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CONTENTS

05 BIOMEDICINE

13 MEDICAL PHYSICS

14 MICROWAVE, LASER, RF AND UV RADIATIONS

18 RADIATION EFFECTS

19 RADIATION IN MEDICINE

20 RADIATION MEASUREMENTS

21 RADIATION ONCOLOGY

23 RADIATION PROTECTION

24 RADIOBIOLOGY

26 RADIOECOLOGY

27 RADIOLOGY

30 OTHER TOPICS

INVITED TALKS

A

ORGANIC ELECTRONIC BIOSENSORS FOR LABEL-FREE FEMTOMOLAR PROTEIN DETECTION

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Point-of-care (POC) biosensors are integrated diagnostic systems employed for the detection of clinically relevant analytes in biological fluids such as blood, urine and saliva. These devices offer the advantage to provide rapid results directly where the information is needed (e.g. patient's home, doctor's office or emergency room), thus facilitating an earlier diagnosis and a prompt patient's treatment. Various technologies have been proposed for the realization of POC biosensors including label-free techniques based on optical, mechanical and electrochemical transducers. However, reliable, quantitative and ultrasensitive devices have not yet been commercialized. Electronic biosensors based on organic thin-film transistors (OTFTs) are a promising choice for the development of the next generation of POC devices. These biosensors can be combined with integrated electrical circuits, microfluidic systems and wireless technologies. Furthermore, they offer high sensitivity, biocompatibility and possibility to produce all-printed low-cost biosensors in flexible and disposable formats. Among them, electrolyte-gated (EG)-OTFTs have been identified as ideal candidates for biosensor development as they operate at low voltages directly in aqueous buffer solutions. Using these configurations of ultrasensitive label-free immunosensors for the detection of C-reactive protein (CRP), a specific biomarker of inflammatory and infection diseases has been developed at the femtomolar concentration level. The devices are also able to perform chiral differential detection of odorant molecules. The specific features of the proposed EGOTFT biosensors as well as their analytical performances will be discussed.

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MEDICAL IMAGING WITH SYNCHROTRON RADIATION

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The coherent and monochromatic x-ray beams available at the synchrotron radiation (SR) laboratories are ideal tools for the development and the initial application of innovative techniques for medical imaging and radiation therapy. In the present communication the first clinical studies in k-edge subtraction imaging with SR are summarized, including coronary angiography and bronchography. In the last two decades the family of the x-ray phase-sensitive imaging techniques was developed and exciting results in bio-medical application were obtained: propagation-based phase-contrast imaging (PPCI), analyzed based imaging (ABI), grating interferometers (GI) and coded-aperture x-ray phase-contrast imaging (CAXPCI). Similarities and differences of these techniques are discussed.

The results of the recent trial in PPCI mammography at Elettra (Trieste, Italy) are discussed, in order to assess the clinical impact of the new imaging modality and the potential interest in its translation to clinical practice. The direct measurement of linear attenuation coefficient of the breast obtained during the SR mammography trial is also presented and discussed considering its consequences on mammography dosimetry.

The new program of phase-contrast breast CT under development at Elettra is presented. Recently, 3D breast imaging (tomosynthesis and cone-beam breast CT) has been introduced in clinical practice with significant improvement in diagnostic accuracy. The aim of the new research is to study the contribution of the phase-retrieval to the image quality of breast CT.

Increasing the image quality of the x-ray medical images at the level of the results obtained at the SR laboratories is highly desirable, hence the promising techniques for the translation of the phase-contrast imaging to the hospitals are briefly discussed.

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KEYNOTE TALKS

B

FDG PET/CT PHYSICAL ASPECTS AND CLINICAL APPLICATIONS IN MEDICINE

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Positron emission tomography/computed tomography (PET/CT) imaging is a hybrid imaging which integrates CT with PET imaging. It combines excellent anatomic information with functional information. PET/CT represents a three dimensional distribution of radioactivity based on the annihilation photons that are emitted by positron labeled radiotracers. This so-called metabolic imaging uses a non-invasive quantitative assessment of biochemical and functional processes in the body and provides unique information about molecular and metabolic changes associated with diseases. There are several advantages of PET/CT over conventional imaging techniques (CT and MRI): earlier detection of malignancy due to the fact that metabolic activity precedes changes in anatomy; it can differentiate between residual disease and fibrosis; excellent contrast resolution; and whole body evaluation in one examination.

^{18}F- fluorodeoxyglucose (^{18}F-FDG) is a radiolabelled glucose analogue. Consequently, it accumulates in tumor cells in proportion to the glycolytic metabolic rate, and is a marker of glucose metabolism. Since glucose uptake is increased in malignant tumors, the major application of F-18 FDG PET/CT is in oncology. However, increased ^{18}F-FDG uptake is found in various benign tumors, granulomatous diseases, tuberculosis, inflammation and infection. The PET/CT scans are evaluated visually, or qualitatively and quantitatively by SUV [standardized uptake value]. SUV is a measure of the metabolic activity and is related to percentage of injected dose per gram. This value is automatically provided and is dependant on blood glucose, time of radioisotope injection, hardware and software.

In oncology, F-18 FDG PET/CT has a role in the diagnosis of unknown primary malignancy and evaluation of solitary pulmonary nodules; staging of the disease on presentation; treatment response evaluation (after radiotherapy and/or chemotherapy), restaging (detection of residual tumor, recurrence and metastases), establishing and localizing substrates in patients with evaluated serum markers, image guided biopsy and radiotherapy planning. In addition, ^{18}FDG uptake correlates with tumor aggressiveness and dedifferentiated lesions show the greatest uptake. This makes PET/CT also important in predicting the clinical prognosis.

BIOCHEMISTRY 01

ESTIMATION OF UNCERTAINTY OF TRYPSIN INHIBITOR ACTIVITY MEASUREMENT IN LEGUME CROPS

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Irradiation of food and feed has emerged as an attractive alternative compared to conventional chemical treatments used to minimize losses occurred during storage and seed production. According to Serbian national legislation and Directive 1999/2/EC of the European Parliament concerning foods and food ingredients treated with ionising radiation, legume crops may be treated with ionising radiation with doses less than 1 kGy. Legume crops are considered to be an important source of proteins, carbohydrates, fats, fibers, essential vitamins, minerals, as well as anti-nutritional factors such as protease inhibitors. Protease inhibitors have anti-nutritional but also anti-carcinogenic properties. As a result, their exploration is of great interest, and in some countries the allowed trypsin inhibitor activity (*TIA*) of the new legume cultivars is statutorily prescribed. The effects of irradiation on nutritive and anti-nutritive components of legumes are reported in many studies, and these are usually accompanied with measurements obtained by using the quantitative analytical methods.

Methods for the *TIA* measurement are based on the hydrolysis of Nα-Benzoyl-, L-arginine 4-nitroanilide hydrochloride (L-BAPNA) by trypsin and include the spectrophotometric measurement of the reaction products. The measurement results of *TIA* are usually accompanied with the standard deviation, however, the uncertainty of the *TIA* measurement along with the analysis of the sources of measurement uncertainty were not previously analyzed. In order to demonstrate the quality of the results of the measurement, it is important to estimate measurement uncertainty. The results accompanied with the statement of measurement uncertainty increase the confidence in the validity of a measurement result and enable comparisons between the results obtained using different techniques or compliance with regulatory levels. The aim of this study was to estimate and to analyze the uncertainty of *TIA* measurements using the microtiter plate method, according to the concept of measurement uncertainty described in the current Guide to the Expression of uncertainty in measurement.

The assaying procedure for the *TIA* measurement was conducted using the seed of *Phaseolus vulgars* (common bean), variety Oplenac, as the starting material. Sample, positive and negative control reaction mixtures were set in each microtiter plate row. The trypsin inhibitor activity was expressed in the number of trypsin units inhibited (TUI) per milligram of seed sample, taking into account the fact that one trypsin unit is defined as an increase of 0.01 absorbance units at 405 nm. A large number of experiments was conducted and the uncertainty analysis was obtained using the uncertainty budget. Measured *TIA* of the common bean variety Oplenac was 56.2 TUI/mg and the estimated expanded measurement uncertainty (with the coverage factor k=2) was approximately 5.2 TUI/mg (9 %). Absorbance measurement and preparation of the sample reaction mixtures took the largest percent (44 %) of the overall uncertainty of the *TIA* value.

SUBACUTE CADMIUM INTOXICATION AND SUBSEQUENT DETOXIFICATION WITH CHELATING AGENTS / A HEMATOLOGICAL STUDY

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Cadmium (Cd) is one of the most toxic environmental and industrial pollutants. The aim of this study is to investigate the effects of the chelating agents, monensin and salinomycin, on the hematological parameters of Cd-treated mice. The experimental animals were divided into four groups (n = 9 mice) as follows: group 1- mice were treated with an average daily dose of 20 mg/kg b.w. Cd(II) acetate for 2 weeks followed by 2 weeks on distilled water; group 2 consisted of mice exposed to Cd(II) acetate treatment for 2 weeks, as described for group 1 and subsequently treated with an average daily dose of 20 mg/kg b.w. monensin for 2 weeks; group 3 included mice exposed to Cd(II) acetate treatment for 2 weeks, as described above and subsequently treated with an average daily dose of 20 mg/kg b.w. salinomycin for 2 weeks; group 4 (untreated control animals) consisted of mice obtaining distilled water. All compounds were dissolved in distilled water and obtained orally. The chelating agents were administered as tetraethylammonium salts of monensic and salinomycinic acids respectively.

The experimental results showed reduced red blood cell count (RBC), hemoglobin content (Hb) and hematocrit (HCT) in blood samples of mice treated with Cd compared to the untreated controls. The addition of monensin or salinomycin improved the erythrocytic parameters. The results presented herein demonstrated the potential application of monensin and salinomycin as antidotes for Cd-poisoning.

Acknowledgments. The work was supported by Grant No 64/2015, financed by the Sofia University “St. Kl. Ohridski” Science Fund.

CHRONIC EXPOSURE TO COBALT CHLORIDE AND MURINE ERYTHROCYTES / AN *IN VIVO* STUDY

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The wide use of cobalt (Co) in medical implants requires a full elucidation of its biological effects on cells, tissues and organs. Elevated concentrations of Co are measured in blood and urine following hip and knee arthroplasty which requires a full elucidation of its biological effects. Pregnant ICR mice were subjected to a daily dose of 125 mg/kg body weight cobalt chloride ($CoCl_2x6H_2O$) before they gave birth to their mice. The compound was dissolved and obtained from drinking tap water. After birth, the mothers continued to be treated with the same dose because cobalt is transferred into the milk and thus the newborn mice were exposed to the metal ions. When the newborn mice were 25 days old they were separated into individual cages to ensure that all experimental animals obtained the required daily dose and the treatment continued until they were 90 days old. The mice were weighed weekly and Co concentration in the water was adjusted accordingly. The animals were sacrificed by decapitation after etherization on days 18, 30, and 90. Erythrocyte count (RBC), hemoglobin (Hgb), hematocrit (Hct), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin content (MCHC) and cobalt accumulation in blood plasma and RBC were studied. The control group consisted of age-matched mice obtaining regular tap water. Results showed adverse effects of cobalt on immature and mature mice. Chronic exposure to $CoCl_2$ induced anemia in immature mice showing reduced RBC, Hgb and Hct values, compared to the untreated controls while in mature (day 90) animals these indices were elevated. The altered erythrocyte count affected MCV which was elevated in day 18 and day 90 mice. The low Hgb content lead to a significant increase in MCH and MCHC in immature (day 18 and day 30) mice. Analysis of blood plasma and RBC samples showed significant accumulation of Co(II) ions in the treated groups compared to the untreated controls. Plasma accumulated ~ 4-fold more metal ions compared to the RBC fractions.

The altered RBC and Hgb content after cobalt treatment explains the ability of the metal ions to induce hypoxia. Chronic exposure to cobalt exhibited adverse effects on the immature and mature mice. The immature mice were more sensitive to the treatment.

DIFFERENCES IN ACCURACY BETWEEN LABORATORY BIOCHEMICAL TESTS AND THE EXTRALABORATORY ONES

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Background: Outside laboratory tests enable testing and monitoring of certain diseases or health conditions beyond the laboratory. The accuracy of these tests is different but still regulated by the FDA, using guidelines issued by the International Organization for Standardization (ISO) 15197: 2003. ISO standard requires 95% of results within range or slightly higher, be within / - 20% of true value.

Aim of the study: Measurement of glucose by two methods: spectrophotometers and glucometer, to see if there are differences between these methods, so if the results obtained from glucometer would fall within +/- 20% of the true value.

Methods: Measurements of the glycemic values were conducted using two methods: spectrophotometer Humalyzer Primus and the glucometer One Touch, using respectively samples as venous and capillary blood. Blood samples and all tests were conducted at the premises of HPS Logos.

Results: In our study, we have found a difference in the measured results with the/a spectrophotometer and glucometer. However, the resulting p values <0.05, it means the difference found between the two methods is not statistically significant.

Conclusions: Extra-laboratory tests are cost-effective, fast and confidential. It is important that the persons concerned (e.g. Diabetic patients) know to perform well the procedure to avoid as much as possible errors. According to our study, there were no statistically significant differences between the value of glycemia measured with the/a glucometer or spectrophotometer (in the laboratory). There are cases in which as a result of not respecting sanitary conditions and storage of the device, may result in wrong values which can be avoided increasingly if work protocol is respected step by step.

ENZYME ACTIVITY AND CELLULAR FUNCTIONS MODIFIED BY ULTRASOUND

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Over the past several years, we investigated the cellular effects of therapeutic levels of continuous-wave and amplitude-modulated ultrasound (US). A number of examples in which US exposure of cells under non-thermal conditions modified cellular functions and structure were obtained. Ultrasonic irradiation modulated membrane properties of red and white blood cells (RBC & WBC), altered the MDBK cellular proliferation, and produced increases in proteins — α- and γ-interferon.

We tested the horse (n=40 animals), cat (n=46) and dog (n=50) blood samples from sick and healthy animals of different sex and age. In our study, none of laboratory animals were harmed. Blood samples of 1.5 ml were sonicated under absolutely identical conditions. The data obtained showed that the result of US action depended upon the kind, health and age of the animal as well as the cell size & type. These findings encompass both continuous and pulsed US at therapeutic levels ranging from 0.05 to 1.0 W/cm^2 either 1-MHz or 3-MHz ultrasound. Pulse amplitude modulation allowed to perform equal–energy exposure on cells and to determine the biologically active frequencies. Active frequencies' spectra were selected experimentally.

Biochemical studies were performed with serum and blood plasma enzymes: aspartate aminotransferase, alanine aminotransferase, lactate dehydrogenase, and creatine kinaze. We deliberately chose those enzymes which may be present both in serum and plasma/blood cells. The absorption of ultrasonic energy by enzymatic proteins led to changes in the enzyme activity that may result in modifications to cellular function. Analysis of blood plasma and serum as well as RBC/WBC samples showed significant change of the cytoplasmic membrane structure, cell aggregation and modifications, a significant change in enzyme activity compared to untreated controls. Moreover, after the blood samples active frequencies' US irradiation *in vitro* enzymatic activity could be varied while remaining unchanged in the serum samples.

The accumulated data could lead to a better understanding of how and when ultrasound should be employed as a therapeutic modality.

Acknowledgments. My sincere thanks to veterinarians Ella M. Komarova and Maria M. Gordiyenko for the blood samples provision during the experiments.

BIOINFORMATICS 02

COLORECTAL CANCER THROUGH THE PRISM OF SIGNALS

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The gene expression analysis of the colorectal cancer presents a clear picture of the difference between the biomarkers' expression at the colorectal cancer samples in comparison to the healthy samples. We successfully applied the Bayesian approach for modeling the probability distributions of the biomarkers, and later used the model for classifying new tissue samples, obtaining 0.98 sensitivity and 0.91 specificity. However, a problem arose when we intended to make a model of the different colorectal cancer stages. The best classification results obtained were 0.73 for stage 1, 0.53 for stage 2, 0.72 for stage 3 and 0.64 for stage 4. The reason for the inaccurate modeling is the high level of similarity, especially between stage 1 and stage 4; and stage 2 and stage 3. Even though the problem between stage 1 and stage 4 seems to be unexpected, it is confirmed to be critical in the literature. Having exhausted the standard techniques for normalization, smoothing and biomarkers' reduction, we took a glance into another intriguing topic - What if we observed the colorectal cancer in terms of signals? Assuming the cancer stages represent different times, we can consider time expression profiles. Applying the Fourier transformation, we can decompose gene expression profiles and obtain the frequency components. Those components we can use to capture biologically relevant information (low-frequency components) and filter the noise (high-frequency components). Having applied the method to filter out the biomarkers that carry the important information during the colorectal cancer progress, we can return into the gene expression domain and model the probability distribution of the biomarkers in each stage. Once again, we can apply the Bayesian approach to distinguish between the critical colorectal cancer stages.

BIOMATERIALS 03

THE EFFECT OF ZINC OXIDE NANOPARTICLES ON THE GROWTH OF RAT LYMPHOSARCOMA

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Recent studies have demonstrated that zinc oxide nanomaterials (ZnO NPs) had an anti-cancer activity *in vitro*. However, in order to develop new classes of anticancer nanoparticle-based agents, there is a need to estimate the influence of nanoparticles on the tumor-bearing organism. The purpose of this study was to investigate the effect of ZnO NPs on the growth of transplantable lymphosarcoma rats.

In this study we used ZnO (II) NPs, spherical in shape, with the particle size of about 20 nm. We investigated the antitumor activity of ZnO NPs in the experimental rat lymphosarcoma (Pliss's lymphosarcoma). The tumor was transplanted subcutaneously in the dorsal region of outbreed white male rats weighing 220-250g. ZnO NPs was administered on the 6th day after tumor transplantation, when the mean tumor volume (MTV) was about 0.50 cm^3. The injections were given for 2 weeks with 4 injections a week (8-fold administration). The animals of the experimental group (10 animals) received saline with NPs intraperitonially (single dose of 1.25 mg/kg). The rats in the control group (10 animals) were intraperitonially injected with saline (0.3 ml). The effect of ZnO NPs on tumor growth was determined by the change in tumors' volume and number of regression cases.

After 2 injections, MTV in the experimental group (4.2±0.98 cm^3) did not differ from the control (5.3±0.73 cm^3). However, after 3 injections, two of the ten rats in the test group showed tumor regression. By the beginning of the 2nd week of therapy, the MTV for the test group as a whole was 19.1±5.68 cm^3, control group – 37.5±2.4 cm^3. After 6 injections, 5 animals showed tumor regression (5.82±2.07 cm^3). In other 5 rats, tumor growth was observed (42.6±4.22 cm^3) which was similar to the control (45.2±3.1 cm^3). On day 2, after the 8th injection, one rat demonstrated a fast tumor regression from 49.0 cm^3 to 19.0 cm^3, yet 3 days later the rat died, probably due to intoxication as a result of a rapid tumor lysis. In other 4 rats with growing tumor, MTV reached 61.34±2.7 cm^{3}which do not differ from the control values. On day 14, after treatment the volume of tumor in rats with tumor regression was equal to zero. So tumor regression was observed in 6 of 10 rats, with the introduction of nanoparticles of zinc oxide to Pliss animals. Lymphosarcoma complete regression occurred in 50% of the cases.

In previous studies, we showed that the ZnO NPs enhanced the growth of experimental fibrosarcoma (C-45) in 60.0% of experimental rats regardless of the injection method (intratumorally or intraperitonially). This data have shown that the introduction of ZnO NPs can induce the inhibition of tumor growth, which leads to the increased survival of tumor-bearing animals. Thus, the antiblastomic effect of zinc oxide nanoparticles depends on the histological type of the tumor.

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RADIO-OPAQUE MATERIALS BASED ON HYDROXYAPATITE AND BISMUTH

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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 the absorption of X-rays, and therefore for improving the visibility of the cement under X-ray examination. Radio-opacity is important for uses of cements in dental filling and dental sealing. Bismuth compounds, due to their radio-opacity, are added to various bone and dental implants, catheters and surgical instruments in order to make them detectable by X-rays and computed tomography. This study relates to a new apatite - bismuth material which is biocompatible and exhibits radio-opacity enhancing its utility in the dental and medical fields.

LOW DOSE RADIOTHERAPY IMPROVEMENT USING FUNCTIONALIZED MAGNETITE NANOPARTICLES

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Radiotherapy has been intensively used in the treatment of various types of cancer by using directed ionizing radiation, however, the potential benefits of low dose irradiation have not been clearly elucidated. One potential approach of cancer treatment refers to the use of nanotechnology in the fabrication of targeted carriers for anti-tumor substances. Even if there are several FDA- approved nanosystems, there is still a continuous urge to find more effective treatment options, which are supposed to overcome the shortcomings of the existing ones. Tumor resistance to radiotherapy and/or chemotherapy was attempted to be exceeded by combining these techniques, but the results were far from expectations, nanoparticle-mediated radiotherapy being an approach for better responses. We propose the use of magnetite nanoparticles functionalized with different types of anti-tumor substances to be used in combination with low dose ionizing radiation in order to obtain higher nanoparticles penetration of the cells and to reduce the quantity of the toxic drug used in therapy, resulting in improved toxic effects against cancer cells.

GELATION OF DNA AND BOVINE SERUM ALBUMIN (DNA-BSA GEL) BY GAMMA IRRADIATION AS BIO-ABSORBENT FOR ACRIDINE ORANGE

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Nowadays, the abuse of synthetic chemicals, which are especially mutagens and carcinogens, such as polychlorinated biphenyl (PCBs), acridine orange and other aromatic compounds, has been severely contaminating the environment and causing many risks to human health. In the cell, these substances can intercalate into the major grooves and interstices between the base pair of DNA double helix, resulting in mutations and cancers. In other words, DNA can be utilized as the most efficient bio-adsorbents of such toxic agents. For this purpose, DNA must be in the water-insoluble state. Recently, radiation is proved as one of the effective method in order to introduce the crosslinking network in the polymer matrix and form the insoluble gels. However, DNA has been known as the radiation degradation polymer, which was easily to be broken by gamma irradiation in the solution state. In this study, we have successfully prepared DNA-bovine serum albumin (DNA-BSA) crosslinked gels from aqueous mixtures of DNA with BSA by gamma irradiation. The gelation behaviors were characterized and their adsorption property was investigated with acridine orange. The results suggest that the radiation crosslinked DNA-BSA gels can be utilized as bio-adsorbents for aromatic toxic agents.

POTENTIAL APPLICATION OF APPLE PEELS AS BIOSORBENTS IN THE REMOVAL OF ORGANIC MOLECULES FROM WASTE WATER

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Activated carbon is an excellent material for the adsorption of color and heavy metal materials from waste water. But given the water quantity and its waste, the cost of using activated carbon as a color removal or waste removal in general would be enormous.

Apples are considered as one of the most widespread fruits in Kosovo, totaling to 46% of the entire production. Our study was based on dye removal of methylene blue, methyl orange and phenolphthalein with a biosorbent, in this research with apple peels. The adsorbent was firstly double washed with distillated water, and then it was dried at 70°C until it reached a constant weight, and was finally grinded and milled to one mesh of dimensions. Peels were used as untreated and in the treated form (with HNO_3 0.4 mol/dm^3) for comparison purposes.

The study was done in different conditions, such as at varying concentrations of dye solution, different times, magnetic stirring, etc.

For comparison purposes, we used activated carbon in the same conditions; based on the obtained results, it can easily be concluded that the sorption capacity of the peels is quite high compared to the other available adsorbents, and cost wise it is much cheaper.

* 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

REMOVAL OF DYES FROM WASTEWATER USING PLANT-BASED BIOSORBENT DERIVATE FROM POTATO PEELS

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Water color is often caused by dissolved organic matter, e.g. humic and fulvic acids (organic decomposition products from vegetation). The color level can often be a good indicator of the organic content of water. Reduced color, and hence the reduction of the organic matter in the water, is therefore an important parameter to control to prevent damage to the industrial process.

In our research, we used biosorbents, such as potato peels, for color removal from organic dyes. We used phenolphthalein, methyl orange and blue methyl as organic dyes. The concentration of colored organic molecules ranged from the highest of $1x10^{-3}$, $5x10^{-4}$, $1x10^{-4}$, $5x10^{-5}$ to the lowest of $1x10^{-5}$ mol/L, in time periods of 5 minutes, 15 min, and 30 min to 1 hour, activated and non-activated biosorbent, etc.

Overall, the study found that the biosorbent peels, such as potato peels, were successful in color removal from the organic molecules. Comparing to activated coal, the study showed promising results that could be used in the future.

* 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 HEAVY METALS IN NUMEROUS RIVERS IN KOSOVO DURING A ONE-YEAR PERIOD

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Heavy metals exist in surface waters in colloidal, particulate and dissolved phases, although dissolved concentrations are generally low. The behavior of metals in natural waters is a function of the substrate sediment composition, the suspended sediment composition, and the water chemistry.

Numerous industrial activities contribute to the pollution with heavy metals directly or indirectly in the atmosphere through the release of solid or gaseous waste, and wastewater. It is now a known fact that pollution with heavy metals is a major concern, particularly when they penetrate in the food chain directly.

In our study, we measured the heavy metals, Cu, Pb, Cr, Cd, Zn etc., in numerous rivers in Kosovo in different periods in 2014. The measurements of heavy metals were done with the atomic absorption spectroscopy (AAS) technique. From the results that we obtained, we can conclude that the rivers are highly contaminated due to the industry discharges, but further analysis is required for a clearer overview.

* 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

NANOSTRUCTURES BASED ON ZNO AND PHYTOCHEMICAL SUBSTANCES WITH COSMETIC APPLICATIONS

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The aim of this work was to prepare novel sunscreens based on natural organic substances (beeswax, shea butter, coconut oil and simple and limonene) and zinc oxide nanoparticles. The nanostructures were prepared by a sol-gel process without further calcination. The sunscreens were prepared by the homogenization of all ingredients. The sunscreens were characterized by XRD, SEM, TEM, EDAX, IR, TGA, ZETA potential, UV-Vis, the *in vitro* and *in vivo* evaluation of distribution. The results recommend these novel biocompatible sunscreens for protection against UV rays, being able to block UVA and UVB rays.

Key words: SPF, sunscreen, UV filter, zinc oxide, nanoparticles.

PHOTOACOUSTIC CHARACTERIZATION OF THIN POLYLACTIDE SAMPLES OF DIFFERENT CRYSTALLINITY

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In this work, frequency photoacoustic (PA) measurements were performed on polylactide samples at 200 μm thickness level. Thin samples were obtained by 20-min compression moulding in a Carver laboratory press at 160°C and a gradual pressure increment, up to 3.28 MPa. One set of the moulded sheets was quenched in the mixture of ice and water, while the other was prepared by slow cooling from the melting to room temperature, thus obtaining two sets of samples with different levels of crystallinity. Photoacoustic frequency measurements were performed by indirect transmission set-up. Thermal diffusivity and thermal conductivity were evaluated using simultaneous analysis of amplitude and phase characteristics of the frequency PA response. Standard composite piston model was used for the direct PA problem, and a novel fitting procedure was developed in order to enable a non-destructive PA evaluation of the crystallinity level in biomaterials and, consequently, the engineering of their properties.

Keywords: Crystallinity, multi-parameter fitting, photoacoustics, photothermal, thermodynamics

THE EFFECT OF EXTREME TEMPERATURES ON MICRO AND NANO HYBRID DENTAL COMPOSITES: AN EXPERIMENTAL FORENSIC STUDY

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Composite resins are the most prevalent materials used for aesthetic restorations. High temperatures induce alterations to composites and can be of great interest to forensic dentistry.

The objective was to investigate color change, surface damage, as well as the composition of two resin composites (micro and nano hybrid) exposed to extreme temperatures for forensic reference purposes.

Te-Econom and *Tetric Evo-ceram* samples were prepared using a metallic split ring. Heating was performed in a furnace at the following temperatures: 400°C, 650°C and 900°C for 30 min. Color changes were analyzed by visual assessment in comparison to controls. Scanning electron microscopy/energy dispersive X-ray spectroscopy (SEM/EDS) was used to characterize the structure and composition of samples.

After exposure to high temperatures, composites changed color: initially they became dark brown, then white and, finally, light yellow. Between the composites, there were no differences in color. Samples of micro-hybrid-composite *Te-Econom* showed a grainy and rough uneven surface on SEM and significantly more pronounced changes at lower temperatures, while nano hybridcomposite *Tetric EvoCeram* underwent major changes at the temperature of 900 ° C, thereby reaching the melting point. EDS analysis showed that the elemental composition of resin composites after being exposed to high temperatures remained almost unchanged.

These results indicate that the parameters observed in both resins are useful as a guide in forensic investigations.

In addition, scanning electron microscope and energy dispersive X-ray spectroscopy can be useful tools for the characterization of severely burnt teeth with composite fillings for victim identification.

Key words: Forensic odontology, dental composites, extreme temperatures, scanning electron microscope, energy dispersive X-ray spectroscopy

DIRECT (IN SITU) ELECTROCHEMICAL DETERMINATION OF SUPERCRITICAL CO_2 EXTRACTED ASCORBIC ACID FROM AQUEOUS SOLUTIONS ONTO PT ELECTRODES

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Vitamin C (ascorbic acid - AA) has a key role in body health. It is present abundantly in food, plant and animal tissues, but it cannot be synthesized by the human body. A recommended daily intake of AA is about 70–90 mg — insufficient intake will have, as a consequence, the appearance of different symptoms (of scurvy, gingival bleeding, and so on); the excess of AA intake will also contribute to urinary stone, diarrhea and stomach convulsion. Due to the importance of AA, its determination is very important. In our study we used a supercritical (SC) CO_2 extraction of AA from aqueous model systems containing AA dissolved in phosphate buffer. The experimental setup consisted of a CO_2 tank, pumps, an extraction vessel, an oven, valves, a flow meter, a pressure and temperature controller. The monitoring of AA concentration was done by immersing two Pt electrodes (one serving as the indicator electrode and the other one as the working electrode, while a graphite rod served as the counter electrode) directly into the extraction vessel and assessing electrochemically the AA content through its oxidation peak by the use of cyclic voltammetry. During our research, we used the static technique of SC-CO_2 extraction. Further work was conducted by studying the effect of two surfactants: Triton-X100 and sodium dodecylbenzenesulfonate on the supercritical extraction efficiency of AA.

* 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

BIOMEDICAL ENGINEERING

04

EXPOSURE SYSTEM WITH HOMOGENEOUS STATIC AND ELF MAGNETIC FIELDS IN EXPERIMENTAL VOLUME

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The omnipresence of electromagnetic fields not only in human environment but all over the Earth raises questions about the positive or negative nature, extent, and threshold levels of influence of this non-ionizing radiation on living organisms. In particular, it has been shown that static, magnetic and extremely low frequency (ELF) electromagnetic fields have significant effects on the skeletal, immune, cardio-vascular, reproductive, as well as the central nervous system. The complexity of electromagnetic fields, i.e., their magnitude, direction, orientation, spatial as well as temporal dependence and gradients, along with requirements related to the specifics of biomedical experiments, e.g., uncertainty of sample positions in *in vivo* experiments, requirements related to experimental volume size and orientation, temperature, light, etc., impose a challenging task to biomedical researchers when describing and specifying their experimental conditions. An exposure system which provides a homogeneous field throughout the experimental volume significantly reduces ambiguities. With the aim to provide the field that will also be scalable and relatively strong within the experimental volume that is large enough for *in vivo* as well as *in vitro* experiments, we considered a solenoid. High homogeneity of the field was achieved with inner modifications of solenoid cross-section. The designed exposure system provides the field with the maximum magnitude of 165 mT and homogeneity of 2 % in the experimental volume with the size of 30 cm x 30 cm x 40 cm.

THE THERMOELECTRIC ENERGY HARVESTING SYSTEMS IODINE-DOPED MEH-PPV WITH CARBON NANOTUBES

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This work aims to develop organic polymer-based thermoelectric (TE) materials and to explore the possibilities of biomedical and other applications of these materials. Based on previous research (3), we prepared drop-cast films of commercially available poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene] (MEH-PPV) with single-walled carbon nanotube (SWCNT). The effects of solvent and molecular weight on the thermoelectric performance of nondoped and I_2doped samples were investigated as a function of SWCNT concentration (0-50 wt %). The samples fabricated with the same molecular weight in a non-aromatic halogenated solvent showed higher power factors with an increasing trend for higher loads of SWCNT. In addition, samples made from a high molecular weight polymer gave 3-4-fold higher TE power factors than those from low molecular weight polymer that were fabricated under the same experimental conditions. Moreover, the electrical conductivity of the samples in all variable conditions gave an increasing trend with the elevated concentration of SWCNT, even before doping with iodine. However, Seebeck coefficients showed a decreasing trend with the increased concentration of SWCNT in all conditions. Also, Seebeck coefficients of the samples made from low molecular weight polymer were slightly higher than those from high molecular weight polymer.

Key words: Thermoelectric, implantable medical, Poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene], SWCNT

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AN APPLICATION OF KINECT BASED 3D SCANNING IN BIOMEDICAL ENGINEERING

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This paper approaches the study on the use of a low-cost Kinect sensor for 3D scans and 3D reconstructions of human parts. The Kinect depth sensor used in this work is based on a webcam-style device and dedicated software. It uses a structured light technique in order to scan and reconstruct 3D surfaces. The study was made in order to observe the applicability of the Kinect-based 3D scans in the case of anatomic surfaces with concavities. Anatomic surfaces of a human head were scanned and 3D-reconstructed using the Kinect sensor and the Skanect software. Following some 3D image processing, a customized acrylic face mask may be fabricated from the 3D reconstructed mesh of the head. Orthotic masks may be applied in the case of facial burns in order to provide a small pressure over the burns. The results of the study show that the Kinect-based 3D scans have good performances in the case of anatomic surfaces with rounded concavities. The Kinect device, having many types of sensors, may have a lot of different applications in the medical engineering area.

Key words: 3D scanning, Kinect, bioengineering, application

BIOMEDICINE 05

NEURONAL DIFFERENTIATION OF ACA-GENERATED PLURIPOTENT STEM CELLS AND THEIR POTENTIAL APPLICATION IN CELL REPLACEMENT THERAPY

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Human neurological disorders are caused by the loss of neural or glial cells in the brain. Cell replacement therapy should provide the basis for the development of new therapeutic strategies for treating many incurable neurological disorders. Neural stem cell (NSC) transplantation could replace the damaged tissue providing curing effects.

