activities were measured. Genotoxicity of underground waters was studied with Allium cepabio assay. Cytogenetic and cytotoxic effects were used as biological endpoints, namely, frequency and spectrum of chromosome aberrations and mitotic abnormalities in ana-telophase cells as well as mitotic activity in Allium cepa root tips. Dependences between biological effects and chemicals and radionuclides concentrations are discussed.

Complex issues are involved in evaluating environmental risk, and an effectively linking of bioindication screening assays to the well-established environmental pollution monitoring approach is a way of improving and upgrading an existing system of the public and the environment protection to meet requirements of consistency between nowadays scientific knowledge and decision-making process.

DISTRIBUTION OF GAMMA-RAY EMITTING RADIONUCLIDES IN THE COASTAL ENVIRONMENT OF THE CANDARLI GULF OF AEGEAN SEA, TURKEY

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The preliminary study focuses on the determination of ^{7}Be and ^{137}Cs in the beach sand samples collected from the 35 locations in Candarli Gulf Coast of Aegean Sea. Apart from these radionuclides, lithogenic radionuclides in the uranium and thorium series in the beach sands have also been determined. For these purposes, the activity concentrations of ^{7}Be, ^{137}Cs, ^{226}Ra, ^{232}Th and ^{40}K in the samples are measured by HPGe gamma spectrometry systems. In this work, preliminary findings facilitate to evaluate the background levels of the studied radionuclides in the coastal environment of the Candarli which is one of the culture and tourism center with its nature, historical magnificence, clean coast line and beaches. As a result, the study is aimed to provide a detailed characterization of the beach sands in terms of naturally occurring radionuclides (including cosmogenic radionuclide ^{7}Be) as well as ^{137}Cs and assess the risk due to public exposure of the natural background radiation as a part of the environmental monitoring program of the Nuclear Science Institute.

Keywords: ^{7}Be, ^{137}Cs, Natural radionuclides, Beach sand, Candarli Gulf Coast, Aegean Sea.

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SOIL AND VEGETATION FROM NOVI PAZAR (SERBIA) AND ROŽAJE (MONTENEGRO): RADIOACTIVITY IMPACT ASSESSMENT

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Soil samples from Novi Pazar (Serbia) and Rožaje (Montenegro) were analyzed by the ORTEC HPGe detectors with relative efficiencies 35 and 40%, for radioactivity due to ^{226}Ra, ^{232}Th/^{228}Ac, ^{40}K and ^{137}Cs. An average radionuclide activity concentration for Novi Pazar soil was found to be 27.6, 49.5, 585 and 14.9 Bq/kg, respectively; while in Rožaje, ^{137}Cs activity concentration was found to be significantly higher - from 33.9 to 322 Bq/kg. Obtained results were used to estimate hazard indices, such as radium equivalent activity (none of the locations showed a radium equivalent activity higher than 370 Bq/kg) and annual gonadal dose equivalent due to natural radionuclides, as well as external terrestrial gamma absorbed dose rate due to ^{226}Ra, ^{232}Th/^{228}Ac, ^{40}K and ^{137}Cs, and corresponding annual effective dose - used to evaluate excess lifetime cancer risk (then compared with the world average of 0.2×10-3, taking into account external terrestrial radiation - outdoor, i.e., average annual effective dose of 0.07 mSv). Vegetation samples from Rožaje - blackberry (Rubus fruticosus), spruce (Picea abies) and beech (Fagus sylvatica) showed 226Ra activity - 4.03, 1.1 and 0.99 Bq/kg, respectively; ^{232}Th/^{228}Ac - 4.5, <1.22 and 2.89 Bq/kg, respectively; ^{40}K - 152, 98.4 and 79.3 Bq/kg, respectively; ^{137}Cs - 3.05, 3.54 and 5.24 Bq/kg, respectively; whilst in Pinus sylvestris from Novi Pazar, they were - 2.7, 2.11, 163, <0.34 Bq/kg, respectively. Soil-plant radionuclide transfer factors were also estimated, and compared with typical ranges given in the UNSCEAR 2008 report. Since the most important radiation source for all terrestrial biota is activity from soil, the dose rates are also evaluated using known internal (and external - in soil) radionuclide activity concentrations, as well as corresponding the dose conversion coefficients for external and internal exposure to particular radionuclide.

NEUTRINO EMISSION AND THE SAFETY OF NUCLEAR OBJECTS

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In 1979, there was a serious accident in the U.S. at the Three Mile Island nuclear power plant (NPP) which involved two NPP units. In 1986, the world witnessed a large-scale disaster in the USSR at the Chernobyl NPP that operated four NPP units. The last major accident occurred in March of 2011 in Japan, where six reactors were involved.

It is known that during the nuclear reactions in the reactors the flows of anti-neutrino are released. At first, the neutrino (ν) emission was postulated as extremely high-penetrating, practically non-reactive to the matter. However, the capture cross sections (CCS) of ν, although really having very low values, are being measured at the extremely rough criteria. The situation here is somewhat similar to what happened to the neutron (n). n also has high penetrating capacity and often low CCS, but, nevertheless, the cases of resonant interaction processes of n, which have CCS of many orders larger than usual, were well known.

Since the discovery of the ν, the "pervasive bias" has been adopted in its properties description, and little is known about its possible resonant interactions with matter. Resonant interactions are widespread in the microcosm and the elementary particles physics, and it is not prudent to exclude their presence for ν, even with a very small probability. It must be said that for the relict ν, the high level of interaction with matter is already discussed, but with the proviso that it is not typical for nuclear ν. It is obvious for the major part of the ν energy spectrum, but not for resonant.

There is also another point: the interaction of ν with matter is among the weak interactions, but the interaction between the particles themselves can proceed according to strong interaction mechanism [1-3]. This radically changes the situation: the presence of two or more ν fields close to each other can lead to a strong interaction between them, precisely:

1) To a sharp acceleration of the inverse β-process which will lead to a large release of additional energy.

2) To an increase in the fraction of excited nuclei in fissile material, which will lead to a decrease in its critical mass, and to an uncontrolled change of the reactor regime to a supercritical state.

Therefore, the work of two or more reactors located near each other is extremely dangerous. However, the tendency to a greater increase in the number of cooperating NPP units (up to 7-8) is clearly observed. The conception of independence of the adjacent units, which is the prevailing conception at present, may appear misleading.

At present, the most dangerous situations exist in Japan, Canada, India, Ukraine and Russia. In addition to the mutual influence of NPP units, the question of the effect of natural neutrino flow on their work also requires a systematic study.

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COLLIDERS AND THEIR POSSIBLE GEORADIOCHEMICAL EFFECTS ON THE ENVIRONMENT

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A dangerous factor is considered, which may precede the formation of black microholes, strangelets, magnetic monopoles and other objects in colliders, – the probability of turning the Earth into the "iron planet" or the flow of iron asteroids and meteorites.

Proceeding only from real experimental evidence and theory-based provisions:
1) the quark-gluon plasma is experimentally proved,
2) the dependence of the binding energy per nucleon on the number of nucleons in the nucleus is both experimentally and theoretically proved,

we can assert that at the present moment the technical conditions for an uncontrolled conversion of all the chemical elements in the Earth to the elements of Fe-Ni-Co subgroup are already established, however with extremely low probability. But the possibilities of colliders are growing at a high speed and the dangerous threshold can be overcome in a very short time.

A special group, established by CERN to evaluate the safety of experiments, presented a report stating that the Large Hadron Collider is not dangerous. The dangerous process, which may occur from the uncontrolled formation of quark-gluon plasma of large volume and density in the conditions of the CERN experiment, is not considered at all. During this process, any substance turns into a cloud of elementary particles, which will condense under the cooling into the most energetically favorable state – the elements of the Iron Triad, which have the greatest values of the binding energy of the nucleons in the nucleus. The released energy will support this process till the complete conversion of all the chemical elements of the substance into the elements of the Iron Triad.

In the colliders, the energy of particles and the density of their flow are continuously increasing, which naturally leads to a "hotter" chromoplasma, and to the increase of its volume and density. According to the prevailing ideas of today, the unlimited expansion of the fireball is very unlikely, but there are other opinions. For example, E.Feinberg believed that the lifetime of fireballs is greatly underestimated [1]; Heisenberg's calculations were already giving the abnormally high cross-section of their formation [2]; and Fermi has long ago presented the scheme which allows a fireball to expand unlimitedly in the flow of the accelerator [3]. B.L.Ioffe also mentioned the abnormal parameters of the fireball, significantly different from L.D.Landau's calculations [4]. The probability of formation of an abnormally large fireball could be significant. The reaction of "ferruginization" may obtain a global or nearly global nature. The possible protective measures to prevent the probable future catastrophe are being considered, as well as the hazardous geotectonic conditions of the experiments at CERN.

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CS-137 IN AGGREGATE FRACTIONS OF ARABLE CHERNOZEMS: PLAVSK RADIOACTIVE HOT SPOT, RUSSIA

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It is generally agreed that strong fixation of Cs-137 by soil solid matter depends upon the specific radionuclide adsorption by clay minerals and clay-organic complexes. At the same time these components are important in aggregation of different grain size particles, which lead to formation of soil structure that is typical for each soil. So peculiarities of soil aggregation, disaggregation and secondary aggregation may reflect on the Cs-137 behavior in soil. To elucidate the contribution of different aggregate size fractions in total inventory of Cs-137 in soil the study in the area of Plavsk radioactive hot spot (Tula region, Russia) was conducted. geochemically related to each other three species of arable chernozems (not-eroded, eroded, deposited) and alluvial soil of the river floodplain with similar general properties (heavy loamy texture, bulk density 1.1-1.2 g/m3, pH 6.5-7.2, humus 5-7%) were selected for detailed investigation. Structural soil aggregate fractions the sizes of >10 mm, 10-7 mm, 7-5 mm, 5-3 mm, 3-2 mm, 2-1 mm, 1-0.5 mm, 0.5-0.25 mm and <0.25 mm were isolated by sieving from the upper 30-cm soil layer, and Cs-137 was measured in these fractions by γ-spectrometry method. It is found that the main parameters of Cs-137 accumulation strongly depend upon water and tillage erosion processes: average level of Cs-317 activity is 540 Bq/kg (120 kBq/m2) in not-eroded chernozem, 520 Bq/kg (160 kBq/m2) in eroded chernozem, 720 Bq/kg (200 kBq/m2) in deposited chernozem and 820 Bq/kg (210 kBq/m2) in alluvial soil of accumulative landscape. At the same time the distribution of Cs-137 over aggregate fractions in not-eroded chernozem and in virgin alluvial soil is relatively uniform, whereas one in eroded and deposited chernozems is more contrast with selective enrichment of aggregate fractions 5-3 mm, 3-2 mm, <0.25 mm for the first (in 1.6 times in comparison with average level for the soil sample) and aggregate fractions 5-3 mm, 3-2 mm for the last (in 1.3-1.4 times). The lowest Cs-137 activities in all soils are typical for blocky fraction the size of >10 mm, these values are about 1.5 times less than weighted average for total soil sample. Nevertheless blocky fraction makes up the large proportion of all aggregate fractions, so a high percentage of Cs-137 inventory in soil is attributed with structural particles >10 mm: 56% in alluvial soil, 36% in eroded chernozem, 19% in deposited chernozem, 16% in not-eroded chernozem. Generally, about 80% of Cs-137 pool is associated with agronomically valuable soil aggregates (10-0.25 mm) in not-eroded and deposited chernozems, while in eroded soil it falls to 60% due to a rise in blocky fraction mass. The smallest share of Cs-137 inventories (only 1-3%) is connected in all soils with negligible presented aggregate fraction <0.25 mm. Thus, spatial transformation of Cs-137 pollution areas could be closely connected with selection of definite soil aggregates in the process of water erosion.

A RECENT UPDATE ON PLUTONIUM RADIOECOLOGICAL MONITORING TECHNIQUE IN LITHUANIA, EASTERN EUROPE

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Plutonium is mainly an artificial radionuclide produced during nuclear testing and severe meltdowns of nuclear facilities and nuclear power plants. Due its radiotoxicity plutonium is of significant importance for radioecology. A modern-approach technique is being implemented for this radionuclide determination in the Center for Physical Sciences and Technology, Vilnius, Lithuania: a high transmission APEX IR module connected right to the high resolution inductively coupled plasma double focusing mass spectrometer. It is show that plutonium concentration and isotopic $^{240}Pu/^{239}Pu$ mass ratio measurements reveal uncertainties down to 12.7% (k=2) and 8.8% (k=2), respectively, besides, it is demonstrated that it is possible to detect plutonium reliably in low contamination environmental samples, too.

LOW LEVEL, CHRONIC EXPOSURE RELATED EFFECTS IN PLANT POPULATIONS

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The consequences of long-term chronic exposure to low pollutant concentrations is neither well understood nor adequately included in risk assessments. To understand effects of real-world contaminant exposure properly we must pay attention to what is actually going on in the field. However, for many wildlife groups and endpoints, there are no, or very few, studies that link accumulation, chronic exposure and biological effects in natural settings. To fill the gaps, results of field studies carried out on different plant species (winter rye and wheat, spring barley, oats, Scots pine, wild vetch, crested hairgrass) in various radioecological situations (nuclear weapon testing, the Chernobyl accident, uranium and radium processing) to investigate effects of long-term chronic exposure to radionuclides are discussed. In spite of high heterogeneity in response, we have detected several general patterns. Plant populations growing in areas with relatively low levels of pollution are characterized by the increased level of both cytogenetic alterations and genetic diversity. Accumulation of cellular alterations may afterward influence biological parameters important for populations such as health and reproduction. Presented data provide evidence that in plant populations inhabiting heavily contaminated territories cytogenetic damage were accompanied by decrease in reproductive ability. In less contaminated sites, because of the scarcity of data available, it is impossible to establish exactly the relationship between cytogenetic effects and reproductive ability. Contamination of the plants environment activates genetic mechanisms, changing a population's resistance to exposure. However, there are ecological situations in which enhanced resistance has not evolved or has not persisted. Consequently, there are good theoretical and practical reasons for more attention being paid to the mechanisms by which populations become more resistant and to those situations where adaptation appears not to be taking place. Since adaptation plays an important role in response of populations on radiation exposure, this process needs to be incorporated into management programmes. To this very day, the effects of chronic exposure on living organisms and populations remain poorly explored, and represent a much needed field of research.

NATURAL BACKGROUND RADIATION AND CANCER MORTALITY

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There are many places on Earth when the natural radiation is high. The studies of populations inhabiting such regions are of crucial importance for understanding an impact of low doses of ionizing radiation. The presentation critically reviews some recent literature that underscores the likelihood of the radiation-induced cancer and early childhood death in regions with high natural background radiation. These data show that the Linear-No-Threshold (LNT) hypothesis does not likely explain the results of recent studies whereas they favor the model of a threshold or hormesis.

BIOLOGICAL IN SITU REMEDIATION OF SUBSURFACE WATER HORIZONS NEAR TO RADIOACTIVE WASTE STORAGE

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Since the mid-twentieth century a significant amount of radioactive waste in different type of storages has been accumulated. A lot of them now are overloaded and conserved before the modern multi-barrier protection layer rule was run. This poses environmental threats to the surrounding territories.

The liquid radioactive waste (LRW) is aqueous solutions of inorganic and organic salts (acetate, sulfate, chloride, phosphate, oxalate, sodium bicarbonate, calcium, iron, ammonium) total mineralization of 300-500 g/dm3. The principal macro-amount components are nitrate salts at a concentration of 1-350 g/dm3.

At the underground storage of liquid radioactive wastes the nitrate anions may cause nitrate-dependent oxidation of the radionuclides adsorbed at the mineral and rock surfaces. This could increase the migration mobility of the considered radionuclides. The limit values observed for nitrate ion is now 45 mg/dm3 (i.e. for the underground fluids in the area of surface storage of the Siberian Chemical Combine (Seversk, Krasnoyarsk region), indicates a 50-fold exceeding the MAC). In case of their pour into the water intakes the risk of toxic effects appears.

The aim of this work was to study the physico-chemical and microbiological parameters of reservoir fluid samples near to conserved surface radioactive waste repository B-2 on the territory of "Siberian Chemical Plant" for the development and feasibility study of biotechnology clean groundwater from nitrate ions.

Denitrifying bacteria have been detected in all samples that were provided by the SCC operators. The samples have been collected from 3 wells located at different distances from the storage in a stream of liquid phase and outside it. The principal aim of this work was the selection of an effective substrate that can act as an electron donor for denitrification process. The complex substrates like dairy whey, kefir and yeast extract were finally selected because of the best efficiency/availability ratio.

The prospects for purification of contaminated groundwater ecosystems from nitrate ions in-situ by stimulating microbial denitrification processes after injection of the solutions containing available organic substrates (p.e. acetic acid, sucrose and the wastes from dairy and brewing industries) have been demonstrated. The technical parameters for the biotechnological process of in situ reprocessing of the injected underground waste of the "SCC" have been précised based on the laboratory tests. Thus the recommendations for its large scale implementation have been issued.

Pilot testing work at "SCC" took place in the period from late September to early November 2014. By injection of the organic components of the reservoir, water was completely decontaminated of the nitrate contaminant, converted to molecular nitrogen.

The environmental ore samples providing from SCC by A. Zubkov is highly acknowledged.

CORRELATION BETWEEN BERYLLIUM-7 IN ATMOSPHERIC DEPOSIT AND GROUND LEVEL AIR IN SERBIA FOR 2014

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Beryllium-7 is a naturally occurring radionuclide produced by spallation reactions through interactions of galactic cosmic rays with nitrogen and oxygen in the stratosphere (~70%) and upper troposphere (~30%). Following production, beryllium-7 is promptly attached to aerosols with diameter of 0.3-0.6 μm whose residence time in the atmosphere is around 20 days. The concentration of beryllium-7 in surface and rainwater is affected by both dry and wet processes. In wet deposition, precipitation transports beryllium-7 from the upper troposphere to the ground where the resident time of beryllium-7 is 10 days. This process usually occurs in the spring and summer, when air transport from the stratosphere to the troposphere is easily induced by the heating of the earth's surface.

Activities of beryllium-7 in depositions and ground level air were monitored in 2014 year, as part of radioactivity monitoring at 5 locations in Serbia (Niš, Vranje, Zlatibor, Zaječar and Palic) by the Radiation and Environmental Protection Laboratory, Vinča Institute of Nuclear Sciences. Samples of deposit were obtained using an area deposition collector (0.1 or 0.2 m2) and were collected on a monthly basis. Samples of air were collected on filter papers (technical characteristics Whatman 41, relative efficiency for deposited dust 80%) by constant flow rate samplers, ashed at temperatures below 400 °C and a monthly composite sample was formed. Activities of both deposit and air were present on sampling day (middle of the month).

The activities were determined on HPGe detectors (Canberra, with 18%, 20% and 50% relative efficiency) by standard gamma spectrometry.

This paper presents correlation between ^{7}Be activity concentration in atmospheric depositions and ground level air.

Key words: beryllium-7, gamma spectrometry, depositions, ground level air, correlation coefficient

ANALYSIS OF RADIONUCLIDES CONTENT IN SOIL SAMPLES FROM AREA OF ALEKSANDROVAČKA ŽUPA, SERBIA

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Naturally occurring radionuclide (uranium, actinium and thorium series and ^{40}K) are widespread in the environment. In addition, significant amount of ^{137}Cs may also be present in the soil as a result of accidents, such as Chernobyl accident. Thus, monitoring of radionuclides content in soil is of great importance. Aleksandrovac is small town in the western part of central Serbia and Župa is identified as the administrative territory of Aleksandrovac municipality. Nature of Aleksandrovačka Župa is under the long-lasting influence of anthropogenic factors, and therefore dominates altered natural landscape. Activity concentration of ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs in 26 soil samples collected from different location in the territory of Aleksandrovačka Župa were determined and presented. All soil samples were milled and sealed in 0.5 l Marinelli beakers, and stored for six weeks in order to reach radioactive equilibrium between ^{226}Ra and its descendants. All samples were measured by means of coaxial semiconductor HPGe detector (ORTEC GEM-30, 37% relative efficiency and 1.8 keV resolution for ^{60}Co at 1332 keV line). The detector was calibrated using the standards in the same geometry spiked with common mixture of gamma-ray emitters certified by Czech Metrological Institute. The activity concentrations of radionuclides ^{40}K and ^{137}Cs in soil samples were determined directly by analyzing full-energy peaks of their principal energies at 1460.83 keV and 661.66 keV, respectively. The activity of ^{40}K was corrected for the contribution of ^{228}Ac (1459.14 keV). The activity of ^{226}Ra was determined by analyzing full-energy peak at 186.21 keV, corrected for the contribution of ^{235}U (185.72 keV) evaluated via ^{235}U photo-peak at 143.77 keV and additionally approved by analyzing activity concentrations of its descendants (^{214}Bi and ^{214}Pb). Furthermore, the activity concentration of ^{232}Th was determined by using the evaluated activity of its descendants (^{228}Ac, ^{212}Bi, ^{212}Pb, and ^{208}Tl). All obtained activity concentrations were corrected for the coincidence summing effect, applying the calculation method of Debertin and Schötzig (1990).

Table1. The ranges and average values with standard uncertainty (s) of obtained activity concentrations in soil samples

Soil samples	^{226}Ra [Bq/kg]	^{232}Th [Bq/kg]	^{40}K [Bq/kg]	^{137}Cs [Bq/kg]
range	12.8 - 50.0	23.5 - 62.4	315.3 – 860.3	0.2 – 32.1
average ± s	30.5 ± 5.4	45.7 ± 2.3	527.6 ± 26.6	7.8 ± 0.5

Measured soil samples have activity concentrations of ^{232}Th and ^{40}K slightly higher than the World's average (30 Bq/kg and 400 Bq/kg) respectively, while activity concentration of ^{226}Ra is lower than the World's average (35 Bq/k) (UNSCEAR 2000). The obtained activity concentrations of ^{137}Cs in analyzed soil samples are comparable with values previously reported.

BIOSENSOR WITH IMMOBILIZED MICROBIAL CELL FOR RESEARCHING TOXIC EFFECTS OF RADIOACTIVE WASTE COMPONENTS

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During the extensive operational period of nuclear military and power facilities, the Russian Federation and the United States have accumulated significant volumes of radioactive wastes, which can cause a number of toxic/radiotoxic effects in the environment.

Radioactive waste consists of radionuclides and heavy metals as a microcomponents and the main macrocomponents are nitrate salts in concentrations up to 300 g per liter, oils, EDTA and other chelating agents. Toxic effects caused by exposure of radioactive waste components are key issues in radioecology and environmental biotechnology, for example, for monitoring nuclear objects after conservation. To assess the toxic effects on ecosystems the test models (algae, plants, protozoa, arthropods, fish) are usually used, but such methods often include expensive and long-termed processes.

The aim of this paper is to assess the toxicity of radioactive waste on the ecosystem by electrochemical method based on the respiratory activity of aerobic bacterial cells immobilized onto sensor surface of the modified Clark electrode. This method allows obtaining the data indicative of the waste components concentration effect on the rate of cellular respiration. The recognizing element (bioreceptor) based on immobilized living species cells was fixed at the measuring surface of an oxygen electrode Clark type using a nylon mesh. In this case, we used the cell suspension, which contained 10 μg of cells. The time consumption for each separate single measurement was about 4 to 8 min.

The living biosensor filling cells used for this work were selected from the collections of aerobic organotrophic bacteria from groundwater samples exposed to radioactive waste from PO "Mayak" and Syberian Chemical Combine. Nitrate ions, metals, organic compounds concentration effects on the process of cellular respiration have been established.

DISTRIBUTION OF ANTHROPOGENIC RADIONUCLIDES IN WATER-SOIL-PLANT ECOSYSTEMS IN ARARAT VALLEY

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Armenian NPP (opened in 1976, operated till 1989, reoperated in 1995) is in a densely populated area of the Ararat Valley with intensive agriculture. Ararat Valley is in the south-western part of Armenia, about 850-900m above sea level. It has dry continental climate, the average annual temperature is 11.0-11.80 C, and the relative humidity is 40% and average amount of annual precipitation: 200-300mm. Since 1996 we have carried out radiomonitoring researches in water-soil-plant ecosystems in zones of the ANPP with a radius of 2-15km, 20km (Ashtarak town territory), 30km (Yerevan, territory of the Institute of Hydroponics Problems). These investigations have practical importance as the developed protective measures can be used in polluted anthropogenic zones. This will give an opportunity to obtain ecologically safer agricultural products. It turned out that irrigation water, irrigated gray soils and plants (herbs-grain, clover (Trifollium L.), amaranth (Amaranthus retroflexus), medicinal plants- broadleaf plantain (Plantago major L.), burdock (Arctium lappa L.), stinging nettle (Urtica dioica L.)) of the agrocenosis surrounding the ANPP exceeded the same objects in Ashtarak and IHP with RN content. The irrigation water in the surroundings of the ANPP (River Metsamor) contained 2.4 and 2.4 times more ^{90}Sr and 1.2 and 1.4 times more ^{137}Cs than the ones in Ashtarak (River Qasakh) and IHP (River Hrazdan). The irrigated soils (0-30cm) in the vicinity of the ANPP exceeded the soils in Ashtarak 1.1 and 2.3 times and IHP 1.3 and 1.2 times with ^{90}Sr and ^{137}Cs content, correspondingly. The content of ^{90}Sr in natural waters exceeded ^{137}Cs in the Metsamor, Hrazdan, Qasakh Rivers 12.0; 7.1; 6.2 times. It was proved that absorption of ^{137}Cs by herbs exceeded the absorption of ^{90}Sr, and in case of medicinal plants the opposite thing happened and the absorption of ^{90}Sr exceeded ^{137}Cs. This can be seen in the observed ratio (OR= ^{90}Sr /^{137}Cs in plant ÷ ^{90}Sr /^{137}Cs in soil) value of ^{90}Sr and ^{137}Cs couple in soil-plant system (OR<1 for grain, clover and amaranth, and OR>1 for broadleaf plantain, burdock and stinging nettle).