Pluripotent stem cells, embryonic stem cells (ESCs), induced pluripotent stem cells (iPSCs) or multipotent adult stem cells can be explored for tackling neuronal diseases. Each of this cell types has various disadvantages and currently there is no efficient way to obtain autologous neural stem cells.

Here, we report about human GPI-linked glycoprotein ACA, a receptor involved in the developmentally conserved signalling pathways. Crosslinking of ACA initiates via PI3K/Akt/mTOR/PTEN, a process of de-differentiation of blood progenitor cells leading to the generation of ACA pluripotent stem cells capable of differentiating into cell types of all three germ layers.

Blood-derived ACA pluripotent stem cells differentiate *in vitro* into neural cells with long branching structures which is confirmed by the means of geno-and pheno-typic analyses.

The phenotypic analysis confirmed the expression of various neuro-lineage markers. ACA neuro cells express neuron-specific class III beta - tubulin abundantly found in the brain, nestin, an intermediate filament protein expressed mostly in the nerve cells where it is implicated in radial growth of the axon, as well as early oligodendrocyte marker O4.

Our data confirms that blood-derived ACA stem cells posses a potential to differentiate into ectoderm represented by neuroectodermal cells and indicate a potential to turn blood to the brain.

Above all, ACA cells differentiate *in situ* upon transplantation in the cortex and striatum of immunocompromised mice into neural progenitor cells expressing vimentin and N-CAM providing so the pool of human NSCs which can be exploited for customised therapy of injured diseased brains.

ANALYSIS OF CYSTIC FIBROSIS IN FEDERATION OF BOSNIA AND HERZEGOVINA

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Aim: The aim of this study is to firstly present total number of tested children in the Federation of Bosnia and Herzegovina and the number of children with positive sweat tests. During the study, we determined the number of ill children, the median age of children with cystic fibrosis, date of initial diagnosis, and an average amount of chloride in the sweat.

Material and methods: The study was a retrospective one, conducted at the Department of Pulmonology, Pediatric Clinic of the University Clinical Center of Sarajevo.

Results: In the period from March 2003 to December 2014, we tested 625 children. 351 children were from the Sarajevo Canton and 272 children were from other cantons. Female children were more affected then male children, in the ratio of 1: 1.105. The average age of female children was 4.19±4.26 years, and the average age of male children was 2.15±3.11 years. The median concentration of chloride in the sweat measured by the sweat test was 103.05±21.29 mmol/L for male children and 96.05±28.85 mmol/L for female children.

Conclusion: Most children in the Federation of Bosnia and Herzegovina have ΔF508 gene mutation. In the post-war period we started using the sweat test. Male children tend to live longer than female children with CF.

THE INFLUENCE OF SYNTHESIZED POLYOXOMETALATES ON Na^+/K^+-ATPASE ACTIVITY

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Polyoxometalates (POMs) are negatively charged inorganic compounds which contain early transition metal ions such as tungsten, molybdenum, niobium, antimony or vanadium, surrounded by oxygen atoms. Furthermore, POMs have been shown to exhibit biological activities *in vitro* as well as *in vivo*, including anticancer, antibacterial, antiprotozoal, antiviral, and antidiabetic activities. Due to their negative charges, they bear resemblance to nucleotides and therefore affect the activity of nucleotide-dependent enzymes.

Na^+/K^+-ATPase (sodium pump) belongs to the P-type ATPase family, the members of which are able to utilize the energy of ATP to transport ions against their electrochemical gradient. Na^+/K^+-ATPase is a cell membrane located enzyme that establishes and maintains a high internal K^+ and a low internal Na^+ concentrations. It is characteristic and essential for normal cellular activities of most animal cells. Moreover, Na^+/K^+-ATPase interacts with neighboring membrane proteins and organized cytosolic cascades of signaling proteins to send messages to the intracellular organelles. Thus, this function of the sodium pump as a receptor and signaling mediator suggests that Na^+/K^+-ATPase has a pivotal role in cancer cell migration and supports the view that Na^+/K^+-ATPase could be an important target for the development of anti-cancer drugs.

In this study, the *in vitro* influence of six new synthesized POMs containing tungstate on Na^+/K^+-ATPase activity was investigated. The tested POMs compounds are soluble in water and stable at the physiological pH value. Na^+/K^+-ATPase is commercially available and purified from the porcine cerebral cortex. The various concentrations (from 1×10^{-7} to 1×10^{-3} mol/L) of POMs were exposed to the enzyme during 15 min at 37°C. The obtained results showed that $NaK_7[SiV_3W_9O_{40}] \times 10H_2O$, $K_7[Ti_2PW_{10}O_{40}]$, and$K_6[PV_3W_9O_{40}] \times 3H_2O$ possessed the most potent inhibitory potential toward Na^+/K^+-ATPase. Micromolar concentrations of these compounds resulted in the reduced enzyme activity. The calculated IC_{50} values, defined as the inhibitory concentration inducing a 50% decrease in the enzyme activity compared to control value, for $NaK_7[SiV_3W_9O_{40}] \times 10H_2O$, $K_7[Ti_2PW_{10}O_{40}]$, and $K_6[PV_3W_9O_{40}] \times 3H_2O$ are 1.7×10^{-6}, 3.8×10^{-6}, and 5×10^{-6} mol/L, respectively. $Na_6[TeW_6O_{24}] \times 22H_2O$ and $(NH_4)_{14}[NaP_5W_{30}O_{110}] \times 31H_2O$ demonstrated the weakest inhibitory power, causing 50% inhibition at the concentrations of $5 \times 10^{-4}$and 1.5×10^{-4} mol/L, respectively. Finally, $K_6H_2[TiW_{11}CoO_{40}] \times 13H_2O$ induced 50% Na^+/K^+-ATPase inhibition at the concentration of 5×10^{-5} mol/L. All obtained inhibition curves followed the sigmoidal function and served for the determination of IC_{50} values.

INTERACTION OF SOME POLYOXOTUNSTATES WITH ACETYLCHOLINESTERASE

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Polyoxometalates (POMs) are polyanionic oligomeric aggregates of transition metal ions, such as tungsten, molybdenum, vanadium, etc. held together by oxygen bridges, with a high density of negative charge. They are relatively stable, some even highly stable in aqueous solutions at biological pH values. In addition to applications in catalysis, separations, analysis, and as electrondense imaging agents, some of these complexes have been shown to exhibit biological activity *in vitro* as well as *in vivo* ranging from anti-cancer, antibiotic, and antiviral to antidiabetic effects. Recent investigations reported some polyoxotungstates as reversible inhibitors of acetylcholinesterase (AChE), making them potential anti-Alzheimer's drugs.

AChE is a serine hydrolase mainly found at neuromuscular junctions and cholinergic brain synapses. Its principal biological role is the termination of impulse transmission at cholinergic synapses. Reversible inhibitors of AChE mostly have therapeutic applications, while toxic effects are associated with irreversible AChE activity modulators. Reversible inhibitors play an important role in the pharmacological manipulation of the enzyme activity, and have been applied in the diagnostic and/or treatment of various diseases such as: myasthenia gravis, AD, postoperative ileus, bladder distention, glaucoma, as well as antidote to anticholinergic overdose.

The effect of four new synthesized polyoxotungstates soluble in water on AChE activity was studied. AChE is purified from electric eel and commercially available. The enzyme was treated *in vitro* with polyoxotungstates in the concentration range from 1×10^{-7} to 1×10^{-3} mol/L at 37°C for 15 minutes, and the incubation time was 12 min. The obtained dependence remaining enzyme activity *vs*. the inhibitor concentration fitted the sigmoidal function. IC_{50}values, indicating the enzyme sensitivity toward the inhibitor and the inhibitory capacity of the analyzed compounds, were determined from the inhibition sigmoidal curves. $Na_{10}[H_2W_{12}O_{42}] \times 27H_2O$ did not markedly reduce AChE activity at the highest investigated concentration (1 mmol/L). $K_7[SiV_3W_9O_{40}] \times 10H_2O$ exhibited a weak inhibitory potential, causing 50% decrease in the enzyme activity at 5×10^{-4} mol/L. However, AChE sensitivity in the presence of $K_7[Ti_2PW_{10}O_{40}]$ was several hundred times higher, reaching IC_{50} at 1.15×10^{-6} mol/L. Furthermore, $(NH_4)_{14}[NaP_5W_{30}O_{110}] \times 31H_2O$ demonstrated the strongest capacity to inhibit AChE. In the presence of its low concentration of 2×10^{-8} mol/L, the enzyme activity was noticeably reduced related to the control value (obtained without inhibitor), while 50% decrease in AChE activity was achieved at 3.8×10^{-7} mol/L.

THE ANTIOXIDANT CAPACITY OF THE KIDNEY TISSUE IN PATIENTS WITH RENAL CELL CARCINOMA

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Renal cell carcinoma is the most common and the most lethal type of kidney cancer with the highest incidence in developed countries. At the moment of diagnosis, many patients already have developed metastases. Tobacco smoking, obesity, hypertension and occupational exposure are established risk factors. Superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx) are antioxidant enzymes (AOE) that have a key role in protecting from reactive oxygen species (ROS) produced in pathological processes. We examined the antioxidant capacity of tumour tissues in patients with the clear cell type of renal cell carcinoma. The results showed a significant decrease of AOE activities in the tumour tissue compared to the normal kidney tissue, indicating that the tumour tissue is under permanent oxidative stress. Renal cell carcinoma is highly resistant to radiation therapy, which is also associated with free radical production. Since the tumour tissue has impaired AO capacity, the findings of this study may contribute to the improvement of the potential therapeutic treatments.

EFFECT OF SILICON DIOXIDE-ENRICHED WATER DURING CHRONIC INGESTION OF ALUMINUM ON FUNCTIONAL CHARACTERISTICS OF PERITONEAL MACROPHAGES

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Background: Silicon dioxide (SiO_2) is an oligomineral found naturally in water, plants, and animals. One of the most important sources of this mineral is drinking water where certain amount of dissolved amorphous silicon dioxide can be detected. Lack of SiO_2 is associated with moderate disorders in the metabolism of the bone tissue. Aluminum food intake enhances inflammation and the production of inflammatory cytokines. It is shown that silicon dioxide has an antagonistic effect with the aluminum in the body and may have a preventive role in numerous diseases. Therefore, the application of natural protectors that have the ability to reduce inflammatory responses and other harmful effects of aluminum are of special importance for contemporary nutrition.

Aim: The main goal of this study was to evaluate the effect of silicon dioxide-enriched water during chronic ingestion of aluminum on functional characteristics of peritoneal macrophages as one of the best-studied macrophage population.

Material and Methods: We used the model of chronic intoxication with aluminum for a period of 90 days by gavages with a solution of aluminum chloride in the form of aluminum salt dissolved in distilled water (1.6 mg/kg in 0.5 ml daily water intake). In total, 21 female Wistar Albino rats were divided into 3 groups, each consisting of 7 animals: chronically intoxicated with aluminum [non-treated (NT) and per os treated (T) with water enriched with silicon dioxide (20 mg/l)] and sham-intoxicated (S). PMF (LPS- or PMA-stimulated) were evaluated according to phagocytic activity and metabolic activity after 24h cultivation *in vitro*. The study also included evaluation of supernatant cytokine (TNF-α, soluble (s) ICAM-1) concentration in supernatants by ELISA method.

Results: PMF from animals chronically intoxicated with aluminum (NT) showed lower metabolic viability/activity compared with PMF isolated from sham animals (S). Treatment of intoxicated animals with water enriched with SiO2 partially restored metabolic viability. T-PMF had higher metabolic viability compared to NT-PMF but still significantly lower than S-PMF. PMF of aluminum-intoxicated animals (NT-PMF) showed very low phagocytic activity, whereas SiO_2 enriched water significantly up-regulated this activity. A daily intake of aluminum increased the release of TNF-α, while the SiO_2 treatment reduced these levels. Up-regulated ICAM-1 shredding by T-PMF were followed by the production of TNF-α.

Conclusion: Our study showed that treatment with water enriched with SiO_2 in concentration of 20 mg/L partially normalized characteristic of PMF of animals intoxicated with aluminum. We can suggest that SiO_2 could be a natural antidote of the aluminum and we may presume its possible benefit role in decreasing the aluminum toxicity commonly present in water and food.

A CORRELATION BETWEEN HEMATOLOGICAL CHANGES AND FETAL CELLS MICRONUCLEI IN PREGNANT WOMEN WITH HYPOTHYROIDISM

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Objective: Maternal dysfunction of the thyroid gland during pregnancy is associated with an increased risk of miscarriage, placental abruption, hypertensive disorders and growth restriction. Thyroid hormones have a significant role in the regulation of the activation of leucocytes, which are important sources of reactive oxygen and nitrogen species. In hyperthyroid patients, an increase in the number of eosinophils and mononuclear cells has been found, as well as a reduction in the number of neutrophils. Activated leucocytes produce large amounts of reactive oxygen and nitrogen species that can damage DNA, lead to genomic instability and impact the formation of micronuclei.

Micronuclei frequency in the cytoplasm of the cells is a sensitive biomarker of DNA damage by endogenous and exogenous toxins. Micronuclei are structures formed as a result of DNA fragmentation or the lagging of acentric chromosome or chromatid during mitosis. The increased frequency of micronuclei as biomarkers of genetic instability is shown in cancer, diabetes, autoimmune, neurodegenerative and cardiovascular diseases.

Methods: The samples of blood and amniotic fluid were collected from healthy pregnant women and pregnant women with hypothyroidism (16-18 weeks of gestation). Hematological characteristics were determined by using standard hematological methods. The frequency of micronuclei was determined in fetal cells after amniocentesis by using standard cytogenetic methods.

Results: The results of this study showed significantly higher levels of the number of eosinophils in hypothyroidism than in healthy pregnant women. Eosinophil and basophil percentage distribution was also documented in hypothyroidism. The increased fetal cells' micronuclei frequency and their correlation with eosinophils and basophils were indicated.

Conclusion: The obtained results suggest that an increased percentage and activities of eosinophils and basophils in hypothyroidism contribute to the formation of micronuclei in fetal cells.

ESTRADIOL IMPROVES MEAN ARTERIAL PRESSURE THROUGH REDUCTIONS OF OXIDATIVE STRESS IN WOMEN WITH PREECLAMPSIA

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Objective: It is known that oxidative stress has a role in endothelial dysfunction and reduction of NO bioavailability in clinical manifestation of preeclampsia. Recent studies indicate that endothelial dysfunction and reduced NO bioavailability in preeclampsia are related to abnormal metabolism of estrogen and reduced plasma level of 17β-estradiol. The present study shows in vivo evidence for benefit short term 17β-estradiol concentrations were unchanged during short term therapy.

Conclusion: Our finding indicates the importance of 17β-estradiol in maintaining vascular function in preeclampsia and supports the investigations of other authors who reported the association of the metabolism of estrogens and vascular dysfunction in preeclampsia.

DUAL-ENERGY X-RAY ABSORPTIOMETRY DETERMINED BODY MASS DENSITY AND ITS RELATIONSHIP TO BONE TURNOVER MARKERS

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Dual-energy x-ray absorptiometry (DXA) is the technique of choice in the assessment of bone mineral density (BMD), the average concentration of mineral in a defined section of bone. Osteoporosis is a common disease characterized by decreased bone mass, increased bone turnover, and increased susceptibility to fracture. Osteoporosis diagnosis is based on bone mineral density, which is generally measured in the spine and hip. Posteroanterior images of the lumbar spine include vertebral bodies L1–L4. The lowest-level data on the femoral neck and total hip are used for diagnosis. Diagnosis is based on T-score, normal being greater than –1.0; osteopenia, –1 to –2.5; and osteoporosis, less than –2.5.

Osteoporosis should not be diagnosed on the basis of densitometric criteria alone. Bone remodeling is also a crucial issue. Bone turnover markers (BTM) can be used to study changes in bone remodeling in osteoporosis. The combination of data from BMD and BTM may improve the monitoring of anti-resorptive therapy response and prediction of bone loss, osteoporosis development and risk of fractures. A high rate of bone turnover is associated with low BMD. Bone-turnover markers are released during bone formation or resorption and can be measured in blood. Osteoporosis is a result of a rather long evolution where in most cases bone resorption is increased, and is not compensated by an equally increased bone formation.

The aim of this study was to determine a correlation between the BMD and the concentration of biochemical bone turnover markers - type I collagen crosslinked C-terminal telopeptide (CTX) as a marker of bone resorption, and osteocalcin (OC) as a marker of bone formation, both expressed in ng/ml, and to evaluate BTM and the rate of bone remodeling in postmenopausal women (PM). According to T-score, patients were divided into three groups: patients with osteoporosis, patients with osteopenia and a control group consisting of patients with normal T-score.

Significant negative correlation was found between bone turnover markers, especially CTX and BMD in osteoporosis. Lowest BMD values in PM women with osteoporosis were associated with highest CTX values in comparison to PM women with osteopenia and the control group, indicating highest bone resorption in PM women with osteoporosis discovered with DXA examination. Higher increase of the markers of bone resorption is a risk factor for osteoporosis in PM women. Postmenopausal osteoporotic women were characterized with the highest CXT values indicating the highest osteoporotic risk associated with osteoporosis in this group. CTX differentiated best the increased osteoportic risk in PM osteoporotic women compared to the other groups, confirming its predictive and diagnostic importance of osteoporosis. We concluded that both procedures, BMD and BTM, have a significant role in the diagnosis and the follow-up of patients with osteoporosis.

RELATIONSHIP BETWEEN CENTRAL OBESITY INDEX AND ITS ESTIMATED VALUES IN CUSHING'S SYNDROME

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Dual energy X-ray absorptiometry (DXA) enables body composition (BC) and body fat distribution (BFD) determination. DXA measurements of BFD may be useful in studies related to obesity-associated disease risk such as Cushing's syndrome (CS).

The aim of this study was to discover central obesity index (COI) as a representative of visceral obesity by evaluation of the differences of the BC and BFD as measured by DXA in women with CS with confirmed abdominal obesity in comparison with healthy control women (C) matched for age, menopausal status, and BMI and to discover accuracy of the estimated values eCOI in comparison with automatically determined COI. Also COI and COI of tissue mass (COIt) had been compared.

DXA examination was performed in women with confirmed CS (n=10) and in a group C (n=10), matched according to their mean age (40.32±11.25 yr.) in CS and 41.91±12.85 yr. in C as well as their BMI (28.89±3.53kg/m2 vs. 29.39±4.04kg/m2). COI as an android (A) to gynoid (G) tissue fat mass percentage (tfm%) ratio (A/G tfm%) was automatically determined by DXA machine during BC measurement but COI as A/G tissue mass ratio (COIt) was calculated. Estimated COI (eCOI) was calculated as a ratio between Atfm% in spine region and Gtfm% in hip region during DXA spine and hip examination.

Atfm% in CS (54.14±6.34) and C (49.29±6.31) and Gtfm% in CS (50.76±4,64) and C (52.76±4.28) were not significantly different ($p>0.05$). COI in CS (1.07±0,15) was higher compared to C (0.938±0.11) ($p<0.036$). eCOI in CS was (1.04±0.13) and it was significantly higher compared to (0.97±0.09) in C. COI and eCOI values were not significantly different ($p>0.05$) and correlated highly significantly in both groups CS and C ($p<0.0001$) as well as with Atfm% ($p<0.001$). Atm (6.67±1.45 kg) and Gtm (10.3±2.89 kg) in CS were not significantly different compared to (5.75±1.19 kg) and (11.8±1.66 kg) in C ($p>0.05$). COIt (A/G tm) in CS (0.67±0.1) was significantly higher compared to C (0.48±0.05) ($p<0.0001$). COIt correlated positively with A in group C ($r=0.83$)($p<0.01$) but COI correlated with A in CS ($r=0.76$) and in C ($r=0.79$)($p<0.01$). Only COIt correlated significantly negatively with G in CS ($r=-0.66$)($p<0.05$).

It can be concluded that BC should not be performed for COI determination because eCOI could be determined during regular spine and hip DXA measurements. Determination of eCOI is more practical, faster, with lower radiation and is more acceptable; moreover spine and hip bone mineral content is determined at the same time. COI and eCOI values correlated highly significantly in both groups, eCOI measurements were reliable and comparable to automatically measured COI. COIt value in CS was significantly higher than C ($p<0.0001$), compared to COI ($p<0.036$), differentiated them better and confirmed its positive association with central, abdominal fat and tissue mass, and abdominal BFD in CS and its positive relation with the abdominal obesity, and the metabolic syndrome.

THE TUMOR ASSOCIATED WITH THE STRESS-INDUCED MOLECULE MICA IN THE BLOOD CAN BLOCK THE ACTIVITY OF NK CELLS IN CANCER

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One mechanism of tumor escape from immune surveillance and destruction is transformed cells dropping molecules expression density which plays a role in the recognition of cells by cytotoxic lymphocytes. The aim of research is assess the concentration of the soluble form of stress-induced molecule of tumor-associated protein sMICA in the blood of cancer patients and compared with spontaneous cytotoxicity blood mononuclear cells. The study included 311 patients with melanoma, non-Hodgkin's lymphoma(NHL), Hodgkin's lymphoma(HL), breast(BC), thyroid(TC), prostate(PC), cervical(UC), hypopharynx(PhC), bladder(BC), colon(CC), gastric(GC) cancer. Each form of cancer includes 10-80 patients. Control - data 59 healthy people. sMICA protein were determined by enzyme immunoassay (ELISA) using a set of antibodies (R & D Systems, USA). The activity of NK-cells was determined by a cytotoxic assay lysis of tumor cells K-562.

The reference group sMICA completely absent or detected in quantities ranging from 15 to 235pg/ml (Me = 37 pg/ml). Level sMICA when TC, BC, PC, HL average did not exceed 80 pg/ml and did not differ from the norm. The median concentration sMICA in other cancer was higher and reached when the NHL - 291, CC -238 RTC, GC - 211 BC -186, WPG - 184 CC -140 pg / ml. This is significantly higher than the control group. If different forms of NHL level sMICA was different. The greatest number detected in diffuse large-cell lymphoma (Me = 334) and B-CLL lymphoma (Me = 288 pg/ml). Evidently, tumor cells with reduced expression of MICA less recognizable NK cells. In turn, the reduction of tumor recognition molecules on killers reduce their activation and destruction of tumors. Assessment of spontaneous cytotoxicity of mononuclear blood in their ability to lyse tumor cells transplantable line K-562 showed that the total group of patients with NHL cytotoxic index below 2 times and made for different ratios of effector/target of 12 to 38%, compared to 30 - 45% in the control group. Increasing the concentration of sMICA in the blood found in a number of cancers (NHL, RTC, RJ, breast cancer, cervical cancer and WGH). Increase their level in the NHL correlated with a decrease in blood mononuclear cells cytotoxicity. The findings expand the existing understanding of the mechanisms of the transformed cells escape from the control of the immune system. Presumably, high levels of tumor-associated molecules may reduce the functional activity of the cytotoxic lymphocytes, and contribute to the progression of the disease. Identified changes can be used to create new means of diagnosis and treatment of cancer with a similar mechanism of tumor escape from the immune control.

IMMUNOGLOBULIN CLASS G FROM BLOOD PLASMA OF STROKE PATIENTS IN ACUTE PHASE AND THE SAME PATIENTS ONE YEAR LATER AS EFFECTORS OF THE HAEMOSTASIS KEY FACTORS

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Background. Unfortunately ischemic stroke provoke irreversible changes in the organism and fully recovery was not observed. Some anomalies of the haemostasis system were shoved during the acute phase of ischemic stroke as well as post disease patients. The idea was explored the fact that specific autoantibody generated in the bloodstream during the acute phase and their existence past one year of disease provoke repetition of stroke or support stable disorders of organism.

Methods and Results. Three fractions of immunoglobulin class G were separated: from the blood plasma of healthy donors, patients with atherothrombotic and cardioembolic ischemic stroke in acute phase of disease and the same fractions from the same patients one year past acute phase. The influence of the separated fractions on the process of hydrolysis of the specific chromogenic substrate by the key factors of the hemostatis system: thrombin, activated protein C and factor Xa were tested. The results were compared with our previous analysis of the effect of immunoglobulin class G obtained from the bloodstream of the patients with the same diseases in the acute phase of illness. The fact that IgG obtained from the donors plasma did not influenced tested process meaningful was proved in our previous research.

Conclusions. It was proved that the influence of immunoglobulin class G all fractions separated from the blood plasma of patients one year past disease were less effective or was equal to zero during the hydrolysis of substrate by enzymes (thrombin and activated protein C). But, the same influence was more intensive during the hydrolysis of substrate by thrombin in comparison with immunoglobulin class G separated from plasma of patients in acute phase. For the both periods of disease IgG obtained from the plasma of the patients with cardioembolic ischemic stroke-effected process of substrate hydrolysis by all examined factors more active in comparison with IgG isolated from the plasma of patients with atherothrombotic ischemic stroke.

COMBINED IMMUNITY INDICATORS FOR DIFFERENTIAL DIAGNOSIS OF HODGKIN'S LYMPHOMA REMISSION AND RELAPSE

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The aim of the work is to evaluate the possibility to use combined immunity indicators for differential diagnosis of Hodgkin's lymphoma remission and recurrence in late periods following the treatment.

As materials of the study 278 records of immunological tests of peripheral blood of patients with Hodgkin's lymphoma in remission (196) and relapse (82) of the disease were used. Similar information on 100 blood donors was used as control. For adequate interpretation of immune status, tested by 23 indicators the principal components (PC), analysis was performed. On the basis of the correlation matrix construction and analysis of weight loads the most informative parameters, such as absolute number (*10^9 cells/l) leukocytes, CD4+T-helpers/inducers, CD8+cytotoxic T lymphocytes, CD19+B-cells, CD16+natural killer cells, CD3+HLADR+ activated T-cells, the levels of IgM, G, A classes of serum, the function of phagocytes , were selected. Immunological parameters of matched groups of patients, included in the first four PC described 70% of information about the immune status. For patients with of remission and relapse mean values and standard deviation for each of the four main components were obtained. As the next step combined immunity indicators, CII, were built with the use of regression analysis, principal components (PC) calculated personally for each patient were used as independent variables. Calculations were made with the use of the soft «STATISTICA 8».

Comparison of four PCs of Student t-test showed statistically significant differences of the groups “remission-relapse”, “remission-donors”, “relapse-donors”. Remission and relapse of the disease significantly differed when compared the averages of combined immunity indicators ($t = 5.57$, $p < 0.001$). These results demonstrated that relapse and remission of Hodgkin's lymphoma could be distinguished by the value of combined immunity indicators. Histograms of distribution of the indicators individual values with the chosen interval were constructed for remission and relapse. 40% of cases with remission only were within the range of individual indicators varied from -2 to 0. 38% of cases with recurrent disease were within the the range of combined immunity indicators varied from 0.5 to 1.5. The central zone (combined immunity indicators from 0 to 0.5) consisted 60% of patients with remission and 62% with recurrent disease. Thus differential diagnosis of remission and relapse of Hodgkin's lymphoma can be made for 40% of patients with remission and 38% with relapse of the disease. Such parameters as the stage of the disease, the volume of exposure to radiation, total radiation dose, specific chemotherapeutics and chemotherapy scheme, the time passed after the treatment can influence significantly the immune status, and determine the duration and stability of remission or relapse. We suggest that the increase in the volume of research with account of the mentioned parameters will improve differentiation of remission and relapse and lead to narrowing of the boundaries of the “gray zone”.

THE ACTIVATION STATUS OF LYMPHOCYTES' SUBPOPULATIONS, APOPTOSIS AND THE LEVEL OF CIRCULATING REGULATORY T-CELLS IN THE DEVELOPMENT OF REPRODUCTIVE SYSTEM DISEASES IN WOMEN LIVING IN RADIOACTIVELY CONTAMINATED TERRITORIES FOLLOWING THE CHERNOBYL ACCIDENT

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Immunity disorders are suggested to play essential role in the development of gynecological diseases, such as endometriosis, uterine fibroids, cancer of the cervix and cancer of uterus, a significant role played by.

The aim of research is to assess the state of cellular and humoral immunity with account of the cellular activation status and apoptosis, cell-level regulators antitumor immune responses in women with clinical presentation of inflammation, benign hyperplastic and malignization. Immune status was studied in 260 women lived in Novozybkov and Klintsy towns of Bryansk oblast, contaminated with radionuclides following the Chernobyl accident: 114 of them did not have reproductive system diseases, and 146 women had hyperplastic inflammatory diseases, benign and malignant neoplastic diseases. The age of women ranged from 16 to 65 years. In immunologic studies, the relative and absolute number of T, B, NK cells, T-helper cells and killer T cells in the blood were evaluated. The activation status of lymphocytes, including the activation of T-helper and T killer cells apoptosis, as well as the level of T-cell-regulators of immune responses (Treg) was evaluated. In patients with reproductive system disorders both activation and suppression of immunity occurred more frequently than in patients without the disorders. Immunity activation prevailed over suppression, the frequency of activation occurrence was 1.5-5 times higher.

Statistically significant increase in absolute number of T-helper cells, T killer, NK-cells and increased expression of apoptosis activation marker on T cells occurred in all patients with gynecologic disorders (146 women). At the same time, Tregs level, that controlled the level of immune response, decreased. The relationship between changes of lymphocyte subpopulations' composition and the type and severity of gynecological diseases is observed. The percentage of lymphocytes and major T-lymphocytes subpopulations was within limits of norm in patients with inflammation diseases and benign neoplasms, though the absolute number of T lymphocytes exceeded the norm level. In patients with benign diseases the number of NK-cells exceeded the limits of norm; and in cancer cases the percentage and the number of CD8+killer T cells and NK cells decreased, the amount (not percentage) of T-helper cells decreased to a lesser extent. Gynecological disorders impact on the degree of lymphocytes activation. Increased activation of T cells by expression of HLA-DR occurred in case of inflammation and benign tumors; activation level of T-helper and T-killer cells apoptosis occurred as well. In cancer patients, the most significant immunity disorders were as follows: reduced number of killer lymphocytes and the extent of activation of the programmed lymphocytes death, as well as increase in the level of Treg cells suppressing immune response. Thus, in inflammatory and hyperplastic processes activation prevailed and in cancer suppression prevailed. Understanding mechanisms in regulation of activation-suppression process will contribute to the development of therapeutic approaches to regulation of activation or death of concerned lymphocyte subpopulations.

BIOPHARMACEUTICALS AND PHARMACOLOGY

06

REDOX-ACTIVE COPPER(II) COMPLEXES WITH 1,2-DIHYDROXYBENZENE DERIVATIVES

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The superoxide radical, a byproduct of cell respiration, is one of the major factors involved in oxidative stress, tissue damage and development of various pathogenic physiologic conditions [1]. In this connection, it is of topical interest to search for compounds decreasing the superoxide content in mammalian cells while behaving as low-molecular analogues of superoxide dismutase enzyme (SOD mimics), particularly Cu(II) complexes [2]. It has been proposed that metal complexes with antioxidants as ligands may be effective as SOD mimics [1]. Among the compounds with such properties it is redox-active Cu(II) complexes with 1,2-dihydroxybenzene derivatives that deserve particular attention [3].

We have synthesized novel bioactive complexes of Cu(II) with 1,2-dihydroxybenzene derivatives: 3-(pyrrolidin-1-ylmethyl)-5-tritylbenzene-1,2-diol, 3-(piperidin-1-ylmethyl)-5-tritylbenzene-1,2-diol, 3-(azepan-1-ylmethyl)-5-tritylbenzene-1,2-diol, 3-(morpholinomethyl)-5-tritylbenzene-1,2-diol, 3-((4-methylpiperazin-1-yl)methyl)-5-tritylbenzene-1,2-diol. According to the data of elemental analysis, the molar ratio Cu(II) : ligand = 1 : 2. The results of thermogravimetric analysis demonstrate that the complexes are thermally stable up to 180oC, and that there are no water molecules in their coordination sphere. The molar conductivity values for acetonitrile solutions of the complexes testify that they are neutral. According to the data of spectral investigations, the coordination cores of the complexes are planar chromophores [CuN_2O_2]. Using enzymatic methods of superoxide generation employing a xanthine and xanthine oxidase assay [4], the superoxide dismutase activity (IC_{50}) of the complexes synthesized was determined, which was equal to 103.1 – 133.4 $\mu mol \cdot ml^{-1}$. The results obtained on the SOD activity, along with a high degree of lipophilicity of 1,2-dihydroxybenzene derivatives and their complexes, allow the compounds synthesized to be regarded as hit compounds for developing new effective antioxidants – traps for superoxide. Moreover, the results of the pharmacological screening of the compounds synthesized allow the latter to be regarded as hit-compounds with a high antimicrobial activity (MIC 1.6÷25.0 $\mu g \cdot ml^{-1}$). The complexes were found to have a moderate inhibition activity against Gram-negative bacteria, while Gram-positive ones are more sensitive to these compounds. What is more, the complexes also demonstrate some antiproliferative activity against HCT-116 cell line.

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THE INVESTIGATION OF THE ANTIGENOTOXIC POTENTIAL OF PAPAVER RHOEAS L. AND SALVIA OFFICINALIS L. EXTRACTS AGAINST AN OXIDATIVE STRESS INDUCER

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Background. In the last decades, natural plant extracts have become a subject of intensive research as a form of medical treatment and an integral part of the cosmetic industry. These bioactive natural compounds possess anticytotoxic, antimutagenic properties, as well as protective potential against reactive oxygen species (ROS). The antimutagenic potential correlates frequently with their antioxidant capacity. The aim of the present study is to determine and compare the anticytotoxic and antigenotoxic effect of *Papaver rhoeas* L. (poppy) and *Salvia officinalis* L. (sage) water extracts against ROS inducer zeocin in two types of test-systems.

Methods. In the present work the protective potential of water extracts of two angiosperms representatives - *Papaver rhoeas* L. (Papaveraceae) and *Salvia officinalis* L. (Lamiaceae) - was investigated *in vitro* using two different model test-systems: meristems cells of *Hordeum vulgare* (reconstructed karyotype MK 14/2034) and human lymphocytes. Chromosome aberrations (CA), induction of aberration hot spots for barley chromosomes, micronuclei (MN) and mitotic activity (MI) were evaluated as endpoints.