It turned out that there are positive strong (^{90}Sr - ^{137}Cs couple correlation coefficient-r=0,8±0,15), positive average (ash-^{90}Sr couple r=0,6±0,19; ash-^{137}Cs couple ` r=0,5±0,22; ^{90}Sr AC -^{137}Cs AC couple r=0,6±0,20), positive weak (OR-^{90}Sr AC couple r=0,2±0,24), negative weak (OR-^{137}Cs AC couple r=-0,3±0,23) comparative connections between plant indices.

Among the studied herbs amaranth was an accumulator of RN. Based on that we can suggest introducing amaranth as a phytomeliorant plant in soils contaminated with RN, in order to obtain radioecologically safer agricultural products (as a radioprotective activity). The content of controlled artificial RN (^{90}Sr, ^{137}Cs) in irrigation water-soil-plant systems of the ANPP, Ashtarak and IHP agrocenosis was within the allowed concentration limits.

BIOACCUMULATION FACTOR OF THE HEAVY METAL IN DIFFERENT FISH SPECIES FROM THE NEIGHBOURING SEA OF KOREA

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The concentrations and bioaccumulation factor of 16 heavy metals in marine organisms at the Korean coast were measured and investigated, respectively. The 88 seawater samples, 105 fish samples, 4 squid samples and 5 shrimp samples were measured the concentrations of heavy metals. The bioaccumulation factor in 88 sampling locations was analyzed in concentration of seawater and marine organisms.

The concentrations of heavy metal in seawater increased in the order of Ba<mn<cd<co<cr<pb<ni<cu<zn<mo<p<fe<rb<sr<br<na.< p=""></mn<cd<co<cr<pb<ni<cu<zn<mo<p<fe<rb<sr<br<na.<><Mn<Cd<Co<Cr<Pb<Ni<Cu< Zn<Mo<P<Fe<Rb<Sr<Br<Na.

Metal concentrations were highest in the whole body shrimp, except for P and lowest in the squid muscle of all the fish species, except for Cu. Highest concentrations of Na (8070±6160 mg·g-1), Fe (258±313 mg·g-1) and Sr (101±53 mg·g-1) were measured in shrimp, respectively. The concentrations of muscle in fishes showed strikingly high Na (1680±1280 mg·g-1), Sr (19.8±9.5 mg·g-1) and Fe (14.1±13.5 mg·g-1). The concentrations of muscle in squid showed Na (758±362 mg·g-1), Fe (6.88±8.30 mg·g-1) and Sr (3.94±3.47 mg·g-1). The results indicated that the concentration of metals in the shrimp was higher than that in the fish and squid.

The mean bioaccumulation factor of the heavy metal except for Ba, Mn, Cd and Fe were similar to the recommended value from IAEA (2004), were not similar to the value reported from KAERI(1989).

DISTRIBUTION OF CS-137 AMONG ABOVE- AND BELOWGROUND PARTS OF AGRICULTURAL CROPS IN THE AREA OF POST-CHERNOBYL HOT SPOT

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Of the radioactively contaminated lands of Russia there are highly fertile chernozem soils, which remained in agricultural use despite Chernobyl fallout as was the case of Plavsk radioactive hot spot (Tula region). currently Cs-137 activities in soils of the area taking into account initial level of contamination, land use and the position of relief vary from 450-700 Bq/kg (170-280 kBq/m2). The process of Cs-137 accumulation in vegetation biomass is urgent to be under radioecological control at this area. To assess parameters of Cs-137 stockpiling in agricultural grass vegetation 8 agricultural crops of field rotation from the territory of Plavsk radioactive hot spot (spring wheat, spring barley, maize, summer rape, galega, potatoes, amaranth, lucerne-grass mixture) were selected for the study. Above- and belowground parts of plant biomass were separated for the detailed examination. To avoid the difference in Cs-137 content in soils of the plots and to appreciate the biological peculiarities of individual crops the transfer factor (TF) values (the ratio of the Cs-137 activities in vegetation and in soil) were calculated. TF values in total biomass (TFtot) for all vegetation species are under 0.1 that confirms a pronounceable discrimination of Cs-137 root uptake from contaminated soils. Among the investigated agricultural crops TFtot is minimal for rape (0.01), middle – for amaranth, lucerne and galega (0.03-0.04), wheat, barley and potatoes (0.05-0.06), and maximal – for maize (0.13). Correlation analysis demonstrate that TFtot is invariant with total as well as above- or belowground biomass and the rate of plant growth, but seemly depends on root capture capacity (r=0.68). Thus, physiological features of different plant species and families affect the specific Cs-137 bioavailability. An accounting the distribution of Cs-137 among above- and belowground parts of agricultural crops on the basis of TFag and TFbg comparison also clearly shows the importance of biological characteristics of plants: wheat, barley and maize (Gramíneae family) are characterized by elevated Cs-137 activity in belowground parts (12-14 times higher than in shoots) with TFbg 0.16-0.19; rape (Brassicaceae family) and potatoes (Solanaceae family) are characterized by similar TFag and TFbg (0.01 for rape and 0.05-0.07 for patatoes); while galega, lucerne and amaranth (Fabaceae and Amaranthaceae families respectively) are characterized by higher Cs-137 activity in aboveground part (4-6 times more than in roots) with TFag 0.04-0.06. Considering vegetation biomass structure and Cs-137 activities in above- and belowground parts of agricultural crops 86-96% of the radionuclide inventory is associated with belowground biomass in cereals communities, while in agrosystems of legumes or amaranth 87-93% of Cs-137 inventories are deposited in green aboveground parts of vegetation. Study was conducted with the support from the Russian Foundation for Basic Research (№– 14-05-00903).

CESIUM-137 MONITORING USING MOSSES AND LICHENS FROM WEST MACEDONIA, GREECE

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^{137}Cs concentrations of mosses, lichens and substrate (soil, bark) collected from North Greece were measured 20 years after the Chernobyl accident. Archive materials from previous works were also used for comparison and diachronic estimation of the radio-contamination evolution. Maximum bioaccumulation capacity of ^{137}Cs was observed in epilithic lichens in comparison to epigeic or epiphytic ones, whilst the epilithic mosses prevailed in comparison to the epiphytic ones. Foliose or crustose lichens were more contaminated than filamentose in the same biotope. Among filamentose or fruticose species those with large surface area to biomass ratio, e.g. Usnea sp., showed also greater bioaccumulation capacity. Autoradiography revealed an amount of ^{137}Cs distributed more or less uniformly in lichen and moss thalli. The high ^{137}Cs activities found in lichens and mosses 20 years after Chernobyl suggest that these primitive plants are effective and suitable biological indicators of the distribution of radionuclide fallout pattern.

POLONIUM ^{210}Po IN CALCIUM SUPPLEMENTS

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Polonium-210 is a radio-ecologically interesting natural element to investigate due to its high radiotoxic characteristics. It occurs widely in the terrestrial and marine environment and as an α-emitter, is an important component of Man's natural radiation background. ^{210}Po belongs to natural uranium series starting from ^{238}U, but its fate depends on further members of this series e.g.^{226}Ra, and most of all on ^{210}Pb. This radioactive element is, together with radon, the natural radioactive material delivering the highest natural dose to living organisms. While it is widely present in the environment, some amount of polonium could occur in natural calcium supplements - mineral (e.g. dolomite) or biological (e.g. marine organism shells) origin.

The aim of the study was polonium ^{210}Po determination in popular calcium supplements for adults. The research covered 8 different supplements: 4 mineral calcium compounds (soluble calcium carbonate, dolomite and 2 produced from marine shells) and 4 organic calcium compound (calcium lactate, gluconate, pantothenate and diglycinate).

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EPIPHYTIC LICHEN (XANTHORIA PARIETINA) AS BIOMONITORS OF ^{210}PO IN THE CATALDAG GRANITOID AREA, WESTERN ANATOLIA/TURKEY

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Lichens are widely used as biomonitors both of trace elements and radionuclides due to their ability to accumulate the persistent pollutants with very high levels. The study has been performed in the Çataldağ plutonic area located in northwestern Anatolia where granitic rocks are widespread. It is well known that the bedrock lithology is a key factor in the presence of radon activity in soil gas as well as airborne radon. On the basis of the dominant lithologies and the radiometric results as well, the lichen samples were mainly collected from the sites located on soil gas radon rich ground in the Çataldağ granitic area in order to evaluate the possible increase of ^{210}Po activity levels by the ^{222}Rn in the air. The distributions of ^{210}Po activity concentrations in Xanthoria parietina from the study area are ranged from 55 to 253 Bq/kg on the dry weight basis with an arithmetic mean value of 124 Bq/kg.

POLONIUM ^{210}PO AND RADIOLEAD ^{210}PB IN EDIBLE MUSHROOMS COLLECTED IN NORTHERN POLAND

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The aim project was ^{210}Po determination in caps and stems of mushrooms from *Leccinum pseudoscabrum, Leccinum aurantiacum, Leccinum vulpinum, Leccinum duriusculum* and *Leccinum quercinum* collected in Pomorskie, northern Poland. Mushrooms contain a lot of water (75-90%) and absorb heavy metals from the environment such as mercury, chrome, cadmium. Our previous studies have shown radionuclides (e.g. polonium, uranium, plutonium) are accumulated in green plants and mushrooms as well. Radioactive elements are taken either from the soil, through the mycelium or directly from the entire surface gathered in the fruiting bodies. After the Chernobyl accident radioactive contamination of the environment has grown considerably.

In our research naturally occurring ^{210}Po and ^{210}Pb were determined. The average ^{210}Po concentration in mushrooms caps and stems ranged from 0.85 ±0.09 Bq·kg-1 in *Leccinum quercinum* stem to 10.77 ±0.47 Bq·kg-1in *Leccinum pseudoscarbum* cap. Analysis of ^{210}Po concentrations in mushrooms showed its higher values in caps in comparison to stems. This means the main source of ^{210}Po was wet and dry atmospheric fallout. The studies showed interspecies differences in polonium and radiolead accumulation among all analyzed species.

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PREDICTABILITY OF LEAD-210 IN SURFACE AIR BASED ON MULTIVARIATE ANALYSIS

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The dependence of the activities of lead-210 in surface air on meteorological variables and teleconnection indices is investigated using multivariate methods of analysis. Concentrations of lead-210 have been monitored at the Vinča Institute of Nuclear Sciences in Belgrade, Serbia, since 1985, and the measuring procedure provides the monthly mean activities determined on HPGe detectors by standard gamma spectrometry. The meteorological data, consisting of eight variables: minimum, maximum and mean temperature, atmospheric pressure, relative humidity, precipitation, sunshine hours and cloud cover data, are obtained from the European Climate Assessment & Dataset and the Republic Hydrometeorological Service of Serbia. Eight teleconnection indices of large scale atmospheric circulation: North Atlantic Oscillation, East Atlantic Pattern, East Atlantic/West Russia Pattern, Scandinavia Pattern, Polar/Eurasia Pattern, Pacific/North American, East Pacific-North Pacific, and West Pacific are obtained from the data archive of the United States National Oceanic and Atmospheric Administration's Climate Prediction Center.

The most appropriate multivariate method of analysis of lead-210 dependence on these input variables is selected from a wide spectrum of multivariate methods implemented in the Toolkit for Multivariate Analysis software package. The evaluation ranking results show that the Boosted Decision Trees method is the most suitable for the variable analysis. Further multivariate analysis results give a mapped functional behaviour of the lead-210 concentration dependence upon the climate variables and large atmospheric circulation (via the teleconnection indices).

The obtained behaviour is then used to test the predictability of lead-210 in surface air. In the test, the lead-210 activities measured in 2011 and 2012 are compared to the calculated values obtained through the mapped functional behaviour which is based on the 1985-2010 measurements. The results are discussed in reference to characteristic time-periods of the examined variables, which are calculated in the wavelet transform analysis.

INVESTIGATION AND ASSESSMENT OF LEAD-210 AND CAESIUM-137 CHRONOLOGY OF LACUSTRINE SEDIMENTATION

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Lakes are dynamic response systems that integrate environmental, climatic and tectonic forcing into a continuous, high-resolution archive of local and regional changes. These changes are studied basing on palaeolimnological approach with the key goal of constructing the reliable chronology for coupling numerous proxies of environmental changes.

Results of investigation of sedimentation processes in a few lakes located in the Baltic Uplands, the western part of the East European Plain (East Lithuania, East Latvia and North East Poland) are presented. The various gravity corers were used for taking short (up to 80 cm in length) sediment cores. The sliced and dried samples were examined for Pb-210 and Cs-137 specific activity and for components of sedimentary matrix (eg. material composition, granulometry, trace elements content). Pb-210 dating of cores (taking into account the peaks of specific activity of Cs-137) was performed according to constant rate of supply (CRS) model with some modification using gamma ray assay for determination of radionuclide activity and estimating dating uncertainty by first-order-analysis. The activity of radionuclides of interest was determined using HPGe coaxial well photon detector system (GWL-series). The well-type detector can accommodate small samples in the well with effective volume up to 4 cubic centimeters. The gamma ray spectra were calculated using Gamma Vision (ORTEC ®) software. The gamma-ray spectrometric system has been calibrated against standard radioactive sources with known Pb-210 and Cs-137 activities and other radionuclides with clear full-energy peaks. The measuring container filling height and sample density was taken into account during both efficiency calibration and actual sample measurements. A number of naturally occurring radioisotopes from the U and Th decay series were also determined.

The estimated parameters for the lacustrine sedimentary records were mean sediment mass accumulation rate, derived linear rate of accumulation of wet bulk sediment layer, percentage of components of sedimentary matrix. Based on radioisotope geochronology, the time intervals of change of sediment sources related with the major hydrological events and hydrographic changes in the relevant catchments were analyzed.

The radionuclides specific activity vertical changes corresponds to trace element contents in sediments what is a straight response to the economic activity in the region during the last 200 years. From the 19th century the sediments accumulated on the bottom of the lakes are characterized by the continuous increase of selected trace elements content of such as Cd, Cu, Pb and Zn (it was so called Industrial Revolution period). For last 20-30 years the concentrations of heavy metals decrease due to the more efficient sewerage and smaller atmospheric supply. This proxy can be used for the improvement of the sediments dating.

INVESTIGATION OF PLUTONIUM AND CESIUM ACTIVITY CONCENTRATIONS IN THE PROFILES OF LAKE BOTTOM SEDIMENTS IN LITHUANIA

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World-wide spread long-lived radionuclides such as plutonium isotopes, ^{137}Cs, ^{241}Am, ^{237}Np, ^{99}Tc are of great concern in studying the radioactive contamination of environmental systems. Investigations of artificial radionuclides in environmental samples after the Chernobyl accident have shown uneven contamination of surface soil and other environmental systems with ^{137}Cs and plutonium isotopes.

The aim of the current study is to investigate vertical distributions of ^{137}Cs, ^{238}Pu and ^{239,240}Pu activity concentrations in bottom sediments of two eutrophic shallow lakes in Lithuania.

Lake Juodis (54°46′49" N, 25°26′29" E) is situated in the eastern part and Lake Parselis (54°05′04" N, 24°41′47" E) in the southern part of the Lithuanian territory at a distance of about 100 km. Lake Juodis is a running through water body without groundwater feeding sources, while Lake Parselis is fed by bottom sources from the nearest swamps. The water layer in both lakes is transparent and of a similar thickness (2-3 m). The sediment cores were taken down to the 40 cm. Each core was divided into 2-2.5 cm thickness slices according to the depth and the analysis for ^{137}Cs, ^{238}Pu and ^{239,240}Pu was carried out. The ^{137}Cs activity concentration in the slice was determined following the γ-spectrometric measurement. Concerning the other radionuclides, bottom sediment samples were radiochemically treated. Anion-exchange and extraction chromatography methods were used to separate and purify the plutonium analyte from interfering stable and radioactive substances. Plutonium isotopes electrochemically deposited on polished stainless steel discs were measured using α-spectrometry.

The distinctly expressed peak activity concentrations of ^{239,240}Pu in a range of ~16-28 Bq·kg-1 in the 16-25 cm depth interval in Lake Juodis were observed. The inventory of ^{239,240}Pu of this vertical profile was 104.3 Bq·m-2. The inventory of ^{239,240}Pu in Lake Parselis was determined to be 94.3 Bq·m-2. A single distinct peak (~ 295 Bq·kg-1) at the ~23 cm depth with a steep slope down to deeper sediment layers and with a rather smooth one up to the sediment surface was characteristic of the radiocesium vertical profile in the sediment core from Lake Juodis. The total load of ^{137}Cs in the core was ~ 1518 Bq·m-2 while the total load of this radionuclide in Lake Parselis was almost two-fold higher, i.e. 3028.6 Bq/m2.

The activity concentration ratios ^{238}Pu/^{239,240}Pu and ^{137}Cs/^{239,240}Pu were applied to identify the origin of plutonium and ^{137}Cs contamination in the cores of bottom sediments.

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WAYS OF SAFETY BARRIERS CREATION USING SILICATE COMPOUNDS

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Safety barriers should be constructed to prevent leakage of radionuclides and other contaminators from radioactive waste storages and repositories. Barrier types can be different in processing technology, materials, location (inner or outer barrier) etc. Combination of different barriers and sufficient quantity of them make whole safety system to be proof.

Materials, used for creation of safety barriers near radioactive waste storages, should be compatible with rocks and formations around the storage. Natural materials based on silicate compounds and minerals (e.g. clays) comply with the requirements. Variants of these barriers creation using natural bentonite clays via dry filling or solution injection are discussed. Creation of “wall in the ground” barrier via injection of various aluminosilicate gel-forming liquids based on liquid glass is also possible. This barrier allows to decrease filtration rate through water-saturated sands down to 10-3 - 10-4 m/day. Good sorption properties of constructed barriers are achieved by adding of phosphates in gel-forming compositions. Actinides distribution coefficient on samples of this barrier reaches 3 ·104 cm3/g.

NATURAL URANIUM IN BULGARIAN DRINKING WATERS-RESULTS AND ORIGIN

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Results for natural uranium content in 952 Bulgarian drinking waters, mainly from the Southwest part of the country are presented. The mean value is 2,17 μg/l with Std. Dev. 7,56 μg/l. Results vary between 0,002 and 110 μg/l. The histogram of the frequency shows that 856 results are less than 15 μg/l and just 4 % are near limit of 30 μg/l. High variations between results, even in the close geographically located sources have been observed. Those relatively large differences in the concentration range of natural uranium probably are due to the wide variety of physical, geographical and geological conditions for the formation, dynamics and the groundwater regime in Southwestern Bulgaria. Higher concentrations of natural uranium are registered in the waters which formation is made near uranium deposits. When considering the results with the highest content presented we found that the aquifers are located in an area characterized by granite and granitoid intrusions (plutons) implanted in metamorphic complexes. For this area, characterized by a high content of natural uranium in the past has pursued uranium mining and processing. It is known that the mining activities could affect the content of uranium in drinking water. Generally deposits of uranium in Southwestern Bulgaria are two types of hydrothermal attached to igneous rocks and sedimentary. Hydrothermal deposits are embedded in rocks of different ages (Paleozoic, Triassic, Paleogene and others.). The yield of this type is carried out mainly underground. Some deposits of sedimentary origin were also developed by mining techniques. In the later stages of operation underground leaching has been applied in some hydrothermal deposits. As a result of the close of mining and processing of uranium in Bulgaria, regardless of the activities carried out by eliminating the consequences continue the process of introduction of uranium and associated elements of it into the environment through processes of physical and chemical weathering. Seized rock can fall surface in physicochemical conditions different from the conditions of their formation, which puts them in disequilibrium with their environment. As a result, start processes of physical and chemical weathering by expressing the necessity to achieve equilibrium with the new environment. Mobility of uranium is controlled substantially by the redox potential of the water through which transports and determines the distance can be transferred this element. It is possible re-mobilization of uranium accumulation not in its own minerals, as isomorphic impurity in oxides and carbonates of iron and manganese. As a result of these processes we found possible second hypothesis for the cause of the higher values in drinking water from the sources which are not located near the former uranium mining sites, but could be influenced by them through physical processes and chemical weathering. This hypothesis puts focus on the range and frequency of the monitoring of drinking water near former uranium mines.

RADIOLOGICAL STATUS OF THE SANDS ALONG THE BULGARIAN BLACK SEA COAST

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In the period 2011-2014 the group from NCRRP in collaboration with the partners through BS ERA NET Project “Radiation background of Black See coastal environment” did an extended research on the Black sea coast. In the research we evaluated many radiological factors. One of the main focuses was to determine radionuclides content in costal sand. Radiochemical analyses on Sr-90 determination in were provided. Gamma-spectrometry analyses on Cs-137, Ra-226, Th-232, K-40 and natural uranium were done.

In this paper are reported results for sands from Bulgarian coast of Black see. The results for K-40 are from 4,9±0,7 to 1152 ±47 Bq/kg. For Cs-137 vary between 0,36±0,12 and 6,36±0,35 Bq/kg. Ra-226 is from 1,83±0,22 to 237±11 Bq/kg. Th-232 vary between 0,79±0,09 and 17,3±1,3 Bq/kg. The natural uranium content is from 0,46±0,16 to 22,1±4,3 Bq/kg. The results for Sr-90 are from 0,26±0,07 to 1,22±0,11 Bq/kg.

The highest values for natural radionuclides were determined in the area named “Vromos bay”. This area was contaminated by ex-mining activities of copper. Despite of the remediation actions that were done, the pollution with high values of natural radionuclides could still be registered.

The content of Cs-137 and Sr-90 is due to Chernobyl accident.

The Project ended last year and we are eager to share our findings.

DOSE CONTRIBUTION OF ^{90}Sr AND ^{137}Cs IN MIXED DIET FROM BULGARIA

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After the Chernobyl accident in 1986 large areas were contaminated with artificial radionuclides. Among radionuclides with particular importance are ^{90}Sr and ^{137}Cs because of their high radiotoxicity and medium-long half-life. Almost 30 years later, the content of both radionuclides is not such as would be expected only in the light of their half-lives. There are other factors that affect their contents into the environment: reactivity of the elements Sr and Cs, mobility in the nature. Strontium compounds are generally more insoluble in water than the cesium ones, which determine lower mobility for strontium compounds and ^{90}Sr in respect. The concentration of radionuclides in the environment to a large extent determines their concentration in food products intended for human use.

In the NCRRP we perform regularly analyses for content of these and other radionuclides in various food products, including mixed 24-hour diet (mixed diet). After calculating of the dose for the period 2008-2013, emerges the conclusion that the contribution of ^{90}Sr to the dose is 5 to 10 times higher than that of Cs-137. The dose, estimated from both ^{90}Sr and ^{137}Cs for that period in the mixed diet vary between 0,57 ÷ 1,20 μSv/y.

The analysis of the content of ^{90}Sr in the food products is much longer, laborious and expensive, compared to the gamma-spectrometry determination of the content of ^{137}Cs. However, the analysis of ^{90}Sr in the food products should not be underestimated and should be performed regularly.

TRANSFER COEFFICIENTS OF ^{137}Cs FROM DIET INTO MILK OF DAIRY HERDS

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Transfer of ^{137}Cs from diet into milk of dairy herds was studied in the paper. Investigation was performed at farm with 500 Holstain-Frisian dairy cows.

Samples of diet components and water were taking during the sampling of fifteen-day milk samples in winter and summer period. The samples of one-day milk were also taking for the purpose of control of obtained results.

High resolution coaxial HPGe detector with relative efficiency of 25 % was used for the measurements. Concentration activities of ^{137}Cs were calculated from the energy of ^{137}Cs at 661.6 keV.

Transfer coefficients of ^{137}Cs were moving in range 0.0027 - 0.0049 d L-1 for the fifteen-day milk samples and0.0029 - 0.0059 d L-1 for one-day milk samples.

Obtained results indicated that lactation period and milk yield had no influence on transfer of ^{137}Cs from diet into milk. Transfer coefficient value of ^{137}Cs was influenced by qualitative diet components, principally by content of crude fiber and cereals.

TECHNOGENIC RADIONUCLIDES IN SOILS AND PLANTS OF THE EAST URAL RADIOACTIVE TRACE (KYSHTYM DISASTER, 1957)

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The East Ural Radioactive Trace (EURT) is a result of the accident at the Production Association (PA) Mayak in 1957. Among long-lived radionuclides ^{90}Sr was the primary emission contaminant. Later, in 1967, the EURT area was contaminated again with air-borne radioactive sediments from the Karachay lake shores. Lake Karachay was used by the PA Mayak for dumping liquid radioactive waste. At this case the primary contaminant was ^{137}Cs (Tsaturov and Anisimova, 1993; Aarkrog et al., 1997). In 1966 the East Ural State Reserve (EUSR) with the total area of 166 km2 was established in the head part of the East Ural Radioactive Trace. This territory is unique polygon for radioecological investigations.

The aim of this work: the study of the distribution of ^{90}Sr, ^{137}Cs and $^{239,240}Pu$ in the soils of the East Ural Radioactive Trace and their accumulation by plants of different taxonomic groups.

The results of the research showed that levels of soil contamination vary: for ^{90}Sr it is 1-70,000 kBq m-2, for ^{137}Cs - 2-1500 kBq m-2 and for $^{239,240}Pu$ - 0.06-170 kBq/m-2 at the EURT territory. Spatial distribution of the radionuclides depending on the distance from the epicenter of an accident with a high degree of reliability can be approximated by an exponential function. 55 years after the accident more than 50% of radionuclides retained in the root-inhabited layer of soil (0-30 cm).