Results. *Papaver rhoeas* L. as well as *Salvia officinalis* L. water extracts exhibit cytotoxic and genotoxic effects in barley root tip meristem cells and human lymphocyte cultures at low concentrations. On the other hand both bioactive compounds possess clearly anticytotoxic/anticlastogenic potential to inhibit and decrease the harmful effects of the radiomimetic zeocin.

The protective potential of both plant extracts against the clastogenic effect of zeocin depends on the experimental design and concentration applied.

Conclusions. Our results indicated that, the water extracts of *Papaver rhoeas* L. and *Salvia officinalis* L. had the potential to reduce the clastogenic effect of zeocin in meristems cells of barley and human lymphocytes, irrespective of their different place on the hierarchical level. Further investigations are necessary for chemical characterization of the active compounds in these plant extracts. The obtained data could be useful to upgrade health research programs and prophylactic therapy use of natural plant compounds.

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THE SIDE EFFECTS OF A GROUP OF ANTIBIOTICS THAT ARE USED THE MOST IN PERIODONTAL TREATMENTS

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Antibiotic combinations are preferred for the treatment of periodontal diseases, with the aim of hitting the bacterial flora, according to its characteristics, aerobic, anaerobic, gram-negative and gram-positive, with certain antibiotics that act on certain bacteria. The aim of the study is analyzing the side effects of the used antibiotics. The data on the side effects (preferably expressed in percentages) of some antibiotics, the favorites in periodontal recipes, are gathered from literature. These data are listed according to the used antibiotic. In the case of providing a periodontal prescription, the patient is in the risk of allergy (5%), nephritis (3%), hematological problems (2-2.5%), gastrointestinal problems (5.5%), disturbance in the nervous system (2%), allergic signs on the skin (5.5%), and problems with electrolytes displayed in lower percentages. Interaction with different medications is present in almost all cases. The influence on the body systems is 4% in total, the maximum value of which is expressed on the skin, and the minimum value is expressed on the nervous system. Cross allergies are in high value because of the expressed structural similarity of antibiotics. Giving a recipe, we have a balance of the percentage of side effects, the percentage of bacterial resistance and the percentage of the success of the recommended dose of antibiotics.

Key words: Antibiotic, via side effects, periodontology

THE PENETRATION OF TIOTROPIUM BROMIDE ON THE BULGARIAN COPD MARKET

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Background. In consideration of the significant economic and humanistic burden of COPD (Chronic Obstructive Pulmonary Disease), therapeutic decisions should be based on an evaluation of the costs and benefits of available treatments. Bronchodilator medications are central to symptom management in COPD and are prescribed on an as-needed or on a regular basis to prevent or reduce symptoms. Long-acting bronchodilator medications are more convenient and produce more sustained relief than short-acting bronchodilators. In particular, long-acting muscarinic antagonists such as tiotropium bromide act by blocking the effect of acetylcholine on muscarinic receptors.Tiotropium has been shown to reduce exacerbations and related hospitalizations, improve symptoms and health status, and improve the effectiveness of pulmonary rehabilitation. The aim of this study is to analyze the economic evaluation of tiotropium bromide and its market access for the period 2006-2015 .

Methods. A combined methodology is applied including documentary analysis for reviewing the normative basis for COPD treatment and IMS data for tiotropium bromide sales for the period 2006-2015 ..

Results. The prevelance of COPD in Bulgaria is 9%. COPD products have a low level of reimbursement till 2009 in comparison with asthma ones. Tiotropium bromide was launched on Bulgarian market in 2003 with a price of 53 Euro. In 2006 this product received 25% reimbursement while in countries like Austria, Slovakia and Hungury this level was close to 100%. The sales for 2007 were 1 818 packs. In 2010 after 75% of reimbursement, sales in units increase rapidly to 94 584 . For 2015 they were 202 989 in units that is 5 148 586,764 in Euro.

Conclusions. The reimbursement statute of a pharmaceutical product influences the sale status of the pharmaceutical product as it can be seen from the market status of tiotropium bromide , compared to its status in other Eastern European countries.

Key words: market, COPD, Tiotropium bromide, long-acting muscarinic antagonists

ECONOMIC ANALYSIS OF CHILDREN WITH TYPE 1 DIABETES ON CONTINUOUS SUBCUTANEOUS INSULIN INFUSION

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Objectives. To evaluate the cost-effectiveness of continuous subcutaneous insulin infusion (CSII) to analogue multiple daily insulin injections (MDI), based on the achieved short term therapeutic results as insulin dosage per kg and average daily blood glucose level.

Methods. Prospective, observational, comparative, controlled real life study performed at the Endocrinology, diabetes and genetic diseases Clinic. 26 children aged 7 to 17 years with type 1 diabetes are included separated in two groups- active on CSII and passive on MDI. The active group included all children who began using the CSII pumps during the period 2007-2014 when the data collection began. Cost of therapy was calculated and short term therapeutic results as insulin dosage per kg and average daily blood glucose level were observed. Towards them was applied cost-effectiveness analysis.

Results. The active and the controlled group do not differ statistically in age and gender. Most participants have suffered from diabetes from 5 to 10 years. The daily quantities of insulin are slightly lower at 27.186 IU (SD 15.422 IU) in the active group than in the control group with 29.708 IU (SD 7.205 IU). The average dose of insulin per kg is also slightly lower at 0.7323 IU/kg (SD 0.307 IU/kg) vs 0.8953 IU/kg (SD 0.165 IU/kg) in the control group. T-value is 0. -.543. Mean glucose levels after 15 days of treatment for 6 patients on CSII have statistically significant lower levels. The statistical processing of our data shows that 46.15% of the patients from the active group (CSII) have statistically significant better control. ICER is below the threshold.

Conclusions. Our study shows that the CSII pumps allow better diabetes control when even short come results are considered. They are also and cost- effective alternative for children with type 1 diabetes.

Key words: Type 1 diabetes, children, insulin, dosage, blood glucose level

BIOPHYSICS 07

STATIC MAGNETIC FIELD EFFECTS ON BIOCHEMICAL REACTIONS INVOLVING REACTIVE OXYGEN SPECIES

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Reactive oxygen species (ROS) are toxic, short-lived, highly reactive by-products of normal physiological and metabolic cellular processes. The excessive production of ROS results in the damage of proteins, lipids, DNA and RNA. Aerobic cells possess antioxidant scavenging mechanisms that are protective against the ROS damage. These relay on the superoxide dismutase (SOD), catalase, glutathione peroxidase (GSHPx), vitamin E and vitamin C. The superoxide anion is converted to the hydrogen peroxide by the action of SOD: cytosolic (Cu/Zn-SOD), mitochondrial (Mn-SOD) or extracellular (Cu-SOD). Alterations in the expression of Cu/Zn-SOD have been implicated as a possible factor in several neurodegenerative disorders (Dröge 2002).

A static magnetic field (SMF) can, among other magnetobiological effects, induce changes in enzyme activity (Amara et al. 2006; Ghodbane et al. 2013). The metabolism of ROS becomes affected, with the reported effects to the lipid peroxidation, tissue damage, etc. whereas the strong and moderately strong SMF can act through the combination of several biophysical mechanisms, it is now accepted that the radical pair mechanism induces changes in the rates and yields of certain biochemical reactions under the influence of weak to moderate SMF (Rodgers 2009). These effects are strongly dependent on the SMF intensity, which could be a reason for the variability of the experimental results obtained by different research groups using various exposure setups.

Free radicals, including the reactive oxygen species, are ubiquitous in biology. Transition metal ions, the compounds of many proteins and enzymes, can act as radical species in biochemical reactions, enabling the modulation by the SMF of the redox cycles of metal-ion containing enzymes. This motivates the investigation not only into the exposure end effects such as the tissue damage, but also into the effects on the molecular level such as the distribution of various metals after exposure to the SMF. The current status of the observed effects to the organism is reviewed by putting into perspective the available data on the SMF induced effects as well as possible health implications.

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OPTICAL CORE-SHELL MODEL FOR NANO-DELIVERY APPLICATIONS

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In this paper, we will analyze the 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 or even decades away, however, potential advances in drug delivery, diagnosis, and development of nanotechnology-related drugs start to change the landscape of medicine. The 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) are just a few concepts on the horizon of research. In this paper, especially, we have analyzed the changes in the 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.

The main advantage of the theoretical approach is the essential knowledge of the mechanisms that allow us to comprehend the experimental conditions that we have to fulfill to be able to get the desired results. The results achieved up to now by our research group in the application of the Green’s function method on flat ultrathin films are promising for applications in the frame of core-shell models. This paper presents the review of our current achievements in the field of theoretical physics of ultrathin films and possible ways to materialize the same in the field of nanopharmacy.

The subject of the research in this paper includes modeling of nanomaterials in the field of pharmaceutical technology for biomedical application. This includes a very precise encapsulated drug delivery on the 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 to be used for layers of drug carrier capsules, biochips and biomarkers. These layers should demonstrate a controlled disintegration of structure, better dielectric properties, discrete luminescence and appropriate bioporosity as all these are the requirements of contemporary nanomedicine.

THE EFFECT OF GAMMA-RAY IRRADIATION ON THE MOTILITY AND CHEMOTAXIS OF *ESCHERICHIA COLI*

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Ionizing radiation causes damage to biological components via the disruption of chemical bonds and via chemical modification by radicals originating from water. Although bacterial cells are known to lose the ability for cell growth upon irradiation, other physiological processes such as metabolism, motility, and gene expression do not cease immediately after irradiation. In that regard, we examined the bacterial motility after irradiation with an accelerated proton beam and gamma rays, and found that the bacterial flagellar motor was robust against ionizing radiation at a dose to stop the bacterial growth.

Bacterial motility is closely related to the chemotactic responses. Here we examined the effect of gamma irradiation on the bacterial response to a repellent using *E. coli* strain JM109. Negative chemotactic response (escaping from repellent) was evaluated using the test-tube method. After irradiation, the bacterial cell suspensions (turbid enough to see) were layered on 1% agar containing motility medium supplemented with 10% glycerol (one of the repellents for *E. coli*) in the test tubes. The test-tube method allowed the visualization of the clear area above the agar after a 30-min incubation. Samples that were irradiated （0.5 kGy ~ 2.0 kGy） either did not show a clear area in the test tubes, or the clear area was much narrower than the non-irradiated control. The average swimming speed of the cells in non-irradiated and irradiated samples was not significantly different, as reported before. These results suggest that the signal transduction system responsible for the chemotactic response is more susceptible to gamma irradiation than flagellar motors.

QUANTUM DOTS AS BIOLOGICAL MARKERS

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We will discuss an application of quantum dots in biology and medicine as biological markers to reveal the presence of a certain biological structure, such as a cancer cell. In a process known as fluorescence, quantum dots emit optical radiation with a very narrow frequency spectrum called the luminescence linewidth. The different-sized dots (cores) are coated with multilayered shells to tailor their electronic, chemical, or biological properties. A shell material (e.g. ZnS) has to be transparent and must be able to be attached to the core to provide a surface to attach a biological structure. The energy reradiated by the dot is less than that which excites the dot; the radiated wavelengths of fluorescence are longer and the difference is known as the Stoces shift. Since the illuminating energy and the reradiated energy can be separated (filtered), the Stoces shift can be used as a biological marker. This provides an advantage for quantum dots compared with fluorescent dyes, which radiate at nearly the same wavelength as their excitation.

MEASUREMENT OF OPTICAL AND THERMAL PROPERTIES OF BIOLOGICAL TISSUES AND ANALYSIS OF TRANSPORT PROCESSES IN THEM

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The understanding of the transport mechanisms in macromolecular structures such as biological tissues is very poor. The recent theoretical studies indicated that the transport mechanisms of heat generated by absorption on infra-red and visible light are different. In this paper, a combination of experimental techniques is proposed that would enable simultaneous measurement of optical and thermal properties of macromolecular structures excited by light with wide spectrum. The results of the experiments would enable credible testing of validity of the predictions of the theoretical studies, and a further insight of the transport processes in biological tissues. Also, this could be the base for the development of novel biomedical diagnostics.

REMOTE SENSING OF THE INFLUENCE OF ENVIRONMENTAL CHANGES ON PLANT BIOPHYSICAL VARIABLES

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Hyperspectral remote sensing technique based on reflectance measurements in the visible and near-infrared spectral ranges was in the last years proven to be highly suitable for the identification of growth anomalies of plants that result from the changes of the environment and different accompanying stress factors. Adverse growing conditions give rise to biophysical (morphological, physiological, biochemical) changes that affect the manner with which plants interact with light. All green vegetation species have unique spectral features, mainly because of the chlorophyll and carotenoid, other pigments, and water content. Because spectral reflectance is a function of tissue optical properties and the biochemical content (chlorophyll, water, dry matter, etc.) of the plants, along with the illumination conditions, it may be used to collect information on several important biophysical parameters such as the color and the spectral signature of features, vegetation chlorophyll absorption characteristics, vegetation moisture content, etc.

In this paper, some applications of leaf spectral reflectance for the assessment of the effects of adverse environmental conditions on plant biophysical parameters are discussed. Stress factors such as enhanced UV-radiation, salinity and viral infections were applied to some young plants (potato, tomato, apples, plums). Hyperspectral reflectance data were collected by means of a portable fiber-optics spectrometer in the visible and near-infrared spectral ranges (350-1100 nm). The differences between the reflectance data of healthy (control) and injured (stressed) species were assessed by means of statistical (Student's t-criterion), first derivative, cluster analyses and some vegetation indices. Statistical analyses were carried out in four most informative regions for the investigated species: green (520-580 nm), red (640-680 nm), red edge (680-720 nm) and near-infrared (720-780 nm). The strong relationship, which was found between the results from the remote sensing technique and some biochemical and serological analyses (stress markers, DAS-ELISA), indicates the importance of hyperspectral reflectance data for conducting, easily and without damage, rapid assessments of plant biophysical variables. Emphasis is put on current capability and future potential of remote sensing and on the optimum spectral region for sensing these biophysical variables.

PHYSICO-CHEMICAL CHARACTERIZATION OF LIPID-2D-MATERIALS SELF-ASSEMBLY FOR BIOSENSORS

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Solid supported phospholipid-bilayer technology [1] is one of the major avenues for development of sensors and nanodevices, especially in the fields of proteomics. Since the drug targeting is usually aimed to the cell membrane associated proteins, building a well-tailored and sensitive biosensor is of utmost value [2]. On the other hand, modern research in material science explores the possibilities of materials suitable for building small, sensitive, and robust sensors. 2D-materials, such as graphene, MoS2, and WS2, in combination with lipid mono- and multilayers present an excellent base for building organic field-effect transistors (oFET), whose properties are able to meet these requirements [1,3,4]. In order to accomplish a satisfactory design of such devices, it is necessary to produce thin (ideally homogenous, defect-free) films of graphene and other 2D-materials and establish their physico-chemical properties, alone and in combination with various biomolecular assemblies, such as lipids, cholesterol and biopolymers. In our study we have obtained composite thin films of these materials (from a few nm to several tens of nm) and explored the elecrostatic properties, structural topography, and chemical bonds of DPPC, DPHyPC, sphingomyelin and cholesterol supported on graphene, MoS2 and WS2 thin films. The AFM, KPFM, FT-IR and Raman spectroscopy have been employed for that purpose.

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THE SOLAR AND MAGNETIC WEATHER – GEOEFFECTIVE IMPACTS

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The appearance of gigantic solar flares, strong sun winds and intense solar storms makes solar weather *(Space & Solar Weather*) extremely important. It has a strong influence on the climate and meteorological changes. Hourly, daily, monthly and yearly values of the index of solar and geomagnetic activity, and the appearance of geomagnetic deviations and geomagnetic storms constitute *Magnetic Weather*. All the changes in the magnetic weather can influence the processes and dynamics in the Earth's atmosphere and climate, and directly and indirectly influence living organisms.

When we discuss space conditions or space weather, then we notice the parameters of speed and strength of the solar wind and observe the activity of sunspot groups, during one or more solar cycles. Conditions in space or solar weather often can be determined by the activity of CMEs emission (**C**oronal **M**ass **E**jections), or by eruptions of coronal plasma and energy. *Solar Weather* is changed as the number of registered solar storms and the number and speed of magnetic clouds is changed, and depending on whether they were observed by weakening or intensive magnetic storms. At a distance of one or two astronomic units (AU), as the solar wind became stronger and accelerated, the conditions in the geomagnetic activity were changed. Magnetically disturbed days (d-days) were registered with intensive geomagnetic activity. Changes in the *Magnetic Weather* were determined by registered magnetospheric and ionospheric disturbances and intensive magnetic storms.

Geo-effective impact of solar and magnetic storms on the dynamics and structure of phenomena and processes in the Earth's atmosphere was observed and analyzed in the minimum and maximum phase of solar activities during three solar cycles. In the months when intense solar and geomagnetic storms were registered, we evaluated changes in meteorological parameters. We analyzed hourly changes in the air temperature, the interval of sun exposure during *quiet days* (low solar and geomagnetic activity) and *disturbed days*, during the period before, during and after a registered geomagnetic storm. Additionally, we analyzed the geo-effective influence of powerful solar and geomagnetic storms on cosmic satellite stations, GPS technologies, telecommunication systems and the electric power network. Finally, we analyzed the effect of solar and geomagnetic disturbances on the biosphere, environment and workspace.

GROWING, BIOCHEMICAL AND EMISSION PROCESS INTENSIFICATION WITH MODULATED ULTRASOUND

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The purpose of our research was to identify the specific effects of modulated ultrasonic waves with different frequency pulse modulation in various organophotoheterotrophic prokaryotes cells. As the test objects the representatives of unicellular organisms, bacteria and archaea, were selected, i.m. – the culture of marine luminescent halotolerant bacteria *Alivibrio fischeri 6* and extremely halophilic culture of archaea *Halobacterium halobium* (*Natrinema pallidum* nom. Nov. NCIMB 777).

A.fischeri culture medium was used with the following composition (g/l): peptone – 10, yeast extract – 1, NaCl – 30, Na_2HPO_4 – 5.3, KH_2PO_4 – 2.1, $(NH_4)_2SO_4$ – 0.5, $MgSO_4 \times 7H_2O$ – 0.1, glycerin – 3 ml; pH 7.4. The growth medium *N.pallidum* included (g/l): yeast extract – 10, casamino acid – 7.5, Na Citrate – 3, KCl – 2, NaCl – 250, $MgSO_4 \times 7H_2O$ – 20, $FeCl_2 \times 4H_2O$ – 0.036, $MnCl_2 \times 4H_2O$– 0.36 mg; pH 7.4. As inoculum it was used cell cultures grown to stationary phase of growth in optimal conditions, respectively, at 20°C and 37°C in the same medium in flasks on a shaker. The intensity of crop growth was assessed by optical density slurries using a calorimeter KFK–2MP at 590 nm or 555 nm when FEKM. Cells were exposed for 15 min to ultrasound (US) intensity I_{SATA} of 0.2 W/cm^2 and 0.4 W/cm^2 with modulation frequency range of 0.1 – 10 Hz and 100 – 1000 Hz using the US therapeutic apparatus UST–5. The carrier frequency was 880 kHz; modulating generators G3–112 and CP–110 provides the ability to create a modularize signal in a wide range of frequencies (0.001 Hz–1999 kHz).

It was found that a treatment with a modulation frequency of 10 Hz significantly stimulated the protein intake, growth and proliferation of *A. fischeri* cells and intensity of bacterial luminescence. Cells were well-preserved and under the higher modulation frequency of 100 Hz. 1000 Hz-modulation led first to a sharp increase in the emission, and then resulted in the destruction and death of the microorganism's cell wall.

Cells of the archaea *N. pallidum* culture were more sensitive. The frequency range of 0.1 – 0.2 Hz changed the nature of growth, suppressing it slightly, slowing down the process of protein intake. The range of 0.25 – 0.5 Hz led to an exponential growth of the culture. The increase to 0.7 Hz suppressed the growth of cells, again. However, the 10 Hz–modulation stimulated the growth of archaea just in the same manner as in the case of*A. fischeri* culture. The modulation frequency of 100 Hz inhibited the growth of archaea cells significantly. Based on the experimental data it was identified a similar and at the same time marked difference response of archaea and bacteria on the impact of such environmental factor as the modulated US. It may be due to their differences in the molecular level of the cell wall structure, and also of the protein fusion components and biochemistry. From our point of view, the intensification of the growth of organisms was caused by the increased permeability of the membrane after US exposure, which leads to activation of cellular respiration and substrate consumption.

BIOLOGICAL ACTIONS OF IONIZING RADIATION COMBINED WITH ANOTHER FACTOR: NUMERICAL APPROACH

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In the earth, every single biological object lives under the combined influence of ionizing radiation and another environmental factor. In many cases, the simultaneous or sequential actions of multi-factors results in synergism. The present study focused on the general rules of the combined action of two factors. Synergism might be an output from an additional lethal or potentially lethal damage due to the interaction of the two different types of sub-lesions induced by each factor. Such sub-lesions could be regarded as ineffective when each agent acted separately. The additional damage responsible for the synergism might be irreversible. Based on the regularities found, a simple theoretical model was formulated. Our experimental results as well as data published by other researchers were used for model validation. Predictions by the model were in fairly good agreement with available experimental data. And application tests of the model to the combined action of radiation with high temperature, ultrasound, chemical, etc. The synergistic interaction of radiation in a constant dose rate with heat could be shown only within a certain temperature range, in all the target organisms analyzed. Decrease in exposure temperature was required to sustain an optimal ratio of heat-induced damage to radiation-induced damage with any decrease in the dose rate, and vice versa. From the radiological protection point of view, prolonged interaction of ionizing radiation with an environmental factor like heat is of practical importance as it is possible for harmful factors of low intensities to interact synergistically with each other.

THEORETICAL STUDY OF THREONINE MOLECULE FRAGMENTATION BY LOW ENERGY ELECTRONS

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Ionizing radiation can be divided into direct and indirect ionization. Direct ionizing radiation (most of the particulate types, except uncharged particles- neutrons) can directly disrupt the atomic structure of the absorbing medium through which it passes and produces chemical and biological damage of organic molecules. Whereas, electromagnetic radiation, X and gamma rays, and neutrons are indirect ionization. Indirect ionizing radiation gives energy to organic molecules in two-step process: 1) first, it produces secondary (low energy) electrons, 2) second, these secondary electrons can interact with variety biomolecules, including amino acids- the building blocks of proteins. Low energy electrons can induce amino acids fragmentation [1].

Threonine plays an important role in protein synthesis. This amino acid is precursor of the other amino acid- glycine. Moreover, threonine is necessary to synthesize the mucin protein that is required for maintaining intestinal integrity and function [2]. The goal of our studies was to elucidate the major channels of the threonine molecule fragmentation caused by low energy electrons impact.

The structure of one of the most stable conformer of threonine ($C_4H_9NO_3$) was studied using density functional theory (DFT) B3LYP method and cc-pVTZ basis set. We used Gaussian 03 Rev D.0 1 program. The peaks with m=57 a.m.u., m=75 a.m.u., m=74 a.m.u. and m=45 a.m.u. are the most noticeable in the threonine fragments mass-spectrum, which is published in NIST database [3].

According to our calculation, the production of the m=57 a.m.u., m=75 a.m.u., m=74 a.m.u. and m=45 a.m.u. fragments is the most energetically favorable. Hence, theoretical results coincident with experimental data. We determined that fragment with mass 74 a.m.u. is $C_3H_8NO^{+/0/-}$, 57 a.m.u.- $C_2H_3NO^{+/0/-}$, 75 a.m.u.- $C_3H_9NO^{+/0/-}$ and fragment with mass 45 a.m.u. is $CO_2H^{+/0/-}$.

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BIOTECHNOLOGY 08

REFRACTIVE PROPERTIES OF BIO- AND NANO-STRUCTURED MATERIALS AS INDICATORS OF THE MODEL MATRIX MACRO PARAMETER MODIFICATION

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In the current paper, a unique role of the photorefractive features of the bio- and nano-doped systems has been considered as the indicator of the dynamic and of the conductive characteristics change. The paper presents some innovative views about the tendency to concurrent role of the bio-objects sensitization of the organic matrixes in comparison with the nano-objects doping one. The results have been supported both by the experimental four-wave mixing technique data as well as by the qualitative model.

LOW-INTENSITY LASER RADIATION IN BIOTECHNOLOGY CULTIVATION OF CULINARY-MEDICINAL MUSHROOMS

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Purpose. The object of this work is the development of scientific bases for using low-intensity laser light to enhance the process of biotechnological cultivation of medicinal and edible macromycetes.

Materials and methods. The study involved pure strains of *Agaricus bisporus, Flammulina velutipes, Ganoderma applanatum, Ganoderma lucidum, Hericium erinaceus, Lentinus edodes*, and *Pleurotus ostreatus*. The helium-neon laser LGN- 215 type with a wavelength of 632.8 nm and argon ion laser with wavelengths of 488.0 nm were used as the sources of coherent visible light. The laser beam has been expanded by the optical system and matched with the size of mycelium spreading. The exposure dose was controlled by irradiation time at known measured laser output power and was defined as the product of power density and time of irradiation. The exposure time was determined from the condition the same amount of the incident energy on the surface irradiated with various types of lasers: for more powerful argon laser with power density on the surface of substrate in the Petri dish, e.g. 3 mW/cm^2 , the defined exposure time is shorter $(230 mJ/cm^2)/3(mW/cm^2) \approx 77$ s and for He-Ne laser with lower power density on the sample surface, e.g. 0,15 mW/cm^2, the exposure time is more long $\approx$1530 s.

Results. A new concept of using low-intensity artificial light in biotechnology of cultivation of edible and medicinal mushrooms has been developed. It has been found for the first time that short-term low-intensity irradiation in the visible part of the spectrum has stimulated growth and biosynthetic activity of macromycetes. Such stimulation has a prolonged effect and it is capable of being transferred to the further ontogenetic stage from the spores to the mycelium. The original and highly environmentally-friendly methods of purposefully regulating biosynthetic activity of macromycetes and intensifying the stages of their growing using low-intensity light of different coherence and spectral composition were suggested. It allowed the induction of spore germination, shortening of the cultivation time, reduction of the amount of seed to inoculate substrates, increasement of the biomass yield and bioactive components in submerged cultivation as well as the yield of fruit bodies and their quality in solid cultivation.

Conclusions. We have obtained new, science-based theoretical and experimental research results of macromycetes photosensitivity to low-intensity light, which together complement and extend our understanding of the fundamental processes of photoreception macromycetes.

PROSPECTS FOR USING LOW-INTENSITY IONIZING AND LASER RADIATION TO ENHANCE THE MELANIN BIOSYNTHESIS WITH FUNGI

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In this study, the prospects for using low-intensity laser (0,15 - 3.00 mW/cm^2) and ionizing radiation in biotechnology submerged cultivation of macromycete (Inonotus *obliquus*) and micromycetes (*Cladosporium*. *cladosporioides* and *Aspergillus versicolor*) to increase the synthesis of melanin were demonstrated. The exposure in the exponential (dose of 85 mGy) and stationary (170 mGy) growth phases strains of *C. cladosporioides* and *A. versicolor* increased the synthesis of melanin pigments by 40%. The short-term exposure of I.*obliquus* sowing mycelium in red and blue ranges of wavelengths of laser light (230 mJ / cm^2) increased the synthesis of melanin by 250% and reduced the duration of the cultivation for 4 days. The use of pulsed laser radiation with a wavelength of 632.8 nm and 488 nm provided additional stimulatory effect compared to continuous irradiation at the same wavelengths, which was expressed in increasing the yield of melanin by 67% and 26% respectively.

MICROBIOLOGICAL COMPOSITION OF DEHYDRATED AGRICULTURAL PRODUCTS FROM THE REPUBLIC OF MACEDONIA

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Microorganisms represent a population which causes various reactions, from which the survival of the world depends and by which we are surrounded. Therefore, in the course of the long history, a need arises for them to be studied by individuals and, later, from a scientific aspect.

Despite the considerably useful role they have, many microorganisms cause various harmful processes with their actions and, in many occasions, fatal consequences. These are pathogenic microorganisms whose toxins cause life-threatening diseases that endanger human and animal lives.

In this paper, dehydrated agricultural products will be examined: carrots, peppers, onions and leeks. In these products, the total number of bacteria, ammonification bacteria, coliform bacteria, yeasts and moulds will be determined. Studies of represented microorganisms in dehydrated agricultural products will be done 15 days after the arrival of the products and 30 days after the arrival.

The results will be presented in the tabular and graphical form for the factory "A" and factory "B". In the end, the results from the factory "A" and factory "B" will be compared.

Key words: Microorganisms, agricultural products, dehydration, factory

THE ROLE OF MICROORGANISMS IN THE PRESERVATION OF SOME GARDENING PRODUCTS

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Fruit and vegetables today and in the past have been used throughout the year. That is normal because of their preservation which allows their consumption in winter. Through the process of canning fruits and vegetables, after the harvest or after their processing is completed, the aim of technological microbiology is to enable a continued durability of the product and to preserve its stability in microbiological and in chemical terms. The products (canned ajvar, lutenica, beets), which are produced according to the standards and regulations stipulated in the Rules for Quality Products, Paper Fruits and Vegetables, are taken and used by various processing factories in Macedonia. Through this research, we also get the information whether the improper storage of these food products in big sales markets results the changes in the microbiological compassion of the tested products and whether these changes make the products unusable for the consumers.

Key words: Microorganisms, canned *ajvar*, *lutenica*, beets

INVESTIGATIONS ON DISPERMIC ANDROGENESIS IN STURGEON FISHES WITH THE USE OF CRYOPRESERVED SPERM: EXPERIMENT ON STERLET AND BELUGA STURGEONS

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Our investigations are devoted to receiving dispermic androgenesis in sturgeon fishes with the use of cryopreserved sperm. This approach is considered as the most promising way to recover endangered species and populations of sturgeons.

The first success in these investigations was achieved on Stellate sturgeon (Grunina et al., 2006). Further with the use of cryopreserved sperm androgenetic progenies of the Siberian sturgeon and androgenetic hybrids between Siberian and Russian sturgeons were obtained (Grunina et. al., 2011). This work studies the possibility of using this approach on Sterlet and Beluga sturgeons. In the experiment it was used eggs of Sterlet sturgeon and criopreserved (freshly frozen) and native sperm of Sterlet and Beluga sturgeons. For genetic inactivation, eggs were X-irradiated at 220 Gy. Sperm was frozen as described earlier (Grunina et al., 2006) using methanol as a cryoprotectant. When freezing the sperm in the cryopreservation medium added antifreeze glycoproteins in an amount of 5% (vol.). For androgenesis induction, irradiated eggs were fertilized with native or thawed sperm. Heat shock (35^{o}C, 2 min) was applied within 1.4-1.6 t_0 (about t_0 see Dettlaff et al., 1993, p. 95) after insemination to promote fusion of male pronuclei.

The use of the procedures of freezing of sperm and heat shock improved in comparison with the previous experiments allowed to receive rather high fertilization rate of irradiated eggs and the survival of embryos after heat shock. The survival of androgenetic embryos obtained from native and cryopreserved sperm was similar. This indicates that the processes of freezing - thawing doesn't damage significantly the DNA of sperm. Earlier, in experiments on other low-chromosomal sturgeon species, Stellate sturgeon, the survival of the androgenetic offspring received with use of cryopreserved sperm was significantly lower, in comparison with the offspring received with use of native sperm (Grunina et. al., 2006).

The survival of androgenetic embryos sterlet x beluga at stage 30 (see Dettlaff et. al., 1993) was much lower than that of androgenetic embryos sterlet x sterlet. Obviously, this caused by nucleocytoplasmic incompatibility in a hybrid pair of sterlet - beluga. We have observed similar result before (Grunina et al., 2006). On late stages of embryogenesis the incompatibility was less expressed.

This research indicates the possibility of obtaining androgenetic progeny from cryopreserved sperm of low-chromosomal sturgeons species – sterlet and beluga, including nucleocytoplasmic androgenetic hybrids.

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THE INFLUENCE OF FOLIAR FERTILIZING ON SOME CHEMICAL PARAMETERS OF THE BROCCOLI (BRASSICA OLERACEA L. VAR. BOTRYTIS)

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The basic goal of this research is to determine the influence of foliar fertilization on the content of dry and mineral matter, vitamin C and total organic acids in broccoli. The experiment was set according to the random block-system, on fluvisol soil with a high concentration of available forms of nitrogen, phosphorus and potassium. It was performed during the vegetation period of 2014, on the territory of the village of Negorci, near Gevegelija, with five variants and three repetitions in fifteen rows. Each variant involved 180 plants in total. The experiment involved the following variants: 1. Control (Non-fertilized); 2. Bioflor; 3. Ingrasamant foliar, 4. Humustim and 5. Rhizoactive. During the vegetation period, a total of four treatments were performed by foliar feeding with 0.4% solution of the above-given fertilizers. Following the broccoli harvest, the average samples were taken for chemical analysis and, from the results of the analysis carried out, it was concluded that the foliar fertilizing and the high concentration of available forms of nitrogen, phosphorus and potassium have positive effects on the chemical composition of broccoli in all variants. The highest of the dry matter (14,31 %), mineral matter (1,40%), vitamin C (50,02 mg%) and total organic acids (0,48 %) content was achieved in the variant no. 5 Rhizoactive.

Key words: Dry matter, mineral matter, vitamin C, organic acids, foliar fertilizing, fluvisol soil

A LIPID MICROENVIRONMENT IMPACT ON LIPOSOMES WITH INCORPORATED PIGMENTS

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The investigation of a possible impact of the liposomes lipids microenvironment, dictated by a chemical composition of the fatty acid branches, on the incorporation and spectral behaviour of chlorophyll a and its derivative, chlorophyllide a, inside liposomes, is the aim of this work. The obtained liposomes were small unilamellar liposomes, made of saturated dimirystoil phosphatidylcholine (DMPC) and phosphatidylcholine (PC) lipid mixture that contained significant fractions of unsaturated fatty acid moieties. The employed techniques were absorption and fluorescence polarization spectroscopy. The obtained data for the two incorporated pigments, that play a role of molecular sensors, were compared. In addition, quercetin, a well-known antioxidant, was employed as the chlorophylls emission quencher, in order to estimate the type of environment sensed by the two pigments for the two liposomes that differ in chemical composition. The results, based primarily on fluorescence polarization data have shown that the emissions as well as the emission quenching were notably affected by a change in the lipids' chemical composition. That is an indirect proof of the impact of the liposomes microenvironment on the incorporated pigments' spectral behaviour.

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ESTIMATION OF YEAST FLOCCULATION UNDER ULTRAHIGH FREQUENCY ELECTROMAGNETIC RADIATION

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Yeast flocculation is the process of cell aggregation into multicellular structures. The ability of yeast to form flocs is widely used in different industries and biotechnological technologies: in winemaking, brewing and the production of other alcoholic beverages, in biofuel production and in various environmental applications. Ultrahigh frequency electromagnetic radiation (UHF EMR) can affect metabolic activity of organisms and alter morphological, physiological, biochemical and genetic features. The observed effects depend on frequency, power density and exposure duration.

In the present study, yeast flocculation peculiarities and *flo1* gene expression encoding lectin-like protein involved in flocculation under UHF EMR were evaluated. *Saccharomyces cerevisiae* cells were irradiated for 15 min to UHF EMR at the wavelength of 12,5 cm (2,45 GHz) and the power of 15 W. The flocculation ability of *S. cerevisiae* was scored in standard conditions, using a microflocculation technique. Gene expression was analyzed by qRT-PCR using SYBR Green I dye.

The results of yeast flocculation ability analysis showed a very slight increase of flocculent cells (up to 7%) after UHF EMR treatment for 15 min. On the contrary, gene expression analysis revealed a rise of *flo*1 mRNA abundance of more than 20 times in irradiated yeast cells compared to the control (non-irradiated) ones that may suppose the enlargement of flocculent cells value. Since the expected increase was not observed, it was speculated that other genes responsible for flocculation should be analyzed. The results obtained in our study suggest that UHF EMR can be used for increasing yeast flocculation ability although additional research is required.

IMMOBILIZATION OF HORSERADISH PEROXIDASE ON HYDROPHOBIC CARRIERS

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The immobilization of enzymes is a process of inclusion of the enzyme molecules isolated in a particular phase, which is separated from the free solution, but is able to react with the molecules of substrates, effectors, or inhibitors that are present in it. In this paper, the process of immobilization of horseradish peroxidase on 12 different hydrophobic carriers was investigated. Benzoyl-cellulose, cinnamoyl cellulose, phenoxyacetyl cellulose, cellulose ester and *g*-phenyl-butyric acid, as well as an ester of cellulose and thymol of acetic acid among the synthesized carriers were present. Based on the obtained results from the investigations of the influence of the synthesized carriers on peroxidase activity, it can be concluded that all carriers showed the inactivation effect on peroxidase activity. Benzoyl-cellulose carriers showed the lowest influence on peroxidase activity, whereby the residual peroxidase activity was about 95%. On the other hand, carriers based on cellulose ester and *g*-phenyl butyric acid ester cellulose, as well as acetic acid and thymol, showed the highest inactivation effect on peroxidase activity and the residual peroxidase activity was less than 10%. After peroxidase immobilization at 25 °C, based on the results of the immobilized activity of peroxidase, it can be concluded that the benzoyl cellulose carriers were the best. The results show a good agreement with the results obtained during the investigation of the influence of different carriers on horseradish peroxidase activity, because the benzoyl cellulose carriers showed the slightest inhibition (and / or denaturacioni) effect on peroxidase activity.

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IZATISON AND ITS CONSTITUENTS MAY INDUCE THE CHANGES OF SOME ADAPTIVE FUNCTIONS OF PLANTS PERSISTING IN THE NEXT GENERATIONS AFTER THE TREATMENT

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The search of the modern preparations to procure the high level of plants productivity in the changed climate and anthropogenic impact on the environment is the principal problem of today, and such preparations may be Izatison, designed in our laboratory (**Iz;** N-methylisatin β-thiosemicarbazone in the solvents composition – DMSO and PEG 400), and the nanosilver SS1000 preparation (**S**), elaborated in Institute for Superhard materials V.M. Bakul NAS of Ukraine and was kindly given to us.

The oat seeds were treated by the water suspensions of the preparations and the solvents DMSO (**D**) and PEG 400 (**P**). The plants were grown in field; the grain productivity (the primary panicle length, **L**; the grains number in the primary panicle, **G**; the grains weight from the primary panicle, **W**; the weight of 1000 grains, **W1000**) was analyzed after gather in the harvest over 3 generations after treatment. Chlorophylls *a* and *b* and carotenoids content determined at the onset of panicles formation over 2 generations after treatment.

The positive effect of Iz and S on the panicles growth and development was observed for the plants obtained from the treated seeds: W increased, when Iz and S were used, caused by the increase of G, and the most stimulating effect was revealed for Iz (on 32,3%, $P<0{,}001$). In the second generation the increment of G was found for P, persisted in the variants Iz and S; W – in the variants Iz and P+S, and it is found the increase of W1000 in the majority variants of experiment. The positive changes of oat productivity were persisting in the third generation also, and the most stable maintenance of L, G and W increase over 3 generations was observed in generations of the plants, those have been treated by Iz. It is found the increase of *chl a/b* ratio conditioned by Iz, S+D+P and S+D in 1 generation. In 2 generation the negative influence of D, P and D+P on *chl a* and *b* content was revealed; the increase of *chl a* portion depended on D+P, S+P, S+D+P; the increase of *chl b* portion – on Iz and P.

It is likely, that the character of the changes, observed in the several next generations after treatment of the oat seeds by Izatison, its constituents and by nanosilver, may be conditioned by the complexes of the signaling molecules to be the components of the studied preparations, the inducers of the broad spectrum of adaptation signaling pathways and possible interplays between them.

Key words: Izatison, nanosilver, grain productivity, adaptability, chlorophyll *a,* chlorophyll *b,* carotenoids, chlorophyll *a/b* ratio

CANCER RESEARCH 09

THE IMPACT OF PREDICTORS ON DISEASE-FREE SURVIVAL IN PATIENTS WITH SUPRATENTORIAL INFILTRATIVE LOW GRADE GLIOMAS (GRADE II)

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Objectives. Analysis of the most significant predictors on disease-free survival in patients with low grade cerebral gliomas (LGG).

Materials and methods. 42 patients with LGG. Morphologically proven diagnosis in 38 patients (90.5%), roentgenological diagnosis -4 (9,5%). Grade1 -2 (4.8%), grade2 -36 (85.7%). Astrocytoma -25 (59.5%), oligoastrocytoma -8 (19.1%), oligodendroglioma -5 (11.9%). Supratentorial tumor – 34 (81%), subtentorial -8 (19%). Women -22 (52.4%), men -20 (47.6%). Mean age 37.86 +/-13.06. Mean Karnofsky Performance Status(KPS) -79,5% +/-9,094. Total or subtotal resection -29 (69%), STB -9 (21.5%). Chemoradiotherapy -30 (71.4 %), radiotherapy -25 (59.5%), chemotherapy -17 (40.5%).

Results. We analyzed the cumulative disease-free survival using the Kaplan-Meier analysis. Significant differences in disease-free survival according to Karnofsky Performance Status (KPS) were received (p = 0.554). 20.0% of the patients with acute cerebral circulatory disorder disease manifestation and 29.7% of the patients in whom the disease manifested with the gradual development of neurological symptoms lived for more than 3 years without progression (p = 0.015). 10% of the patients with supratentorial localization and tumor crossing midline and 62.5% of the patients with supratentorial localization without midline crossing lived for more than 3 years progression free (p = 0.002).

Conclusion. We are looking forward to evaluate other predictors on disease-free survival, quality of life and treatment effectiveness, thus improving the existing standards of LGG treatment.

Key words: Low-grade gliomas (LGG) (Grade II), predictors on disease-free survival

THE ANTITUMOR EFFICIENCY OF REPEATED ELECTROCHEMOTHERAPY WITH CISPLATIN ON A BREAST CANCER TUMOR MODEL IN MICE

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The purpose of this study was to investigate the efficiency of Electrochemotherapy (ECT) and repeated Electrochemotherapy (ECT) with cisplatin. The tumor treatment was evaluated on large invasive ductal carcinoma tumors (IDC) in mice. The spontaneous mouse mammary tumor, i.e., an invasive ductal carcinoma, was transplanted by implanting a 4 mm^3 into the flank of anesthetized mice. Tumors of an average volume of 630 mm^3 were treated with cisplatin, electric pulses, as well as in combination, ECT and repeated ECT. Two trains of 4 pulses of 1000 V/cm and 100 µs and repetition frequency of 1 Hz were applied. The therapeutic effectiveness was evaluated by the tumor growth delay, tumor-doubling time and inhibition ratio. ECT was more effective than the individual treatments with cisplatin or the electric pulses alone. When ECT was repeated on the 15th day after the 1st treatment, it was more effective. At repeated ECT, inhibition ratio was 79% and 2 animals out of 8 were in complete response. The repeated ECT was more effective than ECT. The results of our study show that ECT increases the therapeutic effectiveness of cisplatin on invasive ductal carcinoma tumors. The repeated ECT is a useful treatment for treating large tumors.

DEVELOPMENT OF APPROACHES FOR THE PRIMARY PREVENTION OF RADIOGENIC CANCER

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Due to the existing environmental situation in the post-Chernobyl period, the probabilistic development of carcinogenic effects of low dose ionizing irradiation and oncogenic hazard of increased level of chromosome changes in cell population. Thus, the goal was to develop a strategy for the primary prevention of radiogenic cancer based on cytogenetic studies. The first key stage of the strategy of primary prevention of radiogenic cancer is the estimation of human individual radiosensitivity. The second key stage is calculation of the influence of co-mutagens. The third key stage is the use of non-toxic effective radioprotectors. We have shown that co-mutagens potentiate the damaging effect of low doses of IR at a high concentration. From here, for the people who are diagnosed with increased individual radiosensitivity and who are working in the scope of the ionizing irradiation, it is necessary to monitor the prescription of medicines with co-mutagenic activity.

It is advisable to carry out the developed preventive measures in the selection of cadres who work in the field of ionizing radiation, including nuclear workers, medical staff (radiation oncologists, radiologists), as well as among the priority groups of people living in areas contaminated with radionuclides.

MISSENSE MUTATIONS IN MTDNA IN BREAST CANCER

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The interest in the mitochondrial involvement in carcinogenesis dates back to the 20s – 30s of the twentieth century. In the recent years, more and more research points to their role in both somatic mutations and polymorphisms resulting in mtDNA. It is probable that mutations in the, i.e. conserved regions in the replication promoters of transcription or the transcription factor binding sites may adversely affect the amount of mitochondrial transcript. This study tries to analyze mutations and polymorphisms in selected genes of mtDNA (*mt- RNA, ND1, ND2, ND3, ND6, RNR1, COI, COII, COIII, CYT B, ATP 6 and 8*) and assess the impact of missense mutations on the biochemical properties, structure and function of proteins. During the study were identified 26 missens mutations. In the COI were found a stop codon mutation that causes a shift of the reading frames, and the formation of a protein structurally different from the cytochrome oxidase subunit. In eight cases of the missense mutations the P_{ds} ($P_{deleterious}$ -Probability of Functional Impairment) value was above 0.5, which shows the effect of these mutations on protein function. The mutations detected in mt- tRNA and rRNA concern the items in which there are Watson- Crick bonds and which may affect the secondary structure both of mt- tRNA and 12s-rRNA. In the studied subunits were detected mutations occurring in patients with mitochondrial diseases as well as those with type II diabetes.Mutations in the genes for mitochondrial proteins cause a wide range of symptoms. Many factors may influence the clinical manifestation of changes in mt- DNA.

IMPLICATION OF AKT KINASE SIGNALING IN INTEGRIN ALPHA-2/BETA-1 DEPENDENT ANOIKIS RESISTANCE IN HUMAN MELANOMA CELLS

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SKMel-147 human melanoma line was used as a model for exploring the integrin-dependent signal pathways underlying the protection of tumor cells from anchorage-dependent apoptosis, anoikis. Silencing of alpha-2/beta-1 integrin expression significantly promoted anoikis of melanoma cells which was accompanied by an up-regulation of the active forms of kinases Akt and mTOR. We have previously shown that depletion of alpa-2/beta-1 in MCF-7 human breast carcinoma cells also stimulated their anoikis, but, unlike SKMel-147, the activity of Akt was not changed upon the alpha-2/beta-1 down-regulation, whereas the activity of Erk1/2 was dramatically increased. Pharmacological inhibition of Erk1/2 in MCF-7 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. In contrast, in SKMel-147 cells, inhibition of Erk1/2 had a negligible effect on anoikis of either control or alpha-2/beta-1-depleted cells while inhibition of the Akt in the integrin-depleted cells reduced their anoikis to the levels of controls. The data demonstrate the high variability and cell type dependence of signal pathways using by integrins in controlling tumor cells resistance to anoikis.

IMPLICATION OF ALPHA-2/BETA-1 AND ALPHA-5/BETA-1 INTEGRINS IN DRUG RESISTANCE OF HUMAN BREAST CARCINOMA CELLS

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Integrin expression and tumor cell resistance to antitumor drugs were investigated in two human breast carcinoma lines highly differing in metastatic and invasive activities. In MCF-7 line with low invasive activity, the predominant integrin is alpha-2/beta-1 expression of which was detected in 90% of cells. The line MDA-MB-231 with high invasive ability did not differ from MCF-7 cells by the expression of alpha-2/beta-1, but, unlike of them, this line is active in expression of alpha-3/beta-1, alpha-5/beta-1 and alpha-v/beta-1. Analysis of cell viability in a medium containing doxorubicin showed that both lines are highly sensitive to the drug. But resistance of MDA-MB-231 cells is about 4 times higher than that of MCF-7 cells. Blocking the expression of integrin alpha-2/beta-1 resulted in a slight increase in the resistance of both cell lines to doxorubicin. Overexpression of integrin alpha5/beta-1 in MCF-7 cells resulted in a substantial enhancement of their resistance to doxorubicin

MINIMAL RESIDUAL DISEASE CAN PREDICT RESPONSE TO TREATMENT OF LYMPHOPROLIFERATIVE DISORDERS

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At present the level of minimal residual disease (MRD) is considered as independent predictor of response to treatment and efficiency of therapy for B-cell CLL. The purpose of the study is to evaluate the potential of the technology for minimal residual disease quantification for prediction of response to treatment of B-cell CLL and non-Hodgkin lymphomas with defeat bone marrow and/or blood. Immunophenotype of tumor cells and quantity of the clonal tumor cells in the bone marrow and peripheral blood in CLL and NHL were identified. Monitoring of MRD level was carried out at various stages of therapy. Eight patients with lymphoproliferative diseases, B-cell CLL, diffuse large B-cell lymphoma, mature cells lymphoma, lymphoma of the spleen, mantle cell lymphoma, were taken in the study. Proliferating clones was detected by 6-color flow cytometry using the cytometer FACS Canto II, BD. The following markers CD45, CD23, CD38, CD43, SD79b, coexpression of CD5 + CD19 + and CD5 + CD20 +, the prevalence of expression of the light chains of the membrane surface immunoglobulin Kappa and Lambda types were used. MRD level was evaluated in accordance with recommendations of the international standardized approach [Rawstron et al. 2007]. MRD was identified with the following markers: CD81+, CD43+, CD5+, CD19+, CD38+, CD20+, CD45+, Kappa+, Lambda+. The MRD level of 0.01% is considered as the limit level of MRD detection. The number of aberrant lymphocytes per 1 000 000 cells was calculated. Bone marrow aspirate and samples of peripheral blood were analyzed at various stages of (immuno) chemoradiation therapy: after 6 cycles of R-CHOP, in 3 and 6 months after chemoradiotherapy. 25 blood and bone marrow samples including 8 – clones taken before therapy and 17 samples of MRD of quantified level in bone marrow (10) and peripheral blood (7) were analyzed.

Initial volume of proliferation of aberrant mature B cells in the bone marrow and peripheral blood was 64%, the range of variation was from 33 to 92%.

Though the count of aberrant lymphocytes in the bone marrow and peripheral blood dropped drastically by about 800 times after the treatment, MRD was found almost in all patients upon completion of the treatment. The average level was 0.08% in the blood and 0.34% in the bone marrow. Tumor cells clone was not detected in the blood, but it was preserving in the bone marrow of one patient with lymphoma of the spleen after 6 cycles of R-CHOP. These results are consistent with published data indicating that to stop the clonal proliferation in the bone marrow is more difficult that in the blood. It should be stressed that the MRD level continued to decrease, in 6 months after the treatment completion it was lower than in 3 months.

According to published data the complete eradication of the disease and immunophenotypic remission of CLL can be achieved in the absence of MRD, it means that the level of aberrant lymphocytes must not exceed 0.01%. Clinical remission was considered to be less stable and runs the risk of recurrence if the number of detected aberrant cells is higher. Thus, the results demonstrate the perceptiveness of MRD application for predicting response to drug and radiation therapy of CLL /NHL.

SYSTEMIC EFFECT OF PHOTODYNAMIC THERAPY FOR CANCER ON CYTOKINE LEVEL

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Photodynamic therapy, PDT, is a promising cancer treatment. Photosensitizer accumulated mostly in the tumor tissue after injection to patients' body. Exposure of tumor to laser light with wavelength corresponding to the absorption peak produces photochemical reaction in the tissue and death of tumor cells and tissues. Cytokines represent the most important and universal system of humoral factors (regulatory peptides), carrying out cell-cell communication. They participate in functioning innate and adaptive immunity.

The effect of PDT on the production of cytokines was studied in treatment of 39 patients with tumors of the skin and melanoma. Cytokines (IL-6, IL-10, IFN-a, IFN-g, TNF-a) level in the serum was measured before PDT, and in 1, 3, 7 days after the treatment, before application of other treatment modalities. The analysis was performed with ELISA reagents of company "Vector-Best".

Initial level of IL-6 was low in the group of cancer patients, and the level of IFN-a exceeded the norm, the levels of TNF-a and IL-10 in cancer patients were higher as compared with the control group. Certain regularity in elevation of cytokines level was found. Cells producing IFN-g were more sensitive to PDT, for the whole period of follow up its level increased by 2.5-3 times, the highest increase was observed on the 3rd and 7th days. Production of IFN-g and IL-10 increased on average by 2-2.5 times, it increased linearly from the 1st through the 7th day. Less pronounced dynamics of the increase was observed for TNF-a and IL-6. It is known that metabolic activity of IFN-g is extremely diverse. It inhibits the tumor growth through activation of cytotoxic activity of NK cells, monocytes and macrophages, cytotoxic T cells. Perhaps, the IFN-g level in the serum of cancer patients can be used as favorable prognostic criteria for PDT application. Increase in the level of such cytokines as IL-6 and TNF-a is in line with published data on mechanisms of PDT action. The important factor in the induction of PDT-mediated immune response has been shown to be damage of cell membranes and blood vessels, the development of an acute inflammatory response and rapid infiltration of leukocytes, bearing receptors of neutrophils tumor growth areas. These processes are accompanied by intensive production of proinflammatory cytokines. Though immune response may be less important than other PDT effects in early stages of the process, it is important for long term control of tumor growth. The presence of an immunological component of PDT allows us to speak not only about the prospects of a combination of PDT and immunotherapy for improving results of cancer treatment, but also about the possibility to use PDT for correcting immunological reactions.

ENVIRONMENTAL CHEMISTRY

10

IS BROMINE A TOXIC TRACE ELEMENT OR IS IT AN ESSENTIAL NUTRIENT?

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Bromine (Br) is one of the most abundant and widespread of the recognized trace elements in the biosphere. It can be found in many organic and inorganic substances. Humans started the introduction of organic compounds of Br into the environment many years ago. These compounds are not natural and can cause serious consequences to human health and the environment. The Br atom was a definitive constituent of a number of industrial chemicals that were produced in large quantities and performed useful functions in society until unexpected environmental impacts emerged and international actions were taken to control their effects. During the last decades, different compounds of Br have been introduced increasingly into the environment.

The metabolism of Br in higher plants remains poorly investigated. This contrasts with a lot of information on accumulation of other halogens such as iodine and chlorine in the plants gathered by now. The importance of Br in the biogeochemical cycles and its biological significance is still not clearly understood. There are also questions on its quantitative requirements for different plant species. Until present time, however, a few studies dealing with these problems have been conducted, and even the concentrations of Br in terrestrial plants have been poorly documented. Now, our knowledge of biological functions of this trace element is still limited. Probably, one of the reasons is an insufficient level of quality of the analytical techniques presently used for the determination of Br in the biological materials, perhaps, except only for the neutron activation analysis. This analytical technique gives an excellent possibility to determine Br in various environmental samples with high sensitivity and accuracy without any pretreatment of samples, thus reducing the possibility of analytical errors at the stage of elemental analysis.

This work is addressed to a deeper understanding of Br pathways in plants and evaluation of the factors important for Br plant accumulation up to high levels. The main objectives of the research are (1) to compare the uptake of Br by several plant species which can differ in the ability to accumulate Br, (2) to assess the variations both in the uptake of Br by the plants and impact of different Br compounds on the plant nutrition and biomasses of the plants, (3) to study the dependence of plant Br accumulation on the concentration of Br in the growth medium, (4) to estimate the relations between Br and other halogens, e.g. Cl and I in the plants and soil, and (5) to detect the effects of Br on the concentration of essential plant nutrients.

THE INVESTIGATION OF THE INFLUENCE OF MN-BI-CU-CE-O CATALYSTS ON THE ENVIRONMENT-FRIENDLY GREEN PROCESS OF LOW-TEMPERATURE AMMONIA OXIDATION TO NITROUS OXIDE

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There is an increasing commercial interest in finding alternative ways to produce phenol that overcome the disadvantages of the current cumene process used to synthesize phenol. The drivers for the change are both economic and environmental. A direct oxidation route for producing phenol from benzene is based on using N_2O as an oxidizing agent in the gas phase in the presence of modified Fe-ZSM5 zeolite. Thus, direct phenol synthesis from benzene in a one-step reaction with high benzene conversion and high phenol selectivity is the most desirable from the viewpoints of environment-friendly green process and economical efficiency. Selective catalytic oxidation of ammonia (NH_3) with air at low temperatures is an efficient method to produce N_2O as an oxidizing agent for organic synthesis. This process has two important parameters: the selectivity and the application temperature. To rationally develop a process for NH_3 oxidation to N_2O over catalysts, the reaction mechanism must be clarified. While several studies have examined the low temperature oxidation process, the mechanism of NH_3 oxidation and N_2O formation is still uncertain. Generally, we use an imide (NH) mechanism in which the first step yields NH, and then the NH reacts with atomic oxygen (O) to form nitroxyl (HNO) and further conversion to N_2 or nitrous oxide (N_2O), or NH could even react with molecular O_2 to produce nitric oxide (NO).

In the present paper, the influence of catalyst composition and some operating variables were evaluated by the IR-spectroscopy in terms of N_2O formation, by using Mn/Bi/Cu/Ce-oxide catalysts. The IR spectra of ammonia adsorbed on the catalysts show the bands at 1594 and 1165 cm^{-1}, which attributed to $sigma_{as}$ and $sigma_s$ model of NH_3 coordinated to Lewis acid sites. Another two bands at 1674 and 1445 cm^{-1} are attributed to $sigma_s$ NH_4^+ and$sigma_{as}$ NH_4^+ resulting from ammonia coordinated to Brønsted acid sites. It is indicated by the increase in intensity of band at 1165 cm^{-1} that more Lewis acid sites are generated on Mn/Bi/Cu/Ce-oxide by the introduction of Ce^{x+} which can also serve as Lewis acid sites. The comparison of IR spectra from the catalyst treated with 1000 ppm NO, 1000 ppm NO_2, and 1000 ppm NO + 2% O_2 shows the five bands at 1610, 1550, 1466, 1291, and 1030 cm^{-1}. The bands at 1550, 1291, and 1030 cm^{-1} can be assigned to bidentate nitrate; the band at 1466 cm^{-1} can be attributed to the monodentate nitrite. The mechanism proposed for N_2O generation at low temperature is based on the formation of surface Ce-ON species which may be produced by the partial oxidation of dissociatively adsorbed ammonia species with NO + O_2 (eventually NO_2). When these active sites are in close proximity, they can interact to form an N_2O molecule.

PHYSICOCHEMICAL CHARACTERIZATION OF THE GOSHICA'S CLAY AND ITS USE FOR NITROGEN ADSORPTION

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Adsorption represents an industrial separation technique for the purification of effluent media. This is a mass transfer operation done by a solid material that can selectively remove dissolved components from an aqueous/organic solution by attracting the dissolved solute to its surface. Adsorption finds application in textile, oil, leather, dyeing, food, cosmetics, plastics and paper industries. Among other materials used for the adsorption, clay minerals are widely used for this process due to their organic molecule adsorption–desorption properties. Clay refers to a naturally occurring material composed primarily of fine-grained minerals, which is/might be plastic in nature at appropriate water contents and will harden when dried or fired. In this study, the Goshica's clay (Viti, Kosovo) was tested for the use as an adsorption material for the nitrogen molecule. The clay was used directly or after acid activation (by 10, 20 and 30 % sulfuric acid). Prior to this study, the clay material underwent physico-chemical characterization. The results show that the differential dispersion of pores for the untreated clay are in the range from 1 to 3 nm and the pore size increases further with the acid treatment. The isotherms obtained through the measurement of the nitrogen adsorption by the clays in desorption exhibit a type H3 hysteresis.

* 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

DECOLOURIZATION OF OIL BY THE GOSHICA'S CLAY: A STUDY OF ADSORPTION ISOTHERMS AND BLEACHING KINETICS

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The removal of pigment and other trace ingredients by the adsorption process (bleaching) is one of the most significant steps in the vegetable oil refining (it removes the chlorophyll, carotenes and other pigments as impurities). This process makes the oil more pleasing and suitable for use. The activated clay has been extensively employed as an adsorbent material. Studying the isotherms and kinetics of the bleaching activities of clays with such oil is a very critical and essential step for the development of the bleaching process. In our study, we used natural and acid activated clay for the bleaching of oil. The used clay was characterized by the use of adsorption isotherms. The adsorption energy for this type of clay was estimated in the range of 8.62 – 11.10 kJ/mol which is characteristic for physisorption. The cation-exchange capacity of the clay was 35.5 mmol/100g clay. The performance of the clay toward the oil bleaching was very high, and this performance increased further by activating the clay.

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VISIBLE LIGHT MODULATION USING CHEMICALLY DEPOSITED ELECTROCHROMIC THIN FILMS

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In this work, electrochromic Prussian blue (PB) and tungsten oxide (WO_x) thin films have been prepared by the chemical bath deposition method. The films have been deposited onto fluorine doped tin oxide (FTO) coated glass substrates. The electrochromic behavior of each film was studied by cyclic voltammetry. The electrochromic test device (ECTD) was constructed by using WO_x as a working electrode, together with a PB film as an opposite (counter) electrode, and aqueous solution of 1 mol/dm^3 KCl, slightly acidified with 2 drops of conc. HCl in 100 ml as an electrolyte. The optical transmission spectra of the bleached and colored states were recorded in the visible part of the spectrum. From these spectra, the contrast ratio was calculated. The coloration efficiency and the time response of the ECTD were also examined.

A COMPARATIVE STUDY OF THE ORGANIC MOLECULE REMOVAL PERFORMANCE OF THE BIOSORBENTS DERIVED FROM AGRICULTURAL PEELS

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Different industries produce a lot of wastewater, which contains a number of contaminants, including acidic or basic molecules, organic or inorganic toxic compounds, etc. Many of the organic molecules are harmful and may affect aquatic life causing a number of diseases and disorders. Hence, their removal from aquatic wastewater becomes very important. The use of peel materials as adsorbents in the purification processes through the adsorption is very favorable particularly as these materials are of near zero-cost for the production. Banana, orange, and potato peels are the most used types of biomass reported in literature. In our study, we used organic waste materials derived from: bananas, apples, potatoes and cucumbers for the adsorption of two-model molecules: phenolphthalein and methyl orange. The estimation of the sorption capacity for these two molecules was done by using UV-VIS spectroscopy. The results show that these materials in general have a good sorption/removal capacity toward these molecules and that this capacity is also dependent, apart from other factors (pH, adsorbents particle size, temperature, etc.), on the composition/type of the used material.

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THE REMOVAL OF ORGANOCHLORINE PESTICIDES FROM THE ORGANIC OR AQUEOUS MODEL SYSTEM THROUGH THE ADSORPTION ONTO COVALENTLY-MODIFIED CARBON POWDER

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Organochlorine pesticides were adsorbed on activated charcoal powders covalently grafted with phenyl and carboxyphenyl layers derived from diazonium salts. This covalent modification of activated charcoal powders was achieved by aryl radicals obtained through the sonically induced dediazonation of "in situ" generated benzene-, 4-nitrobenzene- or 4-carboxybenzenediazonium chloride. The grafting reaction was assessed electrochemically by observing the reversible redox signal for the transformation of the bonded nitrophenyl group to nitrophenyl radical anion. The adsorption of the different pesticides onto these modified materials displayed high sorption efficiency and sorption capacity. The sorption percentages onto carboxyphenyl modified ACP of the pesticides (measured by GC-ECD) were in the range of: 90-100 % (DDT, δ-HCH, γ-HCH, endrin aldehyde), 80-90 % (methoxychlor, endosulfan II, p,p-DDD and β-HCH) and 60-80% (α-HCH, DDE, endosulfansulfate, endrin, endosulfan I, aldrin, heptachlorepoxid, dieldrin, heptachlor).

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MEDICAL PLANTS IN DIFFERENT SOILS WITH HEAVY METALS

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The goal of this study is to determine and evaluate environmental indicators and pollution presence in various regions of Kosovo. *Juniperuscommunis* L (black juniper), *Cupressaceae*, *Juniperusoxycedrus* L. (red juniper) are medical plants known and useful for their therapeutic aspect. The biggest pollution is in Obiliq, at A and B thermal electric power plant complex and in the extended outskirt of Prishtina. Industrial processes on the outskirts of Prishtina and in the region of Mitrovica have resulted to have contaminated soil, water and plants significantly with heavy metals over the internationally-allowed norms. Such contamination presents a permanent risk to the environment as a result of uncontrolled releases into river waters and in the lands nearby industrial zones. *Juniperusoxycedrus* L. samples have been taken in Mitrovica, 10 km close to Zveqan foundry, also on the outskirts of Trepca. *Juniperuscommunis*, has not been found as a result of extreme contamination. The sample of *Juniperuscommunis* L have been taken also in Sllatintë Vogel, Fushë Kosovë, Obiliq. Additionally samples of *Juniperuscommunis* L have been collected in Novoberdë, Gjilan, which have extended use with therapeutic effects, mainly due to ativesutbsances acting like anti inflammation and coloristic. Some other substances like flavonoidet and polifenols are present in black juniper seeds and in other parts of this plant. The samples of *Juniperusoxycedrus* L have also been collected in Mushtisht – Suharek, as they have wide therapeutic usage, as diuretic, carminative and anti inflammatory.

ASSESSMENT OF NATURAL RADIONUCLIDES IN BELARUSIAN DRINKING WATER SOURCES

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A new integrated radiochemical technique has been used for the assessment of activity concentrations of natural radioisotopes of lead and polonium 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-activity 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. The identification of radionuclides was fulfilled by the alpha spectrometer “Alpha Analyst” with the detector A 450-20 AM Alpha Pips (“Canberra”) and the beta radiometer “Berthold” LB-770PC.

The goal of the work is the assessment of activity concentrations of ^{210}Pb and ^{210}Po in the samples of natural waters, which are used as the sources of drinking water and comparison of the received obtained data with the standards for drinking water established in Belarus (RPL-2000).

The objects of the investigation were the surface and ground waters, which were sampled within the territory of Gomel and Mogilev regions in 2008-2011.

It was established that activity concentrations of radionuclides in the water samples are within the limits for ^{210}Po in the water samples and varies in the range 0.01–0.26 $Bq \cdot kg^{-1}$. But in some water samples it was higher than the intervention level for this radionuclide that is equal to 0.12 $Bq \cdot kg^{-1}$. The activity concentration of ^{210}Pb in water samples was 0.006–0.15 $Bq \cdot kg^{-1}$ and it corresponds to the operating standard for drinking water because it is lower than the intervention level (0.20 $Bk \cdot kg^{-1}$).

It was found that the highest total activity of the natural radionuclides is predominantly occurred for water from artesian wells. The lowest activity of the radionuclides usually revealed in the surface water samples. The activity of ^{210}Po in surface waters was always lower in comparison with other types of natural water sources in the same area. The processes of hydrolysis and complex formation determine the solubility of polonium in natural water. In the pH range of 6–7, polonium forms positively charged colloids, which are easily captured by the negative charged colloids on clay minerals, and precipitates on the bottom of water sources.

The obtained data show that distribution of radionuclides in the ground waters depend on the depth of artesian wells. The activity of ^{210}Pb and ^{210}Po in groundwater varies within wide limits with changes of depth. The maximum concentration of the radionuclides is in artesian water of the Gomel and Mogilev Regions sampled at the depth of about 100 meters.

The study of the activity concentrations of ^{210} Pb and ^{210}Po in water sources of Belarus is of interest and requires further research.

THE REMOVAL OF URANIUM FROM THE CONTAMINATED SOIL BY ELECTROKINETIC TECHNOLOGY

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A large number of nuclear facility sites have been contaminated by a leakage of radioactive waste-solution during a long-term operation of nuclear facilities. Indoor electrokinetic decontamination equipment for treatment of 1.2 tons of the contaminated soil per batch was manufactured to remove uranium from soil using high removal efficiency during a short time. For a reduction of waste electrolyte volume and metal oxide volume, the reuse period of waste electrolyte in the electrokinetic decontamination experiment and the method of a reduction of metal oxide volume in the cathode chamber were drawn out through several experiments using the manufactured electrokinetic equipment. In addition, the time required to reach below the clearance concentration level for self-disposal was estimated through experiments using the manufactured electrokinetic equipment. When the pH of waste electrolyte increased more than 5.47, the percentage of metal oxide volume generated in a cathode chamber increased more than 90%. Namely, it was found that the optimum pH of the waste electrolyte in a cathode chamber for a reduction of volume of metal oxides was below 2.35 at 25℃. When the initial uranium concentrations in soils were 7.0 - 27.0 Bq/g, the times required for uranium concentrations in soils to reach below 5.0 Bq/g, the reuse periods of the waste electrolyte were 5 – 25 days with waste electrolyte. Finally, it was found that when the initial uranium concentrations in soils were 7.0 - 20.0 Bq/g, the times required for uranium concentrations in soils to reach below the clearance concentration level (1.0 Bq/g) for self-disposal were 25 - 40 days with waste electrolyte and reclaimed electrolyte.