Studied plants (grass, mosses, lichens, woody plants) differ by morphological, physiological and ecological characteristics, life expectancy. The plants (regardless of their taxonomic affiliation) accumulate the most of all ^{90}Sr, after that ^{137}Cs and the least $^{239,240}Pu$ in the EURT contamination gradient.

The specific activity of radionuclides increases in aboveground plant mass with the rise of density of contamination in the soils. This enhancement is well approximated by a power function of the type $y = axb$. Differences in the accumulation of ^{90}Sr by plants of different taxonomic groups are small. Most of the observed values are located in a relatively narrow diapason (one order of magnitude). Apparently, the accumulation of ^{90}Sr into plants was determined primarily by the level of soil contamination.

Accumulation of ^{137}Cs and $^{239,240}Pu$ differ largely in studied groups of plants. The main factors determining the absorption of these radionuclides are the morphological features of the plants and environmental conditions. Significant differences revealed in the accumulation of these radionuclides between higher plants on the one hand, mosses and lichens on the other. The specific activity characteristics of woody and herbaceous plants, approximately two orders of magnitude lower than that - for mosses and lichens. Difference of accumulation within each taxonomic group was determined by the plant species characteristics.

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URANIUM AND RARE ELEMENTS IN TECHNOGENIC AEROSOL OF SIBERIAN CHEMICAL COMBINE REGION (SEVERSK, RUSSIA)

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Results of the geochemical research of technogenic aerosol of the Siberian Chemical Combine' region (SCC) are discussed. SCC is Seversk nuclear fuel cycle plant (Russia): Uranium hexafluorides are its main product.

The SCC emission plume is revealed to spread at a distance up to 100 km. But the main technogenic aerosol pollution is outlined by the radius of 20 km to the north and northeast from Seversk. The mineral component of aerosol is formed by SiO2 – 64 %, Al2O3 – 21.7 % and Fe2O3 – 7.65 %.

High concentration of U, Th, lithophilous elements Sr, Ba, Y, Nb, Zr, REE in aerosol are revealed to be geochemical indicators of SCC emission. Average concentration (ppm) of Sn is equal 5.77 (maximally – 13.4), W – 3.1 (5.2), Ba –1229 (1620), Nb –19.4 (28.0), Y – 34.4 (44.7), Sr–5.77 (13.4), radionuclides Th–17.7 (24.4), U–7.0 (9.8), respectively. Concentration of these elements in aerosol is 1.8-6.4 times higher than their average concentration in Upper Continental Crust (named Clarke concentration).

Summary REE content is equal 264-325 ppm. Aerosols are enriched with heavier REE, so (La+Ce)/(Yb+Lu) ratio decreases to 28.9 while for the Earth's crust this ratio is equal = 40.7. A negative Eu anomaly is observed: Eu/Eu*= Eun/ (Smn • Gdn) = 0.58, while for the Earth's crust Eu/Eu* = 0.71. With a helpscanning electron microscopy phosphate and oxide is revealed to be main forms of Sr, Ba, Y, Nb, Zr, Th, REE–aerosol particles (238 individual aerosol particles consisting of these elements were studied).

The aerosols are enriched with ^{235}U: so the isotope ratio $^{238}U/^{235}U$ decreases to 74.28 (while natural ratio $^{238}U/^{235}U$ is equal to 137.9). But with a help scanning electron microscopy U-particles are not found. So, U is assumed to be diffused in the aerosol mass.

Key words: industrial emission, aerosol, uranium, rare elements, snow, mass spectrometry with inductively coupled plasma

CARBON ISOTOPE (^{14}C AND ^{13}C) EXCHANGE PROCESSES IN THE BIOSPHERE: CASE STUDY OF THE PLITVICE LAKES

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Radiocarbon activity ($a^{14}C$) and ratio of stable isotopes $^{13}C/^{12}C$ ($\delta^{13}C$ values) were measured in different samples collected in the natural habitat of the Plitvice Lakes: terrestrial plants (deciduous and coniferous), marsh and aquatic plants and surface soil. The $a^{14}C$ and $\delta^{13}C$ values were compared with those of the atmospheric CO_2 as well as of dissolved inorganic carbon (DIC) of Plitvice waters with the aim of determining origin of carbon in the biosphere.

^{14}C activity of terrestrial plants (100 to 110 percent of modern carbon, pMC) followed ^{14}C activity of the atmospheric CO_2, with some differences between deciduous and coniferous trees. ^{14}C activity of marsh plants partly submerged in the water (sedge) also followed the ^{14}C activity of the atmospheric CO_2. Aquatic plants completely submerged in the lake waters showed different ^{14}C activity depending on the sampling location and their $a^{14}C$ correlated with the $a^{14}C$ of DIC. Steady increase of $a^{14}C$ of DIC in downstream direction also reflected in the increase of $a^{14}C$ of the aquatic plants but the values were about10 pMC higher than that of DIC. Top 20 cm of surface soil represented the average of organic material (humus) deposited in several years and $a^{14}C$ it was slightly higher than that of atmospheric CO_2 in the last year.

$\delta^{13}C$ values of measured samples correlated with the origin of carbon in different materials. For the plants which used atmospheric CO_2 for photosynthesis, terrestrial plants and marsh (sedge), $\delta^{13}C$ values ranged from -31‰ to -27‰. The aquatic plants $\delta^{13}C$ values varied in a wide range from -48‰ to -30‰, showing that the source of carbon is mainly DIC in water and also carbon of organic decomposition. Plants partly consumingCO2 from atmosphere and partly from DIC, e.g. moss from the waterfalls, have less negative $\delta^{13}C$ values and higher ^{14}C activity than the aquatic plants.

^{14}C activity and $\delta^{13}C$ values of different plants collected in the Plitvice Lakes area and their correlation with atmospheric CO_2 and DIC showed which processes and/or sources of carbon were involved in the biosphere of the karst area.

RADIOACTIVITY CONCENTRATIONS IN SPA WATERS – DOSE ASSESSMENT

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In this study 6 different spa water samples from Serbia, Hungary and Czech Republic were investigated in order to determine their radioactivity concentrations. These waters have been used on a large scale for medical and bathing purposes; for therapy, rehabilitation and recreation and also used for drinking, which is the most important. The obtained results showed that natural activity concentrations of alpha emitting radionuclides was within World Health Organization recommended levels and Serbian applicable regulations, but the gross beta activity exceed 1 Bq L^{-1} for some of the samples. Considering the fact that gross beta activity in four samples was higher than recommended levels, gamma spectrometric measurements were performed, in order to identification radionuclides which caused increase of the gross beta activity. Based on the obtained results the annual effective dose was calculated.

VARIATION OF SPECIFIC ACTIVITY OF ^{137}Cs IN THE BOTTOM GROUND OF WATER RESERVOIRS AND WATERSIDE SOIL IN VILNIUS CITY, LITHUANIA

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Nuclear test fallouts and atmospheric deposits after nuclear power plant accidents (Chernobyl, Fukushima and so on) converted many water bodies all over the world into a repository of radionuclides. It is known that after the radioactive impact radionuclides are quickly (for some months) removed from the lake water and accumulated in the bottom sediments. However, that radionuclide burial in lake sediments is not terminal. With time, due to processes of lake self-cleaning, running through lakes turn into a secondary source of radionuclides for water systems. This problem is very urgent for Lithuania, which is a laky country where there are almost 6000 lakes and impoundments. Besides, it is known that in the nearest future Lithuania may occur in the environment of three nuclear power stations. The one way to tackle ecological consequences of radionuclide inputs to the open water bodies is a thorough study of the radionuclide behavior and of mechanisms of lake and impoundment self-cleaning.

It is known that during the winter in most lakes a near-bottom anaerobic zone is formed. An appearance of the zone is related to processes of oxygen consumption in the thermally stratified water column due to bottom sediment organics decomposition. For many years, it was believed that elevated mineralization (as well as elevated radiocesium concentrations) of near-bottom waters in winter were only related to the anaerobic zone formation. However, some data showed that elevated concentrations of pollutants in the water column were also possible under aerobic conditions in autumn. Evidently, near-bottom waters with elevated concentrations of pollutants are the main self-cleaning potential of the running through water bodies. Thus, during spring and autumn overturns of dimictic lakes, water pollutants are evenly distributed in the water column and partially can leave the lake with the flushing waters. It means that running through lakes can act as a most powerful secondary source of radiocesium for outflowing rivers.

The present work is related to radiocesium (^{137}Cs) behavior in some Lithuanian lakes. The main object of the study is a radiocesium behavior in a relationship with the seasonal variations of standard water parameters in Lithuanian lakes.

^{210}Pb AND ^{210}Po IN THE OF ENVIRONMENTAL SOUTHEAST REGION OF BELARUS

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The main sources of ^{210}Pb and ^{210}Po in the environment are natural origin. The areas of their local concentrating may be the results of intensive flows of radon, uranium deposits and industrial pollutions. The presence of radioactive isotopes of Pb and Po in the environment are not connected only with decay of ^{238,235}U and ^{232}Th, but also with permanent deposition of aerosol particles from the atmosphere due to decay of ^{222}Rn. Artificial flow of ^{210}Po and ^{210}Pb into the environment primarily depends on the burning of fossil fuels, activities of uranium mining and processing enterprises, production of phosphate fertilizers.

The purpose of the work is estimation of natural radionuclides activities in the environment of south-eastern region of Belarus. Objects of the study were the surface and ground waters and the associated samples of soil and crop of agricultural plants (potato, cabbage and beet), which were sampled within the territory of Gomel and Mogilev regions in 2008-2013.

A new integrated radiochemical technique has been used for determination of activity concentrations of natural radium, polonium and lead radionuclides in the samples of surface and ground waters. This technique determines the conditions and order of radiochemical operations and appropriate measurements of beta and alpha-activities of radionuclides, which were separated from water samples. It was tested and recommended for radionuclide determination by the State Committee of Standardization of the Republic of Belarus. After radiochemical extraction and preparing of counting plates beta activity of ^{210}Pb was measured using the LB-770PC beta-radiometer. Activity of ^{210}Po was measured by the Alpha Analyst (“Canberra”) spectrometer with the semiconductor type of detectors. Mathematical analysis of the α-spectrometry results was carried out with the «Genie 2000 Alpha-apex» software packages.

It was revealed that activity concentration of ^{210}Po in the water samples varied in the range of 0.01–0.26 Bq·kg–1and in some water samples, it was higher than the intervention level for this radionuclide that is equal to 0.12 Bq·kg–1. Activity concentrations of ^{210}Pb in water samples varied between 0.006–0.15 Bq·kg–1 and these levels corresponded to operating standard for drinking water because they were lower than intervention level of 0.20 Bk·kg–1.

Distribution of ^{210}Pb and ^{210}Po in the soil profiles showed a sharp maximum of 210Pb and 210Po activity in the top 0–5-cm layer of soils. It could be explained by deposition of radionuclides from atmosphere in the form of aerosols containing the products of ^{222}Rn decay and their accumulation in the top soil layer. The ratio of radionuclides approached to equilibrium values (within analytical error) with the depth of the soil layer.

It was found that the activity concentrations of ^{210}Pb in arable (0-20 cm) soil layer of southeastern region of Belarus varied within 4.62–5.45 Bq/m2. The activity concentrations of ^{210}Pb in the plant crop from this area were 3–7 mBq/kg for potatoes, 34–96 mBq/kg for cabbage and 3–13 mBq/kg for beets. Activity concentrations ^{210}Po in the plant production grown on soils with activity of the radionuclide in the arable layer of 1.95–3.21 Bq/m2were 9–23 mBq/kg for potatoes, 6–27 mBq/kg for cabbage, 10–18 mBq/kg for beets.

Accumulation of ^{210}Pb and ^{210}Po by plants depended on several unequal sources: the direct deposition of isotopes on the plant surface from atmosphere, the root uptake of these isotopes from the soil, the accumulation of ^{210}Pb and ^{210}Po due to decay of the parent radionuclides received from the soil. It was found that ^{210}Pb accumulated mainly in the aboveground parts of the plants and mostly in the upper young parts. ^{210}Po was also concentrated in the aboveground parts of the plants, but it was mostly concentrated in the bottom older plant parts.

URANIUM (^{238}U, ^{234}U, ^{235}U), POLONIUM (^{210}Po) AND LEAD (^{210}Pb) CONTAMINATION OF SOIL AND RIVER WATER COLLECTED IN THE AREA OF PHOSPHOGYPSUM STOCKPILE IN WIŚLINKA NEAR GDAŃSK (NORTHERN POLAND)

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The aim of this study was the determination of the concentrations of ^{210}Po, ^{210}Pb, ^{234}U, ^{235}U, ^{238}U in surface soils samples and surface water samples collected in the area of phosphogypsum waste heap in Wiślinka (northern Poland). The stockpile was closed in 2010 and covered with sewage sludge in order to immobilize phosphogypsum. Even though there is still high probability that phosphogypsum waste heap in Wiślinka could be extremely important from the environmental point of view. Sixteen million tons of stored phosphogypsum is located near Martwa Wisła river on one side and crop fields on the other side. The mean values of ^{210}Po, ^{210}Pb, ^{238}U, ^{234}U and ^{235}U concentrations in phosphogypsum are following: 946.71 ±12.29 mBq ·g-1, 941.40 ±14.88 mBq ·g-1, 60.84 ±6.81 mBq ·g-1, 59.40 ±4.81 mBq ·g-1 and 2.78 ±0.77 mBq ·g-1, respectively. The values of radionuclides concentrations in analyzed soils samples lie between 3.0 ±0.2 mBq ·g-1 and 324.5 ±15.4 mBq ·g-1 for ^{210}Po and between 3.6 ±0.2 mBq ·g-1 and 229.9 ±5.4 mBq ·g-1 for ^{210}Pb. The activities of ^{234}U, ^{238}U and ^{235}U in soil samples range from 2.2 ±0.2 mBq ·g-1 to 109.5 ±10.5 mBq ·g-1, from 2.1 ±0.2 mBq ·g-1 to 109.6 ±10.5 mBq ·g-1and from 0.10 ±0.04 mBq ·g-1 to 3.9 ±1.2 mBq ·g-1, respectively. Lower values of ^{234}U and ^{238}U concentrations in analyzed soil samples in the vicinity of phosphogypsum stack in comparison to ^{210}Po and ^{210}Pb activities are connected with the process of phosphoric acid production, during which polonium migrates to phosphogypsum fraction but uranium is located in phosphoric acid. For the visual presentation of the contamination of the area of phosphogypsum waste heap in Wiślinka, we created interpolation maps for every analyzed radioisotope using SADA software and scatter plots. This allowed us to isolate zones that are categorized by different activities of ^{210}Po, ^{210}Pb, ^{234}U, ^{235}U and ^{238}U. For the examination of the impact of possible leachates from the stockpile on the river, we collected the surface water samples from six sites located on the Martwa Wisła river. The river water samples were collected along the flow of the river and in its gradient. The values of ^{210}Po concentrations in analyzed surface water samples lie between 0.8 ±0.1 mBq ·L-1 and 2.0 ±0.1 mBq ·L-1 while ^{210}Pb concentration ranged from 1.2 ±0.1 mBq ·L-1 to 3.21 ±0.10 mBq ·L-1. The activities of ^{234}U, ^{238}U and ^{235}U in river samples range from 10.2 ±0.3 mBq ·L-1 to 13.2 ±0.4 mBq ·L-1, from 9.1 ±0.4 mBq ·L-1 to 11.7 ±0.3 mBq ·L-1 and from 0.35 ±0.14 mBq ·L-1 to 0.41 ±0.10 mBq ·L-1, respectively.

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ECOLOGICAL CLASSIFICATION OF ENVIRONMENTAL INDICATORS ALONG THE DANUBE IN SERBIA

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Actual problems of pollution of aquatic systems require the determination of the ecological status of the Danube, stressing the importance to the realization of the principles of sustainable water management, Directive 2000/60EC, as well as the preservation of the environment. The aim of this paper is to monitor oxygen concentration demand by measuring stations along the river, to determine the ecological status of the Danube in Serbia. Indicator of the oxygen regime of the watercourse involves monitoring the concentration of biological oxygen demand (BOD-5) and ammonium ions (NH4-N), by monitoring the state of the environment based on the load of surface water with organic matter and ammonium, respectively (Regulation on the national list of environmental indicators, "Official Gazette of the RS", no. 37/2011). The paper used the Republic Hydrometeorological Service of Serbia (RHSS) quality water data for the year 2012, obtained from ten hydrological measuring stations on the Danube. The Danube is one of the type of large rivers dominated by fine sediment, Type 1, for which the actual Regulations define concentrations of BOD-5 = 2 mg/l and NH4-N = 0.1 mg/l of high ecological status, and class I surface waters (Regulation on the parameters of the ecological and chemical status of surface water and the parameters of the chemical and quantitative status of groundwater, "Official Gazette of the RS ", no. 74/2011., and Regulation on limit values for pollutants in surface and ground waters and sediments and deadlines for their achievement, "Official Gazette of the RS ", no. 50/2012). The results show that the mean monthly values of concentration of the biological oxygen demand, ranging from BOD-5 = 1.58 mg/l to BOD-5 = 2.37 mg/l, and the ammonium ion ranging from NH4-N = 0.05 mg/l to NH4-N = 1.13 mg/l at the observed measurement locations. Mean annual concentrations values of two indicators of oxygen demand, calculated for the year 2012, are BOD-5 = 1.93 mg/l and the NH4-N = 0.08 mg/l, respectively. Comparative analysis, based on the values of these environmental indicators, showed that the water quality of the Danube in Serbia fits high ecological status or class I surface waters. Surface water belonging to this class provides, on the basis of the limit values of the elements of quality, requirements for the functioning of ecosystems, as well as protecting fish, and can be used for the following purposes: drinking water supply with appropriate treatment, bathing and recreation, irrigation, industrial use.

Keywords: The environmental indicators, Ecological classification, Danube

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OXIDATIVE STRESS AND DEVELOPMENT OF THE BIOLOGICAL CONSEQUENCES UNDER RADIATION ACTION AT THE DIFFERENT EXTENT

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Nuclear power plants and radiochemical factors accidents, as well as the development of natural resources in biogeocenoses with increased radiation background cause a necessity of the detail researches of the biological consequences under the radiation action at a wide range of doses. We have at present enough evidence indicating that the lipid peroxidation (LPO) regulatory system plays an important role for the regulation of cellular metabolism in tissues of intact animals and the development of the biological consequences of ionizing radiation at a wide range of dose. Complex studies of parameters of the LPO regulatory system in the different tissues of mice (spleen, liver, brain, blood components) were performed under following actions: X-ray irradiation at low doses under changing dose rate, g-irradiation at the dose of 15 cGy under the different dose rate, single acute X-ray irradiation at the sublethal and lethal doses. It was shown that the different variability and the ability to normalization of the antioxidant activity and composition of lipids, intensity of LPO, the peroxide content of lipids and their antiperoxide activity in tissues are due to the antioxidant status of tissues and radiosensitivity of mice. Besides, the contribution of the LPO regulatory system parameters to the organism resistance varies depending on the dose and dose rate. The inverse dependence of LPO intensity on both dose rate and the ionizing radiation dose itself results in the most contribution of LPO processes to the organism resistance at low doses. This conclusion is a good agreement with data about the state of LPO processes in tissues of wild rodent inhabiting both in the exclusion zone of the Chernobyl accident and living under the increased natural background for a long time (Kudyasheva at al., 1997; 2006, 2007; Shishkina et al., 2012).

Results of the own and literature data about of the state of the LPO processes in animal tissues after the action of ionizing radiation allow us to assume a assessment of biological consequences of exposure to ionizing radiation for the animal group by the scale changes of interrelations between the examined parameters of LPO regulatory system.

OXIDATIVE STRESS GENERATED BY MODERATE URANIUM IN *PISUM SATIVUM* PLANTS

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Uranium (U) present in soil/water enters the plants through roots and is distributed in different parts of the plants. Since plants play a major part of food for human beings and as uranium is a toxic element, high intake of uranium and its decay products through plants and foodstuff may lead to harmful effects in human beings. The toxic effects of U in living organisms depend on uranyl ion speciation and their solubility. In our present study, we given the treatment of [U]=25 and 50 µM respectively to P. sativum plants in amended Hoagland medium for 5 days and studied how moderate U concentration generates oxidative stress in tested plants. For the confirmation of oxidative stress generated by U, we explored the production of NO and H_2O_2 by epifloroscence microscope and also checked some antioxidative enzymes such as CAT, GR and non-enzymatic antioxidants like Cysteine, NP-SH and Lipid peroxidation as oxidative-damage marker along with U uptake in tested plants.

Our observation suggest that, a decrease in NO production was noticed in [U]=50 µM treatments in both root/leaves in comparison to control. On the other hand, production of H_2O_2 was enhanced in both root/leaves in [U]=50 µM treatment in comparison to control. Antioxidants such as CAT and GR activity was lower in roots and shoots in compare to control at higher concentration ([U]=50 µM) but it was interesting to note that non-enzymatic antioxidants such as cysteine and NP-SH was higher in root as well as in shoots in higher concentration ([U]=50 µM). It was also noticed that there was a significant increment in lipid peroxidation in both root and shoots. U accumulation was also higher in roots rather than shoots. From our present results we conclude that increment of H_2O_2 may create oxidative damage to root and leaf membranes of P. sativum plants, suggesting that oxidative stress is involved in the toxic mechanism of U. Therefore, the reduction of NO induced by U in the present work could contribute to the accumulation of ROS and oxidative stress. Increase in the level of thiols and cysteine may be due to stimulation of enzymes of sulfate reduction pathway such as APS reductase and Serine acetyltransferase. The decline in CAT and GR activity might be due to the inhibition of the enzyme by post-transcriptional alterations or down-regulation of gene expression. Increment in lipid peroxidation indicates the prevalence of oxidative stress and perhaps this may be one of the possible mechanisms by which toxicity due to U could be manifested in the plant tissues. However, the level of lipid peroxidation was lower in roots as compared to that of shoots. This was attributed to low U load in shoots that probably resulted in low oxidative stress and membrane damage. The detail of this work is going to be discussed in the meeting.

RADIOACTIVE SAND ACCUMULATIONS ON THE BEACHES OF THE WHITE SEA, THE BLACK SEA AND THE SEA OF AZOV

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The natural hazard on some seashores is the so-called "black" or monazite sands, which are radioactive sands formed naturally by geological processes. The main radioactive elements in them are ^{232}Th, ^{238}U and their decay products. There are many coastlines in the world which are known to have radioactive objects (India, Brazil, Sri Lanka, etc. [1]), while similar radioactive deposits of the White Sea, the Sea of Azov, and partly Black Sea are hardly described. The presence of radioactive sands is often confined to the crystalline massifs. For instance, White Sea sands are due to the Baltic Shield, and the sands of Sea of Azov are due to the Ukrainian crystalline shield.

The exposure dose in the places of "black sand" accumulations on the seashoes investigated are 0.05 - 0.3 mR/h on average, but may reach as high as 0.9 - 1.0 mR/h in some deposit placers during some years. Chemical, mineralogical and grain-size analyses of the radioactive sands as well as gamma spectrometry and analysis of their radioactive emanations were carried out [2]. The dependence of the radiation background of the coast on the meteorological parameters was also studied [3].

Radioactive deposit placers of the White Sea are not a serious environmental hazard due to the low population density and the absence of vacationers. On the other hand, the northern shores of the Black Sea and the Sea of Azov are unique as they have the "black sands", and strong winds in the areas of high population density and a great number of vacationers. The absence of even one of these factors would remove the problem or, at least, make it irrelevant, but their simultaneous acting creates a situation which is extremely dangerous and has no analogues.

While it is not possible to ignore the hazard of the “black sands,” it is not necessary to ban the whole coastline for public recreation. It is enough to detect all the localizations of black sands, to control them and to carry out protective measures [4]. One must also bear in mind that not all the "black sands" of the seas are radioactive.

Azov Scientific Research Station (ANIS) is a joint project of the Lomonosov Moscow State University of Russia and the Azov State Technical University of Ukraine. The Azov Station has been carrying out research on the shores of the Sea of Azov, Black and White Seas since 1996. The Department of Radiochemistry of the Chemistry Faculty of Lomonosov Moscow State University was the initiator and main organizer of the ANIS. The priorities of ANIS work are the following: radio-ecological marine studies, geomorphology of coasts, and marine geology.

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MODEL FOR CALCULATION OF PARAMETERS OF FOREST FIRES AND ATMOSPHERIC TRANSFER OF RADIONUCLIDES WITH SMOKE

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Forest fires are extremely dangerous and they cause significant economic, social and environmental damage to the national economy of the Republic of Belarus

According to the statistics, there are 98% of grounds fires which are dominant over many years (from 2000 to 2010). For this reason, ground fires were selected as research subjects. The aim of this work is modeling of atmospheric transport of ^{137}Cs with the smoke of forest fires in the contaminated areas and assessment of the potential threat of secondary contamination of the neighborhood as a result of ground fires in forest.

The proposed model FORESTFIRE built on a modular principle. Part of the model modules developed by the authors of this work directly, some modules are models of other researchers [Yoschenko et al., 2006]. Model parameters were chosen respectively from our own experiments, or from the literature [Sviridenkov, 1993].

To simplify calculation process and for the more convenience of its practical use, the input parameters include some of baseline characteristics of forest areas: breed, age and type of forest plantations. The data of radioactive contamination of fuels materials, some weather data (wind speed, air temperature and humidity) are also used as input parameters. According to these data, model calculates the amount of fuel materials, the total released of radioactive combustion products and speed of propagation of the fire front.

To validate the model, correct selection of parameters and calculation method, we compared the calculated results and experimental data. The data described in the following publication [Budyka, 1995] were also used for validation. Results of comparing the experimental data and the values calculated by using the Gauss model and FORESTFIRE model shows that the average relative deviation of «Gauss model – experiment» is 0.13 ± 0.10; «model FORESTFIRE - experiment» - 0.20 ± 0.10, «Gauss model - model FORESTFIRE» - 0.12 ± 0.10. All values are compared by Student's test ($t > 1,6$) at 95% confidence level does not contradict each other.

Keywords: Model, forest fires, input parameters.

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SPECIFICS OF USING *PHRAGMITES AUSTRALIS* FOR HOLDING A RADIOECOLOGICAL MONITORING

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The comparison of sampling methods and analysis of the radionuclides concentration in the samples of common reed in the Chornobyl Exclusion Zone (CEZ) was held.

The observation was held during 2008-2013 in the CEZ ecosystems of six water bodies Phragmites australis (Cav.) Trin. ex Steud were sampled. The concentration of ^{90}Sr and ^{137}Cs was measured in the samples. Sample collection and analysis were made using two methods. For the first method, whole plant was taken three-four times a year and the analysis was made without control of moisture loss. For the second method, the leaves from 30 plants were taken in each month of observation with the analysis of the dried samples. Sometimes stems and roots were studied as well.

Assessment of methods was given with indication of the total statistical uncertainty of measurement (u). Value u was calculated from the experimental data standard deviation.

In 2013, the concentration of ^{137}Cs and ^{90}Sr in the samples of common reed plants selected by the first method was 1,3±1,5 kBq/kg and 0,8±0,9 kBq/kg respectively. The concentration of ^{137}Cs and ^{90}Sr in the common reed leaves selected by the second method was 10±12 kBq/kg and 6,6±7,4 kBq/kg respectively.

Further assessment to the factors that influence the uncertainty size in the observation was given using the first method. We found that the water maximum loss during shipment of the samples from the place where they were taken to the laboratory reached 73%. The heterogeneity of ^{90}Sr and ^{137}Cs accumulation in roots generates u value of 69% and 85% respectively. Different correlation of ^{90}Sr and ^{137}Cs in stems leaves and root mass of the samples gives u value of 85% and 68% respectively. The heterogeneity of the influence of individual characteristics plants radionuclide concentration constitutes 46% for ^{90}Sr and 54% for ^{137}Cs. According to our calculations in the first method should be sampled about 20 plants for the entire growing season to ensure the accuracy of 45%.

In the study with the second method only the individual differences plants radionuclide concentration influence creates of the uncertainty size – 21% for ^{90}Sr and 23% for ^{137}Cs (with the confidence level 0.90). The second observation method is more suitable for radioecological monitoring; in particular, it allows to monitor seasonal differences of the radionuclide concentrations. According to our data they are 10-20%.

A STRONTIUM-90 ACCUMULATION IN A BONE TISSUE OF YOUNG RODENTS DEPENDS ON A HETEROGENEITY OF STRONTIUM-90 CONTAMINATION OF AN AREA

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The levels of ^{90}Sr accumulation in a bone tissue of small mammals, one species and caught in the same area, can differ up to three orders of magnitude (Il'enko, Krapivko, 1989; Barakhtar et al., 2003). The most likely reasons for this variability are:

1. the animals travel over a gradient of contamination;

2. a different accumulation of ^{90}Sr in an animal feed;

3. a heterogeneity of ^{90}Sr contamination.

The third factor is rarely regarded as a significant because rodents actively move in the area. However, young rodents may lead a sedentary life in a small area. We expected that the heterogeneity of ^{90}Sr contamination is a significant factor to explain the variability of ^{90}Sr accumulation in this group.

The study was conducted on the territory of East Ural radioactive trace. The level of ^{90}Sr contamination was 5.5-11 MBq/m2. The animals were caught out at the site of 120*300 sq m in July 2010, in July 2011, in July 2012. We analyzed 554 non-breeding juveniles four rodent species (Apodemus uralensis, A. agrarius, Microtus oeconomus, M. gregalis). The specific activity of ^{90}Sr +90Y of bone tissue were measured via nondestructive-radiometry. Heterogeneity of soil contamination with ^{90}Sr in a place of the animal capture was determined by measuring the density of beta-particles flux in soil surface of the areas of 100 m2 and 400m2. The dependence of the logarithm specific activity of ^{90}Sr in bone tissue on the level of soil contamination was established with using a linear regression (outliers were deleted).

The relation between the accumulation of ^{90}Sr+^{90}Y in bone tissue and the soil contamination at the site of capture of M. oeconomusis is statistically significant ($p<0.01$, coefficient of determination (R2) = 0.55 for the area of 100 m2 and 0.62 for the area of 400 m2). The same relation was ascertained for A. uralensis was just in 2010 (R2 = 0.19 for the area of 100 m2 and 0.37 the area of 400 m2). For A. agrarius this relation was noted in 2012 (R2 = 0.13 for the area of 100 m2 and 0.30 for the area of 400 m2). Microtus are herbivorous rodents, Apodemusare omnivorous. The difference in forager sources determines the differences in the R2 coefficients between species probably.

Thus, ^{90}Sr accumulation depends on heterogeneity of ^{90}Sr contamination even for actively traveling animals like rodents.

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MONITORING OF POLLUTION WITH GROUNDWATER INFLOW ^{90}Sr TERRESTRIAL ECOSYSTEMS NEAR A RADIOACTIVE WASTE STORAGE

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The paper presents radioecological studies in the territory of a regional RAW storage. This object had been put into operation in the 50-70s of the last century. Now the object is a closure. In 1998-1999 the increased specific activity of ^{90}Sr had been revealed in the surveying wells and in the following this was stipulated by surface water penetration in one of the facility. In reservoir overfilling, ^{90}Sr and ^{137}Cs radionuclide exposed water escaped outside. Multi-year studies allowed one to establish that ^{90}Sr contributes much to radioactive contamination on the territory near the storage and in the adjacent territory.

Soil samples are collected by a special sampler with a set of Edelman hand soil drills. Layer-by-layer sampling had been carried out in a 5 cm increment to 50 cm and a 10 cm increment up to 2-3 m at controlled sites. Soil sample preparation for assessing ^{90}Sr content had been realized according to the. Plant – great nettle (Urtíca dióica) - samples were collected at the same sites. Terrestrial mollusks Bradybaena fruticum were collected from plants and soil under plants at the tested sites.

The activity of ^{40}K, ^{90}Sr and ^{137}Cs was measured in a scintillation β-spectrometer «BETA-01C» according to the standard procedure for assessing ^{90}Sr concentration from β-radiation of its daughter ^{90}Y radionuclide in environmental objects.

The analysis of long-term data (2004-2007) on the ^{90}Sr radionuclide content in the soil of the studied site and the continued experimental work (2010-2013) allowed us to establish the following. A 1.5-2-fold reduction of the specific ^{90}Sr activity in soil near the studied object had been observed from 2005 to 2012. The increase was observed of ^{90}Sr concentration gradient from the contamination source (emergency storage) to the sampling sites located beyond the object territory

We must note that texture of the soil (silt, clay) of the adjacent territory contribute to minimization of the ^{90}Sr migration processes. The area of radioactive contamination to be calculated with a value which exceeds the minimum significant activity 1kBq/kg for the tested soil layers: the contaminated area for the 0-5 cm soil layer amounted to 1800 ±85 m2, for the 5-10 cm soil layer amounted to 300±12 m2, for the 10-15 cm soil layer amounted to 180±10 m2. It is found that ^{90}Sr accumulation proceeds in a natural sorption geochemical barrier of the marshy terrace near flood plain.

Terrestrial mollusks Bradybaena fruticum have been chosen as reference species most properly reflecting the ecosystem ^{90}Sr effect. Practically the whole amount of radioactive strontium is concentrated in a mollusk shell. The exposure doses for terrestrial mollusks Bradybaena fruticum from ^{90}Sr in the study area are 35-653 mGy/year.

Screening analysis of biota conditions during radioecological studies has shown that this contamination is local in character. Therefore further studies in the territory should be conducted in accordance with local contamination conditions at certain sites.

RADIATION-EPIDEMIOLOGICAL ESTIMATES OF THE INCIDENCE AND MORTALITY OF CEREBROVASCULAR DISEASE AMONG EMERGENCY WORKERS OF THE CHERNOBYL ACCIDENT

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The author presents retrospective cohort study of the incidence and mortality of cerebrovascular disease among emergency workers of the Chernobyl accident, for the follow-up period 1986-2012. Cohort selected for analysis consists of 106,199 Russian emergency workers registered in National Radiation Epidemiology Registry (NRER) who worked in the Chernobyl exclusion zone. External radiation whole-body dose varied from 0.0001 gray (Gy) to 1.41 Gy, with a median of 0.113 Gy. Over the follow-up period 1986-2012 a total of 43,368 cerebrovascular diseases (ICD10: I60-I69) were identified, and a total of 2,258 deaths from cerebrovascular diseases in the study cohort were reported. The analysis of standardized mortality ratio (SMR) has shown a statistically significant decrease in cerebrovascular mortality in the cohort as compared with baseline non-cancer mortality among males of Russia (SMR = 0.76, 95% confidence interval (CI): 0.73; 0.79). Values of excess relative risk of cerebrovascular mortality and mortality incidence per 1 Gy (ERR Gy-1) are 0.80 (95% CI: 0.66; 0.94; p-value < 0.001) and 0.39 (95% CI: -0.11; 0.97; p-value = 0.13), respectively. The non-parametric RR estimates in dose intervals showed that the at-risk groups with respect to cerebrovascular diseases are those who received external radiation doses greater than 150 mGy. The radiation risks in this cerebrovascular study were not adjusted for recognized risk factors such as smoking, alcohol consumption and others. Special consideration is given to cerebrovascular diseases in the cohort of 53,772 emergency workers who arrived in the Chernobyl zone during the first year after the accident. The highest radiation risk was found among group of emergency workers with the the duration of stay in the Chernobyl zone less than 6 wk and with the presence of both risk factors of diabetes mellitus (ICD-10: E10-E14) and atherosclerosis (ICD-10: I70) - ERR Gy-1= 3.60 (95% CI: 0.99; 8.59; p-value < 0.001).

RADIOACTIVITY OF COAL IN BOSNIA AND HERZEGOVINA AND JUSTIFICATION OF THE USE OF ASHES AND SLAG IN CONSTRUCTION

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Coal thermal power plants are one of the biggest reasons for redistribution of natural radioactivity. This is caused by burning of organic components of coal which results in volume of coal to decrease. During this process, ashes and slag are created with concentrations of radioactivity in these components. This material is disposed in temporary or permanent landfills where it is accumulated and potentially could pose a health risk. Therefore, radioactivity monitoring in and around thermal power plants has been the imperative.

There are four coal thermal power plants in BiH: Kakanj, Tuzla, Ugljevik and Gacko. As a part of radioactivity monitoring in Kakanj and Tuzla, for years there have been significant amounts of radionuclides detected in the coal and consequently in ashes and slag that is discarded and used in construction. Kakanj power plant uses coal from the following mines in BiH: Vrtliste, Haljinici, Breza, Bila, Gracanica, Tusnica and Zenica. Tuzla power plant uses coal from these mines: Dubrave, Mramor, Sikulje, Stanari, Visca and Banovici. Coal samples have been taken from within the power plant while ashes and slag samples have been collected from the landfills two times per year (early summer and late fall) for the period of 10 years (2002-2012). Measuring was performed on the background-protected coaxial detector p-type, vertical configuration “POP-TOP” model "GEM 30P4" relative efficiency 30 % and resolution 1.85 keV at 1.33 MeV produced by EG&G ORTEC. The homogenised samples were transferred to 330 gram plastic containers (bottom diameter 8.5 cm, top diameter 10 cm, height 5 cm) for gamma measurements and sealed for 12 weeks to ensure secular equilibrium between ^{238}U and ^{234}Th, and radium and its radioactive progeny. The measurements of the specific activities are determined with a level of confidence of 95% (2 σ).

Results of the research show that content of natural radionuclides (U-239, Ra-226, Th-232, K-40) found in coal from BiH, is mostly within the averages found in coal from other locations in the world. Furthermore, the conclusion is that use of ashes and slag in construction does not pose a significant radioactivity risk.

The exception is coal from Tusnica mine which has increased content of Ra-226 and U-238. Use of ashes and slag from this specific coal source would pose significant radioactivity risk. Therefore, Kakanj power plant which uses this coal is taking necessary and controlled measures to ensure using Tusnica coal only by mixing it with coal from other mines (10% of Tusnica coal). As a result, ashes and slag found in the landfills still remain safe to be used for construction.

INVESTIGATION OF THE TRITIUM CONTENT IN SURFACE WATER, BOTTOM SEDIMENTS (ZOOBENTHOS), MACROPHYTES AND FISH IN THE MID-STREAM REGION OF THE YENISEI RIVER (SIBERIA, RUSSIA)

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In the Krasnoyarsk Region, the major source-term of radioactive environmental contamination has long been the operation of the state-operated «Mining and Chemical Combine» (MCC) facility located in the town Zheleznogorsk, Siberia (Russia). These operations are located on the so-called "right bank" (eastern bank) of the Yenisei River, approximately 50 km north (down-stream) of the city Krasnoyarsk. Discharges of 3H into the Yenisei River are almost entirely in the form of HTO. The MCC produced weapons-grade plutonium for many years, and as a result, there are considerable quantities of radioactive waste, which are currently dispositioned in storage facilities and open ponds located within the MCC's facilities. However, the great majority of wastes produced by the facility have been injected into the deep aquifers of the nearby "Severny" testing site, located 12 km north of the MCC radiochemical plant, situated at the confluence of the Yenisei and the Bolshaya Tel Rivers.

A baseline determination of 3H content in water, sediments, zooplankton, submerged plants and fish in an ecosystem comprising a region of the Yenisei River near the Mining and Chemical Combine nuclear facility has been established. In the present study we have not studied the impact of the possible sources of tritium on the ecosystem of the Yenisei River. Measurements of 3H content in these sample types in this region of the Yenisei River water demonstrated that:

- The observed 3H concentrations in the open-water main-channel environment of the Yenesei River were 4-6 BqL-1, which were taken as the background values of the tritium content for the water of the Yenisei River, especially after the last MCC nuclear reactor shutdown in 2010.
- The 3H concentration in the bottom sediment of the Yenisei River after 2010 did not exceed a value of ~4 Bq kg-1, which was obtained for bottom sediments taken near the MCC discharge area. Approximately 1.5 Bqkg-1 was taken to be the background value.
- The 3H concentrations in aquatic plants growing nearest to the impact area of the MCC (6-8 Bqkg-1) considerably exceeded the background values determined for the upstream site (village Yesaulovo, 2-3 Bq kg-1), which is the control site in our investigations of the tritium behavior in the Yenisei River ecosystem.
- The 3H concentration in some species of commercial fish was not influenced by the fishing area, the 3H concentration being 12-20 Bqkg-1 of wet weight.

After the last nuclear reactor shutdown (in 2010) these results suggest that 3H produced by Rosatom MCC operations do not result in a significant impact on the Yenisei River ecosystem studied. Our results suggest that this is likely due to the physico-chemical peculiarities of 3H, its high migration ability, weak accumulation and fast exchange with the water. However, 3H tends to accumulate in the food chain due to the potential transformation of 3H from the free tritiated water into the bound state with organic macromolecules of biological objects. This can contribute to the bioaccumulation of 3H in living organisms and should be monitored in areas that have been impacted by 3H releases.

RADIONUCLIDES IN FISH OF THE CHERNOBYL EXCLUSION ZONE: SPECIES-SPECIFICITY, SEASONALITY, SIZE AND AGE-DEPENDED FEATURES OF ACCUMULATION

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The results of studies during 2006-2013 of fish species from 12 water bodies with different hydrological mode within the Chernobyl exclusion zone (ChEZ) are presented. The specific activity of ^{90}Sr and ^{137}Cs for 17 species of fish, concerning to the various ecological groups was estimated. Among predatory fishes (obligate and facultative ichthyophagous) have been analyzed the wels catfish (Silurus glanis), the northern pike (Esox lucius), the chub (Leuciscus cephalus), the asp (Aspius aspius), the pikeperch (Stizostedion lucioperca), the European perch (Perca fluviatilis) and the sichel (Pelecus cultratus). Among pray fish the representatives of following groups have been studied: phytophagous fishes - the common rudd (Scardinius erythrophthalmus); zooplanktophagous fishes - the zope (Abramis ballerus); benthophagous fishes - the Prussian carp (Carassius gibelio), the crucian carp (Carassius carassius), the silver bream (Blicca bjoerkna), the tench (Tinca tinca), the common weatherfish (Misgurnus fossilis), the roache (Rutilus rutilus), the common bream (Abramis brama) and pelagic evryphagous fishes - the bleak (Alburnus alburnus). The fish of stagnant water bodies of the ChEZ continue to be characterized by the high concentration of ^{90}Sr and ^{137}Cs. The highest levels of radionuclide specific activity determined in fish of the water bodies located on the territory of the left-bank flood lands of the Pripyat River (Vershyna Lake, Glyboke Lake, Daleke Lake and Krasnensky former riverbed) - 900-31800 Bq/kg (wet weight) of ^{137}Cs and 1450-81200 Bq/kg ^{90}Sr are registered. Radionuclide specific activity in fish of closed water bodies of the ChEZ during our studies in all cases exceeded maximal permissible levels, according to the standards, accepted in Ukraine for fish production - in 53-2892 times on ^{90}Sr and in 6-212 times on ^{137}Cs. In fish of riverbed sites of the Pripyat River within the ChEZ the single cases exceeded the maximal permissible level on ^{137}Cs, mainly for the predatory fish, are registered. The analysis of radionuclide specific activity data in fish of various size, weight and age groups on an example of the common rudd and the European perch from Glyboke Lake has allowed revealing a dependence of ^{90}Sr and ^{137}Cs accumulation from weight of body and age of fishes. More intensive radionuclide accumulation during the early periods of fish ontogenesis was determined. The representative differences in dynamics of radionuclide accumulation by pray and predatory fish species with increase in size-weight and age characteristics are revealed. The specific increase in ^{90}Sr and ^{137}Cs concentration in the common rudd with primary accumulation of ^{90}Sr already at early stages of development is registered. In the European perch during the first years of development the higher concentration of ^{90}Sr in organism also is observed in comparison with ^{137}Cs, however during the next years the specific activity of ^{137}Cs starts to exceed ^{90}Sr which accumulation, on the contrary, is gradually slowed down with the years. The seasonal dynamics in accumulation by representatives of pray and predatory fish species with maximum values of radionuclide concentrations during the summer period is determined.

Keywords: fish, radioactive contamination, ^{90}Sr, ^{137}Cs, Chernobyl exclusion zone

INFLUENCE OF RADON ON THE FORMATION OF RADIO-ECOLOGICAL ENVIRONMENT OF ABSHERON PENINSULA

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Radon is one of the most toxic and radioactive gases. The problem of radiological influence of radon on people arose at the beginning of 80-ies. According to the International Committee on Radiation Protection, 40-75% from common doze of people's exposure by natural radioactive sources comes from radon and its decay products. In 1987, radon and its decay products were identified by experts of the International Agency on Cancer Research to the group of carcinogenic elements for humans.

Absheron peninsula is one of the more ecologically tense regions of Azerbaijan with multimillion population and developed infrastructure. Therefore, environment on Absheron peninsula and in Baku can be characterized by extreme gas contamination and high levels of radioactive elements. According to the research results conducted in Geology and Geophysics Institute of Azerbaijan National Academy of Sciences radiation background in areas with radionuclide pollution of Absheron peninsula exceeds maximum permissible standard by 40-60 times.

Natural radioactivity background of Absheron Peninsula ranges in 4-10 mR /hr, rising in areas of outcrops of Oligocene-Miocene strata for 20-25 mR /hr. Though such favorable natural radiation environment, here also can be found the areas of man-caused pollution with abnormally high radioactivity, where the intensity of gamma radiation exceeds the maximum permissible concentrations. Areas with abnormally high radioactivity are found mainly on the territories of old oil fields located in central and south-western parts of Absheron Peninsula. As a result of the conducted gamma-spectrometric analysis it has been determined that the radium isotopes are the main sources of the pollution in this areas.

In consideration of the radon danger on human health, in 2010-2012 under the financial support of the Swiss National Science Foundation (SNSF) scientists from Switzerland [Radon Competence Centre (RCC), University of Applied Sciences of Southern Switzerland (SUPSI)] and Azerbaijan (Institute of Geology and Geophysics) jointly carried out the project for creation of radon cadastre in Azerbaijan.

As a result of processing of findings the maps of the distribution of radon volume activity for the various administrative regions of Azerbaijan (mean values) and the detailed map of distribution of volume activity of radon in territory of Absheron peninsula have been constructed.

Analysis of the results indicates the strongly pronounced dispersion of radon concentration values for various oil and gas producing areas of the Absheron Peninsula, which varies in a wide range: from 4.96 Bq / m ^{3} to 1014.29 Bq / m ^{3}.

TRITIUM CONTENT IN PRECIPITATION IN BELGRADE - DETERMINATION OF DEPOSITION

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Tritium in precipitation has been measured in Serbia since 1976. as an essential research tool in hydro-climate studies, and to contribute to the Global Network for Isotopes in Precipitation (GNIP). Precipitation is the main route for the elimination of tritium in the atmosphere, whether it is created by natural or artificially. This paper presents part of the results for tritium (3H) content in precipitation taken at Meteorological Station of Belgrade at Zeleno Brdo (ZB). Results cover the period January 2013 - May 2014. Measurement of low-level tritium activities in natural waters, e. g. in precipitation, ground water, and river water requires special techniques for water pre-treatment and detection of low-level radioactivity. In order to increase the tritium concentration to an easily measurable level, electrolytic enrichment must be applied. Concentrations of 3H have been determined using ultra-low background liquid scintillation spectrometer Quantulus 1220. Based on the monthly amount of precipitation recorded in Belgrade and 3H concentration in precipitation samples, the monthly 3H deposition was calculated.

CALIBRATION OF HPGe DETECTORS FOR ENVIRONMENTAL SAMPLES USING GEANT4 SIMULATION

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Determination of full energy peak efficiency is one of the most important tasks that have to be performed before gamma spectrometry. Calibration of the measurement system for measuring environmental samples poses a special challenge to the laboratory. Many different approaches to this task have been developed and examined. One of the most detailed is GEANT4, a Monte Carlo simulation toolkit developed for wide variety of applications. The aim of this paper is to apply GEANT4 simulation for calibration of three HPGe detectors, for measurement of aerosol, plant and coal-like environmental samples. The detectors were modeled using the certificate provided by the manufacturer. The samples chosen for the simulation were secondary reference materials produced in the Laboratory for the purpose of experimental calibration. The efficiencies obtained using a simulation were compared with experimental results, in order to evaluate the trueness of the results. Measurement uncertainties for both simulation and experimental values were estimated in order to see whether the results of the realistic measurement fall within acceptable limits.

RADIOACTIVITY LEVELS AND HAZARDS OF SOILS IN THE KUCUK MENDERES BASIN, TURKEY

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The aim of present work is to study the distribution of natural and artificial radionuclides along Kuçuk Menderes Basin of Aegean Region, Turkey. Surface soil samples were collected at 40 different locations from the eastern, central and western basins of Kucuk Menderes. In the study, the mean activity concentrations of ^{226}Ra, ^{232}Th, ^{40}K and fission products ^{137}Cs in the soil samples measured by using high-purity germanium gamma spectrometry were 48.4, 20.5, 744.8 and 3.3 Bq kg−1, respectively. The results show that the activity concentrations of ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs measured in the soil samples are comparable with those measured in other studies and worldwide mean values measured in the earth's crust. The natural gamma radioactivity of the terrestrial radionuclides in soil samples and the gamma absorbed dose rate, the annual effective dose equivalent, the radium equivalent activity, the external hazard index, were calculated and compared with the international recommended values.

INVESTIGATION OF RADIONUCLIDE ACCUMULATION BY FISH FROM THE RIVES INFLUENCED BY MAYAK AND SIBERIAN CHEMICAL COMPLEX

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In this article represented data concerning radionuclide accumulation by fish from the areas influenced by «Mayak» and Siberian chemical complex. The results of long-term investigations of the ^{137}Cs, ^{90}Sr, ^{40}K and accumulation in the tissue of food species of fish in the Tobol, Irtysh and Tom, Rivers were analyzed. It was revealed, that the highest specific activity of ^{137}Cs is characteristic for predatory species of fish. The tendency to the lowering of the specific activity of the man-caused ^{137}Cs values was revealed for the entire time of radio-ecological investigations of fish from the Tobol and Irtysh Rivers. The comparative analyses of the ^{137}Cs accumulation in fish tissue were carried out at the different parts of the studied rivers.

MONITORING OF ^{137}Cs AND ^{90}Sr ISOTOPES CONTENT IN BIOGEOCENOSIS OF YENISEY RIVER FLOODPLAIN

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More than 50 past years Krasnoyarsk Mining-Chemical Complex (KMCC situated in Zheleznogorsk-city in 35 km to the north-west from city of Krasnoyarsk) make significant impact on the Yenisei River floodplain. There are three reactors in the Complex. Two of them are direct-flow type and water used for cooling of reactors` active zones was run without additional cleaning in Yenisei river; both was stopped in 1991. Third reactor is of close type and used as power supply for both the Complex and the Zheleznogorsk-city; this was stopped in 2010. The Complex also contains a radiochemical and head-end plant and repositories for radioactive wastes; until now the plant processes radioactive wastes not only from Russia, but from EU as well.

In 2004, 2011 and 2013 soil and plant samples were collected on different distances from KMCC for determination of ^{137}Cs and ^{90}Sr specific activities. The measuring showed up a steady decline of radiation levels on sampling sites. In 2004 the radiation level was about 100 μR/h, it lowered to 75 μR/h in 2011 and to 35-40μR/h in 2013. The similar situation was detected for sites located at more distant from the discharge point, at these the radiation level lowered from 60 μR/h in 2004 to 30-35 μR/h in 2013.