THE INFLUENCE OF OIL ON THE RYE GRAIN CULTURE OF S. *CEREALE (L)*

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The toxic effect of oil on a gramineae species - rye *S. cereale L.* has been studied. When introducing oil into soils it has been found that the soil fraction with the particle size being 0,05 - 0,45 mm absorbs the oil least of all. Here, the distribution of the estimated polyaromatic hydrocarbons is directly dependent on the portion of the size fractions of the soils under study. During the experiments the oil loss from the soils amounts to ~17 %, which is due to the possible oil decomposition by the plant roots and partial evaporation of oil from the soil surface. With the oil content being 9 %, the young rye shoots are suppressed, but the biomass is quite viable, which is evidenced by IR spectroscopy and morphological indicators. However, chromosome disturbances have been observed as a result of cytogenetic studies of the root system of rye, which are associated, among other things, with the effect of the soil particle agglutination around the root system. This may disturb the chloroplast motion in the cells, giving rise to anomalies in cell structures. Thus, the conducted experiments can indicate that rye can be applied for the photoremediation of soils polluted by oil spills.

THE EVALUATION OF DITHIZONE PERFORMANCE AS A COMPLEXING REAGENT FOR THE SUPERCRITICAL CO_2 EXTRACTION OF HEAVY METALS FROM AQUEOUS SOLUTIONS

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Heavy metal ions in liquid samples apart classical methods of extraction, they can be also efficiently and environmentally friendly extracted by the use of supercritical CO2 , containing a suitable complexing agent - ligand. This study represents the experimental data for the extraction of three heavy metals (Cu, Zn and Cd) from aqueous samples in the presence of Dithizone as a ligand. The extractions by supercritical CO_2 were accomplished at p=120 bars with t=50°C through the use of the dynamic technique. After the CO_2 addition on the aqueous solution containing corresponding heavy metal ions, the pressure and temperature were set and extraction was performed in three different time periods: 30, 60 and 120 min (t=const. , p=const. with a CO_2 flow rate of 2 mL min^{-1}. Once the extraction was stopped, the CO_2 was released slowly through a restrictor. Methanol was used as a modifier (v/v) 10% and the pH value was set 10. After the accomplishment of the extraction process, the left over aqueous solution in the extractor was analyzed for its metal content by the use of the Atomic Absorption Spectrophotometer (AAS). The overall performance of the use of the dithizone as a ligand in all three cases of heavy metal ions enhanced greatly the extraction efficiency of these ligand/metal species.

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CORROSION INHIBITION OF MILD STEEL IN AQUEOUS SULFURIC ACID SOLUTION USING HETEROCYCLIC MERCAPTO COMPOUNDS

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Mild steel is widely useful constructional material in many different industries mainly due to its excellent mechanical properties and it's low cost. Main problem with this material and generally with other materials it's their susceptibility toward the corrosion, thus their surface must be protected from this process. The metal protection apart the use of classic inhibitors [1,2] can be also achieved through the use of surface modification strategies by chemical or electrochemical methods such SAM's (Self Assembled Monolayers) formed from phosphonic acids [3,4] or electrochemical reduction of aryldiazonium salts on metals [5], with the exception of 2,6-dimethylbenzene diazonium salt [6]. In this study two different mercapto compounds: a) 4-methyl-4H-1,2,4-triazole-3-thiol and b) 2-mercaptonicotinic acid were used as corrosion inhibitors for mild steel in 0.1M sulfuric acid solution using potentiodynamic measurements. The results showed that the inhibition efficiency (IE) of these compound in general improved by the increase of their concentration in the corrosion media. The IE of the both studied compounds exhibited satisfied results toward the protection of mild steel from corrosion in this acid media.

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EFFECT OF KOH ACTIVATION ON HYDROCHARS: FT-IR SPECTROSCOPY ANALYSIS

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Hydrothermal carbonization (HTC) has been proven as one of the simplest and most efficient technologies to produce a variety of carbon-based hydrochars with various applications. Like other types of biochars, hydrochar is porous and has reactive, functionalized/aromatic surfaces. Those properties make hydrochar a potential low-cost adsorbent for water purification or soil remediation. In order to increase its ability to remove heavy metal contaminants from aqueous solutions, chemical modification/activation of hydrochar surface using KOH has been suggested. The presented FTIR spectroscopy analysis of hydrochars obtained from grape pomace and miscanthus showed that KOH modification increases the oxygen-containing functional groups, particularly hydroxyl and carboxyl groups, on hydrochar surfaces. As a result, activated hydrochars may demonstrate enhanced sorption efficiency.

GROSS ALPHA AND BETA PARTICLE ACTIVITIES IN PUBLIC WELLS IN THE TERRITORY OF THE AP OF VOJVODINA

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Aim. To determinate gross *alpha and beta* particle *activities in public wells in the territory of the AP of Vojvodina (APV).*

Method. The water samples were taken true the period 2012-2015 in 81 settlements (30 municipalities) of APV. Sampling was done according to SRPS EN ISO 5667-1:2008, SRPS EN ISO 5667-3:2007, SRPS ISO 5667-5:2008 and Ordinance on the limits of radionuclide in drinking water, food, animal feed, drugs, general use items, building materials and other goods that are placed on the market, Official Gazette of RS, No. 97/13. There were collected 259 samples of drinking water.

Simultaneous measurement of gross alpha and gross beta activities by liquid scintillation counting technique using Quantulus 1220 liquid scintillation counter (LSC) equipped with Pulse Shape Analyzer (PSA) is described. Water samples were prepared for measurements according to the ASTM D 7283-06 Standard Test Method. Liquid Scintillation vials 20 ml of low-potassium glass and scintillation cocktail (Optiphase Hi Safe 3) were used in the measurements.

Descriptive analyses (average, minimal and maximal values and standard deviation) were used for interpretation of the results, as well as frequency distribution. If the number of valid data was under the 95%, the average value was established by determination.

Results. Average gross *alpha* particle *activities in samples of drinking water were* 0.10±0.08 Bq/l, minimal <0.005 Bq/l and maximal 0.47 Bq/l (found in municipality Senta). The highest average values of gross *alpha* particle *activities were found in municipality* Pećinci (0.36 Bq/l), Senta (0.31 Bq/l), Ruma (0.28 Bq/l), Stara Pazova (0.26 Bq/l), Šid (0.20 Bq/l), Inđija (0.19 Bq/l) and Irig (0.15 Bq/l).

Average gross *beta* particle *activities in samples of drinking water were* 0.26±0.2 Bq/l, minimal <0.03 Bq/l and maximal 0.94 Bq/l (found in municipality Sid).

In 5 (1.93%) controlled samples of drinking water, mainly in municipalities Šid, Pećinci and Stara Pazova, the gross *alpha and beta* particle *activities were above the limit value defined in National Ordinance, so there were necessary to determinate the activity of radionuclide radium* (^{226}Ra), *thorium* (^{232}Th) *and cesium* (^{137}Cs). *The average concentration of* ^{226}Ra *and* ^{232}Th *was* 0.16 Bq/l and 0.08 Bq/l, respectively, while the concentration of ^{137}Cs in all analyzed samples was in range <0.07 - <0.12 Bq/l.

Conclusion. The average gross *alpha and beta* particle *activities in public wells in the territory of APV is in accordance with National Ordinance. In the single samples where* gross *alpha and beta* particle *activities were above the limit values, the activity of radionuclide radium and thorium were not above the prescribed limit values.*

EXPERIMENTAL AND THEORETICAL (DFT/B3LYP) STUDIES ON CORROSION BEHAVIOR OF SOME MONO AND POLYHYDROXY AROMATIC DERIVATIVES ON COPPER

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The copper alloys and the metal itself are important materials from which are made important industrial equipment such as: cooling systems, desalination plants, heat exchangers, etc. This extensive use of such materials is related due to their important and much desired proprieties: strength, electrical/thermal conductivity, etc. Even if these material are more resistant than the mild steel toward the corrosion phenomena, they are still susceptible to it, thus they need to be protected. In this study six different mono and polyhydroxy aromatic derivatives: A. sinapic acid, B. syringic acid, C. 2,3,4-trihydroxybenzoic acid, D. methyl-4-formylbenzoate, E. methyl-3,4,5-trihydroxybenzoate and F. 4-hydroxy-3-methoxy benzoic acid were tested for their corrosion behavior toward the copper. DTF quantum calculations were performed to determine: $E_{(HOMO)}$, $E_{(LUMO)}$, energy gap (ΔE), dipole moment, etc. for each used molecule and these parameter were tested for correlation with experimentally evaluated corrosion behavior of these molecules toward the copper metal.

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THE CORROSION INHIBITION PERFORMANCE OF THE COVALENTLY BONDED POLY(BROMOPHENYLENE) LAYERS ONTO MILD STEEL

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Electrochemical generation of aryl radical through the electroreduction of aryl diazonium salts enables the covalent modification of vast number of materials [1,2]. The grafted organic moieties may contain a number of different functional groups, which can give rise to functionalized surfaces with specific properties. These formed layers as they are covalently bonded, they are very stable [1]. In our study the modification of mild steel was achieved through the electroreduction of 4-bromobenzenediazonium tetrafluoroborate in acetonitrile solution containing 0.1M tetrabutylammonium tetrafluoroborate. The grafting is performed by imposing a negative potential to the mild steel electrode. TThe efficiency of these strongly grafted layers onto mild steel surface to protect its surface against corrosion is tested by potentiodynamic measurements. Polarization curves indicate the decrease of corrosion rate of modified iron electrodes immersed in aqueous acid medium.

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THE EVALUATION OF THE PORE SIZE AND PORE DISTRIBUTION FOR THE GOSHICA (KOSOVO) CLAY MODIFIED WITH QUATERNARY AMMONIUM IONS

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The replacement of the inorganic cations in clay by quaternary ammonium ions is known to cause considerable modifications in the hydration and swelling properties of the clay and has impact also on the pore distribution and pore size of these materials. In this study we analyzed the dispersion of the clay pores for activated clays at different temperature range and also for modified ones with quaternary ammonium ions. The found size dispersion of the organic modified clay pores are in range of 0.7 to 3 nm and those of activated clay (75 % of pores) are between 1.2 to 2.5 nm. The differential dispersion of pores treated thermally at more elevated temperatures are 0.8 to 6 nm and represent 65% of the total pore volume (1.7 and 2.1 nm are dominant pore values). For the thermally treated organic modified clay, the dominant pore radius are 3.6 and 6.3 nm.

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COLOR REMOVAL FROM AQUEOUS SOLUTIONS CONTAINING DISSOLVED ORGANIC MOLECULES USING THE MATERIAL DERIVED FROM CUCUMBER PEELS AS A LOW COST BIO-SORBENT

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In the recent years, adsorption processes have been shown to be highly efficient for removal of dyes from industrial wastewater. Granular activated carbon is the most popular adsorbent, which has been used for decades and has shown great success, but it is expensive if used for water treatment. Use of waste materials as low-cost adsorbents is suitable due to their contribution in the reduction of costs for waste disposal, therefore contributing towards environmental protection.

In our study, we used cucumber peels as bio-sorbents for removal of the wastewater's color. During laboratory work, firstly, the cucumber peels were dispersed in distilled water for 24 hours, and were then dried until they reached constant weight. The peels were then grinded and as such, 0.01 grams were used for study purposes. Cucumber bio-sorbents have been successfully utilized for the removal of dye from wastewater. The effects of different parameters such as contact time, solution concentration, pH value . . . were investigated.

Our research shows promising results of the use of the cumber derived bio sorbents for the removal of the water color.

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THE PRESENCE OF HEAVY METALS IN FISH CANS IN ALBANIA

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The consumption of fish is the most significant source of ingestion-related mercury exposure in humans and animals. Mercury and methl mercury are present in only very small concentration in seawater. However, they are absorbed, usually as methyl mercury, by algaeat the start of the foodchain. This algae is then eaten by fish and other organisms higher in the food chain. Fish efficiently absorb methyl mercury, but only very slowly excrete it. Methyl mercury is not soluble and therefore is not apt to be excreted. The level of mercury in sardine fish canned is 0.013ppm. The danger level from consuming fish depends on species and size. Greater fish weight leads to additional mercury found in fish body tissues. This study is referred to the sardines fish canned that are imported from different countries in Albania. While various studies have shown high concentrations of mercury accumulated in fish, medical cases often go unreported and pose a difficulty in correlating mercury in fish with human poisoning.

THE ORGANOCHLORINE PESTICIDES IN POTATOES

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Pesticides can be determined as “antibiotics” of the plants. They are very common used in agriculture to control the thousands of weed species, harmful insects and numerous plant diseases that afflict crops. Residues of these compounds are detectable in plants and have been monitored since the 1950s. Organochlorine pesticides have extremely strong bonds between their chlorine and carbon components and are attracted to fats and highly insoluble in water. Exposure data to organochlorine pesticides (OCPs) of potatoes samples were measured from different locations of markets in Tirana, Albania. The samples have been taken in random. There are set 24 organochlorine pesticides including :dieldrin, aldrin, endrin, lindan, chlordane, heptachlor, DDT, α HCH, β- HCH, γ- HCH, BCH, PCB29, Heptachlor epoxide ,op-DDE, α Endosulfan, p-DDE, op-DDT, p-DDD, p-DDT, β -Endosulfan ,Captane, Methoxychlor, Mirex .In this study, we have detected mostly lindan at 31.5% of samples. The samples have been examined by the methods of FAO, with gaschromatography ECD detector and the results are frequently used as degradation in the environment. The measurements have been calculated in ppm levels.

THE IMPACT OF ATMOSPHERIC IONS ON AEROSOL SIZE DISTRIBUTION

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Atmospheric aerosols are the major indicator of atmospheric climate. Although there have been more measurements and research, the way of their creation and their growth is still uncertain (Enghoff *et al*). Different theories have been developed in this direction, but we will focus on the formation of aerosols due to the presence of atmospheric ions. The theory on which we will rely is called Ion Induced Nucleation. Ions which are created from various natural factors, such as cosmic radiation and radon, stimulate the creation and growth of aerosols. In this article, we have created an approximate model of aerosol growth mechanism in the presence of atmospheric ions. The measurements of aerosol concentration are made in three channels 0.5μm, 0.3μm and 5μm in different moments of time.

MEDICAL DEVICES

11

MADU INNOVATIVE MEDICAL DEVICE

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Innovative MADU health technology is scientifically approved and confirmed in practice as efficient, safe and environmental friendly registered and ratified by Ministry of Health of the Republic of Serbia (№ 022-04-19/2006-07). This patent was internationally researched by the Patent Cooperation Treaty WIPO UN as Novelty (N), Inventive step (IS) and Industrial applicability (IA).

MADU strips are used in eleven different forms with deep influence up to 55 cm of depth. MADU is magnetic, deep unipolar oriented field and it belongs to non-invasive medical techniques. Permanent magnets in placed in a certain order wrapped in silicone with magnetic influence of 600 to 3,500 mili teslas are placed over the skin as a strip. Magnetic field oriented in this way as an energy aspect similar to biophysical mechanisms of living beings, allows principal changes in an organism. Basic principles are: **biophysical effects** at the cellular level, the impact on water and its cluster structure, ferromagnetics and paramagnetics and opening of ions channels. Biophysical effects promote **biochemical effect** with membrane potential change and improve modulation of the potential of the potassium/sodium pump, synchronization of endogen oscillation of calcium ions; enzymes activation, especially of metalloenzymes, ATP production improvement. Those changes provoke bioelectrical effects: bioconductivity increase the cell's membrane is equivalent to electrical battery due to diffusible and other ions concentration. Because of these local and global principles and mechanisms we achieved the following therapeutic effects: reducing **of pain** (analgesic, hypoesthesic, morphinemimetic effects); **reducing of inflammation** (anti-inflammation and ACTH-like effects); **reducing of swelling** (dipoles settlement, anti-oedematous effects); **tissue oxygenation and nourishment** (vasodilatation, spasmolytic effects, microcirculation, metabolism activation and acidity reduction); **various tissues regeneration**(angioneogenesis, cartilage neogenesis, opening Gap Junction channels, improvement of alkaline reaction, calcium ions building into the bone favor of mature healthy mature cells); due to these effects indication area is getting broader each day. The newest achieved effects are the chondroneogenesis and the neuroneogenesis of peripheral nerves.

Key words: Regeneration, MADU health technology, MADU device, chondroneogenesis, angioneogenesis, neuroneogenesis

MODELING OF HEART KINEMATICS IN EXPERIMENTS ON THE CONVERSION OF HEARTBEATS INTO ELECTRICAL ENERGY TO POWER EPICARDIAL PACEMAKERS

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The aim: to explore the kinematic activity of the movement of the heart wall to convert the latter into electrical energy to power epicardial pacemaker.

Methods: The Bakoulev Scientific Center for Cardiovascular Surgery is working on the creation of the epicardial pacing system with a converter of the kinematic energy of the heart into electrical energy.

We are carrying out the experiments to create a compact system of energy conversion based on the effect of the occurrence of vibrations of the unbalanced inertial mass when making movements with an acceleration that is converted to EMF by magnetoelectric generator.

There have been developed and manufactured the Delta robot with six degrees of freedom for laboratory tests, which fully imitated the moving trajectory of the selected part of the epicardium according to the vector analysis of moving particles obtained by Echocardiography in patients with various cardiovascular pathologies.

The study was carried out on 6 groups of patients with different cardiovascular pathology: with the lesions of the right coronary artery, the left coronary artery, valve diseases, angina pectoris, myocardial infarction and in patients with lesions of the left main coronary artery.

Results: According to the data of 90 patients with different cardiovascular pathology the experiments on Delta robot have been successfully done.

The first experiments showed the possibility of achieving a specific electrical power on the level of 30 UW, which is sufficient to power the stimulator in the "demand" mode.

Conclusions: It is established that the transformation of kinematic energy of the heart into electricity, allows reaching required power for a pacemaker in the "demand" mode. Further research is necessary to increase the specific gravity of the converter by optimizing the design and to determine the reliability of the converter.

MEDICAL IMAGING

12

THE TRANSFORMATION OF THE BRACHIOCEPHALIC ARTERY TORTUOSITY AT THE VERTICALIZATION OF A PATIENT

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The purpose – to estimate the form and hemodynamic changes in the area of pathological brachiocephalic artery tortuosity depending on the patient's body position (horizontal and orthostasis).

Materials and methods. At brachiocephalic arteries duplex scanning (350 patients), local and system hemodynamic importance of tortuosity of the internal carotid arteries and pre-mouth deformations of the vertebral arteries was estimated. For the first time, the study was carried out not only in the horizontal, but also in the vertical position (patent N 2553925RU). The comparison group consisted of 120 patients who were simultaneously examined by the means of a computer angiography (mean beam loading was 3.6±0.4 mSv) and magnetic resonant angiography.

Results. In the examined patients, deformations of internal carotid arteries were revealed in 38.6% of cases, tortuosity of the left internal carotid artery was considered to be pathological in 18.5% of cases, of the right – in 23.7%. In 66.7% of patients, the lesion was of bilateral character. The acceleration of blood flow rate parameters to 55–65% in the area of tortuosity was registered; the mean value of the systolic blood flow rate was 166±28.3 cm/s on the left and 174±30.2 cm /s on the right. In the vertical position, tortuosity transformation was found in 31.6%: the angles of deformation became obtuse, the gradient of the blood flow rate parameters decreased or was absent, and in some cases the course of arteries became rectilinear. Pre-mouth deformations of the vertebral arteries course were revealed in 79.4% of patients, the tortuosity of the left vertebral artery was considered to be pathological in 15.1% of cases, of the right – in 8.6%, the mean value of the systolic blood flow rate was 92±15.3 cm/s on the left and 76±125 cm/s on the right. In orthostasis pathological vertebral arteries deformations, the form of deformation transformed to non-pathological tortuosity was found in 28.8% of cases.

Conclusions. Orthostatic studies of patients open new approaches in the diagnostics of pathological deformations of brachiocephalic arteries and indications to surgical treatment without significant beam load on a patient.

The method of color duplex scanning is a choice method in the diagnostics of pathological tortuosity of brachiocephalic arteries due to high informational content, not invasiveness, lack of beam load and possibility of determination not only of the local, but also system hemodynamic importance of deformations.

Key words: Duplex scanning, internal carotid, vertebral artery, pathological tortuosity, non-pathological tortuosity, beam load.

SUSPECTED ADVERSE REACTIONS TO CONTRAST MEDIA IN THE CAMPANIA REGION (ITALY): RESULTS FROM 14 YEARS OF POST-MARKETING SURVEILLANCE

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Objective: During the last years in Italy, contrast media (CM) use increased. An increase of monitoring activities on CM-induced adverse drug reaction (ADR) is necessary, also in our regional territory. The main aim of this study was to give a preliminary evaluation of all Spontaneous Reports of ADRs (SRA) attributed to CM sent to the Campania Pharmacovigilance Regional Center (CRFVC) from 01 January 2001 to 31 October 2014.

Research design and methods: For each SRA we evaluated: frequency and source, ADRs onset (time to event, seriousness and outcome), sociodemographic characteristics and risk factors of cases, the most reported CM (checking for pharmacodynamic and pharmacokinetic interactions).

Results: A total of 111 SRA were sent to CRFVC; specialist in radiology was the main source of reports. Ninety-seven SRA (87.3%) were referable to hypersensitivity reactions. Thirty-four SRA (30.6%) reported serious ADRs. The most reported CM were iopamidol, gadobenic acid and gadoteric acid. We identified two SRA induced by pharmacokinetic and/or pharmacodynamic interactions.

Conclusions: During 14 years of post-marketing surveillance, only a few SRA concerning CM-induced ADRs were sent to CRFVC probably due to underreporting. We aim to improve the monitoring activity on CM-induced ADRs especially in hospitals. The most reported ADR and CM were in line with the current body of literature.

THE DYNAMIC MR IMAGING OF MEDIASTINAL TUMORS

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The purpose: evaluation of usefulness of dynamic MR imaging in differential diagnosis of anterior mediastinal tumors

Material and Methods: Thirty-three patients with suspected medistinal tumors were examined during three years. All of them went dynamic MR imaging with gadopentate-dimeglumine administreted in bolus injection. Sequential images were obtained in 5 minutes. A comparison of mean peak time (MPC) of time intensity curves with microspopic findings (cytology, biopsy) revealed significantly different MPC for different types of tumors. Diagnosis was confirmed in 18 cases with fine needle aspiration, in 10 by biopsy and in 5 with surgical excision surgery.

Results: Statistically significant differences in MPC were found between tymoma and non-thymoma lesiones. MPC was about 1.5 and 3.5 in non-thymoma cases. It was possible to differentiate stages I and II with stage III based on MPC. MR showed optimal specificity and sensitivity at "cut of point of 2.5 minutes.

Conclusion: Dynamic sequences of MR may help in differentiation between tymoma and non-thymoma lesions in anterior mediastinum.

INTERACTIVE COLOR IMAGE PROCESSING IN PHOTODYNAMIC THERAPY

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Photodynamic Therapy (PDT) is an evolving method for the diagnosis and treatment of oncologic pathologies. PDT is based on using special kinds of drugs called photosensitizers – substances that are sensitive to visible light and low-intensity laser emission with wavelength that matches photosensitizer's absorption peak. The development of a new kind of photosensitizer – "Photolon", which consists of polyvinylpyrrolidone and E6 chlorine salt – opened up new ways of improving PDT methods.

A software complex for processing and structural detailization of color images was developed that allows the analysis of color images acquired using PDT. The aim of the software complex is to increase the productivity of endoscopic diagnosis by using image pre-processing and structural analysis of images acquired using videoendoscopic systems. The proposed pre-processing methods include contrast enhancement and optical system distortion correction. The structural analysis comprises multiple steps, such as determining the fluorescent component of the image and detecting oncological formations.

The software complex also includes algorithms for calculating the area of regions of interest, and provides the ability to perform volumetric planning for further treatment and diagnosis.

The complex is developed using ImageJ image processing package plug-in platform and it is a cross-platform solution. The developed software allows the users to interactively solve various specialized problems of videoendoscopic image processing and allows the extension of its capabilities.

CORRELATION BETWEEN SONOGRAPHIC FEATURES AND CYTOLOGY FINDINGS IN THYROID GLAND NODULES

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Purpose: To evaluate the value of ultrasound (US) in predicting US-guided fine-needle aspiration cytology (FNAC) findings in thyroid gland nodules.

Material and Methods: 168 US-guided FNAC specimen adequate for analysis. US features of thyroid nodules that were assessed: size, echogenicity, echotexture, margins regularity, calcifications, and the presence of a hypoechoic rim.

Results: FNAC revealed 150 benign and 18 malignant nodules. The mean size of malignant nodules was 28$\pm$12 mm vs. 18$\pm$12 mm for benign nodules ($p<0.05$). US features that were suggestive of malignancy: hypoechogenicity, calcifications, irregular margins, and the absence of a hypoechoic rim.

Conclusion: US is able to differentiate between benign and malignant thyroid nodules. Thyroid nodules that are ultrasonically suspicious of malignacy should undergo US-guided FNAC.

COMPARISON OF THE BIOLOGICAL BEHAVIOR OF RADIOLABELED $[^{18}F]$FDG-GLYCYLGLYCINE AND $^{99M}TC(CO)_3^+$-GLYCYLGLYCINE

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In recent years, several radiolabeled molecules such as peptides, proteins, and aptamers have been proposed as radiopharmaceuticals for molecular imaging, highly target-specific PET (Positron Emission Tomography) imaging probes and nuclear medicine for the treatment of tumors.

Peptide receptors are overexpressed on tumor cells more than normal cells. This is the molecular basis of a number of peptide applications. Nuclear medicine studies showed that some tumor cells are sensitive to certain types of peptides and selecting a suitable peptide gives opportunity for specific imaging or tissue targeted therapy.

As valuable biological tools, radiolabeled small peptides are under investigation and they are excellent candidates for nuclear medicine applications. Glycylglycine (Gly-Gly) is a small peptide which has favorable pharmacokinetic properties.

The aim of this study was to compare the biological behavior of $[^{18}F]$FDG radiolabeled Gly-Gly and $^{99m}Tc(CO)_3^+$radiolabeled Gly-Gly *in-vivo*.

In the current study, we conducted experiments in four stages. The first stage was radiolabeling glycylglycine with$^{99m}Tc(CO)_3^+$. The second stage was $[^{18}F]$FDG radiolabeling of glycylglycine. Thin layer radio chromatography (TLRC) and high performance liquid radio chromatography (HPLRC) methods were used to perform the quality control studies of radiolabeled glycylglycine. The third stage was *in vivo* biodistribution studies on male Wistar Albino rats and the final stage was the comparison of the biological behavior of the radiolabeled compounds. Additionally, the biodistribution of $^{99m}Tc(CO)_3^+$ radiolabeled Gly-Gly was studied *ex vivo*.

Radiolabeling of Gly-Gly was achieved with a high radiolabeling yield for both $^{99m}Tc(CO)_3^+$ and $[^{18}F]$FDG. The *in vivo* study results of both radiolabeled complexes showed the increased uptake in the kidneys and bladder, whereas the excretion from the body was both hepatobiliary and renal. Consequently obtained new radiolabeled compounds were thought to contribute to the literature as imaging agents.

EVALUATION OF VARIABILITY OF SUPRAORBITAL NOTCHES AND FORAMINA USING THREE-DIMENSIONAL COMPUTER TOMOGRAPHY VOLUME RENDERING

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Background. The supraorbital notch and supraorbital foramen (SON/F) are important anatomical landmarks which allows the passage of supraorbital vessels and nerves into the facial region. Knowledge of their precise anatomical localization is important in maxillofacial surgery and in planning supraorbital nerve blocks. Three-dimensional computer tomography (3D-CT) volume rendering is novel technique in clinical and research setting to qualitatively and quantitatively examine the cranial foramina in living subjects.

Aim. In this study, we aimed to estimate the anatomical variations of SON/F using 3D-CT volume rendering and to compare them with sex and side.

Material and methods. One hundred and five adults (53 men and 52 women), aged 21 to 83 years, without any trauma or bone malformation of facial bones, were included in our study. Data of the subjects were collected in the Center of Radiology, Clinical Center Nis, Serbia. The 3D-CT images of the skull are obtained with a technique of lighting, removal of overlying anatomic structures and rotation. Presence of SON/F, its shape, diameter in millimeters, and distance from reference point were recorded. Obtained results were statistically analysed.

Results. The most common presentation of the supraorbital passage was single SON and it was noted in 51.4% on the right and in 56.2% on the left skull side. The single SOF was noted in 3.8% on the right and 6.7% on the left skull side. Double notch was found in 1.9% on the right and in 0.9% on the left side, while double foramen was not found in subjects included in our study. SON/F was not found in 42.9% and 36.2% on the right and left side, respectively. The average SON diameter was 3.7±0.9 mm, and the average SOF diameter was 1.7±0.5 mm. The average distance of SON/F to the facial midline was 21.9±3.1 mm. The average distance of SON/F to the temporal crest of the frontal bone was 26.0±3.0 mm and to the frontozygomatic suture was 27.5±2.6 mm. There was no statistically significant difference between the left and right skull sides for all parameters ($p>0.05$). However, statistically significant differences were found between males and females for some of these parameters.

Conclusion. The results of this study provide useful information about location of the supraorbital neurovascular bundle and may be used in preoperative evaluation.

THE ROLE OF THE INFRARED THERMOGRAPHY IN DIAGNOSING THE UNILATERAL COMPLEX REGIONAL PAIN SYNDROME TYPE I

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Background: Infrared thermography is a non-invasive, non-contact and painless method that can be contribute to diagnoses the pathologic conditions that directly or indirectly affects the vascular microcirculation tonus that is regulated by autonomous nervous system. Considering that one of the basic pathophysiologic mechanisms participating in the occurrence of the complex regional pain syndrome is sympathetic dysfunction, infrared thermography can be provided information which points to this pathological condition.

Aim: The aim of this study is to examine the role of the infrared thermography in diagnosing of unilateral complex regional pain syndrome type I, observing the relationship between findings of the qualitative and quantitative analysis of thermograms and clinical presentation of the disease.

Methods: This study included 28 patients with unilateral complex regional pain syndrome type I, that were treated at the Clinic for Physical Medicine and Rehabilitation of the Clinical Center Nis (Serbia), during the period December 2004-January 2007. Complex regional pain syndrome type I had been diagnosed clinically on the basis of the modified research diagnostic criteria defined by the Budapest consensus group. The examined patients were recorded by infared thermovision camera (Varioscan high resolution 3021) and the obtained thermograms were qualitatively and quantitatively analyzed. The analysis of the thermograms was done by IRBIS graphically-oriented software package.

Results: The qualitative analysis of the thermograms verified the hyperthermic area in respect to the contralateral at 27 patients, and a hypothermic area at 1 patient.

Quantitative analysis of the obtained thermograms determined maximal temperature values of as the regions of interest (ROIs), expressed in degrees Celsius. For each patient and for each separate region of interest, a difference in maximal temperature values was calculated, between region of interest of unaffected and affected lower extremity, according to the formula: ΔT_{max} = T_{max} temperature ROI unaffected –T_{max} temperature ROI affected extremity. The difference in maximal temperature value between homologous regions of interest of the lower extremities was in the range from 0.61 and $3,32^{0}$C. The average value ΔT_{max} of $1,70^{0}$C was determined.

Conclusion: By detecting changes in skin temperature, infrared thermography can contribute to diagnosing of unilateral complex regional pain syndrome, thus supplementing the findings of clinical examination.

NEED FOR REVISING PATIENT DOSE PROTOCOLS IN PET MEDICAL IMAGING BASED ON NOVEL TECHNOLOGY IMPROVEMENTS

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Time-of-flight (TOF) implementation in positron emission tomography (PET) brings additional information, coincidence timing resolution, to the imaging process. Compared with non-TOF imaging, coincidence timing resolution results in a reduction in uncertainty that permits images to be created using fewer iterations and yields images with better signal-to-noise-ratio (SNR). TOF in PET as a concept has existed for more than 30 years, with applications in cardiology and brain imaging using N-13 and O-15. Ten years ago, new scintillator detectors based on lutecium were introduced, combining both high light output and short decay time. These scintillators brought the needed timing resolution for standard whole-body TOF PET using F-18.

Better robustness (in the sense that the images are less sensitive to errors in data collection) and lesion detectability (in combination with point-spread-function (PSF) correction) enables thinking toward site optimization benefits. Bearing in mind that the dilemma in clinical practice, to speed up the scan or to reduce the patient dose, depends mostly whether a facility has a medical cyclotron or not, this work focuses on theoretical considerations about the potential reduction of patient dose based on appropriate clinical studies.

Compared to the non-TOF technology, clinical studies have shown that it is possible to reduce patient dose up to 30%. On the other hand, it has been shown that, combined with the PSF information and current ordered-subset-maximum-likelihood (OSEM) algorithms, image quality for overweight patients could be significantly improved by applying TOF. This encourages further study and a change of the model based on patient weight. This change would result in a revision of the existing EANM procedure guidelines, either replacing them or combining them with a system based on a body-mass-index (BMI) concept, and thus result in significant dose reductions with stronger patient-based dose optimisation. Consequently, this will also reduce exposure of the nuclear medicine staff.

CONNECTIONS BETWEEN NOISE EQUIVALENT COUNT RATE AND IMAGE NOISE IN PET MEDICAL IMAGING

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Assessing PET image quality is a challenge due to its clinical subjectivity and difficulties in standardisation. Methods to evaluate the PET image quality include image noise (IN) and noise equivalent count rate (NECR) which are automatic and objective measurements determined from the reconstructed image or PET raw emission data from phantoms. The NECR is mostly used to measure the overall count rate performance of a PET system, and it is equal to the true coincidence rate that would give the observed SNR if there were no randoms and no scatter. Since randoms and scatter reduce the SNR, this effective true coincidence rate is always less than the observed true coincidence rate.

The NECR is proportional to the SNR ratio in the final reconstructed images and, therefore, serves as a good, objective parameter to compare the performances of different PET scanners. Image noise can be minimized by maximizing NECR, and manufacturers emphasize scanner performance by stating peak NECR. Indeed, the count rate capabilities of modern PET scanners are high, but it must be noted that the peak NECR is often outside clinically relevant activity concentrations. This means that administered activity is limited by radiation safety factors, as opposed to scanner count rate considerations. Patient-based NECR estimates can provide insight into maximum injected activities that should be used with the scanner in order to avoid operating beyond the peak NECR. Near the peak NECR, the improvement of SNR with increasing activity is very small. A very large increase in injected activity yields only a small increase in SNR when operating near the peak NECR of the scanner. This implies the possibility of a considerable reduction in injected activity without significantly compromising image quality. According to patient-based NECR estimates, for patients with large BMI, injecting more activity based on weight improves the image quality only minimally. From a view of radiation protection and image quality, it is preferred to increase the duration of the scan.

With the current three-dimensional-ordered-subset-maximum-likelihood (3D-OSEM) algorithm, SNR^2 versus NECR is nonlinear at activity concentrations beyond the peak NECR. For the range of activity concentrations usually found in the clinic, image SNR varies with activity concentration and is dominated by the 3D-OSEM reconstruction algorithm and associated parameters. SNR cannot be predicted by the NECR when using 3D-OSEM reconstruction, particularly for those clinical applications, such as cardiac imaging, that require high activity concentration. The 3D-OSEM algorithm does not correct for scatter and random counts by subtraction of the estimated values, but rather incorporates the corrections inside the iterative loop. This approach minimizes the error propagation in correcting scatter and random counts and improves image quality. Plotting SNR^2 versus the coincidence trues rate for the 3D-OSEM reconstruction shows a dominant linear relationship regardless of reconstruction parameters. This suggests that scatter and randoms do not impact image quality. Image noise in the EM algorithm is related to the true image value, so one can infer that this could also be true for OSEM. One consequence is that for 3D-OSEM reconstruction, the suggested limit of injected activity, traditionally based on NECR, should be based on the trues count rate. This means that images with higher SNR will be produced by increasing the injected activity to match the peak trues count rate for 3D-OSEM.

THE MENTAL FORAMEN POSITION IN RELATION TO THE RADIOGRAPHIC APEX OF THE MANDIBULAR SECOND PREMOLAR

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The identification of the mental foramen location is important for both diagnostic and clinical procedures. In the field of endodontics, radiographic appearance of the mental foramen may result in misdiagnosis of radiolucent periapical lesion in the area of mandibular premolar teeth. Panoramic radiographs provide the ability to view the entire body of mandible and allow more accurate localization of mental foramen in both horizontal and vertical dimension.
The purpose of this study was to determine the position of mental foramen in relation to the radiographic apex of the mandibular second premolar on panoramic radiographs.
Two hundered digital panoramic radiographs were analysed in this study. Horisontal and vertical position of the mental foramen was determined in relation to the two reference lines. A horizontal line was paralel to the occlusal line at the radiographic apex of the second premolar, while the vertical line was perpendicular to the horizontal line at the apex of the tooth. Horizontal position was recorded as mesial, intersecting or distal to the vertical line, while vertical position was recorded as above, intersecting or below the horizontal line.
Fifty percent of the panoramic radiographs showed that the mental foramen position was mesial and below the radiographic apex of the second premolar. Intersecting and below position was observed in 8% of the radiographs, distal and below in the 6%, mesial and intersecting in 21%, distal and intersecting in 2%, while 13% of the radiographs showed centered position of the mental foramen at the radiographic apex of the second premolar.
The most common position of the mental foramen was mesial and below the radiographic apex of the mandibular second premolar. Visualization of the mental foramen in increased when a panoramic radiograph is available for examination.

THE INCIDENCE OF DEHISCENCE OF THE TYMPANIC SEGMENT OF THE FACIAL NERVE CANAL ESTIMATED COMPUTED TOMOGRAPHY

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Background. The anatomical variations of the temporal bony represent a significant problem for otologic and nurootologic surgery. Dehiscence of the facial nerve canal is most common variations which makes facial nerve vulnerable. The High Resolution Computed Tomography (HRCT) with multiple rows of detectors is a recommended method for evaluation of temporal bone and facial canal.

Aim. In this study, we aimed to determine both the presence and the incidence of dehiscence of the tympanic segment of the facial nerve canal using HRCT and obtained results compare with age and sex.

Material and method. The retrospective-prospective study was performed at the Clinic for Radiology, University Clinical Center Sarajevo. After the criteria for participation and non-participation in the study were applied, the study included 295 patients (135 men and 166 women) of age ranging from 5 years to 75 years with performed computed tomography (CT) of temporal bone as a part of standard procedure due to suspicion of pathological activity in that area. We divided the subjects into seven age groups. Each group included the ten-year period. Presence of dehiscence of the facial nerve canal was recorded and obtained results were statistically analysed.

Results. Of the total number of patients included in the study, the dehiscence of the tympanic segment of the facial nerve canal was found in 95 patients (32%). Of 590 temporal bones, there were 118 temporal bony with facial nerve canal dehiscence in tympanic segment (20%). The dehiscence without stenosis of the oval window was noted in 110 temoral bony (18.6%). The dehiscence with stenosis of the oval window was noted in 8 temporal bony (1.4%). There was no statistically significant difference between age groups ($p=0.245$, Pearson's $\chi 2$ test). However, there was no statistically significant differences between males and females ($p=0.385$, Pearson's $\chi 2$ test).

Conclusion. The visualisation imaging techniques as CT is the preferred method for evaluation of temporal bone and facial nerve canal. Determination of both the presence and the incidence of dehiscence of facial nerve canal is of great importance in standard practice of radiologists as negligence to call attention to them during preoperative evaluation. According to that, it may be concluded that it can results in iatrogenic nerve injury which will have severe psychophysical consequences for the patient.

Key words: Dehiscence, facial nerve canal, tympanic segment, computed tomography

ANALYSIS OF SUSCEPTIBILITY-WEIGHTED IMAGES USING SUPPORT VECTOR MACHINE IN PARKINSON'S DISEASE

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The purpose of the present research work is to differentiate between the stages of Parkinson's disease (PD) by extracting specific features at individual level. To this end, the study was performed by analyzing brain magnetic resonance (MR) susceptibility-weighted images (SWI) by means of support vector machine (SVM) classification algorithms. Magnetic susceptibility images are relatively a new type of MR images within the field of medical imaging modalities. These images display better contrast comparatively to T1- and T2-weighted MR images.

Previously reported studies have shown that using SVM classifiers to analyze magnetic susceptibility images can provide significant information about discriminating at individual level between PD and/or other types of neurological diseases. The main purpose of the study is to further refine the analysis of PD patients in order to delineate the initial from the advanced stages of disease at individual level. The results will be statistically validated using a fundamentally different classification approach like hierarchical fuzzy cluster analysis (FCA) and/or spatial independent component analysis (ICA).

The data used in the present work were acquired from a group of 16 patients with PD and from a group of 25 healthy subjects using a MR scanner at 1.5 T. The patient group was subsequently divided in two subgroups: advanced stage patients and initial stage patients.

The analysis was structured on 4 cases comparing: (i) the two main groups (patients – healthy subjects), (ii) the advanced stage patients and healthy subjects, (iii) the initial stage PD patients and healthy subjects, and (iv) the initial stage PD patients and advanced stage PD patients.

The research will mainly promote means for faster diagnosis of PD and more efficient therapy.

ANALYSIS OF RESULTS OF TREPHINE BIOPSY UNDER VISUAL CONTROL OF BREAST LUMPS PROVIDED AT ASTANA ONCOLOGY CENTER

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Objective: to analyze the results of sighting trephine biopsy under ultrasound control among women with breast lumps.

Material and methods: Technology of histological diagnosis has been used in Oncology center of Astana during the three years. In the period from September 2014 to March 2015, we attended the trephine biopsy under visual control of breast lumps. All patients are performed ultrasound diagnostics and digital mammography before invasive procedures. Ultrasonography was conducted online on the expert class apparatus “Toshiba Alio 400” with using linear transducer with 7.5-10 MHz.

We analyzed outpatient cards of 75 women with breast disease, who had diagnostic investigation of breast lumps. Morphological verification of diagnoses was performed by histological analysis of biopsy material. They obtained after trephine biopsy from interested areas by "free hand" with using "gun-needle" (BARD-Magnum, 16 G).Blood flow in the area of upcoming biopsy was evaluated before performing trephine biopsy under visual control with using "gun-needle" in order to select the most secure acoustic windows and reduce risk of bleeding.

All procedures were performed on outpatient basis. After compliance the rules of asepsis and antisepsis linear transducer of ultrasound machine was directed to the mammary gland. After local anesthesia with 0.25% lidocaine under ultrasound guidance we took an average of 4 column tissue of formation, which was sent for histological examination.

Results: The histological analysis of biopsy materials obtained from 105 cases of benign breast lumps were identified in 29 (27.5%) cases. Among them: fibrocystic disease prevailed in 72.4% (21 cases).Histologically verified diagnoses of breast cancer were 76 cases, accounting for 72.3% of the total number of patients. Among them: medium differentiated infiltrative breast cancer prevailed in 85.5% (65 cases).

So, all 105 cases, which directed to trephine biopsy under ultrasound control, involved from 76 cases of malignant tumors and 29 cases of benign breast lumps.

After analyze the age groups, 76 cases with malignant tumors were women about 50-69 years.

It revealed the average age of patients with fibroadenoma -22 years, with local fibrosis - 56 years old, fibrocystic disease - 50 years old, infiltrative ductal carcinoma - 47 years old, medium differentiated infiltrative carcinoma -62 years old, low-grade differentiated infiltrative carcinoma -59 years old, high-grade differentiated infiltrative carcinoma - 57 years old .

So, trephine biopsy under ultrasound control is an integral part of early diagnosis of breast cancer to exclude malignant tumors among women.

Conclusion: The advantage of the method of trephine biopsy under visual control is that you can avoid a lot of unjustified operations due to false "positive" results of investigation. And, vice versa, it puts proven histological diagnosis of breast cancer after false "negative" conclusion mammography. Histological examination with sensitivity of up to 99.0% can put final diagnosis of malignancy of mammary gland and determine individual pre-operational treatment. So, it increases chances of recovery and 5-year survival. This method can be a "gold" standard for all cancer services in Kazakhstan.

ENDOPROSTHESIS REPLACEMENT AND X-RAY DIAGNOSTICS OF KNEE JOINTS AMONG PATIENTS WITH HEMOPHILIC ARTHROPATHY

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Objective: To estimate complex diagnostics and providing tertiary care in the form of endoprosthesis replacement in patients with hemophilic arthropathy amongst population of the Republic of Kazakhstan

Materials and methods: The work is based on an analysis of results of examination and treatment of 65 patients with hemophilic arthropathy of large joints. To determine the volume of orthopedic care at admission and after surgery, all patients with hemophilia A, besides hematological laboratory work also used the following methods: X-ray, CT and MRI, rentgendensitometry and ultrasound osteometry.

Results: The clinicoradiological classification E.Z. Novikova (1967) was used when using standard X-ray to assess severity of joint destruction in patients with hemophilia. According to X-ray findings: in 26% of cases revealed no pathology (although the patients complained of pain in the joints), I stage is set in 5,8% of patients, II stage - in 6,7%, 37.5% , IV stage in 24,4% , during the examination of the hip joints - III-IV stage

Lately, X-ray computed tomography widely used for pathology of joints. We evaluated progression of hemophilic osteoarthritis with using standard radiography and computed tomography in order to accurately determine bone changes at different stages of osteoarthritis.

Stage 1: the x-ray: height of joint space is not reduced or decline slightly (to 10%), marginal osteophytes and subchondral cysts are absent; on computer tomograms: subchondral cysts with sporadic sclerotic rim, minor subhodndral sclerosis, glomerular bone structure in edge of articular ends as a sign of osteoporosis unexpressed.

Stage 2: the x-ray: small (from 10 to 25-50%) reduction height of joint space, isolated small osteophytes; on computer tomograms: 2-3 small subchondral cysts with sclerotic rim, sometimes with breaking line, local subhodndral sclerosis in tibiofemoral area or patella-femoral joint region, regional erosion in subchondral epiphysis, joint contours rough, bone structure is glomerulal, cellular.

Stage 3: the x-ray and computer tomograms deformation of articular ends, reducing height of joint space of more than 50%, subchondral layer is destroyed due to single large or 3 small marginal osteophytes or more, 2-3 large or 3-5small subchondral cysts and more; on computer tomograms as in aseptic necrosis - signs of depressed fracture, moderate subchondral sclerosis, intercondylar eminence smoothed and destroyed, bone structure of metaphysis glomerular.

Stage 4: the x-ray and computer tomograms articular surface is deformed, flattened, joint space narrowed or complete obliteration of the interosseous space, with fibrous and most bony ankylosis, large marginal osteophytes, 4-5 large subchondral cysts in subchondral layer, significantly pronounced common subchondral osteosclerosis; on computer tomograms increase CT density areas of depressed fracture, displacement of patella and its various deformation, osteoporosis as a major cellular structure.

CT, unlike X-rays, has high sensitivity characteristics in diagnosis of hemophilic arthropathy (91.8% and 72.7%, respectively), whereas specificity of radiography superior CT specificity (86.4% and 71.3%). The combination of X-rays + CT increases sensitivity to 96.7%, at the same time ratio of TM and DS is optimal (3: 2).

Conclusion. Our experience of highly specialized medical care to patients with hemophilia in Kazakhstan with active implementation of early surgical rehabilitation of affected joint contributed to increase number of positive results was due to recovery of life's quality of patients in this category. Using wide arsenal of methods of diagnostics like X-ray, ultrasound and magnetic resonance imaging has allowed to assess joints' changes in hemophilic arthropathy. They play an important role in evaluation of disease's dynamics, in planning of operations and timely prevention of severe complications of hemophilic arthropathy.

COMPARISON STUDY OF CLINICAL MEASUREMENTS AND MONTE CARLO METHOD ON RADIATION DOSE RATE CHANGES BY DISTANCE IN COMPUTERIZED TOMOGRAPHY (CT) FACILITY

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A Computerized Tomography (CT) scan associates a series of X-ray images obtained from different angles to create patient's cross-sectional images of body parts. It can be used especially for bones, blood vessels and soft tissues. As a comparison between two devices, the obtained information by using CT scan on the patient is more significant than the information obtained by a normal plain X-ray device. Since CT uses various doses of X-rays for imaging of the body, radiation protection became a major topic of investigation. One of fundamental principles of radiation protection is the distance factor. In CT facilities, the maximum dose occurs near the gantry and the dose rate is decreases by distance. In order to know the rate of reduction of the amount of dose, that distance is very important for radiation protection procedure, especially for applying the criteria of the International Commission on Radiological Protection (ICRP) on radiation protection. In this study, we measured the dose rates with small distance rates from the gantry to the exit door and compared them with the Monte Carlo (MC) results. In order to calculate the Monte Carlo results, we also modeled a simulation input for the CT facility by using MCNP-X (version 2.4.0) Monte Carlo code. We obtained the dose rate changes on the distance factor by using the Monte Carlo method. We achieved a good agreement between MCNP-X results and clinical experimental results. It can be concluded that Monte Carlo (MC) is a strong tool for radiation protection calculations in CT facilities.

ANALYSIS OF FILTERING MATERIAL AND ITS EFFECT ON X-RAY FEATURES BY USING MONTE CARLO METHOD FOR MEDICAL IMAGING APPLICATIONS

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In recent years, x-rays with different radiological devices have been frequently used. X-rays are produced in vacuum tubes by bombarding a metal target with high-speed electrons and radiological images occur after the resulting radiation passes through the patient's body onto a photographic plate or a digital recorder to produce a radiological image. X-ray used devices can be classified in radiology as radiography, fluoroscopy, mammography and CT. In this study, we present a general approach for the simulation of x-ray spectra emitted from targets bombarded with electron beams for different energy ranges which are widely used in different radiological devices. The electron and photon transport is simulated by using the SpekCalc GUI code (version 1.1). In this study, we calculated the total photon spectra of the Tungsten (W) target for 150 keV and 12^{c} anode angle and certain energies for required energy values which are necessary for the successful radiodiagnostic process. We also performed simulations with same parameters by adding the filter material into the/an x-ray tube. We achieved a good agreement between the clinical data and the Monte Carlo (MC) method. The results showed that the Monte Carlo (MC) method is in accordance with the manufacturer parameters.

AN INVESTIGATION ON PHOTON BEAM SPECTRA BY CONSIDERING ANGULAR VARIATIONS AND DEPTH DOSE CHARACTERISTIC FOR MAMMOGRAPHY BY USING MCNP-X

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A mammogram is an x-ray image of the breast. It can be used to periodic control for breast cancer who have no signs or symptoms of the disease. It can also be used if there is a tuber or other indication that may be related with breast cancer. In order to obtain image contrast with these materials, basic requirement is to produce highly low energy photons. A way of obtaining a very low energy beam is to use a low kV in X-ray tube. In this study, an investigation on effect of angular variation and also effect of depth dose characteristic on certain target has been done and also related results observed. Results showed that the photon beam spectra and their mean energy are changed significantly with anode angle. Electron and photon transport is simulated by using the general-purpose Monte Carlo code MCNP-X (version 2.4.0).

ESTIMATED RADIATION RISKS, CLINICAL FACTORS AND PATIENT DOSE IN MAMMOGRAPHY

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Mammography is a non-invasive technique that helps physicians diagnose. A mammogram is basically an x-ray picture of the breast. A mammography unit is a specific type of X-ray for breast imaging. Mammography uses low radiation dose X-rays to detect breast cancer early, before women experience symptoms. Like all X-ray units, mammograms use doses of low ionizing radiation to generate images. However, sometimes low doses of ionizing radiation can increase the risk of longer term effects, such as cancer. In this work, our purpose was to compare patient radiation doses and patient lifetime attributable risks. We measured radiation patient doses and background radiation in two different mammography units (digital, analog).

LOCATION OF THYROID GLAND AND CHEST X-RAY IMAGING IN CHILDREN

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Purpose: To investigate whether standard chest x-ray in children includes thyroid gland and to indicate possible harm of radiation exposure in children.

Methods and materials: Study based on population of 109 children age 0 to 18 years, divided into six age groups: infants (0-1 years of age) , toddlers (1-3), preschoolers (3-5), middle childhood (6-11), young teens (12-14) and teenagers (15-18). Thyroid gland position was determined by screening MRI images. MRI images were collected searching patient data base retrieved from PAC system. Data on vertebral position were collected for the superiod poles of thyroid gland, isthmus and the inferior poles of thyroid gland, afterwards statistical analysis was performed.

Results: The mean values and standard deviations of all parameters calculated. Study showed the inferior poles of thyroid gland in 51% of children in all age groups was located at level of seventh cervical vertebra. The superiod poles of thyroid lobes in 31 % of children were located at level of C5, and isthmus in 32% of children at level of C6. We performed Kruskal Wallis Test that has showed significant difference in position of thyroid gland between the age groups, however there was no significant difference between the sexes.

Conclusion: Our study has shown that standard chest x- day includes inferior poles of thyroid gland. As chest x- ray is one of the most used imaging methods in childhood further investigation is needed in order to indicate consequences of radiation exposure.

MEDICAL PHYSICS

13

EVALUATION OF MEASUREMENT DOSE UNCERTAINTY OF GAFCHROMIC EBT3 BECAUSE OF LOCAL INHOMOGENEITY

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Purpose or Objective. The operation of any dosimeter assumes the knowledge of the expected uncertainty that could be caused by different factors. The possible sources of uncertainty for Gafchromic EBT3 film were investigated (Phys. Med. v. 29(6), (2013) p. 599) where it was shown that the error amounted 0.55% neglecting local inhomogeneity of the film. The homogeneity of Gafchromic EBT2 film was investigated (Med. Phys. v. 37(4), (2010) p. 1753) and it was shown that the inhomogeneity of absorbed dose amounted 6%. The purpose of current work was to calibrate Gafchromic EBT3 films using 10 MV photon beam, 6 MeV and 10 MeV electron beams and to estimate the value of the measured absorbed dose uncertainty caused by the local inhomogeneity of the film.

Material and Methods. The calibration of Gafchromic EBT3 film was carried out using 10 MV photon beam and 10 MeV electron beam of Elekta Axesse linac, and also at 6 MeV electron beam using compact betatron for intraoperative therapy. In the case of Elekta Axesse, the Farmer FC65-P cylindrical chamber and DOSE-1 electrometer were used. In the case of betatron, we used the plane-parallel chamber PTW 23342 (Markus) and Unidose-E electrometer. The pieces of Gafchromic EBT3 film were irradiated by different doses up to 40 Gy which resulted in calibration curves. Due to the fact that the films were irradiated by the uniform field, it was possible to estimate the local inhomogeneity. The obtained calibration curve allowed us to calculate the dose from the net optical density of the irradiated films. Using standard error propagation techniques, it was possible to estimate the calculated dose uncertainty.

Results. The experimentally obtained dependences of the reference dose on the film net optical density were fitted by the expression *D=a NetOD +b NetOD^n* (*a,b,n* are the free fit parameters). The comparison of calibration curves for different sources showed that the ones for 10 MeV electron beam and 10 MV photon beam coincide in the range (0.86-1.06) for the red channel and in the range (0.94-1.04) for the green channel depending on the value of net optical density. In the case of electron beams of different energies, the coincidence was better for both channels. The values of the obtained dose uncertainties lay within 5.5% for 6 MeV electron beam, 5% for 10 MeV electron beam and 7% for 10 MV photon beam (0.95 confidence interval).

Conclusion. The present work shows that the homogeneity of the new generation of Gafchromic EBT3 film is better than previous generation one according to the measured dose uncertainty.

FEASIBILITY OF USING ARTIFICIAL NEURAL NETWORK ALGORITHM TO ESTIMATE DOSE DISTRIBUTION FOR RADIATION TREATMENT

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Both the accuracy and the speed of dose calculation are crucial a clinical field of radiation treatment. Our previous study showed that an artificial neural network (ANN) algorithm has the potential to estimate an unknown point dose distribution after training with the known point data. In this study, the application of ANN was extended to predict the percent depth dose for a medium with an unknown density. First of all, a step known as learning process is necessary. We considered the data set with the pairs of a point-wise dose and its position for training an ANN. The percent depth doses were calculated using the commercial radiation treatment planning system of ECLIPSE (Varian, USA). The ANN was modeled using the Neural Network tool of MATLAB 7.0 (Mathworks, USA). It was constructed with three layers including one hidden layer. The Levenberg-Marquardt method was considered, introducing the second order differentiation of dose distribution as the feedback to the weight of the hidden unit of the neural network. Considering various densities, such as 1.0[g/cc], 0.8[g/cc], 0.6[g/cc], 0.4[g/cc], and 0.2[g/cc], the obtained data was applied to train the ANN. The internal weights and thresholds were optimized using the cross validation method. The validated ANN was applied to estimate the PDD for the medium with the densities such as 1.1[g/cc], 0.9[g/cc], 0.7[g/cc], 0.5[g/cc], 0.3[g/cc], and 0.1[g/cc]. In order to examine the accuracy of dose estimation by the ANN, we compared the PDD estimated by ANN with that calculated by the ECLIPSE. For the most case of densities, such as 0.9[g/cc], 0.7[g/cc], 0.5[g/cc], and 0.3 [g/cc], the PDD estimated by ANN was very close to that by ECLIPSE with the relative error of less than 1%. For both densities of 1.1[g/cc] and 0.1 [g/cc], the PDD estimation by ANN showed some different curves from that by ECLIPSE. As the depth is increased from the surface, the error was magnified. Based on the obtained results, we can expect the ANN algorithm to apply for estimate PDD as far as interpolation is concerned. It indicates that we can develop a real-time estimation of PDD with the well-trained ANN. Further careful investigation should be performed to solve the problem with dose extrapolation.

INVESTIGATION OF DOSE BUILDUP REGION OF ELECTRON BEAM USING POLYMER FILMS AND IONIZATION CHAMBER

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Putting the film parallel to the beam axis allows us to obtain the depth distribution of the dose in water during “single shot” of the accelerator. This method could be useful for the characterization of the electron beams of intraoperative accelerators due to the fact that, for this modality, it needs a precise knowledge of the dose depth curve starting from the phantom surface. The use of ionization chambers is a routine technique, but the spatial resolution of the measured curve is worse. The purpose of this work is to compare depth dose curves obtained using Gafchromic EBT3 film and ionization chamber during the experimental investigation and Monte-Carlo simulation.

Materials and Methods. The experimental comparison of the depth dose curves was carried out using 6 MeV and 9 MeV electron beams of Elekta Synergy accelerator and 6 MeV electron beam generated by the compact betatron for intraoperative therapy. The dose distributions were measured by ionization chambers in water and by Gafchromic EBT3 films in solid phantoms. The film was situated in different geometries, namely along the beam axis and across it. The simulation of the process was carried out using PCLab software that allows the simulation of the beam interaction with the matter. The first geometry was the absorbed dose distribution in pure water that was assumed to be an ideal case. The second geometry assumed film situated along beam axis. The third geometry simulated the ionization chamber depth scan. The simulation was carried out for different beam energies assuming monoenergetic beams. In the case of the film in water, it was possible to simulate the value of dose in water directly or in the film sensitive layer. In the case of ionization chamber, the value of energy lost in the air volume was measured as a quantity proportional to the dose in water.

Results. Results of the simulation and measurements show that the dose depth distributions obtained for water, using the film and ionization chamber, coincide well at depths deeper than the maximum dose. In the case of depths from the surface up to the maximum, the dose measured by the ionization chamber is larger than the dose measured by the film and simulated in pure water. The experimental investigation of the depth dose distribution also shows that the ionization chamber overestimates the dose values at small depths.

Conclusion. Simulation and measurement results show that the depth dose distribution from the electron beam in water measured by the radiochromic film is more accurate at small depths than the one measured by the ionization chamber.

APPLICATION OF POSITRON ANNIHILATION AND EMISSION MÖSSBAUER SPECTROSCOPY FOR DETECTION OF CHEMICAL CARCINOGENS

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Chemical carcinogens are now considered as the main cause of cancer. Usually they are electrophiles, possessing high electron affinity. We have shown that positron annihilation spectroscopy (PAS) can detect chemical carcinogens by the means of inhibition of the positronium (Ps) atom formation in liquid media under the presence of dissolved carcinogens. The suggested method is based on the following facts:

- majority of chemical carcinogens are strong electrophiles. These are the substances with high electron affinity [1];

- after being dissolved in liquid cyclohexane, chemical carcinogens are currently characterized through their very high reaction ability towards numerous track electrons produced in the solvent under the action of ionizing radiation [2];

- positronium, which appears in a condensed molecular milieu (including cyclohexane) under irradiation by fast positrons, is formed as a result of the combination of thermalised positrons and intratrack electrons. Thus, electrophilic carcinogens, dissolved in the milieu, will intercept thermalised track electrons (Ps precursors) and efficiently inhibit the Ps formation [3]. The available biophysical data indicate that similar experiments can be carried out in frozen media (for example, in ice along with the studies of liquid aqueous solutions), which may efficiently simulate an intracellular environment. So, Emission Mössbauer Spectroscopy (EMS) can be used for the identification of chemical carcinogens as well. It allows us to determine the final output of the charge states of $^{57}Fe^{2+}$ and $^{57}Fe^{3+}$ ions, formed in reactions with secondary thermalised electrons in the Auger blob [4]. Therefore, EMC and PAS can be considered as complementary methods in the screening of chemical carcinogens.

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SHIELDING REQUIREMENTS FOR PET/CT USING THE AAPM TASK REPORT 108

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Whether installing PET/CT in an existing department or building a new facility, shielding for PET/CT is complicated and expensive [1]. The energy of positron annihilation radiation is greater than the energy of radiation used with other diagnostic imaging modalities. National regulatory limits dictate the annual radiation exposures for uncontrolled and controlled areas, and it is necessary to consider not only areas immediately adjacent to the PET/CT, but also areas above and below the facility. Barrier shielding must be determined for floors, ceilings, and adjacent walls. The short half-life of PET radionuclides and movement of injected patients within the department are also factors that must be considered when planning a PET/CT installation. Various materials can be used in order to shield positron annihilation radiation, and choices should be cost effective and practical. Effective planning for the installation of a PET/CT will include a medical physicist, workers from the nuclear medicine department, an architect, and the PET/CT manufacturer. Methods for estimating the shielding required for PET/CT take into consideration decay of the radionuclide, attenuation in the patient, and the examination protocol.

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DOSIMETRY OF HIGH ENERGY PHOTON AND ELECTRON BEAMS FROM MEDICAL LINEAR ACCELERATOR: STUDY OF INTERNATIONAL PROTOCOLS WITH VARIOUS IONIZATION CHAMBERS

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The high energy X-ray photon is widely used for the cancer patients treated with tumor at depth whereas electron beams are used for the superficial structure near the skin and soft tissue. The aim of radiation therapy is to maximize the killing of cancer cells in a tissue by radiation beams keeping the sparing of healthy cells at an acceptable level. The effectiveness of the output of treatment is highly dependent on the radiation dose being delivered to the treatment site. The clinical practice leads to generally agreed recommendations on the required accuracy in the clinical dosimetry for radical curative being given in International Commission on Radiation Units & Measurements (ICRU, Report-24, 1976) for at least accuracy of ±5%. The output dose measurement of two CLINAC (DHX-3186 and 2300CD) with photon beams of energies 6 and 15 MV and electron beams of energies of 4, 6, 9, 12, 15, and 18 MeV at the National Institute of Cancer Research and Hospital (NICRH), Dhaka, Bangladesh have been measured with parallel plate ionization chambers TW23343 & A10 for electron beam and Fc65-G for photon beam using IBA water phantom at reference conditions. Three different dosimetry protocols (TRS-398, AAPM TG-51 and DIN 6800-2) were used in the present work. The dosimetry of electron beam has been measured with the maximum uncertainty of ±1.74%. A deviation between the chambers has been observed with a maximum value of 4.62% using AAPM TG-51. The deviation among the protocols using TW23343 chamber has also been observed with a maximum value of 3.67% between TRS-398 and AAPM TG-51, 3.92% between AAPM TG-51 and DIN 6800-2 and 0.95% between TRs-392 and DIN 6800-2. Two cylindrical chambers FC65-G (2005) and Fc65-G (2009) have been used for the photon, showing a maximum deviation of 1.16% for TRS-398 & AAPM TG-51 and 0.68% for DIN6800-2. The deviations among the protocols for the photon beam have been observed with a maximum of 1.18% between TRS-398 & AAPM TG-51, 1.56% between AAPM TG-51 & DIN 6800-2, and 0.41% between DIN6800-2 & TRS-398. The uncertainty in dose measurement for the photon beam is about ±0.57%. The higher deviation is observed in AAPM TG-51 in comparison with other two protocols.

COMPARISON OF CTDI MEASUREMENTS IN STANDARD PMMA AND IN-HOUSE FABRICATED MDPE PHANTOM

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The most common parameter to check the proper working of CT and to estimate the patient dose in computed tomography is CT dose index (CTDI), which represents an averaged dose to a homogeneous cylindrical head and body phantom (16cm and 32 cm in diameter), this measurements are only approximation of the patient dose. However, in radiotherapy this parameter is measured to check the proper working of CT simulator in general, because the dose for patient received during the simulation of radiotherapy treatment is significantly lower according to treatment dose. Well calibrated CT by definition has 0 HU for water and -1000 HU for air, and CTDI measurements usually are performing with 10cm pencil chamber in standard PMMA body and head phantom, which HU is relatively close to the water. Those measured CTDIs often are higher or lower than system calculated values but within regulation-specified limit of ±20% for diagnostic radiology CT, unlike in radiotherapy CT simulator which should be within ±8%. Comparison of CTDI measured on two CT simulators in standard PMMA and same dimension in-house fabricated phantom made of MDPE (medium-density polyethylene) with HU number closer to water, for investigated standard simulation protocols, shows decreasing difference between measured and system-calculated CTDI.

CT AND MRI IMAGE FUSION TO IMPROVE TARGET POSITIONING FOR STEREOTACTIC RADIOSURGERY (SRS) TREATMENT PLANNING

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Objectives. To improve image registration accuracy by using markers on patients for head SRS treatment planning. Contour shifts were compared after image matching based on anatomy correspondence and markers superposition.

Materials and Methods. Ten patients with head localisations planned for radiosurgery were studied. Scanning procedures using skin markers were done on CT - GELightSpeed RT16, with 1.25mm slice thickness and MRI–GESigna 1,5T following AxT2 FRFSE, AxT1 and T2FLAIR, MRPerf Ax Dynamic SI C+ and Ax 3D T1 FSPGR. Image fusion of data sets was applied after anatomic landmark matching before target contouring. Alternatively image matching was also implemented by marker superposition. Translation and rotation corrections were calculated from markers' displacement and applied in the matching procedure. Target anatomy contours obtained from both procedures were compared and contour shifts measured. These shifts were analyzed to find how the type of matching procedure would affect target contour displacement.

Results and Discussion. Coordinates of markers showed geometrical displacements (0.15cm - 0.35cm) in transverse direction and rotation angles (1.5 - 2.0 degree). These values were used for compensation in the image matching procedure, achieving visual correspondence of target anatomy after image fusion. Target contour displacement after applying both procedures were found to be within the range of 0–0.3cm.

Conclusions. The precise positioning and method using markers is essential to achieve good quality in the image matching, as well as the accuracy in the SRS. It could be improved with more than 1mm for the target and organs at risk, which makes the SRS treatment procedure itself more effective.

Key words: Treatment planning protocol, image fusion, external markers

NEW APPLICATION OF UNFOLDING TECHNIQUE IN ESTIMATION OF ENERGY SPECTRA OF THERAPY PHOTON BEAMS

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Knowledge of linear accelerator photon spectra can be very useful in standard dosimetry as well as in applications of advanced methods for dose calculation in therapy planning. Considering that high energies and intensities of therapy beams do not allow utilization of some standard photon spectroscopy techniques, a number of indirect measurement techniques were developed. Attenuation analysis is the simplest method for spectrum determination because the equipment existing in clinical environment is sufficient for measurement. A modified method for evaluation of bremsstrahlung spectra on the basis of transmission measurement using one single depth of several different attenuation materials is analyzed. Estimation of photon energy spectra is done by the use of standard unfolding technique, already well developed in the field of neutron activation measurements.