Despite obvious reduction of man-induced impact on floodplain biogeocoenoses of KMCC near impact zone after stopping the last reactor, significant ^{137}Cs and ^{90}Sr specific activities were detected in upper parts of coastal plants in recent years. In 2011 it was detected significant increase of the specific activities compared to the previous years on all sample sites: the level of ^{137}Cs specific activities reached 7400 Bq/kg whereas in 2004 it was 234 Bq/kg; the level of specific activities of 90Sr increased to 1185 Bq/kg from 26 Bq/kg in 2004. In 2013 at the nearest to KCCM sample site a ^{137}Cs content still was at the same level, but at the distant sample sites ^{137}Cs content declined. As to the ^{90}Sr specific activity it was lowered to 2004 values at all sample sites.

The work was partly supported by RFBR Grants 14-05-00139 and 14-05-00155.

APPLICATION OF MICROBIOLOGICAL PREPARATION EM-1 AND MINERAL SORBENT FOR GROWING LATTICE ON THE SOILS CONTAMINATED BY RADIONUCLIDES

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Internal dose contributes significantly part to the exposure of the population on the long-term consequences of the accident at the Chernobyl nuclear power plant. It is formed by the consumption of contaminated food. Development and application of new methods for reducing the amount of radionuclides in crop production is particularly relevant at this stage. The aim of the work was to study the effect of various soil additives on the behavior of radionuclides and heavy metals in the system: soil - plant.

The experiment was carried out on the land of the private farm in the town of Vetka. Site coordinates 52032”^{2}59.6”^{3} NL and 31010”^{2}14,9”^{3} EL. The power of exposure dose 0.2 μGy/h, the total flow (alpha + beta) on the ground surface and at the height of 1 m is 10.2 and 5.5 impulses per minute per sq cm respectively. The density of soil contamination: ^{137}Cs is 198 kBq/m2, ^{90}Sr is 6.46 kBq/m2. For the experiment we chose lattice variety “Red oak leaf” as an object of research. Mineral sorbent Trepel (Khotimsk mine, Belarus), microbiological preparation EM-1 and soil meliorant "bokashi", based on wastes and EM-1, was used as soil additives in the experiment. The Bokashi and the Trepel mineral sorbate application before planting: 600 and 100 g per 1 m2. The soil treatment before planting with 1 per cent EM-1 solution. The green plants were treated 3 times with 0.1 per cent EM-1 solution (3 l per 1 m2 every ten days).

In two months the tested plants were cut and weighed. We assessed ^{137}Cs, ^{90}Sr and heavy metals transfer into the lattice aboveground part. Additionally we assessed ^{40}Zr transfer into plants.

It was stated that when the soil is enriched with Trepel mineral sorbate and the soil and the plants were treated with microbiological preparation, all this stimulates ^{137}Cs transfer decrease in the plants. The radionuclide specific activity in the plants decreased by 47.3 and 35.7 per cent when compared with the controlled plants. If the soil is treated with Bokashi before planting, this also stimulates the radionuclide transfer decrease into lattice. In this variant ^{137}Cs specific activity decrease was 26 per cent when compared with the controlled data.

The testing of ^{40} Zr specific activity (potassium ion is about analog of cesium ion) showed that the plants consumed potassium approximately in similar concentration in all experiment variants. That’s why ^{137}Cs transfer decrease from soil into lattice in experiment variants is possibly connected with the qualities of the additives that were used in the experiment.

As for ^{90}Sr, it should be noted that this radionuclide specific activity has almost the same indexes that ^{137}Cs specific activity. But ^{90}Sr transfer coefficient exceeds by 2 times ^{137}Cs transfer coefficient. It is connected with the fact that the soil contains unsteady forms of these radionuclides. As for the experiment itself, the essential differences of this radionuclide transfer into the plants with different growing conditions were not detected.

The heavy metal gross concentration in the soil corresponds to the background levels. The heavy metal transfer into plants depended on the additives used in the experiment. Cd and Pb are the most dangerous for living beings according to their toxicity. The highest biological accumulation indexes for these two elements were detected in the plants on the controlled variant of this experiment. EM-1 application and Trepel enrichment led to significant decrease of these indexes. Plants huge absorption of V, Cr, As and Fe was observed in the variants when the soil was treated with Trepel.

CONTENT OF RADIONUCLIDES IN MATERIALS (USED FOR CONSTRUCTION) FROM SRI LANKA

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The paper presents the measurement results of radionuclide content in materials such as stone, granite, sand and brick from Sri Lanka, that are used for different edifices. The samples were analyzed by gamma spectrometry and results showed the presence of natural radionuclides ^{226}Ra, ^{232}Th, ^{40}K, ^{235}U, ^{238}U, and the produced radionuclide ^{137}Cs (from the Chernobyl accident). Activity concentrations were in the range 21-63 Bq/kg for ^{226}Ra, 25-150 Bq/kg for ^{232}Th, 50-750 Bq/kg for ^{40}K, <12-93 Bq/kg for ^{238}U, <0.5-3.8 bq/lg for ^{235}U and <0.1-0.6 Bq/kg for ^{137}Cs. In order to evaluate the radiological hazard, calculation of gamma index, I, radium equivalent index, Raeq, gamma absorbed dose rate, effective dose rate, DE, and external and internal hazard indeces Hexand Hin are presented. The present study shows that the measured samples are within the recommended safety limit and do not pose any significant source of radiation hazard.

ACTIVE PARTICLES IN ALLUVIAL SOILS OF THE RIVER YENISEI: ISOTOP COMPOSITION, MORPHOLOGY AND STRUCTURE

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Level of long-term influence of an ionising radiation on environment components, contaminated by induced radionuclides (IRN), is defined not only by activity of the IRN and the physical nature of induced radiation (α, β, γ), but also by migration ability and speciation of the IRM in natural conditions. Contamination by IRN ingressed into the structure of "hot" particles (HP), is the most typical for alluvial deposits of an island system of the river Yenisei in the near influence zone of the Krasnoyarsk Mining and Chemical Combine (KMCC). Active particles (AP) are very important here. As opposed to typical HP the AP activity is low (0,1-1000 Bq/particle). But they are extremely widespread. Their contribution to the total contamination reaches up to 100% for some IRN. At present they are studied insufficiently. Several types of the AP were revealed in the contaminated soils. The Cs-Am, containing ^{137}Cs and ^{241}Am, and Cs-poly-isotopic (^{137}Cs, ^{154}Eu, ^{155}Eu, ^{60}Co and ^{241}Am) AP have the micron sizes and are close to the typical Yenisei HP by their gamma-emitting isotope composition. The Eu-poly-isotopic (^{152}Eu, ^{154}Eu, ^{155}Eu, ^{137}Cs, ^{60}Co and ^{241}Am) AP are the most prevailing. Presence of 152Eu in their structure indicates that the nature of these particles differs from that of the HP. On the composition of the gamma-emitting isotopes the Eu-poly-isotopic AP are close to the surrounding soils.

The scanning electron microscopy study have shown: 1. The Cs-Am AP (^{137}Cs-67 Bq and ^{241}Am-4 Bq) represents amorphous grain of uranium oxide 40 mkm in diameter. It confirms the supposition of relationship of such AP with HP of reactor type. 2. The Eu-poly-isotopic AP have absolutely different morphology and structure. The particle that was chosen for the study have the next IRN activities: ^{152}Eu–95 Bq, ^{154}Eu-20 Bq, ^{155}Eu-2,1 Bq, ^{137}Cs-0,09 Bq, ^{60}Co-3,0 Bq, ^{241}Am-0,07 Bq. The particle has a flat glassy, multilayered formation of irregular shape with 200Ñ…400 mkm dimensions. A thickness of the particle is 30-35 mkm. The glassy layer of 20-25 mkm thickness consists mainly of aluminium and iron oxides. One of surfaces of the glassy layer is covered by multilayered formation which thickness varied from 5 to 15 mkm. This layer is mainly represented by compounds of iron, chrome, titan, calcium, phosphorus and silicon. The particle is very fragile: during preparation to analysis the uniform big particle was broken up to several fragments with the sizes from hundreds to tens micron and smaller. This apparently explains AP wide abundance in the contaminated soils. The element composition of such particles suggests, most likely, their low solubility in natural conditions.

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ASSESSMENT OF RADIONUCLIDE CONTENT IN LATVIAN ENVIRONMENT

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Results of the long-term study of radionuclide content in Latvian environment are presented. These data cover the contamination level of various samples with artificial radionuclides (Cs-137 and H-3), their accumulation and migration in the soil and ground waters in the vicinity of the decommissioned Salaspils nuclear reactor (SNR) and the radioactive waste repository "Radon"; the H-3 content in industrial and communal water sources in all Latvian regions; as well as the concentration of natural radionuclides (K-40 and the decay products of the Th-232, U-238 (Ra-226) decay chains) in building materials used in Latvia and produced from local resources (mostly clay).

Concentrations of gamma radioactivity in different samples were determined using the high resolution HPGedetectors and gamma-spectrometers Ortec or Canberra with the GenieTM 2000 software system. The uncertainty of measurements was within the range of 3-10 %, the minimal detectable activity - 0.3 Bq/kg. Measurements of tritium activity in water were carried out with the liquid scintillation spectrometer Packard TRI-CARB 2100 and Hidex 300SLusing the scintillation liquid OptiPhase "HiSafe"3. The measurement time for H-3 didn't exceed some hours and uncertainty was less than 2 %. Beta-activity in water was determined with the Tennelec-Solo device. Credibility of obtained results was ensured by the quality assurance and control according to the main requirements of the ISO/IEC 17025:2008 standard.

Obtained data provide a comprehensive view about the radioactive pollution level in Latvian environment. Concerning SNR and "Radon", it has been found that the tritium activity in the ground waters of these territories has decreased within last years. Concentration of tritium in the wells outside the SNR territory is below the level permitted for drinking water in Latvia. Results of Cs-137 monitoring in soils show that the activity concentration varies in different places of the SNR territory. However, it doesn't exceed the average Cs-137 concentration value in Latvian soils. The control of drinking water in food industry and urban water taps has shown the conformity with the EU Council Directive 98/83/EC requirements. The concentration of tritium in measured drinking water samples never exceeds the 10 Bq/l limit. The highest concentrations of natural radionuclides were detected in granite and its products, as well as in some clay ceramic products.

REDISTRIBUTION OF CESIUM-137 BY THE CHEMICAL FORM AFTER THE APPLICATION OF EM-1 AND BOKASHI

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The problem of contamination of vegetables by radionuclides remains on the some territories of Belarus. Liming of soils and the use of chemical fertilizers have a detrimental effect on environmental surroundings. Microbial preparations are one of the few alternatives to reduce percentage of bioavailable forms of radionuclides in the soil.

The object of the study was spring barley varieties "Brovar". The aim of the study is to determine the impact of microbial preparations EM-1 and soil improver "Bokashi" on the redistribution of caesium-137 by the chemical forms in the soil.

We used for the experiment used a sod-podzolic sandy loam and peat soils in the ratio 2:1. Sod-podzolic sandy loam soil was taken in a meadow near the p.l. Radin (ten-kilometer zone of the Chernobyl nuclear power plants). Peat soil was taken on the territory Hmelyky 30 km zone of the Chernobyl NPP. The soil was sieved on 1 mm sieve and was thoroughly mixed. Filled soil was put in plastic pots (900 g of dry soil on the vessel). Specific activity of soil ^{137}Cs 21.9 ± 1.1 kBq/kg. Full field water capacity of the soil was 34 %. In each container was planted 28 germinated barley seeds to a depth of 2 cm.

Processing of all experimental variants, with application of the EM-1, carried out on the day of planting, and three more times after at intervals of ten days. One milliliter of activated preparation EM-1 was diluted in a liter of water and added into the soil at the rate of 7 liters per square meter.

The physics-chemical forms of cesium-137 in the soil were evaluated according to the method of sequential extraction BCR after 70 days from germination of plants.

Measurement of the specific activity of cesium-137 were carried out in accordance on gamma-spectrometer CANBERRA Packard coaxial with semiconductor detector Ge(Li) extended energy range.

^{137}Cs in soluble and exchangeable forms was small and did not exceed 0.5 %. However, detailed examination of the individual forms allows us to find significant differences between experimental variants and control.

In the control percentage of 137Cs in the exchange and mobile forms was significantly higher than in the experimental variants (0.35 % of total content). Significant differences from control at P = 99.9 % were observed in variants with simultaneous application of EM-1 and "Bokashi" (0.12 %). Significant differences from control at P = 95 % also were observed in variants with the application of microbial preparation EM-1 (0.16 % of the total content) and "Bokashi" (0.14 %) separately.
Thus, adding in the soil microbial preparation EM-1 and "Bokashi" separately and together reduced the content of the exchange and mobile forms of ^{137}Cs in the soil. Supposed this is connected with the peculiarities of interaction of soil microorganisms and their metabolites with radionuclides.

INVESTIGATION OF THE TRITIUM CONTENT IN UNDERGROUND BRINES OF THE "UDACHNAYA" DIAMOND PIPE

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It is proved that in the drainage brines of the "Udachnaya" diamond pipe a geological tritium presents. Long-distance migration of artificial radionuclides from the cavity of the "Crystal" underground nuclear explosion (UNE) does not exist.

Key words: tritium, quarry of the "Udachnaya" diamond pipe, liquid scintillation spectrometry, drainage brines, distillate.

MEASUREMENTS OF HEAVY METALS IN SEVERAL RIVER SEDIMENTS IN KOSOVO WITH SAA

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Atomic absorption spectroscopy (SAA) is a method often used in analytical chemistry for determining the concentration of numerous chemical elements in the sample.

In our research, we present the results we obtained from eight river sediment samples, namely from the rivers of Rubovc, Vragoli, Lismir, Dardhishtë, Palaj, Plemetin, Pestovë and Mitrovica; these results were obtained by making use of the Atomic Absorption Spectroscopy (SAA). Lead, cadmium, copper and zinc were among the heavy metals which were analyzed.

The results obtained from the samples we analyzed show the concentration of heavy metals starting from the lowest in cadmium, which ranges between 0.11 to 18.45 mg/kg; Pb with 0.25 to 130.2 mg/kg; Cu with 1.42 to 81.05 mg/kg; and Zn with 0.98 to 315 mg/kg.

Based on our research and our results, we have concluded that the sediments from these regions are severely polluted with these heavy metals.

* This definition does not prejudge the position of status in accordance with UNSC Resolution 1244 and the International Court of Justice on Kosovo's Declaration of Independence

BIODIVERSITY OF THE NOCTURNAL MACROLEPIDOPTERA IN AN URBAN ECOSYSTEM

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The nocturnal macrolepidopterans haven't been studied too much in Galaţi county. The programs of research have been made in the Garboavele Forest (Alexinschi & Olaru 1967, Olaru & Nemes 1968, Olaru & Nemes 1969), Hanu Conachi (Alexinschi 1954, Olaru et al. 1968), Tecuci, Rogojeni and Galaţi city (caught by Olaru, published by Marcu & Rákosy 2002).

The purpose of this paper is to bring new data regarding the nocturnal macrolepidoptera of the eastern part of Romania and to study how the fauna of lepidopterans is establishing here during the years and how the lepidopterans community will evolve hereafter.

The research has been made in the Botanical Garden of the Natural Sciences Museum Galaţi. The Botanical Garden Galaţi is placed in the NV of Galaţi city, near The Danube River.

The present study was conducted in a period of 5 years: 2004, 2005, 2008, 2009 and 2010. The increasing plant diversity, and also, the developing of the vegetation every year is correlated with the increasing diversity of the nocturnal lepidopterofauna and with the stabilization of the populations effective of the species. The Lepidoptera species from the surrounding areas (private or public gardens, parks, Danube Meadow, Siret Meadow, green spaces from the city) found here sources of food and favorable conditions for reproduction.

APPLICATION OF ULTRA-HIGH-PERFORMANCE LIQUID CHROMATOGRAPHY /TANDEM QUADRUPOLE MASS SPECTROMETRY FOR MULTI-CLASS MONITORING OF PESTICIDES IN HONEY SAMPLES FROM MACEDONIA

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The possible presence of pesticide residues in honey has impelled the need for setting up monitoring programs to determine the proper assessment of human exposure to pesticides. Nevertheless, there are two forms of contamination of honey: during pollen and nectar collection by bees, characterizing cross-contamination, and through treatment of hives in which pesticides can migrate into honey as direct contamination. Established maximum residue limits (MRLs) of pesticides in honey by the European Union are generally at the limit of quantification of the analytical methods. This paper describes an effective multi-class method using a modified QuEChERS sample preparation for detection and quantification of 18 pesticides with Ultra-high-performance liquid chromatography (UHPLC) – tandem quadrupole mass spectrometry.

The method was validated according to the requirements laid down in DG SANCO 12571/2013 document. Levels of detection and quantification were lower than the established MRLs, the obtained precision was better than 20 %, and the recovery values were between 74.4 and 104.1 %. Fifty honey samples within the national monitoring program were collected from August 2014 until November 2014 and tested for presence of carbaryl, carbofuran, fenvalerate, cypermethrin, deltamethrin, permethrin, bifenthrin, amitraz, coumaphos, bromopropylate, dichlorvos, diazinone, malathion, parathion, dimethoate, omethoate, methomyl and thiametoxam. Trace levels of methomyl, diazinone and fenvalerate were detected somewhat above the reporting level for these pesticides (0.010 mg/kg), indicating a possible cross-contamination during pollen and nectar collection by bees.

UHPLC coupled with tandem mass spectrometry has demonstrated to be valuable technique for the detection and quantification of pesticides in monitoring programs, designed to cover a wide range of pesticides in honey samples. The monitoring of pesticide residues is important because honey is a route of human intake of pesticides, since it is a food and an alternative medicine, and serves as a way to evaluate the dispersion of pesticides in the environment and can be associated with the global phenomenon of disappearance of hives. This work presents the first insight on the presence of pesticide residues in honey samples from Macedonia.

Key words: tandem quadrupole, liquid chromatography, pesticides, QuEChERS, honey

LEVELS OF HEAVY METALS IN LIVER OF WILD GAME OVER THE TERRITORY OF REPUBLIC OF MACEDONIA

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Study of the wildlife exposure to environmental contamination by heavy metals is a motivating challenge, which needs further exploration. To determine the ambient concentration of lead, cadmium, arsenic and mercury in our ecosystem we used livers from different species of free-living wild game, including three mammalian (wild boar, wild goat and European rabbit) and six bird species (rock pigeon, European turtle dove, grey partridge, common quail, wild duck and Eurasian jay) as biological indicators or as biomarkers. Liver samples were collected during yearly licensed hunting seasons (2013-2014), from all eight statistically divided regions over the territory of Republic of Macedonia. The samples were totally digested by using microwave digestion system with nitric acid and hydrogen peroxide and were analyzed using graphite furnace atomic absorption spectrometry and flow-injection mercury system. Methods of analysis were validated for linearity, precision and accuracy using a freeze dried liver as certified reference material. The obtained data showed average values within the range of 443.6± 2331.7 μg/kg for Pb, 381.9±1383.6 μg/kg for Cd, 37.1±37.6 μg/kg for As and 19.0±31.4 μg/kg for Hg. The minimum and maximum values ranged between 0.0-27035.7 μg/kg for Pb, 0.0-14541.0 μg/kg for Cd, 0.0-223.2 for As and 0.0-206.6 μg/kg for Hg.

For all four heavy metals, the detected levels showed statistically significant geographical variations ($P<0.05$), as well as between different wild game species. By the comparison of our investigation with the results obtained from previous environmental studies accomplished in our country as well as in neighboring and Balkan countries, it was assumed that the essential sources of emissions of heavy metals are anthropogenic activities, industrial and traffic facilities in preselected geographical regions in Republic of Macedonia and their environment.

Keywords: environmental contamination, heavy metals, biomarker, liver, wild game

DETERMINATION OF HEAVY METALS IN NUMEROUS RIVER SEDIMENTS IN KOSOVO USING THE ICP-OES TECHNIQUE

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One of the methods - often considered as the most effective - for the determination of numerous elements, particularly heavy metals, in trace concentration is the inductively coupled plasma optical emission spectrometry (ICP OES).

This study presents the results we gained after analyzing river sediment samples. More specifically, the concentration of heavy metals such as cadmium, copper, zinc and lead were analyzed in the samples using the ICP-OES technique. Furthermore, a total of eight samples were collected from various regions in Kosovo.

After due analysis with the ICP-OES technique, our samples showed that the concentration of cadmium ranged between 0.1 to 17.53 mg/kg; the concentration of lead ranged between 0.24 to 127.69 mg/kg; copper ranged between 1.35 to 77.75 mg/kg; whereas zinc ranged from 0.93 to 309.25 mg/kg. Therefore, we have come to the conclusion that the pollution of these sediments is of great concern.

* This definition does not prejudge the position of status in accordance with UNSC Resolution 1244 and the International Court of Justice on Kosovo's Declaration of Independence

DETERMINATION OF POLLUTION IN THE SITNICA RIVER AS A RESULT OF COAL CONTAMINATION FROM KOSOVO'S POWER PLANTS

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The most prone to pollution of environment is the aquatic system, especially surface water. This mostly stems from the contaminants in the air, soil or land which eventually end up in the aquatic systems via either air or rainfall.

Sewage, industrial wastes and agricultural chemicals - such as fertilizers and pesticides - mineral and petroleum exploration, as well as exploitation are however, the main causes of surface water pollution. The burned ashes can, without any difficulty, penetrate to a river via air or other atmospheric deposits; when entering the water, they often cause permanent damage to water.

In our research we measured a wide variety of water pollutants, all of which are caused by coal - this being the main source of electricity in Kosovo's power plants. In this sense, we measured different physical and chemical parameters and the concentration of heavy metals by make use of the Atomic Absorption Spectroscopy (AAS).

This study presents detailed data of the pollution of river Sitnica; according to our findings, we have concluded that the river of Sitnica is highly contaminated due to the pollutants which are released to this river.

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MEASUREMENTS OF DIFFERENT POLLUTANTS SEDIMENTED IN THE RIVER DRINI I BARDHË IN KOSOVO

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Sediments, which stand for different depositions in water formed by the larger particles that cannot stand afloat, are classified by the U.S. Environmental Protection Agency as the most common pollutant of rivers, streams, lakes, reservoirs and the like. Their presence in water is a major concern because of their harmful effects on the ecosystem, as well as the human health.

Heavy metals show a tendency of incorporation into the sediment; their origin may be of geochemical or anthropogenic nature. Their bioavailability ranges from low, medium to high and this depends on their source. Heavy metals may be dissolved by sediment due to possible changes in water system conditions - such as flooding or acidification - and this process results in them returning to the aqueous phase.

We collected and analyzed sediment samples from the Drini i Bardhë river in western Kosovo. The sediment samples were digested according to the ISO 14869-1 standard and then analyzed for heavy metals with an Atomic Absorption Spectrophotometer (AAS). The obtained results for heavy metals were compared with the allowed heavy metals in sediments, as per Dutch standards.

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DETERMINATION OF HEAVY METALS IN ASHES RELEASED FROM KOSOVO'S COAL POWER PLANTS

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Using coal as a source of energy impacts the atmospheric quality negatively; this, then, results in the increase of pollutants. Given that coal contains potentially hazardous substances, its use in coal-powered plants and its disposal can cause undesirable environmental effects.

According to the Environmental Protection Agency of the United States, living near sites of coal ashes is more hazardous than smoking a pack of cigarettes a day. Coal ashes contain high levels of toxic and hazardous elements such as arsenic, mercury, lead and other health concerning toxins, some of which are thought to cause cancer.

Some of the factors which determine the physical and chemical properties of coal ashes include the geological origin of the coal, efficiency of particulate removal, combustion conditions as well as the degree of weathering before final disposal.

Throughout our research, we collected numerous ash coal samples released from the power plants of Kosova; these were then measured for their concentration of heavy metals using an Atomic Absorption Spectrophotometer (AAS). The ash samples were treated in teflon vessels with diverse acid treatments such as HNO_3, $HClO_4$, HF and HCl according to the ISO 14869-1 standard.

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PERFORMANCE OF ESTIMATED GLOBAL HORIZONTAL IRRADIANCES BY THE WRF MODEL IN THESSALONIKI, GREECE

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It is quite clear that during the past decates the interest for more accurate predictions of renewables (solar and wind energy) has increased since new technologies are able to exploite adequately these energy sources. The systems that can produce electricity resulting from solar energy can be divided into two main categories. Solar Thermal Power Plants (STPP) take advantage of the Direct Normal Irradiance (DNI) while the PhotoVoltaic (PV) systems use the Global Horizontal Irradiance (GHI). According to studies, both can produce enough amount of electricity that could relief the world's demand on power and reduce the impact of soil energy production.

In this study, estimations of GHI from the middle scale atmospheric model WRF (Weather Research and Forecasting) are evaluated through ground-based measurements from a CM21 Kipp & Zonen pyranometer in Thessaloniki, Greece (40.63N - 22.96E). The evaluation of the assimilations was conducted for the years 2011-2013 for both the 10x10 km2 grid as well as for the 2x2 km2 grid respectively. The two datasets were divided into clear skies cases and all weather cases based on the characterization coming from a suitable algorithm, while the model's estimations of cloud transmittance (cmf) were evaluated too. In conjunction with the model's predicted cmfs, a third division of our datasets (10x10 km2 and 2x2 km2) took place and the statistical analysis was repeated.