PROPOSAL OF TESTS THAT SHOULD BE CONDUCTED BEFORE THE TREATMENT, PERIODICALLY AND DURING RADIOACTIVE SOURCE REPLACEMENT, WITH THE AIM OF INTRODUCING QUALITY CONTROL AND QUALITY ASSURANCE IN BRACHYTHERAPY

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In current Rulebook on application of sources of ionizing radiation in medicine brachytherapy as radiation therapy modality has not been recognized, and the parameters that should be checked before treatment, periodically and during radioactive source replacement has not been defined [1,2]. Bearing in mind that the primary goal of Quality Assurance Programme is providing accurately and reliably functioning of mechanics, software and device containing radioactive source during planning and application of therapy in order to establish reliability of application of radioactive sources in this field in accordance to standards and to decrease risk of accidental situations [3,4], there is proposal of tests in this paper that should be conducted before each treatment, in determined time intervals and during the replacement of radioactive source in High Dose Rate brachytherapy (HDR). In three tables the following is defined: roles of personnel (radiation oncologist, radiotherapy technician, nurse and/or medical physicist), time points of each staff member and means for performing tests. Beside brachytherapy device, Quality Assurance Programme covers both treatment planning system and corresponding simulator. Introducing of quality control and quality assurance in brachytherapy in legal framework should provide required preconditions for establishing reproducible, safe and regular brachytherapy treatment.

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COMPARISON OF MEASURED AND CALCULATED OUT-OF-FIELD DOSES IN A PAEDIATRIC ANTHROPOMORPHIC PHANTOM / OUT OF THE BODY SCATTER CONTRIBUTION EVIDENCE

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Purpose or Objective. The life expectancy of a child submitted to external radiotherapy is increasingly higher. The induction of secondary induced cancer is thus an increased concern during radiotherapy, and a minimization of future risk is being pursued. An estimate of scattered dose distribution and the evaluation of the most effective tools are mandatory.

Material and Methods. A 5-yr ATOM (CIRS) anthropomorphic phantom was irradiated using a standard 3DCRT radiotherapy three beam configuration. A cranio-caudal beam was employed in this irradiation. The plan was performed in Varian Eclipse v. 13.5 TPS, using the AAA algorithm. The plan was obtained within an extended calculation volume, taking the treatment couch into account in the calculations. The 2D scatter dose distributions at several planes away from the isocenter were measured using Gafcromic EBT3 radiochromic film, with a calibration curve at 24 hours, and compared with the calculated ones. Both dose distributions (scatter related) were compared at several distances from the isocenter (thyroid, lungs, abdomen and pelvis). To overcome the lack of film sensitivity at very low doses, the phantom was irradiated with 150 Gy (10x15 Gy) at isocenter.

Results. The maximum measured doses per 1 Gy at isocenter (0 cm) were 8 mGy, 2 mGy, 0.7 mGy and 0.2 mGy at thyroid (14 cm), at lung (24 cm), at abdomen (39 cm) and at pelvis (49 cm) respectively. At the thyroid and lung levels, the calculated dose distributions differ considerably from the measured ones. At the thyroid level, for example, a maximum of dose is observed in the posterior region in the Gafchromic film while it shifts to the left side of the neck in the TPS dose distribution. There is a general trend for the measured dose to be higher than the calculated at these distances (> 50%) at some points, particularly where the cranio-caudal beam has left the body but is still near the surface of the phantom. Furthermore, the effect of the asymmetric cranio-caudal beam is evident in both calculated and measured dose planes, although yielding different results in both distributions.

Conclusion. For secondary induced cancer risk estimation, it seems evident from the results that the present TPS, even using a reliable algorithm as AAA, is not satisfactory for out-of-field dosimetry for all situations and must be considered with care. Specifically, the contribution from scattered radiation from air or objects outside the patient body does not seem to be properly considered by the TPS. Different tools, like Monte Carlo (MC) simulations are necessary if correct dose estimation must be obtained for risk models application. These preliminary results can lead to a further detailed measurements of out-of-field dose distribution in anthropomorphic phantoms and should be complemented by robust and validated MC simulations for the same beam geometries allowing the creation of a reliable tool capable of out of-field dose calculation.

PRELIMINARY STUDY ON MAMMOGRAPHY QUALITY CONTROL IN MOROCCAN HOSPITALS

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The image quality and patient dose are a priority in X ray imaging, especially in mammography as the breast is a very radiosensitive organ. The challenge is to minimize patient dose while keeping an adequate image quality in order to make a good diagnosis.

The quality of the image depends on radiological parameters and exposure conditions. The main parameters involved are the anode-filtration couple materials, voltage X-ray tube (kVp), the current of the X-ray tube (mA) and the exposure time (s). The optimization of these parameters requires an estimation of lesion detectability for each exposure condition.

In the present work, measurements were carried out with a digital mammography. A dosimeter was used to quantify the dose delivered and breast thicknesses were simulated by a phantom using plaques of polymethyl methacrylate (PMMA).

At the standard thickness of 40 mm polymethyl methacrylate (PMMA), and according to exposure parameters used, the image quality is determined by the analysis of the contrast detail CDMAM phantom images, where threshold contrasts are calculated for different gold disc diameters. Results of the contrast threshold are compared with the acceptable and achievable norms adopted by the European guidelines. The contrast to noise ratio (CNR) is also calculated for all breast thicknesses required.

To determine the dose absorbed in the breast, the average glandular dose is calculated (ADG) stimulated by different thicknesses of PMMA and in compression plates. Different doses are obtained compared with the limits of acceptable and achievable doses recommended.

The results show that the average glandular dose values obtained and the threshold contrast visibility are within the norms set by the European Guide lines.

DEVELOPMENT OF BREAST SOFTWARE PHANTOM DEDICATED FOR RESEARCH AND EDUCATIONAL PURPOSES

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Physical test phantoms are valuable tools in the assessment of novel breast imaging techniques. It is important that they reproduce the breast characteristics as close as possible. The Department of Radiology, Catholic University of Leuven has developed a physical phantom that produces a structured background in both 2D mammography and breast tomosynthesis. The phantom that consists of acrylic spheres placed in air and respectively in water. To improve further the existing physical phantom in terms of inclusion of breast lesions, use of other more appropriate materials or structure presentation different than the use of spheres, we started the development of a simulation platform that will allow the creation of software versions of this phantom with parameters (sizes, shapes, materials) that can be adjusted by the user. This work presents results related to the use of this platform to generate software phantoms, dedicated for breast imaging research as well as for educational purposes.

Description of the phantom. The software (and the physical) phantom is composed of two main parts: an acrylic semi-cylinder container of thickness 58 cm and diameter 200 mm, and equal volumes of acrylic spheres of six different diameters: 15.88, 12.70, 9.52, 6.35, 3.18 and 1.58 mm. The software application, called *LUCMRGen*, samples the location of the spheres randomly in the semi-cylinder, starting from the spheres with largest diameter. As in the physical phantom, the total volume of each different sphere type was set to be equal (60806 mm^3).

Projection images. X-ray projection images of the software phantom were obtained with the*XRAYImagingSimulator* using mammography setup. Images were simulated for monochromatic x-ray beam with energy of 19 keV. Scatter and detector responses were not simulated. Distances from the source to the breast support table, where the phantom was placed and to the detector surface were 600 mm and 650 mm, respectively. The size of the images and their resolution was 1200 pixels and 0.25 mm, respectively in each direction.

Simulated planar images of the software version were visually compared to images of the physical phantom filled with water and air. Real images are produced with Siemens Inspiration system, with distances from the source to the breast support table and to the detector equal to 633 mm and 650 mm.

Besides the research aspects of the software phantom, the software tool LUCMRGen has turned out to be very useful tool for training of Medical Physics Experts. Specifically, the tool has been used in the training of the participants of module 5 “Anthropomorphic Phantoms” from the EUTEMPE-RX project (www.eutempe-rx.eu), related to qualification of Medical Physics Experts in Diagnostic and Interventional Radiology.

The paper demonstrates the successful application and usability of complex and realistic breast software phantoms for breast imaging research and advanced training of Medical Physics Experts.

A MEDICAL PHYSICS TRAINING OPPORTUNITY FOR YOUNG PHYSICISTS IN ITALY

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The University of Trieste (Italy) and the Abdus Salam International Centre for Theoretical Physics (ICTP, Trieste, Italy) have initiated in 2014 a Master of Advanced Studies in Medical Physics (www.ictp.it/programmes/mmp.aspx), a two-years training programme, co-sponsored by the Academy of Sciences for the Developing World (TWAS).

The Master Programme is designated to provide young promising graduates in physics, mainly from developing countries, with a post-graduated theoretical and clinical training suitable to be recognised as Clinical Medical Physicist in their countries. Every year participants from Africa, South America, Asia, Europe and Middle East have been selected among more than 700 applicants. During the first three academic years 47 students have been enrolled: 18 from Africa, 14 from Latin America, 10 from Asia and 5 from East Europe.

The University of Trieste and the ICTP, a UNESCO educational institution with training initiatives in the area of medical, have developed the Master programme according to the recommendations of International Organization of Medical Physics (IOMP) and International Atomic Energy Agency (IAEA) for the education and the clinical training. The first year of the Master Programme in Medical Physics consists of basic and advanced courses and practical given by experts in these fields. The second year is spent in a medical physics department of the hospitals' network for a full time clinical training in radiotherapy, diagnostic and interventional radiology, nuclear medicine and radiation protection.

IOMP and IAEA are seeing this initiative as an answer to the growing demand of Medical Physicists in developing countries. Full or partial scholarships are awarded to successful candidates from developing countries, thanks to the support of the IAEA, TWAS, IOMP, EFOMP and ICTP.

ENERGY DEPENDENCE OF GLASS DOSIMETER RPL GD-301 AND TLD LIF:MG,TI AND OSL AL_2O_3:C DOSIMETERS BY USING MONTE CARLO SIMULATIONS

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The aim of this study was to compare the energy dependence of three kind of luminescent detectors without filter, RPL glass dosimeter GD-301 with TLD LiF:Mg,Ti and OSL Al_2O_3:C dosimeters.

In this work, a Monte Carlo simulation with MCNP5 was carried out to estimate the energy responses of these dosimeters. The following common clinical radiation qualities were applied: 6 -15 MV photons, 50-200 kVp X-rays, ^{192} Ir gamma rays, and ^{60} Co gamma rays as the reference.

In this study, for MV photons we found that the energy responses were approximately 2.6 % for GD-301 and Al2O3:C dosimeters and 1% for TLD-100 dosimeter. For ^{192} Ir gamma rays were found to be within 22 %, 15.2 % and 1% for RPL glass dosimeter, OSL and TLD respectively. In kilovoltage photon beams, the dosimeters displayed an increasing response with decreasing energy with a significant over response of GD-301 and Al2O3:C about 352% and 278% respectively, and a maximum of about 11.2 % at 50 kVp for TLD-100.

In conclusion, the dosimeters GD-301 and Al_2O_3:C (without filter) are used in high energy photon beams such as in radiotherapy, whereas the TLD-100 detector in medium and high energy.

Key words: Luminescent detectors, GD-301, TLD-100, Al_2O_3:C, Monte Carlo simulation, MCNP5.

STUDY OF DOSE DISTRIBUTIONS IN BIOLOGICAL TISSUES OF A PATIENT AND DOSIMETRIC CONTROL OF RADIATION THERAPY TREATMENTS

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High-energy linear accelerator (linac) is a valuable tool and the most commonly used device for external beam radiation treatments in cancer patients. In the linac head, high-energy photons with energies above the threshold of (γ,n) interaction produce photoneutrons. These photoneutrons deliver the extra dose to staff and the patients undergoing radiation treatment and increase the risk of secondary cancer. Owing to the limitation and complication of experimental neutron dosimetry in mixed beam environment, including photon and neutron, the Monte Carlo (MC) simulation is a gold standard method for calculation of photoneutron contaminations. On the other hand, the complexity of treatment head makes the MC simulation more difficult and time-consuming.

In this study, the possibility of using a simplified MC model for the simulation of treatment head will be investigated using Geant4-Gate code to calculate the neutron and the secondary gamma ray energy spectra and the dose equivalents at various points inside the treatment room and along the maze. As a part of comparative assessment strategy, we will compare our results with those evaluated by the recommended analytical methods, and with experimental and simulated values published in the literature. After validation, the shielding effects of various neutron material shields on the radiotherapy room wall will be also investigated in order to find the material having enough efficiency to reduce both neutron and secondary gamma ray doses.

Key words: Radiotherapy, accelerator, photoneutrons; Monte Carlo simulation, dose

MICROWAVE, LASER, RF AND UV RADIATIONS

14

TRENDS OF UV INDEX MEASURED IN NOVI SAD FROM 2004 TO 2013

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We studied the trends of UV index in the city of Novi Sad (latitude 45.3N, longitude 19.8 E at the 80m height) in the time period 2004-2013. The measurements of UV index were performed with *Yankee Environmental System* (YES) UVB-1 piranometer. The linear regression method was used to calculate the trends of UV index. The yearly trend of UV index from the relative monthly differences considered with climatological value was investigated. We obtained the yearly UV trend of about 8% per decade at the location of Novi Sad. Further on, the monthly UV trends were investigated. We obtained significant positive trends in April, August, October and December, with no significant negative UV trends.

WIDE-BANDWIDTH MEASUREMENTS OF NON-IONIZING RADIATION: THEIR ERRORS VERSUS THE MOBILE PHONE SYSTEM OPERATING LEVEL

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It is well demonstrated by high scale measurement campaigns that 20% of the total of electromagnetic field level that citizens are exposed to come from mobile systems (Base stations and mobiles). Overall, average exposure levels for a big city are below 5V/m, while you need approximately 1 mV/m, for a mobile phone's normal operation.

As it is easy and economical, the use of broadband measurement instruments is very common. It is important to take into account that their sensitivity is on the order of 1V/m, then it is so difficult to identify which is the real contribution of the mobile phone system. But the most important error source in non-ionizing radiation measurement is the electromagnetic noise level outside the band of interest. Simple noise power integration at frequencies below AM Broadcast Systems plus the noise power integration at frequencies above mobile phone bands will result in values one magnitude order higher than the real radiated field from the mobile phone system.

The present work will show the level of these errors and an alternative to minimize them. As current discussion of exposure guidelines, it is related to a correct non Ionizing Radiation measurement procedure.

THE DEVELOPMENT OF PULSED UV UNITS AND REGIMES OF AIR AND SURFACE DECONTAMINATION IN A LANDING MODULE

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Planetary protection or planetary quarantine (PQ) is a key issue in the context of remote space exploration. The danger of the terrestrial life transfer to other space bodies motivates studies with the end goal of minimizing the risks of microbiological contamination of solar planets. To cope with this problem in the ExoMars-2018 project, an antimicrobial strategy must be defined and a program of planetary quarantine procedures crucial for the success of the mission to Mars must be substantiated.

The purpose of the effort was testing a laboratory model of no-heat decontaminating unit (NHDU) and its regimes for the microbial control of air and surfaces within an ExoMars-2018 landing module (LM). Laboratory NHDU is outfitted with a xenon lamp generating radiation that reaches the target at 20 cm distance. An average bactericidal flux to target is 22 W/cm^2 with the UV pulsed power of 300 kW/cm^2.

NHDU was tested in experiments performed to detect resistant bacterial and fungal strains and to identify the most effective doses for the elimination of the microorganisms isolated from samples collected at the Baikonur technological complex. Highly resistant bacterial and fungal strains were used to measure the antimicrobial effect of the continuous spectrum of the UV lamp.

The permeability of various transparent packaging media for pulsed UV radiation was evaluated. In view of the low polymers permeability for UV radiation, we sought for a technology of the best possible decontamination of packaged objects with a vapor-delivered disinfectant (ethanol, peroxide, isopropanol) and simultaneous exposure to pulsed UV radiation.

As a result, it was shown that laboratory NHDU is capable to decontaminate very effectively objects wrapped in a high-pressure polyethylene film. The experiments demonstrated that the combination of hydrogen peroxide vapor and pulsed UV produces the most evident effect on resistant microbial strains (above 99.99 %).

YEAST CELL WALL POLYSACCHARIDE CONTENT UNDER ACTION OF RF EMF AND CHEMICAL STRESSES

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Polysaccharides are important structural elements of all live organisms. A lot of them have a commercial potential in various biotechnological processes and they perform a set of functions among which is a chemical and physical stresses resistance. These are a very labile cellular fraction that changes in respond to the environmental perturbations and thus can be good indicators of biological action of non-ionizing electromagnetic fields.

Yeast *Saccharomyces cerevisiae* strains were used to study the action of RF EMF pretreatment on the cell wall polysaccharide (CW PS) composition changes under action of chemical stresses. Hydrogen peroxide (25-100mM), acetic acid (25-100mM) and osmotic shock (sorbitol 0.25-1.0M) were used to cause changes in the CW PS composition. Stresses were applied after 30 min exposure to radiofrequency EMF (40.68 MHz, 15W power, 30 min). Effect of EMF was evaluated by changes in the CW PS quantity detected by the lectin-gold binding test. Experimental design and analysis of results were carried out by central composite design (*alpha* for rotatability was 1.68 and *alpha* for orthogonality was 1.29). The lectins, conjugated to gold nanoparticles, with the affinity to D-mannose and D-glucose, N-acetyl-D-glucosamine (GlcNAc), N-acetyl-D-galactosamine (GalNAc) and N-acetylneuraminic acid (Neu5Ac) were used.

Yeast cell walls were showed to contain 49% of D-mannose and D-glucose of which 1.7% was in *alpha* form and others were in *beta* form, 25% of GlcNAc and 24% of GalNAc, 1.2% of D-galactose and 0.1% of Neu5Ac. The minor components of the CW PS showed the most variability (over 40%) in respond to the stresses action, while the variability of the major components was low (5-10%). The osmotic shock and acetic acid were main factors affecting the total content of CW PS (38.9 and 17.6 unites, correspondingly) and the content of minor components (*alpha* forms of D-mannose and D-glucose, D-galactose), while hydrogen peroxide caused slight effect on the content of *beta*-forms of D-mannose and D-glucose (-2.2 un.), GlcNAc (2.3 un.) and GalNAc (2.4 un.). RF EMF changed a dose-dependent effect of hydrogen peroxide on GlcNAc and GalNAc from negative to positive and correspondingly the effects of acetic acid and osmotic shock became opposite. These results indicate that pretreatment with RF EMF does affect the CW PS content changes under the chemical stresses and that CW PS is a sensitive marker of biological action of non-ionizing EMFs. The opposite character of CW PS composition changes may be a result of necessity of cellular adaptation to an increased outer membrane permeability that occurs under this type of EMF treatment.

EXPERIMENTAL MODEL OF RISK ASSESSMENT AND MANAGEMENT IN OCCUPATIONAL EXPOSURE TO RADIOFREQUENCY/MICROWAVE RADIATION

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Due to steep progression of radiofrequency (RF) radiation applications, this paper aims to stimulate medical practitioners, from a practical perspective, to learn more about RF exposure, health/biological effects, health risk assessment and to advise main actors from companies to apply a better management strategy in this field.

Based on their research expertise the authors propose a health risk assessment model in chronic RF exposure, with main stages:

1. Electromagnetic characterization of work environment.2. Experimental studies in vivo, on laboratory animals (targeting immune system behaviour and oxidative stress)3. Occupational clinical studies watching: possible genotoxic effects, specific questionnaire for exposure related organic symptoms, identification of possible markers for exposure and biological effects 4. RF management strategy design.

As a basis of discussion for this strategy is the recent European Directive for electromagnetic fields (Directive EU/35/2013).A good management plan in occupational RF exposure can help to put into perspective the relative risk of RF exposure and in the same time can provide valuable information about exposure and health effects. The strategy will contribute to identifying of the RF electromagnetic sources and work practices that present likelihood of overexposure, dealing with any special situation that may occur.

BEHAVIORAL EFFECTS OF LOW FREQUENCY ELECTROMAGNETIC FIELD MEDIATED BY NITRIC OXIDE IN RATS' HYPOTHALAMUS

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Objective: In recent years, the mean level of low-frequency electromagnetic field (EMF), have progressively increased. Several studies have concluded that EMF may be linked to the disturbance of neuroendocrine activity of the organism. The present study has investigated the potential effects of extremely low frequency (ELF-EMF, 50 Hz) exposure on the rats behavior.

Study design: Ten experimental rats (*Wistar albino*) were arranged in two groups: control group - without exposure to EMF and experimental group - exposed to 50 Hz EMF for 7 days. After exposure, effects of nitric oxide (NO) and oxidative stress in the hypothalamus on the emergence of anxious behavior of rats were examined. The behavior of rats exposed to EMF was monitored by application of elevated plus-maze test and open field test, while the levels of NO and oxidative stress parameters in hypothalamus were estimated by measuring the concentration of superoxide anion radicals ($O_2^{\bullet -}$), nitrite (NO_2^-) and peroxynitrite ($ONOO^-$).

Results: The obtained results show that ELF-EMF exposure decreased mobility of the rats and increased time spent in the closed arms of plus-maze and at the periphery of open field compared to control group. Also, seven days exposure to ELF-EMF increased the concentrations of $O_2^{\bullet -}$ and NO_2^- in hypothalamus.

Conclusion: The main findings of this study were that exposure to ELF-EMF induces anxiety development in rats through increasing NO concentration in hypothalamus.

THE EVALUATION OF THE SHORT TERM PHOTOSTABILITY OF THE ALPRAZOLAM DRUG

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Alprazolam is widely prescribed sedative and antidepressant benzodiazepine (BDZ) drug. Chemically known as {8- chloro-1-methyl-6-phenyl-4H-s-triazolo(4,3-a) (1,4)benzodiazepine} and it belongs to the class of anxiolytic, sedative and hypnotic anticonvulsant. It is believed that alprazolam (ALP) is more fairly safe and it rapidly reduces the symptoms of anxiety through control of the central nervous system (CNS) excitability by a selective and potent enhancement of inhibitory gammaamino butyric acid (GABA) mediated neurotransmission. Accelerated photochemical stability of alprazolam was performed under several conditions. The study involved the evaluation of photostability of Alprazolam in active mater, in coated tablets and coated tablets embedded in different colored blister pickings. The evaluation of the stability was done using special stability test chambers at 60% controlled humidity, temperature and UV irradiation. The High-Performance Liquid Chromatography (HPLC) was used to analyze the content of the Alprazolam before and after UV irradiation. The mobile phase was a 60:35:5 volume mixture of acetonitrile: buffer (phosphate pH=6): tetrahydrofuran (THF). The obtained results for short term photostability study do not show any significant degradation of this molecule by the UV irradiation, in active mater and this holds true for the coated tablet and also for the coated tablets embedded in different colored blister pickings

*(The authors would like to thank the TrePharm – a pharmaceutical manufacturer- for the use of their instrumental platform for the study).

* 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 USE OF UV-SPECTROPHOTOMETRY IN THE EXAMINATION OF ANIMAL HAIR

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The UV spectrophotometry method is based on the ability of biological solutions to absorb light with different intensities under various conditions and wavelengths. As a result, we can determine the absorption spectrum, characterizing each substance. One of the main ingredients of animal hair is keratin. This protein has high sulfur content in its composition. The presence of aromatic amino acids of proteins determines the light absorption in the region of 250–300 nm. In the 230–300 nm absorb light sulfur-containing amino acids. The UV spectrophotometry method applied demonstrated high sensitivity. Groups of animals with whom we have worked, ground the concepts of this method: *1*. Sheep home – *Ovis orientalis aries*, Karakul breed, Russia, 2 females and 2 males. *2*. Red Deer – *Cervus elaphus*, 3 males and 2 females, Russia, Caucasus. *3*. Reindeer –*Rangifer tarandus*, 2 males and 2 females, Russia. *4*. Spotted deer – *Cervus nippon*, 1 female and 4 males, Russia, Caucasus. *5*. Black Celebes Crested Macaque – *Cynopithecus nyger*, 2 females and 1 male, South Asia. *6*. Siberian roe deer – *Capreolus pygargus*, 2 females and 2 males, Mongolia. *7*. European Mink –*Mustela lutreola*, 3 males and 3 females, Russia, Moscow region. *8*. The Amur tiger – *Pantera tigris altaica*, 3 males and 3 females, Khabarovsk, Russia. *9*. Seal – *Pusa sibirica*, 1 female and 2 males of. Baikal, Russia. *10*. Polar Bear – *Ursus maritimus*, 1 male and 3 females, Russia. *11*. Fox silver–black cell breeding – *Vulpes vulpes*, 3 males and 3 females, Moscow region, Russia. *12*. Arctic fox – *Alopex lagopus*, 2 males and 1 female, Russian. All the hair was taken from the animals withers. It was possible to identify even small amounts of the substance in a multicomponent biological system. We have been successful using this technique to identify the species of animal hair.

THE EFFECT OF THE PRE-PLANTING TREATMENT OF TUBERS WITH THE LOW-FREQUENCY PULSE ELECTRIC FIELD ON SOME BIOMETRIC PARAMETERS OF POTATO PLANTS

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Due to the increasing pesticide press, the problem of crop improvement by environmentally friendly methods becomes to be more and more relevant for the world agriculture. Possible ways to solve this problem are the breeding of more resistant and productive cultivars, application of biopesticides and biostimulators, and the use of various physical fields for a stimulating treatment of seeds. The technology of a pre-planting treatment of seed material with low-frequency pulse electric field (PEF) developed at the All-Russian Research Institute of Phytopathology has already proved its stimulating effect concerning seeds of some crops. In this study the effect of the pre-planting PEF treatment of tubers has been assessed in relation to several plant characteristics, such as the plant height, number of stems per a plant, number of leaves per a stem, fresh weight of foliage, and number and weight of generated tubers per a plant. Field trials were performed in the Saskachewan province of Canada and included nine potato cultivars. The pre-planting treatment was carried out using a PEF generator providing a low-frequency high-voltage pulse electric field with a complex amplitude-frequency spectrum close to that of natural fields. The working signal was characterized by a frequency 16 ± 10% kGz, modulated with a meander-shape sequence of bipolar impulses (150-300 Gz). The exposure time was 24 h (earlier determined optimum time for the treatment of potato). The time between the treatment and planting did not exceed 7 days. The trials demonstrated a reliable positive effect of the PEF treatment on the number of stems and the total number and weight of tubers per a plant. The averaged increase of these parameters in treated plants makes 24.65, 29.93, and 37.55%, respectively. Concerning other parameters (plant height, number of leaves, and fresh weight of foliage), the obtained data did not allow us to conclude about any stable positive or negative effect of such treatment on these parameters. The results agree with the data of other authors worked with various electrical fields on potato.

LOW-FREQUENCY PULSE ELECTRIC FIELD: A NEW GREEN TECHNOLOGY TO IMPROVE THE YIELD OF VEGETABLE CROPS

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High productivity of agricultural crops is one of the crucial factors characterizing the efficiency of agricultural industry. Many cultivars of agricultural crops demonstrate a high productivity potential during their trials, but not under field conditions that can be caused by insufficient adaptation potential of a cultivar to the ecological and climatic conditions of a region of its cultivation. The possible solution includes either the improvement of the environment to provide more favorable conditions for the plant development (use of fertilizers, protective treatments, and other agrotechnical measures), or the stimulation of a plant development using various chemical, physical, or biological methods. In the case of Russia, where the majority of territories belong to the zones of risky agriculture, the second way seems to be the most relevant and efficient. Today there are many chemical and microbial preparations stimulating the growth and development of plants. The range of developed physical stimulation methods is rather narrow, and the majority of them were tested only under laboratory conditions. At the same time, seed treatment with physical fields has all advantages of green technologies, and able to provide stable crop increase and quality improvement.

In this study we assessed the effect of a pre-planting treatment of seed material with low-frequency pulse electric field (PEF) on the yield increase of several agricultural crops, including potato (cv. Latona), cabbage (cv. Novator), onion (cv. Red Spark), red beet (cv. Ruzhet), and carrot (cv. Abliko). The pre-planting treatment of seeds was carried out using a PEF generator providing a low-frequency high-voltage pulse electric field, which distinctive feature is a complex amplitude-frequency spectrum close to that of natural fields. The output signal was characterized by a frequency of 16 ± 10% kGz, modulated with a meander-shape sequence of bipolar impulses (150-300 Gz). The exposure time varied within 1-24 h depending on the crop. The period between the treatment and planting did not exceed 7 days. Field trials were arranged at the fields of the Fruhtring agricultural company (Moscow region, Russia). For each crop, the total planting area of treated or untreated variant was 3-5 hectares; the size of experimental plots was 15-50 m^2 depending on the crop; the plots were randomly located on the field. Each variant was tested in three replications.

According to the results of two-year trials, the pre-planting PEF treatment increased yield in all crops. The averaged increase (%) made 10.4 (potato), 13.4 (cabbage), 27.6 (onion), 11.7 (red beet), and 15.6 (carrot). The obtained results confirmed the efficiency of the proposed technology as a simple and ecologically safe tool to provide a stable and significant increase in the crop capacity of different vegetable crops.

ELION TECHNIQUES IN APPLICATION AND IN SCIENCE WITH ACCENT ON ECOLOGY AND CULTURAL HERITAGE

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The scope of application of elion techniques in modern civilization is large, and still increase. New devices are being developed, which emit defined beams of nuclear particles (protons, neutrons) and radiation, but also ionic beams, in a large diapason of energies and intensities from "classical acceleration" devices, from defined chemical reactions, etc.

Nowadays, plasma processes may also be classified as elion techniques (electron, laser, ion, and neutron). Another approach to unification of beam techniques would include acoustic waves as well. The result of interaction of today's powerful laser beams and production of a series of harmonics would lead to the field with X and gamma photons, while processes with condensed and gaseous state of water would lead to forming of a series of particles, so laser could generally also be used as a source of various ions, isotopes from defined interactions, including plasma processes, production of acoustic processes, etc. The degree of present application, as well as application in the near or far future, depends on the complexity of technical systems where this is experimentally achieved.

The paper discusses several issues concerning application of irradiation with suitable already applicable methods, which for years have been the practice of many teams for the purpose of detailed studying of effects of various irradiations on materials (here the accent is on gamma irradiation) and assessment of principal changes caused by them.

Special attention is paid to the dosimetric side of the experiments, with a discussion of possible effects on interpretation of the references, if principles of proper assessment are not respected. This dosimetric part shall be viewed also as a dosimetric approach with laser (*irradiators*) and with parts of dosimetry where care should be taken of overlapping and differences (of dosimetry in nuclear technique and laser dosimetry).

The part concerning experimental work with electronic beams discusses the properties of the coupling or scathing of materials and the heat affected zone – HAZ and discusses the relation with LAZ. As for cultural heritage, there is an analysis of possible uses with nuclear irradiation (disinfection), and, as for laser beams, it seems that at least in smaller surfaces nuclear particles could be successfully removed from surface layers with their control.

Small areas (or dimensions of materials) certainly present smaller problems, but in larger ones the geometry of irradiation should be set sensibly, as well as assessment of exposition with differentiating various dose types.

Some scathing shall be discussed, caused by beams of particles and laser, and claims concerning changes of material properties, of which the objects of cultural heritage, or others of interest, are subjected to elions technique in comparison to other solutions, including mechanical ones, etc.

THE INFLUENCE OF MOBILE PHONES RADIATION ON THE OCCURRENCE AND DEVELOPMENT OF HEAD AND NECK TUMORS

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Mobile or cell phones might have the potential to cause certain types of cancer or other health problems. Mobile phones are known to generate heat and emit radio frequency radiation in the form of non-ionizing electromagnetic radiations in the range of 800-2,200 MHz, similar to many home appliances. Tissues nearest to where the phone is held can absorb this energy. Because cell phones are held directly against the head, there is a concern that cell phones may contribute to tumors of the brain, head and neck. These include benign tumors of the brain, malignant tumors of the brain, benign tumors of the hearing nerve, tumors of the salivary glands and oral cavity tumors as well as skin tumors of the head and neck region.

The aim of our study is to assess influence of mobile phone radiation for occurrence and development of head and neck tumors. The investigation was performed in multidisciplinary collaboration of pathophysiologists, pathologists, neurosurgeons and maxillofacial surgeons. Particularly designed questionnaires (including mobile phone use habits and mobile phone characteristics) are used for evaluation of risk factors for head and neck tumors. Hystopathollogical analysis was used to confirm influence of mobile phones to occurrence and development of tumors. The study confirms presence of correlation between usage of mobile phones and occurrence and development of tumors of the head and neck. If cell phones caused head and neck cancer, we would expect to see an increase in these kinds of cancers as cell phone use has dramatically increased.

DATA OF EMF MEASUREMENTS IN URBAN AREAS WITH HIGH DENSITY OF SOURCES AND SUCH WITH "SENSITIVE PLACES AND BUILDINGS"

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In the framework of the project BG07 Program: "Initiatives for public health," measurements and exposure assessments of electromagnetic field (EMF) levels in populated areas were planned. To fulfill the requirements set in the project, measurements were carried out in places "with a high density of EMF sources" as well as with "the existence of sensitive buildings and places", which led to the development of methods for the selection of measurement points in urban areas.

The developed methods are based on two approaches for selection - controlled and randomized.

The first method of "controlled method for the selection and designation of the points for measurement and evaluation of the electromagnetic field in populated areas" requires preliminary information about the location of the emitters, and an electronic geographical map as well.

The second method "Selection of points for measurement and assessment of EMF" in "sensitive buildings and places" requires information in advance concerning the location of sensitive buildings and places for a particular region, while no information for the emitters and distribution on the field is necessary.

The report presents the results of measurements in locations determined using two methods for the selection of points for the measurement of EMF in urban areas.

OCCUPATIONAL AND ENVIRONMENTAL EXPOSURE TO MAGNETIC FIELDS IN RESIDENTIAL BUILDINGS WITH BUILT-IN TRANSFORMERS

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The purpose of this study is to perform an exposure assessment of magnetic fields in apartment buildings with built-in transformer rooms located throughout the city of Sofia. This study was a part of the International project TRANSEXPO the aim of which was to find the epidemiologic association between extremely low frequency magnetic fields (ELF-MF) and childhood leukemia.