Furthermore, in order to investigate the impact of the aerosol load in the atmosphere to the outcome of the WRF's applied scheme (MM5), the hourly ratios of modeled to ground-based measurements were compared to aerosol optical depths derived from the cimel sun-photometer of the AErosol RObotic NETwork, NASA (AERONET) that is established in the station.

Conclusions on the model's performance are induced and a better understanding of the influence of clouds and aerosols into the WRF's MM5 scheme is achieved.

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REMOVAL OF Ba^{+2} AND Sr^{+2} IONS FROM AQUEOUS SOLUTION USING SYNTHESIZED HYDRATED CERIUM DIOXIDE

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Hydrogen form hydrous cerium dioxide powder was prepared from ammonia cerium (IV) nitrate salts in order to investigate adsorption behaviors of barium and strontium ions from radioactive waste solutions. The structure and morphology of the granular form adsorbent were identified and characterized by SEM, XRD, TGA/DTA, ICP-OES and Surface Area analysis. The Ba^{+2} and Sr^{+2} ions uptake capacity of hydrated cerium dioxide has been investigated with batch method depending on effecting parameters such as pH, initial concentration, temperature, contact time, particle size and selectivity towards competing ions. Adsorption data have been explicated in terms of Freundlich, Langmuir and Dubinin-Radushkevich equations. Thermodynamic parameters such as Gibbs free energy (ΔGo), standard enthalpy (ΔHo) and standard entropy (ΔSo) changes were calculated for Ba^{+2} and Sr^{+2} adsorption systems and the results showed that the adsorption mechanisms are endothermic and spontaneous process. Calculated values of the adsorption mean free energy, E for Ba^{+2} and Sr^{+2} adsorptions 3.79 and 3.63 kJ.mol- showed that physical forces are more effective in adsorption mechanism.

UTILIZATION OF TBP-IMPREGNATED SILICA-GEL FOR THE REMOVAL OF URANIUM FROM ACIDIC WASTE SOLUTIONS

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The nuclear fuel cycle consists of a great number of physical and chemical processes such as ore mining, concentration, conversion, purification, fuel element fabrication, burning fuel in the reactor, storage and/or reprocessing. In this cycle different waste solutions containing significant amounts of uranium are produced. Between these processes, purification process has an important place. In generally, during the process, uranium can not to be completely extracted with TBP due to the crud formation, solvent degradation or process conditions and an important amount of uranium is inevitably present in the aqueous effluent. These nitrate solutions contain also impurities arising from the “yellow cake”. Uranium beside of to be a precious metal, is also a harmful material to give to the environment over the allowed concentration limits. Thus, the selective removal and recovery of non-extracted uranium from solvent extraction effluents is an important task. In this work the sorption of minor quantities of uranium present in the large quantities of nitrate solutions from the effluents of the solvent extraction process, on the TBP impregnated silica-gel were investigated. Kinetics and equilibrium studies on the sorption system were carried out using batch technique. The sorption behaviors of uranyl ions on TBP impregnated silica-gel were studied as a function of pH, time, uranium concentration and temperature. Sorption data have been interpreted in terms of Langmuir, Freundlich and Dubinin-Radushkevich equations. Thermodynamic parameters for the sorption system were determined. The rate of sorption was determined under particle diffusion controlled conditions.

STRONTIUM REMOVAL FROM AQUEOUS SOLUTIONS BY D2EHPA-IMPREGNATED AMBERLITE XAD2 RESIN

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Increased activities of nuclear industries and nuclear laboratories are possible sources of release of radioactive wastes to the environment. There are a number of liquid processes and waste streams at the nuclear facilities that require treatment for the removal of radioactive contaminants. ^{90}Sr and ^{137}Cs are well known contaminants which have relatively long half-life of approximately 30 years. New type of materials is needed for the selective removal of these radionuclides from nuclear waste solutions. The ions to be removed are generally in low concentrations and are associated with an assortment of other cations. In the present study the removal conditions of strontium from aqueous solutions with D2EHPA impregnated Amberlite XAD2 resin were investigated. D2EHPA impregnated resins have been prepared by direct adsorption of solvent into the Amberlite XAD2 resin by using the dry impregnation method. The sorption behavior of strontium ions has been studied as a function of pH, temperature, time, metal concentration and competing ions. Sorption data have been interpreted in terms of Freundlich, Langmuir and Dubinin-Radushkevich equations. Thermodynamic parameters have been calculated for the sorption process.

SORPTION STUDIES OF STRONTIUM ONTO ZIRCONIUM-ANTIMONY OXIDE/POLYACRYLONITRILE (Zr-Sb OXIDE/PAN) COMPOSITE USING EXPERIMENTAL DESIGN

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During nuclear fission reaction, heavy uranium atoms split and fission products such as cesium-137 and strontium-90 occur. These radioctive isotopes are responsible for the heat and penetrating radiation in high-level waste. Sr-90 has half-life of about 30 years. Due to its ability to accumulation in human bones it is considered one of the most hazardous pollutants. Removal of high heat emitting fission products reduces the radiation fields in subsequent reprocessing streams and provides a reasonably short-term (100 yr) heat source reduction in the repository.

Sorption is one of the versatile and important treatment methods in separation and purification processes that has been using in the nuclear industry. It is very effective at transferring the radioactive content of a large volume of liquid into a small volume of solid. A study on the sorption of Sr^{2+} onto zirconium-antimony oxide/PAN (Zr-Sb oxide/PAN) composite was conducted. Zr-Sb oxide was synthesized in an acidic hydrolysis reaction and was then turned into composite spheres by mixing it with PAN. The weight ratio of (Zr-Sb) oxide to PAN was kept as 4:1. Sr^{2+} sorption capacity of the Zr-Sb oxide/PAN was investigated in acidic solutions by batch technique. A five level, four-factor Central Composite Design (CCD) was used to optimize sorption and to evaluate the single and combined effects of initial pH, initial Sr^{2+} concentration, temperature and contact time on Sr^{2+} removal. The obtained results were evaluated by regression analyses, analysis of variance (ANOVA) and response surface plots. Furthermore, Langmuir and Freundlich sorption isotherms were employed to explain the sorption mechanism. Thermodynamic parameters such as ΔH^o, ΔS^o and ΔG^o were calculated.

Regression analyses revealed that all of the single factors were determined significant for the sorption of Sr^{2+}. According to the ANOVA, the model F value (25.87) points out that the model is statistically significant. The optimum conditions for Sr^{2+} sorption were determined as initial pH, 4.74; temperature, 60 ^oC; initial Sr^{2+}concentration, 95.4 mg/L and contact time of 270 minutes. At the optimum sorption conditions sorption capacity of Zr-Sb oxide/PAN was found as 39.78 mg/g. Sorption isotherm data pointed out that Langmuir model is more suitable for the Sr^{2+} sorption. Thermodynamic parameters such as ΔH^o, ΔS^o and ΔG^o indicate that Sr^{2+} sorption process is endothermic and spontaneous.

The sorption data demonstrated that Zr-Sb oxide/PAN can be used as an effective material for strontium. In addition, the easy preparation of the sorbent must be taken into account.

Key words: strontium; zirconia; antimony oxide; polyacrylonitrile; experimental design.

SYNTHESIS, CHARACTERIZATION AND SORPTION BEHAVIOR OF ZIRCONIUM ANTIMONATES FOR STRONTIUM

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The study presented focuses on the synthesis and characterization of zirconium antimonates with four different initial Sb:Zr mole ratios. The materials obtained by co-precipitation were characterized by X-ray diffraction (XRD), Scanning electron microscopy-Energy dispersive X-ray (SEM-EDX), X-ray fluorescence (XRF), and zeta potential analyses. Strontium removal from acidic aqueous waste was investigated by batch technique as a function of contact time and initial solution pH.

The results revealed that higher strontium uptake capacities were observed for the materials with initial Sb:Zr mole ratios of 4.0 and 9.0. This behavior can be explained as the formation of more acidic surfaces due to the increasing antimony content. Zirconium antimonate with an initial Sb:Zr mole ratio of 9.0 has a strontium uptake capacity of 22.21 mg g^{-1}. However, mechanical strength becomes worse as the initial antimony ratio increases.

In comparison to the data given in the literature, this work has successfully demonstrated the suitability of Zr antimonates for the removal of Sr^{2+} from acidic solutions. Further investigations should be done to increase the mechanical strength of the material.

Key words: antimony, zirconium, co-precipitation, adsorption, strontium

SYNTHESIS OF SILICA SBA-15 WITH MESOPOROUS STRUCTURE AND INVESTIGATION OF ITS URANIUM SORPTION

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Uranium is one of the most important heavy metals because of the chemical toxicity and radioactivity. Excessive amounts of uranium have entered into environment through the activities of nuclear industry. It is usually found in the environment in the hexavalent form. The toxic nature of uranium (VI) ions, even at trace levels, has been a public health problem for many years. For this reason, removal of uranium from wastewater is of great importance.

In this study, SBA-15 (Santa Barbara Amorphous) has been synthesized which is in highly ordered hexagonal structure, with very high surface area (707.5 m2/g) and homogeneous pore size distribution (5.83 nm). The characterization of the synthesized material was done by using XRD, SEM, surface area and porosity analysis. Characterized material SBA-15 was studied in the use of uranium adsorption with batch methods.

For batch studies, an experimental design was prepared with central composite design method. The ANOVA (analysis of variance) analysis for prepared experimental design was made to check experimental values and predicted values. The significant value of the model was $P<0.05$ which revealed that the model is statistically significant. The correlation coefficient value (R2) was %96, which indicates compatibility between experimental and predicted values. According to the model, the optimal conditions for adsorption were with pH= 5.0, initial uranium concentration= 50.6 mg/L and adsorbent dosage= 0.002 g. The maximum adsorption capacity at these conditions was 196.15 mg/g. Adsorption process is compatible with Langmuir isotherm. According to the adsorption kinetics study, the pseudo second-order equation was found to better explain the adsorption kinetics.

Key words: SBA-15, mesoporous, uranium sorption, experimental design, kinetics

CONTAMINATED AREAS OF SOUTHERN BOSNIA AND HERZEGOVINA

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One of the key problems today is irradiance and what is irradiating us. We are irradiated like all generations before us and after us. Natural radionuclides are incorporated in all the substances around us and in us. This is our natural environment in which we live, where life originated and developed. In recent decades, in addition to natural radiation we are exposed to artificial radiation. After the war activities in Bosnia and Herzegovina the dust was lifted around the ammunition of depleted uranium and radioactive waste that had been dumped into lakes throughout the country. Within the project "Investigation of potentially contaminated areas in the Federation of BiH", we went in search of contaminated areas in footsteps of newspaper articles. We measured the radiation in southern Bosnia and Herzegovina from Livno to Trebinje. Measurements have shown certain increase of activity on coasts of potentially contaminated lakes.

Key words: natural and artificial radioactivity, contaminated areas, depleted uranium, radioactive waste

REMOTE SENSING TECHNIQUES FOR EARTH OBSERVATION - APPLICATIONS FOR PRESERVATION OF PLANT ECOSYSTEMS

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Remote sensing applications in environmental research are the basis for advanced Earth observation datasets used in environmental monitoring and ecological research. Lately, sensors and technologies used improve significantly the capability to gather information measuring the reflected and emitted electromagnetic radiation in the ultraviolet, visible, infrared, and microwave ranges. The aim of this study was to examine the potential of remote sensing data for detection, severity quantification, and differentiation of plant diseases. The visible/infrared and fluorescence spectroscopy have been used as a rapid, non-destructive, and cost-effective methods for the detection of plant diseases. Physical principles and some applications of hyperspectral reflectance (reflected radiation in the visible and near infrared spectral ranges) and chlorophyll fluorescence (emitted radiation after excitation with a beam of light from the ultraviolet spectrum), are briefly discussed with a view to the responses of the terrestrial objects (in particular vegetation) to adverse environmental changes.

Plant diseases influence the optical properties of plants in different ways. Depending on the host pathogen system and disease specific symptoms, different regions of the reflectance and fluorescence spectrum are affected, resulting in specific spectral signatures of diseased plants. Green vegetation species all have unique spectral features, mainly because of the chlorophyll and carotenoid, and other pigments and water content. Spectral reflectance and chlorophyll fluorescence are functions of tissue optical properties and biophysical status of the plants, and the illumination conditions.

Hyperspectral reflectance and fluorescence data were collected by means of a portable fiber-optics spectrometer in the visible and near infrared spectral. Spectral reflectance analyses were performed in four most informative for green vegetation regions: green (520-580 nm), red (640-680 nm), red edge (690-720 nm) and near infrared (720-780 nm). Ten optimum spectral bands have been suggested to detect and quantified the disease. The statistical significance of differences between the reflectance of healthy (control) and infected species were assessed by means of the Student's t-test. Three primary types of indices (simple ratio, normalized difference, and red edge) have been developed for estimation of the plant damage. Fluorescence spectra were analyzed at five characteristic wavelengths located at the maximums of the emitted radiation and at the forefronts and rear slopes. The strong relationship, which was found between the results from the two remote sensing techniques and accompanying serological analyses, indicates the importance of hyperspectral reflectance and fluorescence data for conducting, easily and without damage, rapid health condition assessments of vegetation.

RADON AND THORON

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EMANATING CHARACTERISTICS OF WEATHERED ROCKS WITH A HIGH CONTENT OF NATURAL RADIOACTIVE ELEMENTS

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Currently the problem of the radon distribution in the environment is very actual. Radon and its decay products are responsible for 80% of the annual effective equivalent dose. In the case of high concentration may lead to a significant threat to ones health.

In this work radon volume activity (RVA) of samples from sooty coal the Kansk-Achinsk coal basin were measured with subsequent determination of the emanations coefficient (EC). This basin is close to settlements, therefore, radon can get into the human environment. Emanating characteristics of these coals is very important from radioecology point of view.

The main goal of this work was RVA characteristic determination. For this purpose, method of measuring the activity in the atmospheric air was used. The samples were weighed, powdered, and then placed into the working chamber. Then in the chamber radon (Rn), and radon's decay products had been accumulating. Gas extraction from the chamber was carried out by the sampling device. To minimize RVA error all measurements was repeated 4 or 5 times. One measuring takes 20 minutes. After each measurement cycle the camera with the sample and the measuring device was cleaned from radon and its decay products. The measurement error was estimated at most of 30%. The measure technique is based on existing certified methods of sampling air from the atmosphere, soil, and water. The developed method is more suited for the measurement of RVA and its isotopes directly in the samples.

Samples of sooty coal from Kansk-Achinsk basin directly used for testing the proposed methodology for determining emanating properties for samples with elevated concentrations of natural uranium-238 and radium-226, characterized by a high degree of weathering.

The first sample is a radioactive coal from Glinka village. It has the following radioactive elements content: 3365 Bq/kg (uranium-238), 4223 Bq/kg (radium-226) and 2880 Bq/kg (lead-210). The second sample is a sooty coal from Berezovsky mine. The radioactive elements contents is: 433 Bq/kg (uranium-238), 2004 Bq/kg (radium-226) and 2050 Bq/kg (lead-210). The third example is a sooty coal from Itatsky section. The radioactive elements content is: 1063 Bq/kg (uranium-238), 1083 Bq/kg (radium-226) and 1131 Bq/kg (lead-210). Thorium content for all samples is not significant.

The first samples were measured only in dry state. Obtained EC is 0.29, emanation rate is 127 Bq, and maximum observed RVA is 32657 Bq/m3. For the location, where this sample was collected radon soil gas volume activity, the background radiation, radon stream value, etc. is correlated with measured values.

The second sample was measured in dry and wet states. The maximum recorded RVA value: for dry sample: 2130 Bq/m3, for wet sample: 4356 Bq/m3. In dry condition EC is 0.22, while in wet 0.41. Emanation speed also for wet sample is also larger 8 Bq vs 4 Bq for dry one.

The third sample was also measured in dry and wet states. The maximum observed RVA in the accumulation chamber was: for dry sample: 1673 Bq/m3, for wet sample: 3239 Bq/m3. The resulting EC for dry and wet sample is equal to 0.15 and 0.30, respectively. The emanation speed was 3 BC and 6 BC, respectively. These results are quite consistent with CA-13/3 sample. Examined specimens are typical representatives of the Kansk-Achinsk coal basin, and obtained results can be attributed to the values obtained EC for whole basin.

CAN TERRESTRIAL GAMMA DOSE RATE SERVE AS PREDICTOR OF GEOGENIC RADON?

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Quantifying the geogenic radon potential (GRP) - however defined - serves for identification of regions in which elevated GRP leads to increased probability of elevated indoor Rn concentrations. In the corresponding so-called geogenic radon-prone areas (RPA) Rn protection measures may be prioritized in terms of denser surveys, establishing stricter building codes and preferential allocation of funds for prevention and remediation.

In a few countries more or less dense surveys of geogenic Rn (Rn concentration in soil air, permeability) have been performed, allowing generation of RP maps. However, extensive surveys are time consuming and expensive and one may ask whether an indicative classification of an area into RPA and non-RPA, after a set criterion, could also be achieved in a simpler way. In particular one would explore already existing environmental quantities for their ability to predict RPAs.

A candidate quantity among such “proxy” or “surrogate” quantities is terrestrial gamma dose rate. Across Europe extends a network of over 4000 automatic dose rate monitoring stations, called EURDEP, established for warning against radiological events. Therefore, in wide parts of Europe dose rate data are readily available. One component of ambient dose rate is generated by terrestrial gamma rays from the decay of U, Th and their progenies and ^{40}K. One may therefore assume that ambient dose rate is - to some extent - correlated with geogenic ^{222}Rn which is a progeny of the 2^{38}U series. (Geogenic ^{220}Rn or Tn is of minor importance.)

The correlation is compromised by the fact that, at the one hand, not only ^{238}U progenies contribute to dose rate, and on the other, that the RP is not only controlled by U progenies. Still, correlation may be sufficient for achieving a classification as envisaged above with tolerable classification error rate.

In this presentation the idea is discussed in more detail, methodology is shown and first trial results are given.

THORON-SCOUT: THE FIRST DIFFUSION-BASED ACTIVE RADON AND THORON MONITOR FOR LONG-TERM MEASUREMENTS IN BUILDINGS

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The chemical element Radon has two radiologically important isotopes which occur in nature: ^{222}Rn (nat. frac. 90%; commonly simply Radon) and 220Rn (9%; usually called Thoron). Both Radon isotopes and their short-lived progeny are members of natural radioactive decay series. While being the rarest noble gas, Radon is a hazardous constituent of airborne due to its radioactivity. Airborne concentrations of Radon and its short-lived progeny are, therefore, of high interest due to their potential for deposition in the lung. Subsequent irradiation and damage of lung tissue, mainly by energetic alpha particles from radioactive decay of ^{218}Po and ^{214}Po, may induce considerable health risk.

Radon is continuously produced by the decay of natural Radium being a progeny of the natural radioactive isotope ^{238}U while Thoron belongs to the radioactive decay series of natural ^{232}Th. In contrast to Radon, substantially less Thoron reaches the breathing zone because of its much shorter half life (56 s) compared with that of Radon (3.8 d).

Taking into account the natural fraction in earth crust, half lifes of ^{238}U and ^{232}Th local geological (or technical) accumulation etc., general health risk of Radon and Thoron may be comparable.

SARAD develops and produces unique measurement techniques for Radon/Thoron, aerosol, toxic or explosive gas and particle size monitoring, dosimeters, Alpha/Gamma-spectrometers, detectors with electronic equipment and provides software support as well as remote data acquisition and transmission via www etc. for a wide variety of applications. (http://www.sarad.de)

RADON CONCENTRATION IN DRINKING WATER AND SUPPLEMENTARY EXPOSURE FROM SOUTH-EAST OF TRANSYLVANIA, ROMANIA

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From the public health point of view, the investigation of the radon and radium content of drinking and mineral waters and the estimation of their contribution to the radiation exposure are our current tasks now days.

Radon is an inert radioactive gas whose concentrations in ground water are reportedly related to a number of factors including emission of radon from surrounding rocks, temperature, pressure, and rainfall and earthquake activities. Generally, higher radon concentration is observed in waters of low mineralization. Also, the radon activity decreases with the depth of the area where the water circulates. When water containing radon is used in the home for showering, washing dishes, and cooking, radon gas escapes from the water into the air.

The aim of this work is to measure the radon concentration of drinking well waters and calculated the effective dose per year.

The places where we measured it was in 94 location in South-East of Transylvania (Brasov, Covasna and Mures county).

In the present study, the measurements of radon were carried out using the LUK-VR system based on radon gas measurements with Lucas cells. The LUK-VR system consists of a LUK-3A device and a VR scrubber dedicated for radon measurements in water samples. The VR-scrubber consists of a glass vessel of 500ml volume where a known quantity of water sample (300ml) is introduced. The principle of operation is that the concentration of the radon dissolved in the water sample is mixed with the air that is on the top of the water level; within the scrubber volume. Following this, air is then transferred from the scrubber to be measured for radon using the Lucas cell method.

Concentrations of the radon were determined in 165 selected well water samples of this region of Romania. The results showed radon concentrations within the range of 0.1 – 10.02 Bq/l with an average value of 1.89 Bq/l.

The use of the water can be one of the factors that increase the indoor radon concentration. At the same time drinking of radon rich waters can contribute to the internal irradiation. For this reason is important to control the radon activity concentration of waters. The corresponding annual effective ingestion dose due to radon from water was determined from drinking water used (1l/person/day) by the population inhabiting the area. For the dose conversion factor, the $3.5 \cdot 10^{-9}$ Sv/Bq value has been used proposed by UNSCEAR and adopted by the European Community too. The calculated annual effective dose from radon was located between 0.128-10.02 μSv/year.

The radon measurements were performed using the Lucas cell method with short counting time during the non-equilibrium state between radon and its progeny. The short counting time allowed the large number of water samples to be measured fast, so to avoid delays within the survey program.

In most of cases, the measured values are not high and do not exceed the radioprotection standards recommended by national and international institutions (US, EPA).

THE EUROPEAN ATLAS OF NATURAL RADIATION

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According to the EURATOM Treaty, it is the mission of the Joint Research Centre (JRC) of the European Commission to collect, process, evaluate and present data on environmental radioactivity. In 2006 the JRC started the project of the "European Atlas of Natural Radiation" that aims at preparing a collection of maps of Europe displaying the levels of natural radioactivity caused by different sources. The overall goal of the Atlas is to estimate the annual dose that the public may receive from natural radioactivity, combining all the information from the different radiation components.

As a first task, a European map of indoor radon (Rn) concentration was tackled, since in most cases this is the most important contribution to exposure, and since it could be expected that data collection would take quite some time, because Rn surveys are very differently advanced between European countries. We show the latest status of this map.

Second, the JRC has undertaken to map a variable which measures "what earth delivers" in terms of geogenic radon potential (RP), due to heterogeneity of data sources across Europe and the need to develop models for estimating a harmonized quantity which adequately measures or classifies the RP. This variable should be calculated considering different input quantities available such as U concentration in rocks and soils, soil gas radon and soil permeability, terrestrial gamma dose rate, geological information and indoor data from ground floor. The European Geogenic Radon Map will give the possibility to characterize areas for radon risk where indoor radon measurements are not available.

While work will continue on the European Indoor Radon, Geogenic Radon and Cosmic Radiation Maps, the next steps for the Atlas will be to develop maps of the concentrations of the elements U, Th and K and of terrestrial gamma radiation. For this latter the plan is to extract the natural terrestrial component from the total gamma dose data available from the EURDEP system (about 5000 stations, see https://eurdep.jrc.ec.europa.eu) by subtracting cosmic, inherent background, artificial, airborne and deposited contributions. We show the progress of some of these maps.

IMPACT OF RADON GAS CONCENTRATION IN THE AEROSOLES PROFILE

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Radon gases released from building materials and from earth surface are the major responsibility of air ionization. Radon nuclear decay can produce an alpha particle with high energy and Radon progeny. This particle and gamma rays can deliver particles in the air and produce ions with different polarities. These ions, because of induced electric charge, can attach with air aerosols and charge them with their electric charge. The charged aerosols can interact with the other aerosols and ions. Because of this exchange, the air conductivity and the aerosol profiles will change dependently by Radon gas concentration and gamma radiation. Observations show an increase in concentration of Radon during the night, and a decrease during the daylight time. The Radon gas concentration changed hour by hour can induce aerosol profile to change. This dependency between the aerosol profiles and the Radon gas concentrations is discussed in this article.

INDOOR RADON CONCENTRATIONS IN SCHOOLS OF THE CAPPADOCIA REGION

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This study presents the results of a survey of radon concentrations in schools (kindergartens, primary schools, secondary schools, high schools, colleges and faculty) located in the Cappadocia region. Radon measurements covered two consecutive 6-month periods in the ground floor classrooms inside the school buildings were performed using a continue active radon detector. Data distribution is well fitted by a log-normal curve. The arithmetic and the geometric mean values of radon concentrations in summer and winter were found as 75 Bq/m^3 and 58 Bq/m^3 and 67 Bq/m^3 and 54 Bq/m^3, respectively. Annual effective dose from radon exposures in summer and winter were estimated as 0.27 and 0.40 mSv and 0.24 and 0.36 mSv for students and teachers, respectively.

EXPOSURE TO RADON OF WORKERS IN UNDERGROUND TOURIST ROUTES IN POLAND

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Background. There are about 200 underground tourist routes in Poland. These are caves, mines, or underground structures. This paper presents the results of research intended to identify the extent of the occurrence of radon concentrations in underground areas of tourist routes.

Material and methods. We conducted the measurement of periodic concentrations of radon (1 to 2 months) in summer with the type of trace detectors Tastrak. We defined the average concentration of radon in 66 underground tourist routes in Poland.

Results. The research results comprise 259 determinations of average radon concentrations in 66 routes. The arithmetic average of the results is 1610 Bqm-3, and the maximum measured concentration was over 20,000 Bqm-3. The minimum concentration was 100 Bqm-3 (threshold method) considering the arithmetic average of the measurements. It was found that in 67% of the routes, the average concentration of radon has exceeded 300 Bqm-3 and in 22 underground routes it exceeded 1000 Bqm-3

Conclusion. The level of radon in over 82% examined routes, for the long-term exposures is important from the point of view of radiation protection. In more than 30% routes the employees have to be included into a environmental or individual dosimetric monitoring program, because of the possibility of exceeding the annual effective dose of 6 mSv (Category A workers' exposure). Radon which occur in many Polish underground tourist routes may be an organizational, legal and health problem. It is necessary to develop a program of measures to reduce radon concentrations in underground routes, especially routes located in the former mines.

ESTIMATION OF RADON EXPOSURE IN GEOTHERMAL SPAS IN POLAND

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Geothermal waters contain, among other components, soluble radon gas. Alpha radioactive radon is a health hazard to humans, especially when it gets into the respiratory tract. SPA facilities that use geothermal water can be a source of an increased radiation dose to people who stay there. It was necessary to assess the exposure to radon among people: workers and visitors of SPA centers that use geothermal waters. Material and Methods: In 2013, workers of the Nofer Institute of Occupational Medicine measured concentrations of radon over the geothermal water surfaces in 9 selected Polish SPA centers which use geothermal water for recreational and medicinal purposes. The measurements were performed by active dosimetry using Lucas scintillation cells. Results & Discussion: There is no risk for the SPA staff to receive doses that exceed the safe limits. According to our research, the doses received by the personnel in Polish geothermal SPAs are below 0.6 mSv/year. In one of the investigated SPAs, estimated annual dose to the staff may exceed 3 mSv/year.

Conclusions: In Polish geothermal SPAs, neither the workers nor the visitors are at risk of receiving excessive doses of radiation from radon.

RADON AND THORON IN AIRPORT ENVIRONMENT

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Introduction. In the years 2011 and 2012, a survey was carried out in 688 work places in 52 airport sites, spread on the national Italian territory, with the aim to evaluation the risk for the workers, due to the exposure to gas 222Rn - 220Rn. In the years 2013 and 2014, the same survey has been carried out again in order to verify the results, in different periods of the year. Every measurement point has been univocally identified with a picture, so to assure its correct position in the following measurements. The range of the difference of the results, obtained in the first survey and in the second one, is 10% -20%. In this paper the Authors describe and analyze the obtained data and want to give some useful advices to solve the problems dealt with during the measures.

Methodology. The measurements were carried out with an active instrument, the ALPHA GUARD P30 detector, for 30 minutes in every measurement point, after the room was closed and empty (without person inside) for at least 12 hours. The qualified expert was entrusted with the choice of the places for the survey. This choice has been based on the legal disposition for the sites characteristics and in relation to their criticality in respect to radon exposure

Results and discussion. The results of the surveys in the 688 places are distributed as in the following:

- in 468 places, 67,3%, the measured values have been less or equal to 1mSv/year;
- in 199 places, 17,3 %, the measured values have been between 1 mSv/year and 2 mSv/year
- in 14 places, 2,08% the measured values have been between 2 mSv/year and 3 mSv/year
- in 92 places, 13,37% the measured values have been between 3 mSv/year and 7 mSv/year

Conclusion. The surveys carried out during the two periods show that the measurements and the evaluation of risk due to the Radon-thorium exposure require the previous knowledge of different problems in relation to:

- the choice of the more suitable methodology and instrumentation;
- the choice of the places where to do the measurements;
- the choice of the value of the risk level, in Bq/m3, to set up;
- the planning of measurement methodology;
- the measurement elaboration, in relation to the physical environmental parameters and to the meteorological ones, due to the month of the year, when the measure was done;
- the choice of modality for the risk level reduction

For each one of these problems the Authors give some indications, for their solution and generalization.

RADON LEVELS IN TAP WATERS IN SLOVENIA

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Following the EURATOM directive 2013/51, radon (222Rn) has been systematically surveyed in 108 tap water samples of about 80 water supply plants (of total 881) in Slovenia. Selection was based on the population density, geology-lithology and indoor radon concentration in public buildings, and covers about one half inhabitants (of total two million) and 6 main lithologic units. Water sample was filled into a bubbler and purged with air to transfer radon into a scintillation cell for measurement. Radon activity concentration ranged from 0.13 kBq m−3to 28 kBq m−3, with an average value of 7.4 ±5.1 kBq m−3, thus ranking us among countries with the lowest radon levels. The highest value with the broadest scattering of values (from 0.45 to 28 kBq m−3) was obtained at alluvial and glacial deposits, while the highest average value of 18 ±7 kBq m−3, over metamorphic rocks. The resulting annual effective doses for adult persons were between 0.67 μSv a−1 and 143 μSv a−1, with an average value of 38 μSv a−1, significantly lower than the worldwide average of 1260 μSv a−1 due to radon in air.

INFLUENCE OF CONSTRUCTIONAL ENERGY-SAVING MEASURES ON THE RADON-CONCENTRATION IN THE AIR IN DWELLINGS

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Due to energy-saving measures the air exchange in residential houses may be reduced.

In order to determine time-dependent courses the indoor radon-concentrations were measured both, before and after renovation for several weeks. In addition, the most relevant climatic conditions or indoor climate factors, as e.g. the CO2-concentration, were measured. Prooving the renovation success, Blower-Door ®-Tests were performed, both as well before and after the renovation. Simultaneously the radon-concentration was measured in the living-rooms.

The results before and after renovation were compared with respect to seasonal parameters and the inhabitant's behavior. By investigation of the correlation coefficient the influencing parameters and the impact of the energy saving measures were analyzed. Based on the findings a model was developed to characterize the time-dependent course based on the influence quantities.

The energy-saving measures at the building considerably influence the radon dynamics. Due to the denser building envelope, fresh air flows in case of underinflation caused by stack effect not only from the outside but even through the basement from the soil. Thus, by this path the radon-containing air can be transported into the dwelling's rooms as well.

These results are supported by the findings of the Blower-Door ®-Tests. In some rooms there was an obvious increase of the radon-concentration caused by the applied underinflation. In contrast, for other rooms, particularly those with poor radon occurrence, no effects have been observed.

THE NRPI MULTI-PURPOSE ON-LINE MONITORING STATION FOR MEASUREMENT OF NATURAL RADIOACTIVITY IN THE AMBIENT ATMOSPHERE AND IN THE SOIL

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During the years 2010-2012 an automated, on-line and wireless outdoor measurement station of atmospheric radon, gamma dose rate and meteorological parameters was designed and realized at the National Radiation Protection Institute (NRPI) of Prague. The results concerning investigated seasonal and diurnal variations of outdoor radon gas have been already published.

At the turn of years 2013-2014 an expansion of the existing station was completed, regarding the possibility of simultaneous continuous monitoring both of atmospheric radon/thoron decay products and of radon from the soil, including measurement of its exhalation rate.

After introduction of the most important detection, operational and transmission characteristics of the station, which can be a part of network stations, in this study are presented the most interesting results of continuous measurement from the network of stations located within the premises of the NRPI, the DIAMO - state enterprise near above-ground disposal sites of radioactive waste and of the Osservatorio Etneo in an area of Mt. Etna volcano located on a major active fault and exposed to the summit craters gas emissions.

INDOOR RADON LEVELS IN SOME ENERGY EFFICIENT HOUSES FROM ROMANIA

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Modern trends in civil construction are based on increasing the energy efficiency of buildings in which we live. But unfortunately efficient insulation of buildings and the introduction of high-performance windows and other architectural and construction energy-efficient concepts lead to reduced of air permeability of building envelope and serves to elevate indoor radon levels and other pollutants.

In this paper the assessment of population exposure to radon in energy efficient buildings was discussed. The study aims to establish: (a) the extent to which the energy efficient or rehabilitation techniques effects the monitored parameters; (b) identify potentially risks induced by radon levels to population exposed in such houses; (c) a remediation protocol based on efficient mitigation methods applicable to energy efficient homes.

To investigate the influence of modern buildings technologies on the accumulation of radon in the indoor atmosphere measurements of radon will be performed in 25 energy efficient houses constructed in the last decade by using mostly solid concrete or gas-concrete blocks. Indoor radon measurements were performed by using nuclear track detectors CR-39 exposed for 6-9 months on ground floor levels of dwellings, according to the NRPB Measurements Protocol.

The overall concentration levels of the indoor radon in the 50 studied rooms from energy efficient houses involved in study varied from 19 to 667 Bq m−3 with a mean of about 170 Bq m−3.

The obtained value is approx. 35% higher than the average reported by authors for conventional homes of Transylvania, Romania. With respect of the year of construction, the mean values of radon concentration in the group of buildings constructed in the last decade are well greater than the average indoor radon level in buildings constructed during 1940-1990, which confirms the assumption that new energy efficient technologies or rehabilitation techniques effects on radon accumulation levels in dwellings.

The correlations between the energy efficient or rehabilitation techniques and the indoor radon concentrations are investigated and discussed.

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RESIDENTIAL, SOIL AND WATER RADON MAP IN SIBIU COUNTY, ROMANIA

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Exposure to radon and radon decay products in homes and at workplaces constitutes one of the greatest risks from ionizing radiation. Risk estimations show figures in the rank of thousands of death per year from cancer caused by exposure to radon and especially to its decay products. Nevertheless, radon constitutes a risk which can be managed and can be reduced at reasonable costs, thereby saving many lives. The news IAEA's Basic Safety Standards put radon issue in a significant position concerning the identification and management of population risks derived from exposure to radon inside buildings.

In the context of the international importance of radon monitoring in terms of impact on public health, the present study brings forward the residential, soil and water radon map of Sibiu County, Romania, based on 228 indoor radon data, 158 for soil and 137 water measurements, as a part of the radon map of the entire country. Additionally, were measured outdoor and indoor gamma dose rates in 240 points. Indoor radon measurements were performed by using nuclear track detectors CR-39 exposed for 3 months on ground floor levels of dwellings, according to the NRPB Measurements Protocol. Radon concentration from the soil gas and water were measured by using the LUK3C radon and thoron detector. Gamma dose rate were measured indoor and outdoor by Gamma Scout dosimeter. The maps were plotted on a reference grid with resolution 10 km x 10 km. In each grid were performed on average 5 indoor measurements and gamma doses, were measured 3 samples of radon in soil and were collected 3 samples from ground water.

The results for indoor radon measurements showed the annual means of 136 Bq m−3 radon concentrations in Sibiu County, higher than the average indoor radon exposure of 126 Bq m−3 for the Romanian houses. The average for radon concentration in soil gas in this area was calculated to be 15 kBq m−3. The obtained average value classifies the soil of Sibiu County, according to the used soil classification, into soil of medium geogenic radon potential. Radon concentrations in ground water were also calculated to be, on average, 26 Bq l-1, with the highest value of 233 Bq l-1.

In this study, we obtained a geometric mean value of 1.09 for the indoor to outdoor dose rate. The result for indoor and outdoor gamma dose rate indicates the arithmetic mean in the normal range. Adapted legislation and proper guidelines are to be enacted, with an aim to limit exposure to radon and to take measures where the risks are substantial.

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RADON ACTIVITY CONCENTRATIONS IN MUD VOLCANOES IN SICILY

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Radon emissions from bubbling mud volcanoes in Paternò, a village in the eastern Sicily (Italy), have been studied in order to investigate about their possible application for geodynamic processes study at the Mt. Etna volcano. In particular, in soil radon activity concentrations have been measured by means of SSNTDs and active devices for continuous monitoring. Radiometric characterization of the waters of mud volcanoes has been performed by means of γ-ray spectrometry and liquid scintillation analysis, on samples collected in the whole area. In order to discriminate shallow environmental effects, barometric and temperature series have been also monitored and compared with radon data. We report the preliminary results of this study, highlighting the limits and the potentialities of the method in view of extending the survey to other mud volcanoes throughout the Sicily.

EXPOSURE TO RADON IN DWELLINGS AND SCHOOLS IN THE SHARRI COMMUNITY, KOSOVO

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Indoor air radon concentration was measured by exposing etched track detectors in the sleeping and living rooms in villages of the Sharri community in Kosovo. Measurements were also carried out in schools of this community. Values for dwellings ranged from 24 Bq m-3 to 209 Bq m-3 with only one exceeding 200 Bq m-3 and for schools from 20 to 236 Bq m-3 with only one classroom exceeding 200 Bq m-3. Based on the assumption that the spring radon concentrations obtained in this survey represent the yearly average, annual effective doses of residents were calculated; they range from 0.89 to 4.7 mSv y-1, with the geometric mean of 2.2 mSv y-1 and geometric standard deviation of 1.5. No mitigation measures are planned to be undertaken.

Keywords: indoor radioactivity, radon, etched track detector, concentration, effective dose.

* This definition does not prejudge the position of status in accordance with UNSC Resolution 1244 and the International Court of Justice on Kosovo's Declaration of Independence

CONTINUOUS RADIATION MONITORING IN NORM INDUSTRIES USING THE DETECTOR TIMEPIX

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The detector Timepix is presented as a lightweight dosimeter providing information about concentration of short and long lived radon progenies and other radioisotopes of uranium/thorium decay chains. In order to identify concentration of short lived radon progenies we developed a new electro-mechanical system used for continuous gas filtering. Sampling on an open face filter is used for estimation of short lived radon progenies concentration. Spectrometric information is also used for identification and concentration estimation of other radioisotopes. An identification of hot-spots is also studied.

ERROR ASSESSMENT ON THE PLANNING STAGE OF NATIONAL RADON CASE-CONTROL STUDY

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In spite of the good correlation of the results of North American and European combined radon case-control studies, some questions about the possible influence of errors of radon exposure assessment on the results still exist. The possible answer on the correct value of the exposure-effect slope coefficient can be obtained during the national radon case-control study, which planned in Russia in nearest future.

The possible influence of errors of radon exposure assessment on the results of planned national case-control study has been analyzed. It was demonstrated that even at good matching of case and control groups by sex, age and smoking status the main sources of the possible errors are: radon measurement errors, short and long term variations of radon concentrations, different scenarios of dwelling occupancy. The measurement errors of the typical in Russia radon short and long term detectors are in the range 30 - 45%. For retrospective radon detectors, the possible error of the single measurement can be as high as 50%. It is demonstrated that, in general, the errors are classical multiplicative errors and, at correctly organized case control study, Berkson error can by minimized. It was demonstrated that classical multiplicative error of radon concentration measurement are not constant in all radon concentration range. At low radon concentrations, the additional influence of Poisson error on the measurement result should be considered.

The modelling of the influence of errors of radon exposure assessment on slope factor of the dependence of lung cancer incidence on radon concentration in dwellings was conducted. The radon concentration distribution typical for Russian dwellings in general (GM = 46 Bq/m3; GSD = 2.72) was assumed. It was shown that the expected level of radon exposure errors can reduce the observed value of slope coefficient at least twice in comparison with the original value for error-free study. The correction of the results of linear assessment of exposure-effect slope coefficient under the influence of measurement errors was realized by regression calibration technique and SIMEX extrapolation method. Both methods give the similar good results in restoring the original unbiased value of exposure-effect slope coefficient, so both these techniques can be used independently.

Additional and most powerful source of error in the radon epidemiological studies is the mistakes in correction on smoking status. The modelling results of the simultaneously influencing errors in smoking status and radon exposure measurements demonstrated that maximum attention should be paid to the stratification by smoking status.

RADON EXPOSURE AND DOSE CALCULATION: PROBLEMS OF CHOICE

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Two general approaches were used by ICRP to the conversion from radon exposure to effective dose. In the Publication 65 ICRP, "dose conversion convention" based on the comparison of radiation detriments at radon expose and whole body external exposure to low LET radiation was suggested. Later, such approach has been reported as incorrect in Publication 115 ICRP, and direct calculations of absorbed, equivalent and as a result effective dose using reference biokinetic and dosimetric models with specified radiation and tissue weighting factors was recommended.

Both positive and negative aspects in application of these approaches should be analyzed in more details. Application of the reference models is necessary to integrate the radon protection to the overall radiological protection system of ICRP. Advantage of "dose conversion convention" is possibility to consider epidemiological data on health effects of radon exposure together with a sex and age structure of population, lung cancer background incidence rate and smoking prevalence. Consequently, it allows building more realistic strategy of protection against radon.

To calculate dose conversion factors from radon exposure to effective dose (DCF) according to "dose conversion convention" approach, radiation risks from whole body gamma-exposure and radon exposure had been calculated for different exposure scenarios. Most recent risk models constructed using the epidemiological data both for occupational and population exposure were considered. The averaged values of radiation induced detriments have been used for DCF estimations.

For male miners and low level exposure, estimated DCF were in range from 12.7 to 19.4 mSv/WLM depending on the age at exposure and 11.0 mSv/WLM at uniform radon exposure from age 20 to 60. For population, radon risk models, based on miner's data, were normalized to the results of European combined indoor radon and lung cancer study. For males, the DCF are in the range from 5.9 to 19.9 mSv/WLM and for females from 1.1 to 3.3 mSv/WLM in dependence on the age at exposure. For lifetime exposure the DCF are 7.8 and 1.5 mSv/WLM, correspondingly. Such male to female difference in DCF arises due to different rates of spontaneous lung cancer incidence and increased absolute radiation risk at external exposure.

Calculations using reference human respiratory tract model was presented in the works of Marsh, Birchall, Hoffman et al. For mine conditions, the log normally distributions of DCF values with GM in range from 12 to 21 mSv/WLM and, for indoor atmosphere in dwellings, the DCF GM values were from 7.0 to 10.5 mSv/WLM in dependence on the choice of relative weighting coefficients of lung regions.

Application of the different dose calculation approaches to protection against radon will be further discussed in final presentation.

A HISTORIC SAND MINE SYSTEM - REAL-TIME RADON CONCENTRATION SURVEY RESULTS AND TIME-AVERAGED SSNTDS, REIGATE CAVES, UK

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The caves in Reigate are situated along Tunnel Road in Reigate, UK. Their history is somewhat uncertain but they have been used in the recent past as air raid shelters, wine stores, a cold-war bunker etc. They consist of an East and West system separated by a road now used for foot traffic only, and a much older cave called Barons cave which is thought to have a medieval origin (11th Century AD) and has been associated with Reigate Castle. Little of the latter now remains.

The western caves were used as air raid shelters during the Second World War and now are home to a shooting range. Measurements for radon gas concentrations were made in this system as a series of snapshot real-time readings, but due to access difficulties the bulk of this project work was undertaken in the eastern caves.

The latter were measured over a 9 month period for radon gas using a Rad7 real-time radon detector taking 2 hourly readings. The data for each 3 months was downloaded at Kingston University and the detector replaced. Alongside the Rad7 CR39 based SSNTDs were placed throughout the eastern cave system to ascertain the overall pattern of radon distribution and compare results with the real-time detector. The latter was placed in the centre of the cave system for the first 6 months, but was moved to an abandoned wine cellar for the last 3 months due to power supply issues. When visits were made to change the desiccation tower used for the Rad7, measurements were also made on occasion using a Sarad Doseman real-time dose monitor. The Rad7 results showed considerable radon variation with a maximum of 640 ± 44 Bqm-3 being noted in the summer months (August 2010), highs in June and July of 417 ± 35 Bqm-3 and 479 ± 38 Bqm-3 respectively, and highs in the winter period of around 239 ± 27 Bqm-3and 341 ± 32 Bqm-3. The winter and spring periods showed lower averaged results than the summer period. This is in an area identified by the Health Protection Agency IN the UK where 1-3% of homes are above the UK indoor radon Action Level of 200 Bq m-3 (Miles et al., 2007).

Samples have been taken of the sands for ICPMS analysis to ascertain their geochemical composition. One reason for doing this is to see if there is a source for radon gas within the sands (whether in other words any gas present in the cave system is supported or unsupported).

Results of our survey suggest that considerable variations in radon gas concentrations occur through both daily and greater length cycles. Analysis is under way to see whether these cycles related to cave occupancy – steel doors to the caves being opened and closed for access introducing fresher air into the system for example – or to cycles associated with weather patterns, tidal variations etc.

DETERMINATION OF INDOOR RADON EXPOSURE FOR DIAGNOSIS OF LUNG CANCER PATIENTS IN IZMIR

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Aim: In the present study, it was aimed to measure and compare the radon activity concentration using LR-115 solid state nuclear track detectors in the homes of patient diagnosed with lung cancer and healthy people residing in the same district in İzmir; to determinate the frequency distribution of indoor radon activity concentration; to make the radon distribution maps for different counties; to investigate the parameters affecting the indoor radon activity concentration; to estimate the dosimetric calculations with passive radiometer and to assess the annual effective doses from the radiation protection point of view.

Materials and Method: LR-115 type solid state nuclear track detectors were installed in the bedrooms and living rooms of the volunteers' houses and were exposed for 2 months. LR-115 detectors were etched for 90 minutes in 10 percent (2,5 M) NaOH solution at 60 centigrade degree and radon activity concentration was determined from observed microscopic track densities.

Results: It was determinated that indoor radon concentration ranged between 28 - 487 Bq/m3 with an arithmetic mean of 210 Bq/m3 in the investigated county of İzmir. Indoor 222Rn activity concentration for lung cancer patients was found in the range of 138 to 472 Bq/m3, while it was found in the range of 28 to 367 Bq/m3 for the healthy group. Exposed annual effective dose equivalents of the patient and healty group participated in the research were estimated in the range of 4.2 to 12.3 mSv/year with a mean of 7 mSv/year and in the range of 1.0 to 9.3 mSv/year with a mean of 3.4 mSv/year, respectively. Because of the geological structure effect on the radon concentration, measured indoor radon concentrations were obtained higher in the county of Buca and Bornova compared to the county of Bayraklı and Karşıyaka.

Conclusion: It is seen that reported values for radon concentrations and corresponding estimated annual effective equivalent doses were in the safe range according to the ICRP and TAEK recommended limits for houses', except for one house in Bayraklı and Bornova and two houses in Karşıyaka. However, radon concentrations in the 59 of the 117 investigated houses were found higher than the ICRP (1993) action level of 200 Bq/m3. It is observed that measured average indoor radon concentration in the homes of patient group (261 Bq/m3) were twice as high as in the healthy group homes (123 Bq/m3).

INDOOR ^{222}Rn LEVELS AND EFFECTIVE DOSE ESTIMATION OF ACADEMIC STAFF IN IZMIR-TURKEY

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Objective: To investigate the annual effective doses from indoor radon received by academic staff in the Faculty building.

Methods: Measurements of indoor radon concentrations were performed in the Arts and Sciences Faculty of Dokuz Eyllil University for two surveys of about 1 month duration respectively using the SSNTD (Solid State Nuclear Track Detectors) method with LR115 detectors. Time integrated measurements comprised different locations inside the faculty building: classrooms, toilets, canteen and offices. Homes of academic staff were also tested for radon.

Results: The arithmetic mean radon concentration is 161 Bq m-3 with a range between 40 and 335 Bq m-3 in the Faculty. Six offices and three classrooms have a radon concentration above 200 Bq m", The results show that the radon concentration in classrooms is generally higher than in offices. Based on the measured indoor radon data, the annual effective doses received by staff in the Faculty were estimated to range from 0.79 to 4.27 mSv, according to UNSCEAR methodology. The annual effective doses received by staff ranged from 0.78 to 4.20 mSv in homes. On average, the Faculty contributed 56% to the annual effective dose.

Conclusion: Reported values for radon concentrations and corresponding doses are within the ICRP recommended limits for workplaces.

RADON LEVELS IN PORTUGUESE THERMAL SPAS

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Radon gas is recognized as the most significant natural source of human exposure and the leading cause of lung cancer incidence, with the exception of tobacco. Thermal spas have been identified as one of the professional activities with potentially higher exposure to radon mostly due to the inhalation of radon released from spa thermal waters. Several studies have been conducted worldwide to measure the concentration of radon in water and in the air of thermal spas in order to estimate the exposure doses both for workers and for users.

The purpose of this work was to evaluate the exposure doses to radon in different workplaces of Portuguese thermal spas. First, a literature review was conducted through several databases to identify the most relevant parameters in the selection of the thermal spas and workers characteristics to be included in the study. Some workers dwellings were also selected to assess the contribution of radon indoor concentration to the occupational exposure.

A survey was made for thermal spas and workers houses to characterize as much as possible all variables which may have influence in the radon concentration levels as well as in the exposure pattern. The assessment of radon concentration included measurements in two different periods (summer and winter) in the indoor air of the selected thermal spas and in the workers dwellings. Regarding the assessment of radon concentration in water a single measurement was carried out in two different locations: at the perforation and in the water used in the treatment rooms.

The results showed that the recommended limit for drinking water of 1000 Bq/L (2001/928/ EURATOM) was exceeded in 24% of the selected thermal spas while radon concentration in indoor air, ranging between 73 and 3479 Bq/m3, exceeded the EU reference level of 200 Bq/m3 in 67% of the measurements and the reference level of 400 Bq/m3 (Directive 90/143/EURATOM) in 81% of the total indoor radon measurements carried in the selected thermal spas. According to the EU Directive, an annual average radon gas concentration of 200 Bq/m3may be taken as an effective dose equivalent of 10 mSv per annum and an annual average radon gas concentration of 400 Bq/m3 may be taken as an effective dose equivalent of 20 mSv per annum.

ESTIMATION OF INDOOR RADON CONCENTRATIONS IN THE REPUBLIC OF MOLDOVA

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The results of radon concentrations monitoring in the air samples collected from different buildings placed on the territory of the Republic of Moldova between 1991 and 2011 are given in the paper. Investigations have concluded that the ^{222}Rn concentrations (92.0 - 1791 Bqm-3) in most cases do not exceed the reference level, with the exception in 1998 year when a level of about 1800 Bqm-3 have been detected.

In 2007, 430 measurements were made in 61 rooms: unit housing (27), private house (2), socio-cultural monument (11), industrial building (21). It was established that 421 222Rn activity measurements presented values lower than 100 Bqm-3, 7 measurements had activities higher than 100 Bqm-3 while only in two locations were measured more than 200 Bqm-3.

In 2008, 280 indoor measurements were made in 39 areas. Measurements have revealed values of 222Rn activity less than 100 Bqm-3 in the majority of cases. Only 2 locations, representing 1% of all investigated houses within the territory of Republic of Moldova exceeds the level of 200 Bqm-3 for radon concentration.

The analysis of ^{222}Rn concentrations in air samples results from 294 cases demonstrate that the values recorded ranged between 15.0 Bqm-3 and 1930.0 Bqm-3. Our research reported the exceeding of the maximum allowable level of radon concentration indoor in two cases of 1993 (280 Bqm-3 and 368 Bqm-3), 10 cased in 1995 (from 201 Bqm-3 to 681 Bqm-3) and 3 cases in 1998 (from 212 Bqm-3 to 1930 Bqm-3).

In the period of 1993-1998 were performed measurements of 222Rn concentrations in several stone mines from Cricova village and underground galleries located on the territory of Chişinău and Mileştii Mici village. The air samples were collected from mines at different depths: 50 to 85 m. The study demonstrated that values of 222Rn concentrations were classified within the acceptable limits, ranging from 92 Bqm-3 to 179.1 Bqm-3 in the majority of cases. The overtaking (211.6 Bqm-3) was registered on 02.12.1998 in an underground gallery of Milestii Mici village, at a depth of 70 m.

The measurements of Radon concentrations made during the period of 30.05 – 02.06.2006 by German expert in the field of radon monitoring Dr. Thomas Streil (radiometer SARAD radon Scout nr.7, Radon Scout Plus Nr.84, SARAD Dose man Pro No.193, SARAD Myriam No.265) in underground galleries of Chisinau and Milestii Mici village, in several mines of the Orhei Town, showed values exceeding the maximum allowable concentrations in all the samples of underground galleries, ranging between 200 Bqm-3 and 1800 Bqm-3 [1].

Conclusions

The results require the need of radon concentrations monitoring carried out in dynamics, with the subsequent elaboration of the radon concentrations maps. It is necessary in developing of the maps to use 5 indicators: the indoor radon measurements, geology, and radioactivity in air, soil permeability and foundation type. The radon genesis is based on specific conditions, definite locality, to form the principles which are used in mapping of radon concentration.

The implementation of the extended national programme for radon monitoring in dwellings and the estimation of the public exposure from radon in different types of houses and building materials need to be more developed in the near future.

The implementation of the programme for mines monitoring and underground gallery workers are suggested.

The extension of the measurement areas together with evaluation of radon concentration in living houses and all existing working mines in the Republic of Moldova is necessary.

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THE EFFECT OF ACTIVATED CHARCOAL AND ZEOLITE HEATING ON THEIR ADSORPTION CHARACTERISTICS

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Recently, an increase in number of studies oriented toward measurement of radon adsorption by alternative types of adsorbing material is evident, and one of those materials is zeolite. Zeolite has a porous structure which enables its good surface adsorption capacity.

In our previous investigation, measurements of radon adsorption by various zeolite granulation was done [Bikit et al, 2015]. The zeolite samples were exposed to elevated radon concentrations up to 1800 Bq/m3 inside a closed chamber (volume ≈ 5.4 × 10−3 m3) and the absorbed radon quantity was measured by high resolution gamma spectroscopy. We found that the adsorption coefficients that were obtained in our experiment for natural zeolite samples for different granulations were similar to adsorbing coefficients for silica gel, but they are an order of magnitude lower than radon adsorbing coefficient for synthetic zeolite. The adsorption coefficient for activated charcoal derived in our experiment (≈3 m3/kg) was in average 50 times higher comparing to the adsorption coefficients obtained for zeolite samples (0.038 m3/kg-0.11 m3/kg). Our results suggested that zeolite, with some constrains, can be used both, to radon measurements (in the case of higher radon concentrations [Sextro, 1987], [Ennemoser et al., 1993]) and radon suppression in the air of dwellings, especially having in mind inexpensiveness of the zeolite and its wide availability.

In order to further test adsorption capacity of zeolite, we will investigate the influence of preheating zeolite samples of different granulation. By preheating the samples, it is possible to eliminate excess moisture and radon already adsorbed in the sample, thus enabling better adsorption when exposed to radon-rich atmospheres.

By heating canisters with activated charcoal which have been already exposed to radon, we intend to test reusing of such canisters and derive appropriate calibration and moisture correction factors.

RADON MEASUREMENTS IN KINDERGARTENS IN URAL RADON PRONE AREAS

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Exposing the LR-115 nuclear track detectors, indoor radon concentrations have been measured in 80 kindergartens in villages and towns of Ural region, Russia. Detectors were placed in 270 rooms for a 1-2 month during the winter and summer time. The arithmetic and geometric means of annual indoor radon concentrations were 57 and 39 Bq/m3,σLN=0.89. The measured levels of the indoor radon were relatively low, we have found only one kindergarten, where radon concentration was above the national level of 400 Bq/m3 for existing buildings. The calculated annual mean effective dose for children during their stay in kindergartens is 0.4 mSv. The statistically significant difference between mean radon concentrations in rooms located on the ground floor (64 Bq/m3) and the first floor (44 Bq/m3) was observed. No significant difference of radon concentrations depending on building materials (bricks or concrete) was found. The seasonal variation analyses in the subgroup of ground floor rooms showed the higher radon concentrations during winter time (heating period).

SOIL GAS RADON ANOMALIES AND SEISMIC ACTIVITIES AROUND BODRUM PENINSULA

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In this study, radon concentrations were monitored in tectonic zones of Bodrum Peninsula, Western Turkey. It was selected twenty stations for soil gas radon measurements. The radon concentrations in the soils were periodically measured by using LR-115 Type 2 nuclear track detectors. Data obtained from Bogazici University Kandilli Observatory and Earthquake research Institute was incorporated in the analysis to correlate with the collected radon concentration. In addition, the relationship between radon anomalies and seismic activities was evaluated by using Dobrovolsky's equation. It was observed that soil gas radon concentrations were varied from 0.7 to 52.9 kBq m-3. The results were compared with other studies.

EXPOSURE FROM NATURAL RADIATION SOURCES IN A ROMANIAN TERRITORIAL AREA

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A two years (2012-2013) campaign measurements for inhaled airborne radon (^{222}Rn) and Radium (^{226}Ra) from water ingestion was conducted to assess the natural exposure of population from the east region of Romania (eight counties). We performed sampling of their individual concentrations, in indoor and outdoor air and in water intended for human consumption, by an active technique. Also, the annual effective doses were estimated using the conversion coefficients published in UNSCEAR Reports and ICRP Publications. The annual effective doses estimated in rural houses were slightly higher (1.77 and 2.33 mSv) than the annual admitted limit of 1mSv/year for the general population in three different counties (Iasi, Suceava, Botosani), the highest value of 8.9 mSv/year being observed in both years for another three counties (Galati, Vrancea, Braila). For water ingestion the maximum effective dose was high (0.236 mSv/year) only for samples in the proximity of an uranium mine (Suceava). We intend to extend this campaign at national level for estimating and mapping the risk to Radon exposure.

NEW CHALLENGES FOR RADON RELATED WITH THE EU-BSS: THE SPANISH EXPERIENCE

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The new Basic Safety Standards (BSS) for protection against the dangers arising from exposure to ionising radiation were issued in January 2014. This Directive aims to establish a common framework of safety standards to protect the health of the people. In particular, this document applies to the management of existing exposure situations, including the exposure of members of the public to indoor radon, the external exposure from building materials and cases of lasting exposures resulting from the after-effects of an emergency or a past activity.

In terms of radon gas, the Annex XVIII of the document summarizes the list of items to be covered in the national action plan to manage long-term risks from radon exposures. This list includes all topics related to the radon issue needed to prepare a radon action plan in the EU member states. It covers aspects from the initial stages to obtain data to the development of strategies aiming to communicate and reduce the radon problem in the different countries.

Spain has been developing radon data acquisition since the 90's. However, the country is in an early stage of development if considering the 14 items included in the Annex XVIII of the EU Directive. The current work pretends to give an overview of what has been done and what is still missing in terms of national radon action plan in Spain.

We include here results of the last attempt to produce the radon map of Spain and, therefore, the identified radon risk areas and resulting radon risk map of the state. To conclude, we come up with a road map designed to implement an action plan in the country to fulfil with requirements of the new EU Directive before the deadline for its implementation into national legislation in 2018.

STUDY OF ^{222}Rn EXHALATION RATE AND NATURAL RADIOACTIVITY IN SOIL SAMPLES FOR THE ASSESSMENT OF AVERAGE EFFECTIVE DOSE

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The activity concentration of natural radionuclides and ^{222}Rn (Radon) exhalation rate in soil samples were determined using NaI Scintillation detector and Scintillation Radon Monitor. Soil samples were collected from different geological formations of the same area. The average value of Radium equivalent activity (Raeq) in soil samples of the studied area was 124.9 Bq kg^{-1}. Raeq was calculated for the analyzed samples to assess the radiation hazards arising due to the use of these soil samples in the construction of dwellings. The ^{222}Rn exhalation rate in the studied area was varied from 6.9 ± 0.2 mBq Kg^{-1} h^{-1} to 33.2 ± 2 mBq Kg^{-1} h^{-1}. A positive correlation was obtained between the ^{226}Ra (Radium) in soil and ^{222}Rn exhalation rate. The overall average annual effective dose in the studied is lower than the world recommended value of 1.0 mSv a^{-1}.

Key words: NaI (TI), Raeq, SRM, 222Rn Exhalation Rate

MEASUREMENT OF EEC AND UNATTACHED FRACTION OF ^{222}Rn AND ^{220}Rn USING DEPOSITION BASED PROGENY SENSORS AND PIN- HOLE CUP DOSIMETERS

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^{222}Rn (Radon), ^{220}Rn (Thoron) and their decay products are the leading sources of radiation exposure to the general public The ^{222}Rn, ^{220}Rn concentration and their separate attached and unattached progeny concentration in units of EEC have been measured in the dwellings of Muktsar district of Punjab (India), using Pin- hole cup dosimeters and deposition based progeny sensors (DTPS/DRPS). The total (attached + unattached) Equilibrium Equivalent ^{222}Rn Concentration (EECR A+U) and total (attached + unattached) Equilibrium Equivalent ^{220}Rn concentration (EECT A+U) was 21 Bqm-3 and 1.6 Bqm-3 respectively. It has been observed that unattached progeny for both ^{222}R and ^{220}Rn was greater for summer season as compared to winter season. The average arithmetic means of fp (Rn) and fp (Th) in the studied area were 0.08 ± 0.02 and 0.09 ± 0.03 respectively. The average equilibrium factors for ^{222}Rn (FRn) and ^{220}Rn (FTh) in the studied area were 0.46 ± 0.11 and 0.09 ± 0.04 respectively.

Key words: Radon (^{222}Rn) and Thoron (^{220}Rn), Pin- hole Cup Dosimeters, DTPS/DRPS, Unattached fraction.

RADON EMANATION CHARACTERISTICS IN CENTRAL YAKUTIA

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The content of radon in living and commercial buildings in the territory of Yakutia was investigated. There is an altitudinal gradient of radon. Low temperatures at an unventilated accommodation contribute to the accumulation of radon. In the nine-floor building with a maximum contents of radon volume concentration of 45 Bq/m3 on the ninth floor a person receives effective dose of 1.935 mSv/year. According to the standards of the International Commission on Radiological Protection an individual annual effective dose from radon should not exceed 10 mSv/year. According to these international standards in this building a person gets dose in 5 times less than the annual effective dose. Agreement with Russian standards the allowable radiation dose from radon should not exceed 3.34 mSv/year. Consequently, in the hostel a person receives an annual dose of 1.7 times lower than the MAC of Russian standards.

Key words: radon, maximum allowed concentration, effective dose

SPACE RADIATION

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IN VIVO ^{56}Fe IRRADIATION OF AORTAE OF WILD TYPE C57BL/6 MICE RESULTS IN INCREASED ENDOTHELIAL ADHESIVENESS

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Atherosclerosis is a well-known consequence of radiation exposure. For example, therapeutic irradiation of head-and-neck cancers increases the risk of stroke years later. Similarly, both atomic bomb survivors and workers exposed after the Chernobyl nuclear accident had an increased risk of myocardial infarction and stroke. Although these risks are well established, the risk of deep-space travel is difficult to predict. Unlike terrestrial radiation, cosmic radiation has a large component of accelerated ions. These ions present particular challenges due to their high energy and propensity to interact with shielding to generate secondary particles. Nonetheless, we showed earlier that, in mice, the effect of ^{56}Fe on atherosclerotic plaque development is very similar to that of x-rays, except that lower doses are required.

The mechanism by which radiation leads to atherosclerotic changes years after exposure, however, is not clear. A possible mechanism is that radiation initiates vascular inflammation, which increases endothelial adhesiveness. Since inflammation, once initiated, can be self-perpetuating, effects could persist long after the initial radiation event. This can lead to monocyte accumulation, differentiation to macrophages, conversion to foam cells, and eventually, formation of atherosclerotic plaques.

We showed earlier that x-rays and ^{56}Fe both have a direct, pro-adhesive effect on isolated endothelial cells in vitro, leading to increased endothelial adhesiveness, but did not rule out other, indirect effects that might also modulate endothelial adhesiveness. Therefore, to address the effect of radiation exposure on inflammation in a more complete system, we irradiated whole mice and assayed changes in adhesiveness of their aortas.

10-week old C57BL/6 wild-type male mice were exposed to 0, 0.5 and 2.0 Gy 600 MeV 56Fe at Brookhaven National Laboratory. At 2 and 6 weeks post irradiation, aortae were dissected out, opened and pinned to dental wax to expose the endothelium. They were then incubated at 37°C with WEHI 274.1 mouse monocytic cells. After washing, the monocytic cells were counted.

We found that aortic endothelial adhesiveness was significantly increased following both 0.5 and 2.0Gy ^{56}Fe as early as two weeks post-irradiation. Further, at the 6-week time point, this radiation-induced adhesiveness persisted. The dose required to significantly increase endothelial adhesiveness was 4-fold lower than that required for isolated endothelial cells in vitro. This suggests that whole-body irradiation either results in additional factors that promote inappropriate adhesion of monocytes to vascular endothelium, or works in concert with other inflammatory factors already present in the body. Importantly, this also suggests that the risk of myocardial infarction or stroke later in life is increased by heavy ion doses similar to that to which astronauts are expected to be exposed on a Mars mission.

FD_ORBIT2 - SOFTWARE PACKAGE FOR CALCULATION OF RADIATION CONDITIONS OF S/C FLIGHT IN COMPLEX EVOLVING EARTH ORBITS

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Presently, there are a lot of programs for calculation of radiation characteristics in the period of spacecraft in-orbit flight. But they all are adapted for S/C performing their flight in orbits with certain given ballistic parameters - perigee and apogee altitudes, inclination, etc. At Lavochkin Association the computer code FD-ORBIT2 was developed; it is intended for determination of absorbed doses and fluxes of charged particles during S/C flight in complex evolving Earth orbits.

The initial data for radiation environment calculation are mission ballistic data (initial elements of an orbit and set of S/C coordinates) and real time of take-off.

The fluxes of charged particle of the Earth Radiation Belt (ERB) are determined using AP8/AE8 [1] models. The program FD_ORBIT2 includes Russian models of solar and galactic cosmic rays and the model of penetration of charged particles into near-the Earth orbits [2-3].

The software is used for calculation of absorbed doses while on the path of flight of orbital astrophysical observatory “Spectr-R” as well as prediction of radiation environment for future Gamma-400 S/C.

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RADIATION INVESTIGATIONS FOR EXOMARS 2016 AND 2018 INTERPLANETARY MISSIONS -OBJECTIVES, EXPERIMENTS AND INSTRUMENTATION

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Deep space manned missions are already a near future of the astronautics. Radiation risk on such a long-duration journey appears to be one of the basic factors in planning and designing the mission. The paper relates to scientific objectives and experiments for investigation of the radiation environment to be carried out during the ExoMars 2016 and 2018 missions to Mars. Described are: 1) The charged particle telescope and the experiment Liulin-MO for measurement the radiation environment onboard the ExoMars 2016 Trace Gas Orbiter satellite as a part of the Russian Fine Resolution Epithermal Neutron Detector (FREND) and 2) Liulin-ML experiment and instrument for investigation the radiation environment on Mars as a part of the active detector of neutrons and gamma rays (ADRON) on the Russian surface platform for ExoMars 2018 mission. Liulin detectors will be used in combination with the neutron detectors to study the radiation conditions both from charged particles and neutrons during the cruise phase, on Mars orbit and on the surface of Mars.

RADIATION MEASUREMENTS ON THE INTERNATIONAL SPACE STATION WITH LIULIN-5 DOSEMETRIC TELESCOPE: SUMMARY OF RESULTS FOR YEARS 2012 / 2014

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Since June 2007 the Liulin-5 charged particle telescope has been observing the radiation characteristics at three depths along the radius of the spherical tissue-equivalent phantom of MATROSHKA-R project on the International Space Station (ISS). In the period from 2012 to 2014 measurements were conducted in and outside the phantom located in the MIM1 module of ISS. In this paper attention is drawn to the obtained results for the dose rates, particle fluxes and dose equivalent rates in and outside the phantom from galactic cosmic rays, trapped protons and solar energetic particle events occurred in that period.

GEANT4: COMPARISON OF SHIELDING EFFECTIVENESS OF ALUMINUM AND PMMA FOR 1 GEV PROTONS

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The Cosmic Radiation (CR) represents a serious health risk for astronauts during space travels. The space radiation is a mixed field, it is possible to distinguish three categories:1. Van Allen radiation belts, 2. Galactic Cosmic Radiation (GCR) and 3. Solar Particle Events (SPE) (Cucinotta and Durante, 2011). In particular, for an unshielded crew, the SPE, composed for 98% of protons with energies up to several GeV and high fluences (≈ 1011 particles/cm^2), represent one of the main health risk for long duration manned interplanetary missions (McGuire et al., 1986). At present, the only countermeasure used to reduce exposure to radiation in space missions is shielding. The study of the interaction between high-energy particles and targets of different materials, is aimed to optimize the shielding.

For this reason, the simulation, of the trend of dose before and after the target (of 20 g/cm^2) of aluminum and PMMA, evaluated with a tissue equivalent ionization chamber, was performed with the Geant4 that is a versatile and powerful toolkit to simulate the passage of particles through matter (Giani, 1995). The simulated experimental setup is constituted by a source of 1GeV protons, placed at 30 cm from the center of the target, in air . The target is a slab of aluminum (d=2.70 g/cm^3) or PMMA (d=1.19 g/cm^3), of parallelepiped shape, of a thickness 20g/cm^2 in the incidence direction of the primary beam and base surfaces 30x30 cm. The dose values are obtained by simulating the presence of a tissue equivalent ionisation chamber produced by Far West Technology, Inc., IC-17 model.

Validation of an application developed in Geant4, for the study and optimization of shielding in the exposure conditions to SPE, was performed by comparison with data of the NIST database PSTAR, available online, and experimental data (Mancusi et al. 2007).

The results that will be presented show a comparison of the performance of dose, in the same conditions of the experimental setup for two different target materials, hydrogenated material (PMMA) compared with aluminum. The comparison, as well as already present in the literature, confirms that the hydrogenated materials have a better shielding effectiveness.

THE PRACTICE OF SPACE RADIATION EXPOSURE ON AVIONICS IN-FLIGHT MEASUREMENTS BY ELEMENTS OF ROSCOSMOS MONITORING SYSTEM

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The spacecraft avionics operates under constantly adverse impact of space radiation, so it is necessarily to estimate remaining resource of avionics. It is approach is realized in Russian Federal Space Agency Monitoring System of space radiation exposure on avionics and electronic components. The key targets of Monitoring System are the improvement of technical requirements of radiation hardness, the improvement of ground test standards, the calculation of spacecraft remaining lifetime, control of algorithmic methods of radiation hardness improvement. The subject considered is in-flight control of TID effects on electronic components.

The base element of space-born segment is set of TID sensors, operating on MNOSFET dosimetry principle. ~40 TID sensors were placed onboard ~20 spacecrafts at the circular orbit ~20000 km since October 2008.

The short-time flight data analysis results are presented. Anomalous increasing dose rate events were observed. The changing of in-flight (charge particles fluxes and dose rate data from different spacecrafts) and ground (neutron monitor data) measured space weather characteristics during dose rate increasing events are analyzed.

Calculations of different particles contribution in dose rate increasing were carried out. Results of calculation and experimental data comparison are presented in the paper. The results are in agreement with experimental data of MSL/RAD. It was shown that solar particles exposure can be a cause of considerable dose rate increase and consequently electronic equipment failure. But the main cause of dose rate increasing events at the circular orbit ~20000 km is electron exposure.

The long-time flight data analysis results are presented. The calculated and measured annual dose rate values were compared. The simplified 3D radiation model of spacecraft, sensor and sensitive element was constructed to calculate dose rate in the sensitive element location. Different space models were used for calculation.

ABOUT POSSIBLE INFLUENCE A POLARITY REVERSAL OF THE SUN'S MAGNETIC FIELD ON GALACTIC COSMIC RAY IN POLAR CAP

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The radiation monitoring service was created for ensuring radiation safety astronauts. Radiation control in the near-earth space by satellites "Meteor" with a polar orbit and radiation control in a stratosphere by radiometric radiosondes RRZ was exercised. Variations of the galactic cosmic ray (GCR) in a polar cap with a cycle of solar activity are investigated. Simultaneous measurements of GCR with energy of protons more than 90 MeV at the height of 800 km ("Meteor") and near border of the atmosphere (RRZ) showed that during a polarity reversal of a magnetic field of the sun their relation significantly change. In case of effect confirmation, it needs to be considered at an assessment of influence of variations GCR on ionization of the polar atmosphere.

OTHER TOPICS

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SERVER'S IMPLEMENTATION IN CLUSTER SYSTEMS

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Environments of today's calculations, oriented towards network include high-performance, independent file system from the network and can perform such as storage requirements of each individual system also the separation of data for cooperating systems. Lustre file system is an open source system, with high-performance built by Cluster File Systems Inc. and is a distributed file system that eliminates the performance problems, the availability and scalability, which are present in the traditional distributed files system.

Lustre is an architecture that combines open standards, Linux operating system and a network of reliable innovative protocols. This neutral system produces a high I / O throughput in clusters, environments with separate data and an independence from the data positioning on physical equipment. Certainly, Lustre provides protection from failures and rapid coverage of the mistakes through cluster re-configuration.

The Scope and the field of the application: the purpose of using this file system is that it offers a number of benefits that are necessary in processing environments based on clusters. The performance, scalability and availability are the topics on which it is based the cluster system. The application areas of this system are very large where can be mentioned experimental laboratories, in universities, in business companies, etc.

AN ANALYSIS OF ENERGY AND PERFORMANCE IN SHARED MEMORY MULTIPROCESSORS

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Multiprocessors on Chips are very frequently used on embedded systems (multimedia, graphic adapter etc) where the most critic point is Energy/Power consumption. One interesting item is cache coherence. This article will focus on comparing three different methods that ensure the cache-coherence: snoop-based (hardware), software based (software) and OS-based (Software and OS). Their comparative analyses of those three methods will be done in order to highlight the amount of impact of each method to energy/performance ratio. Tests will be realized in Benchmark (2 applications, producer-consumer and reader-writer) and a cycle-accurate simulator. Finally we will show that: In the case of OS based method is a very high cost. Snoop based method improve the performance, but requires a large consumption of power/energy with the increasing amount of data in the system. Software based approach has an efficient energy consumption, but has a very lot of work to do with the program.

Keywords: energy, performance, multiprocessors

STUDENTS CHARACTERISTICS AND SCHOOL SUCCESS

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Having in mind the fact that different factors (features) affect school results differently, in this work we have analysed the effects of social status and psychological features of students on their school achievements.

The main objective of the research is to , by the analysis of the degree and the structure of the relationship between psychological and social factors with school achievements of students, consider the influence of certain factors on success in high school that are characteristic for this social environment in present time.

The objective of the research is to determine social status and psychological features of students that affect school achievements and direct intellectual and social functioning, so that they are understood better and directed, so as to contribute to school achievements.

The research was carried out in 2011. The sample consisted of the students from grammar and vocational schools in Budva, Podgorica and Niksic.

Regarding content and methodology, interdisciplinary approach was used.

It has been found out that social status and psychological factors have considerable influence on school achievements. The students with better marks have better educational-material conditions as well as property and status conditions in the family. The connection between certain indicators of the social status with school achievements is unequal regarding the modality of schools, age and gender. The students of schools with different curriculums do not differ in respect to emotional intelligence but in respect to some motivation characteristics and value choices.

The students of grammar schools have more persistence in achieving their goals and they are more related to private life and emotional bonds with the family and friends.

There is a connection between emotional intelligence, conative-motivational characteristic, interests, attitudes and value orientations of students and their school achievements.

The students with better marks at school have better understanding of emotions and better emotion control, as well as a better developed achievement level. The students with better marks are more inclined to making friends whereas the students with worse marks are more interested in media popularity and public influence.

The connection of school achievements with certain psychological features is unequal in respect to school modalities, classes, gender as well as socio-demographical characteristics in some segments. Age has moderating effect on the connection between school success and some of the motivation components for achievements. For different kinds of schools there is a somehow specific, for them characteristic, group of features that gives the highest contribution to the multiple relationship between school success and the system of psychological variables.

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