The paper presents the results of measurements of power frequency electric (EF) and magnetic fields (MF) performed in 43 randomly identified buildings with built-in transformers from all regions of Sofia. In each building, measurements were made in the following types of apartments: apartments that had rooms directly above and next to the transformer; apartments selected on the same floor as the ones directly above and next to the transformer; apartments on the upper floors randomly selected among all the other apartments of the building. Measurements were performed also inside the transformer rooms for exposure assessment of the personnel responsible for the technical maintenance of the stations.

The measurement results show clear differences among the magnetic field values measured in every one of the three categories of apartments, respectively 0,4 μT for the “exposed” apartments, 0,23 μT on the same floor, and 0,1 μT on other floors. The electric fields’ strengths do not show dependence on the apartment’s category.

The measured values of magnetic flux densities inside the transformer stations are in the range: 0.56 mT to 60 μT and depend on the measurement location. The highest values are found at the low voltage section of the transformer station. The electric field strengths measured inside the transformer stations are up to 208 V/m.

The exposure assessment in the buildings with built-in transformer stations shows that the apartments can be reliably categorized as exposed, low exposed or unexposed based on their location in relation to the transformer stations.

The measured values in transformer rooms are in compliance with limit values according to the National legislation and Directive 2013/35/EC (ICNIRP 2010).

Key words: Exposure assessment, transformer, built-in, magnetic field, electric field, measurement

THE EMF EXPOSURE OF THE GENERAL PUBLIC AFTER THE DIGITALIZATION OF BROADCAST TECHNOLOGY

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Bulgaria completed the process of the digitization of the broadcast system, regarding the Directive 2002/21/ EC of the European Parliament and of the Council from 7 March 2002, in September 2013. The aim of this report is to present the exposure assessment of EMF emitted from broadcast transmitters, after the digitalization of the equipment. The paper presents the exposure assessment procedure of the electromagnetic field (EMF) for TV and radio transmitters.

Calculation methods were used for a theoretical evaluation of the hygienic safety zone. The exposure assessment was made using non-selective and selective methods for measuring the EMF values.

The measured values of the electric field and power density in the regions of the emitters show compliance with the national legislation for protection of general public from RF EMF exposure. Higher values were measured in the close proximity to the facility where access of the general public is not permitted, so places where limit values for controlled (working) environment are applicable.

Key words: EMF, digitalization, exposure assessment, broadcast, limit values

THE ROLE OF MAGNETIC AND ELECTROMAGNETIC INTERACTIONS IN VIRUS INFECTIONS: IMPLICATIONS AND NEW OPTIONS FOR MEDICINE

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Participation of electromagnetic force in infection process and immune reactions is currently underestimated, underlying mechanisms are not understood. We've studied correlation between electric and biological features in Influenza virions and Influenza-specific antibodies. The electric charge of virions and antibodies was evaluated using free-flow electrophoresis method.

It was shown that the electrokinetic characteristics **(EKP)** of virus strains are relatively stable in standard permissive conditions. But short time passage of a virus population in presence of specific antibodies or an antiviviral drug cause alteration of the electric charge of virions. In other words, various limiting virus reproduction influences cause alterations in electric charge of virus particles. In most cases decrease of the virus infectivity supervened on appearance of the “charged” virions in viral population. Interrelation between the EKP of virions and immunogenicity of studied virus strain has been detected.

Average titers of strain-specific AB+ in human sera correlated with intensity of circulation of corresponding virus strain in the target human population. The bigger was average ratio (specific **AB+** titer / specific **AB-** titer) for studied virus the higher was probability that given influenza strain will cause epidemics during nearest season.

To explain the magnetic field effects on Influenza epidemic activity we've proposed that proteins of Cryptochrome family (**CRY**) represent the magnetic field-sensitive part of the epigenetic controlling mechanism. It is known that CRY are repressors of circadian transcriptional complex CLOCK/BMAL1 activity. At the same time, functional activity of CRY is highly responsive to weak MF because of radical pairs that periodically arise in the active site of CRY and mediate the radical pair mechanism of magnetoreception. The major circadian complex influences expression of genes related to NF-κB- and glucocorticoids- dependent signaling pathways. Therefore MFs are capable to alter the immune response and endocrine regulation that facilitate the epidemic spread of virus diseases.

Conclusions:

1) Formation of “charged” virions witnesses the viral population experience deadaptation.

2) Correlation between the EKP of virions and biological features of the virus strain has been shown.

3) CRY are unique proteins, which combines the MF-sensory and genome-regulatory functions. They act as mediators between living beings and their electromagnetic environment thanks to the radical pair mechanism of magnetoreception;

4) Biological reactions in leaving beings, including response to stress and infection depends on the function of the circadian transcriptional complex, which in turn may be regulated by magnetic fields, including the Geomagnetic field.

5) Estimation of electromagnetic properties of viruses and specific antibodies, as well as Geomagnetic data analysis could improve epidemiological prognosis, evaluation of virus isolates and vaccine strain selection.

NEUTRON AND HEAVY ION RADIATIONS

15

NEUTRON MATTER AND ITS PLACE IN THE PERIODIC SYSTEM OF ELEMENTS

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Neutron matter is principally different from other states of the matter and consists only of neutrons. The substance turns to the neutron state under ultrahigh pressure, which is still not available in laboratories. The neutron matter has the density close to nuclear one, which exists inside the neutron stars. Under transformation to the neutron state, the electrons of a substance unite with protons and they both convert to neutron (neutronization). Since the neutron matter can be regarded as a chemical simple substance, the question inevitably arises about the Element of neutron and its location in the Periodic System (PS). From the logic of Periodic Law (PL), which postulates that the atomic number is equal to the electric charge of nucleus, the atomic number of the neutron matter should be equal to zero, which brings to mind D.I.Mendeleev's ideas about the zero group and zero period in the PS. It is known [1], that D.I.Mendeleev assumed the existence of chemical elements X and Y, which should be located in the PS before Hydrogen. The element X (Mendeleev called it as Newtonium – "I would like to call it as Newtonium – to commemorate the immortal Isaac Newton"[1]) should be located in the zero period of zero group as the lightest analog of noble gases. Moreover, Mendeleev allowed the existence of one more element, which is lighter than Hydrogen – the element Y or Koronium (Crownium) [1]. The problem of "zero elements" is clarified if we expand the idea of "atom" – as a sum not only the electric charges, but other charges, too (baryon and lepton) [2]. Under such point of view, before Hydrogen one can locate Positronium (a pair of electron and positron), which has long been regarded as the atomic system, and Newtonium of Mendeleev as two isotopes – Neutronium (a pair of neutron and antineutron) and Neutrinium (a pair of neutrino and antineutrino). "The expanded charge" concept of an atom is discussed [2]. Beside the gravitation neutronization, other mechanisms of the neutron matter formation are discussed (condensation of ultracold neutrons and neutronization due to critical increasing of the atomic number of elements in PS). On the example of ultracold neutrons, it can be seen that they are already handled in the physical laboratories like the ordinary matter: they are stored in the vessels and "pumped" through pipes as a gas. The possibility of chemical interaction of ultracold neutrons with the elements with odd number of electrons is discussed. The broadening of PL beyond the boundaries of classical elements and the coverage of the expanded PL to a much broader area of matter of the Universe, based on the forgotten Mendeleev's ideas, are proposed. It is proposed that the neutron and its isotopes (dineutron, tetraneutron and so on) are the beginning of PS and neutron star matter is the end of PS.

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STUDY OF BIOLOGICAL EFFECTS INDUCED BY ACCELERATED ^{12}C IONS WITH ENERGY OF 450 MEV/N ON MICE *IN VIVO*

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In connection with the active space exploration and the search for new sources for the radiotherapy of tumors, the studies of the effects of low doses of radiation, which are characterized by a high LET, are currently of particular interest. Heavy ion beams have a better dose distribution in the target than photon radiotherapy and exert a more sparing effect on the healthy tissue near the tumor. The therapy with heavy charged particles becomes of more and more interest all over the world, and many medical centers tend to use heavy ion beams in radiotherapy. However, when irradiated to the Bragg peak, healthy tissues also experience a dose load that should also be taken into account.

The purpose of this study was to investigate the biological effects induced by accelerated carbon ions with the energy of 450 MeV/n to the Bragg peak in mice: the dose dependence of cytogenetic damage in the bone marrow, thymus and spleen cellularity, the induction of reactive oxygen species – ROS, in whole blood, and calculate the value of relative biological effectiveness (RBE).

Experiments were performed with male outbred albino SHK mice at the age of two months. The animals were kept under the standard conditions in the vivarium of the Institute of Theoretical and Experimental Biophysics (Russia). The mice were irradiated with U-70 particle accelerator at IHEP (Protvino, Russia) in a dose range from 0.1 to 2 Gy to the Bragg peak. We used the pulsed radiation mode (one pulse per 8 s). For comparison, the other group of mice was irradiated with X-rays (1 Gy/min, Pushchino, Russia) at the same dose range. Sham-irradiated animals were used as controls. The gafchromic EBT3 films (USA) and neutron monitor were used for the carbon beam profile verification and dose control. The level of cytogenetic damage in the bone marrow was assessed using the micronucleus test, the level of ROS production was assessed in whole blood using luminol-dependent chemiluminescence, and the cellularity of the thymus and the spleen was estimated by the index of mass.

The study of the biological effect of carbon ion irradiation in the dose range from 0.1 to 2 Gy on mice *in vivo* showed that the dose dependence of the yield of cytogenetic lesions in the bone marrow was nonlinear, the thymus and spleen index of mass was considerably reduced as compared to unirradiated mice, the level of ROS was increased and that the X-ray irradiation at the same dose range led to the reduction of thymus and spleen index of mass at the doses of 1.5 and 2 Gy. The average value of RBE for the accelerated carbon ions with the energy of 450 MeV/n in the investigated dose range was from 1.3 to 2.4.

ESTIMATION OF HEAVY IONS LET FOR SEE TESTING OF ELECTRONIC COMPONENTS USING ROSCOSMOS TEST FACILITIES

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Influence of space heavy charged particles is one of the main origins for uprising of upsets and failures in the modern electronic components for spacecraft equipment and systems. These effects occur when single charged particle hits in sensitive volume on the semiconductor chip and names single event effect (SEE). The main features that describe level of hardness to SEE are the value of linear energy transfer (LET) when effects starting to appear (threshold LET), the saturation cross-section of effects and also the dependence of cross-section from LET (usually Weibull curve). To determine features of hardness to SEE it is necessary to carrying out testing using heavy ions accelerators. At present time, in Russia, test facilities for SEE testing of electronic components and equipment were created and put into operation. These facilities are based on accelerators U-400 and U-400M and located in Dubna city, Moscow region. Two types of facilities are used for SEE testing – with low (3-6 MeV/nucleon) and high (20-60 MeV/nucleon) initial energy of particles.

In order to define dependence of cross-section effect from value of LET it is needed to register not less than four points with effects during test campaign. With the facilities of low initial energy we use four different types of ions with specific LET to obtain four experimental points. The most common combination of ions is Xe; Kr; Ar; Ne with LET approximately 69; 40; 15; 6 MeV cm^2/mg. The exact values of LET for each ion are determined on the basis of initial energy which is measured after the output of each ion.

The peculiarity of testing with low energy ion beams is necessity of vacuum ion guide tube and test chamber. This is a prerequisite for the delivery of ions from source to device under testing with no loss of energy. Thus, by measuring initial energy in vacuum tube (channel) we obtain the data to following LET calculation. Another feature of systems with low energy is a low range of ions in materials of electronic components (30-40 mkm). Therefore, decapsulation of electronic devices is required for SEE testing in order to ensure impact of heavy ions to open die (with no package). For the most of modern electronic components such range of ions is sufficient to achieve sensitive volume of chip, since the thicknesses of the passive layers (passivation, metallization, etc) is no more than 15 mkm. The information about type of ion and its initial energy is used for LET calculation. For LET estimation SRIM software is applied. A significant disadvantage of low energy facilities is long changeover time from one ion to another (from 6 hours for gaseous to 24 for metals), therefore the cost of tests increase.

The test bench with high initial energy differs from low-energy facilities by more powerful ion injector. With increasing of initial energy, the increasing of ion range and reducing of LET are observed. However, through reducing of the initial ion energy we can achieve similar values of LET in comparison with low energy facilities and a significant growth in particle range (from 200 up to 2000 mkm for different LET). This allows us to test devices with a deep depth of sensitive volume or samples which cannot be fully decapsulated. Moreover, for obtaining several values of LET we do not need to change type of ion, so, for getting four experimental points we need only two ions. Since the change of initial energy in accelerator in short time is impossible, special thin foils (or stack of foils) are used. In this case, the information about type and initial energy (in channel) and also about material and thickness of energy absorber is used for LET calculations with SRIM software. In full version of this work, the analyses of available LETs and ranges for different ions and they initial energies we will be presented. Also, the estimation of evaluation errors will be discussed.

$BaCe_{0.85}Y_{0.15}O_{3-\delta}$ BASED MATERIALS FOR SOLID OXIDE FUEL CELLS: NEUTRON DIFFRACTION STUDY

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Solid oxide fuel cells (SOFCs) offer a promising green technology of direct conversion of chemical energy of fuel into electricity. Among the families of metal oxides, which can be successfully used as electrodes (cathodes or anodes) in SOFC, certain members of the large family of transition-metal oxides with perovskite structure ABO_3were found very prospective to fulfil most of the features required for preparation of mixed ionic-electronic conductor (MIEC) oxide materials for SOFCs 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. The characterization of the chemical composition and stability, oxygen stoichiometry and cationic ratios of each synthesized phase is of great importance to understand the defect-chemistry that would govern the transport properties. We report on oxygen-deficient $BaCe_{0.85}Y_{0.15}O_{3-\delta}$ (BCY15) perovskites prepared by auto-combustion with following calcination at high temperature. The structural details of powder, dense and porous samples of materials based on $BaCe_{0.85}Y_{0.15}O_{3-\delta}$ (BCY15) were investigated from full profile analysis of neutron and x-ray diffraction patterns. The materials were used recently as cathode, anode and central membrane in an innovative monolithic design of SOFC.

NUCLEAR MEDICINE 16

CASE STUDY OF IMPROVED IMAGING WITH DATSCAN AFTER DEEP BRAIN STIMULATION IN PARKINSON'S DISEASE

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Parkinson's disease (PD) is a progressive neurodegenerative movement disorder which is primarily characterized by bradykinesia, muscular rigidity and tremor.

We reported the "DAT scan in diagnosis of idiopathic Parkinson's disease in our hospital" at the Third RAD conference.

We found the case of improved imaging on DAT scan after deep brain stimulation in idiopathic Parkinson's disease among them.

We report this case and discuss about the dopaminergic system and furthermore the possibility of observation for DAT scan imaging on other therapies, such as stem cell therapy, in the near future.

INTERMITTENT USAGE OF ZOLENDRONIC ACID AND PAMIDRONATE BETWEEN RADIONUCLIDE THERAPY COURSES

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Introduction: Bisphosphonates are widely used for treatment in bone metastasis. To prevent bony complications in metastatic cancer, it must be used long enough. However, bisphosphonates application might cause serious side effects that should be considered with high importance for patients receiving courses of radionuclide therapy. Two bisphosphonates have mild side effect profile – zolendronic acid and pamidronate (Maltzman J.). To prevent cumulative toxicity, these bisphosphonates were administrated in rotation between radionuclide courses.

Materials and methods: The results of 14 patients' treatment — 8 females with multiply bone metastasis of breast cancer and 6 males with multiply bone metastasis of prostate cancer were analysed. Average patients' age: females -~ 57.5; males ~ 61.5. Zolendronic acid (4mg) and pamidronate (90 mg) were administrated according to the regular instruction (once per month during 3-4 months). The dosage depended on calcium levels in plasma and creatinine clearance. At the same time, calcium and vitamin D (in zolendronic) or calciotonine (in pamidronate) were administrated between courses. The course of radionuclide therapy (Sm ^{153}-oxabifor 55.5-74 Mbq/kg or Sr ^{89} cloride 150 Mbq or P ^{32} phosphat natrium 370-420 Mbq) followed the bisphosphonate course. Zolendronic acid or pamidronate was administrated not early than 3-4 weeks after the radionuclide course. The repetitive course of radionuclide therapy was conducted 3-4 months after (before that, 3-4 doses of exact bisphosphonate were received once per month). Finally, all patents got from 3 to 4 courses of radionuclide therapy following the same treatment scheme.

Results: The patients treated with the intermittent usage of zolendronic acid and pamidronate admitted the reduction of pain symptoms earlier than other patients (receiving the only bisphosphonate during the whole period of radionuclide treatment); the reduction of pain intensity by the VRS scale and Karnofsky scale was from 30-40 to 60-70 in average. Scintigraphic control — positive shifts were registered in 7 patients with decrease of focuses and intensity reduction; 5 patients — stabilization of the process and prolongation in 2 patients. The quality of life improvement (10-20% higher vs. non-intermittent group), no pathological bone fractures in all patients, as well as the prolongation of the remission period for 2.5 months in average was registered during 12-18 months' tracking period. No critical renal or dentical complications were determined during the observation period.

Conclusions: The intermittent usage of zolendronic acid and pamidronate between radionuclide therapy courses of multiply bone metastases demonstrated higher efficiency vs. mono-bisphosphonate approach. The most probable reason behind higher efficiency of the intermittent usage of new low-toxic generation bisphosphonates is lower cumulative toxicity.

THE ASSESSMENT OF ABSORBED DOSE IN RADIONUCLIDE THERAPY

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The radionuclide therapy (RT) is one of the most fast developing fields of nuclear medicine, it is based on administration a radiopharmaceutical (RP) drug directly to the pathological lesion in the patient's body, it is supposed to radiate the tumor with tolerant level of radiation of other tissues. However, one of the most significant problems in the RT is control of absorbed dose in the tumor sites, accumulating RP α-, β- and γ-emitting radionuclides. Such control is necessary not only for evaluation of therapeutic effect of RT, but also for estimation of absorbed dose in distant metastases, which is important for subsequent external beam radiotherapy planning.

For calculating cumulative local dose in our study, we propose a scheme of calculation of absorbed dose in the tumor, based on simulation results with MCNP code of scintigraphic research of pathological area on gamma camera section of patient's body. Stages of obtaining the necessary data includes simulation scintigraphy gamma-chamber vial with administered to the patient activity of RP, located at a fixed distance from the collimator, and conducting a similar study with identical geometry measurements and the same value of the activity of radiopharmaceuticals in the pathological site in patient's body. For obtaining such calculation results in the MCNP code was modeled adapted Fischer-Snyder human phantom. The calculation was performed for different sizes of pathological sites and different depths of tumors.

Based on the obtained data, several mixed-β-γ-emits (^{131}I, ^{177}Lu) and pure β-emitting (^{89}Sr, ^{90}Y) therapeutic radionuclides showed increasing of counting rate of detector concomitant with increasing of the size of the tumor site and its depth, at constant input RP activity. We also obtained correction factors for absorption and scattering of radiation of radionuclides for different radiation energies and efficient energy of the bremsstrahlung spectrum, different depths of occurrence and quantity focus that provides the basis for the new approach to radionuclide therapy dosimetry planning.

PREPARING FOR A CLINICAL DRIFT OF PET/CT, AN EXAMPLE FROM NORWAY

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The challenge of installing and starting clinical operations of PET/CT in a hospital requires cooperation from a multidisciplinary team. This is well described by the AAPM Task Group 108 and IAEA [1,2]. When not only the PET/CT modality is new to the department, but also the entire hospital facility is new, even greater efforts are required in order to successfully begin clinical activity. At the new Østfold Hospital Kalnes, the decision to install a PET/CT in the nuclear medicine department required starting from scratch in every possible way. The decision to install a PET/CT was made after designing and planning a room for SPECT/CT, which meant modifying the physical buildings of the new hospital during a late phase of construction. Shielding had to be increased in order to accommodate positron annihilation radiation energy. Østfold Hospital Kalnes had the opportunity to choose among three manufacturers of PET/CT machines. In order to decide which machine to purchase, extensive research and evaluation by a multidisciplinary team was necessary. The team had to choose a machine that will be suitable for the present and future ambitions of the hospital. The staff of the nuclear medicine department is well experienced in clinical SPECT/CT, but nobody had previously worked with PET/CT. Training became a critical part of preparing for the installation and clinical implementation of a new modality. Department seminars highlighted radiation safety and clinical PET/CT protocols, and visits to other hospitals were made in order to observe clinical routines and quality control procedures. Since Østfold Hospital Kalnes is not a university hospital and is completely new to PET/CT, it was decided to join the EARL FDG quality assurance program from the European Association of Nuclear Medicine. Participation in EARL will enhance confidence in both the staff and the public because accreditation shows that the department performs PET/CT studies at a level that is comparable to university hospitals that have a long clinical history with clinical PET/CT. The program will also increase possibilities for collaboration and research.

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A COMPARATIVE SURVEY OF THE AWARENESS LEVEL OF WORKING DOCTORS AND MEDICAL STUDENTS IN THE HAMADAN PROVINCE CONCERNING THE MEDICAL RESPONSE AND PREPAREDNESS IN NUCLEAR ACCIDENTS

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Introduction: as a result of ever-increasing use of nuclear technology in various fields, increasing the awareness for coping with nuclear and radiation accidents as a part of the care education becomes a requirement. The objective of this study is survey of the awareness level of working doctors and medical students in Hamadan province concerning medical response and preparedness in nuclear accidents.

Methods: in this descriptive cross-sectional study, the awareness levels of 132 working doctors and medical students of Hamadan were compared by use of a researcher-made questionnaire consisting of two parts. The data concerned were analyzed utilizing SPSS 16 software, the descriptive statistics, and Chi square correlation test and/or Fisher exact test.

Findings: in this study, 49% of working doctors and 51.9% of students were male. The doctors' awareness regarding the consequences of a nuclear accident and acquaintance with special therapeutic protocol for the nuclear injured was significantly more than that of the students. None of them had significantly attended any training courses and both groups considered attending specialty training courses for acquaintance with nuclear accidents as necessary.

Conclusion: considering the results of this study, the awareness level of working doctors and medical students regarding medical response and preparedness in nuclear accidents is not acceptable. Therefore, inclusion of topics related to radiation accidents in the syllabus of medical students and, as well, planning for continuous education of working doctors appears to be necessary.

Key words: Ionizing radiation, nuclear accidents, the nuclear injured, medical response

CLINICAL EXPERIENCES WITH TC-99M RENAL SCINTIGRAPHY

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Ionizing radiation, such as x-ray or gamma ray, is used routine in hospitals and clinics for creating diagnostic imaging procedures. Gamma rays are ionizing radiation, and they are thus biologically hazardous. Nuclear medicine uses gamma rays which come from radiopharmaceutical used for making diagnostic imaging. Radiopharmaceuticals are agents used to diagnose certain medical symptoms or treat certain diseases. Radiopharmaceuticals are given to the patient in several different ways – they may be given by mouth or given by injection. In this work, we used Tc^{99m} at a nuclear medicine clinic. Tc^{99m} is given to patients through an injection under the direct supervision of a doctor with the specialized training in nuclear medicine. In this work, we performed this routine examination in nuclear medicine. Firstly, we noted injection radiation doses which come for diagnosis in the nuclear medicine clinic. Later, patient radiation doses were measured with a dosimeter.

CARDIAC NUCLEAR MEDICINE PROCEDURES AND RADIATION EFFECTS

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Nuclear medicine imaging uses safe, painless and effective techniques to image the body. Recently, nuclear medicine is playing an important role in medical imaging and the number of nuclear medicine examination is sharply increasing. Nuclear medicine uses small amounts of radioactive materials and traces their move on your body. This technique is originally detection of gamma photons emitted by radionuclide injected. In nuclear medicine protocols, radioactive agent give to patient, agent move on organ, image of organ scan and the end patient image with camera. In all this protocol patient and workers may take radiation. The aim of our study was to estimate effective dose from most common procedures performed in nuclear medicine departments. Data of nuclear medicine procedures performed in nuclear medicine departments during 1 month.

RADIATION DETECTORS 17

NEWLY-GENERATED NUCLEAR RADIATION SENSING FIELD EFFECT TRANSISTOR (NÜRFET) FOR IRRADIATION DETECTION

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The initial device characteristics, Co-60 gamma irradiation response and fading characteristics of Nuclear Radiation Sensing Field Effect Transistor (NürFET) fabricated in NÜRDAM-Turkey were investigated. Various gate oxide thicknesses were studied and obtained results were compared with commercial 400 nm implanted gate oxide RadFETs. The results demonstrate that the initial trap densities of NürFETs are convenient for microelectronic technology and that the sensitivity of devices increases with increasing the gate oxide thickness. The fabricated NürFETs exhibit almost similar fading behaviors with RadFETs. In addition, good or even better linear ΔV_{th}- dose relations were observed for NürFETs than for RadFETs. Consequently, NürFETs have promising potential to be used in gamma-ray irradiation measurements.

A DETAILED STUDY OF THE RADIATION RESPONSE OF Er_2O_3 MOS CAPACITOR UNDER ZERO GATE BIAS

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The MOS based radiation sensors/dosimeters have been widely used in different areas, such as space applications, high energy physics experiments, and radiotherapy. The studies on sensors have continued in different aspects, such as the determination of the average deposited energy in the gate oxide by Monte Carlo simulation, investigation of the alternative gate dielectrics to traditional SiO_2, and evaluation of the dosimetry aspects of different oxides.

The aim of this study is to investigate the usability of Erbium Oxide (Er_2O_3) in radiation sensors. For this purpose, Er_2O_3 film was deposited on a p type Si (100) wafer by RF magnetron sputtering and these films were annealed at 500 ^oC under N_2 ambient. After that, Al/Er_2O_3/Si/Al MOS capacitors were fabricated. After that, these capacitors were irradiated under ^{60}Co radioactive source in a dose range of 4-76 Gy. Capacitance-Voltage (C-V) and Conductance-Voltage (G-V) curves were obtained at 100 kHz. The sample description was made by the XRD, FTIR, and AFM analyses. The XRD and FTIR results show that there is no Erbium silicate formation in the structure. The dielectric constant of the film was calculated from 1 MHz measurements as 12.22. The bidirectional shift in the flat band voltages was observed: to right side compared to ideal one in the dose range of 4-16 Gy and to left side after 16 Gy. The variation of the flat band voltages decreased with increasing dose range due to the electric field screening that occurred at high doses. Therefore, the linearity of the flat band voltage shifts as a function of the applied dose showed different behaviour in the dose ranges of 4-16 Gy and 16- 76 Gy. The oxide trapped charge density was increased with increasing irradiation dose. The interface states remained in the order of 10^{10} eV cm^{-2} in the studied dose range. This result showed that the applied radiation dose did not cause a significant degradation in the capacitor. The calibration of the capacitor was determined using flat band voltage shifts. The values showed that the Er_2O_3 MOS capacitor was more sensitive to gamma radiation compared to SiO_2 and Sm_2O_3 based capacitors.

LUMINESCENCE STUDY OF NEODYMIUM-DOPED CALCIUM SULFATE

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Different rare earth elements (REE) doped calcium sulfate ($CaSO_4$) based dosimeters are being used in personnel dosimetry, such as $CaSO_4$:Dy and $CaSO_4$:Tm. In this paper, optically stimulated luminescence (OSL) characteristics of $CaSO_4$:Nd crystalline prepared by the precipitation method was studied. The structure of the produced $CaSO_4$:Nd powder was characterized using the SEM-EDX method. The effect of the heating rate (HR), preheat and reusability properties were investigated after beta (β) irradiation. Furthermore, thermoluminescence (TL) glow curves were recorded and TL glow peaks of $CaSO_4$:Nd were determined after the preheat process at 90^{o}C.

Key words: Optically-stimulated luminescence, doped calcium sulfate, REE, thermoluminescence, preheat

THERMOLUMINESCENCE PROPERTIES OF ANHYDROUS SODIUM SULFATE

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In this study, thermoluminescence (TL) properties of anhydrous sodium sulfate (Na_2SO_4) were studied. These TL properties include the dose response of Na_2SO_4 for beta (β) irradiation, reusability, TL kinetic parameters, and short-term fading. All TL measurements were carried out on three aliquots of 40±0.15 mg samples by using a Risø TL/OSL DA-20 reader. Irradiation was performed with a $^{90}Sr/^{90}Y$ β source, which has 40 mCi activity (dose rate: 6.689 Gy/s). TL glow curves were recorded up to 250 °C in nitrogen atmosphere at a constant heating rate of 5 °C/s. The Na_2SO_4 samples exhibit a prominent glow peak at 100 °C along with a shouldered peak at 150 °C. It was observed that the intensities of these low temperature TL peaks increase linearly with the β-dose. The activation energy (E), order of kinetics (b), and frequency factor (s) of the samples were determined using the computerized glow curve deconvolution (CGCD) method after being exposed in different β doses.

Key words: Thermoluminescence, sodium sulfate, dose response, reusability, fading.

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THALLIUM BROMIDE SEMICONDUCTOR CRYSTALS GROWN VIA VERTICAL TRAVELING MOLTEN ZONE METHOD FOR FABRICATING GAMMA-RAY DETECTORS

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Thallium bromide (TlBr) has high atomic numbers (Tl: 81 and Br: 35), a high density (7.56 g/cm^3), and a wide bandgap energy (2.68 eV). Therefore, it is suitable for gamma-ray spectrometry operating at room temperature. To obtain TlBr crystals with high purity and high charge collection efficiency, the multipass zone refining and the horizontal traveling molten zone (HTMZ) methods have been typically combined. HTMZ facilitates TlBr crystals growth, since the purification and growth are performed at the same horizontal zone-refining furnace. However, the TlBr crystals' diameter is limited to approximately a half of the inner diameter of the ampoule. To overcome this problem, in the present study, the vertical traveling molten zone (VTMZ) method was applied instead, thereby producing TlBr crystals with a large diameter. TlBr crystals were grown using both HTMZ and VTMZ from purified material, and TlBr detectors were fabricated from each crystal. The detector's performance and crystallinity were evaluated, in each case, from gamma-ray energy spectra and X-ray diffraction patterns.

DEVELOPMENT OF SILICON STRIP DETECTORS OF NUCLEAR RADIATION WITH ORTHOGONAL FIELD

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The solution of many problems of modern science and technology in experimental nuclear physics requires the creation of new and improvement of existing devices for the registration of nuclear radiation. In recent years, it is becoming more widely to use semiconductor detectors (SCD) based on silicon, germanium and compound semiconductor type compounds as A^3B^5 and A^2B^6. Among the broad class of nuclear radiation detectors based on semiconductor crystals, silicon-lithium detectors occupy a special place.

The development of semiconductor strip detectors with orthogonal field with high energy and position resolution, linearity of the signal over a wide energy range for various types of particles, is closely connected with the production technology of the detector modules and properties of the original semiconductor crystal. This paper deals with physical and technological features of the manufacture of Si (Li) strip detectors with orthogonal field with a large sensitive area.

The disadvantages of existing semiconductor strip detectors are that they do not have high position resolution, as well as the impossibility of combining the thin entrance window with a sufficient thickness of the sensitive area. Processing methods for creating resistive layers and modes are not covered enough in technical literature. The identity of the elements of discrete strip detectors with orthogonal field and characteristics of resistive layers of continuous strip detectors caused by the initial parameters of the semiconductor in particular coordinate the distribution of inhomogeneities in the volume and nature. If spectrometry heterogeneity manifested in the form of large-scale traps, but their nature and coordinate distribution of the track remain undetected. The known correlation of the effective dimensions of inhomogeneities and their spectrometric characteristics of the detectors is not investigated in the working conditions of detectors with orthogonal field.

The investigation of various defects in semiconductors, to control the possible management of their concentrations, have fundamental importance in the development of high-quality semiconductor strip detectors with orthogonal field and with large amounts of sensitive area, as these characteristics ultimately determine the coordinate and computing spectrometric characteristics of these devices.

Consequently, we will report the creation and optimization technology of strip detectors with orthogonal field on the basis of Si (Li) p-i-n structures with, big area of workspace. The results of the energy resolution of these detectors are measured by using a source of ^{226}Ra - α particles and ^{207}Bi- β particles.

FLEXIBLE ORGANIC X-RAY DETECTORS

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In recent years, the first studies on the employment of organic materials as direct detectors of ionizing radiation, i.e. its direct conversion into an electrical signal, have been proposed and we reported about the performances of solution-grown Organic Semiconducting Single Crystals (OSSCs) as direct X-ray detectors, operating at room temperature and in the atmosphere, showing a stable and linear response with increasing dose rate [1]–[3]. The results obtained so far with organic single-crystal based detectors have paved the way not only to a deeper understanding of the X-ray photon-to-electron conversion processes in organic materials, but also to the development of a new class of organic-based direct detectors with higher performances. Therefore, in order to easily scale the dimensions of our detectors and to exploit the light weight, simple processability, and mechanical flexibility of organic materials, we are now focusing on the study of devices fabricated by the employment of easy, low cost wet-technologies (e.g. drop cast, inkjet printing, solution sharing), over flexible substrates (e.g. polyethylenetherephtalate (PET), Kapton). Indeed, the possibility to cover large curved surfaces is of great technological interest in the cultural heritage and medical 3D imaging for the determination of dose distribution on artworks and patients' body. Organic small molecules are suitable candidates for this purpose for their excellent solubility in several common organic solvents and their processability at low temperature (few tens of °C), which allow us to employ thin plastic flexible foils as substrates. We will report about the results on the employment of organic thin films based, fully bendable, devices as direct X-ray detectors, obtaining sensitivity values up to several hundreds of nC/Gy at very low bias of 0.2 V. We also assess the possibility to use the detector under the mechanical strain and give the first demonstration of a 2×2 pixelated matrix organic detector.

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THERMAL COMPENSATION FOR DMOS TRANSISTORS USED AS REAL TIME DOSIMETERS IN ELECTRON BEAMS

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Introduction. Intra-operative radiotherapy (IORT) is a complementary technique that consists of applying an electron beam just after the tumour extraction during surgery in order to kill the residual tumour cells. The dose is delivered in only one session with the patient on the stretcher, thus an error in dose cannot be corrected in followings sessions. Commercial lateral transistors have been used as dosimeters due to their linear response and easy thermal compensation, using one current where the thermal dependence is minimal (I_{ZTC}) or three currents as we showed in our previous works [1][2]. However, the I_{ZTC} was not found in DMOS transistors, thus these thermal compensation algorithms cannot be applied. In this work, the use of the parasitic diode of DMOS is presented, as well as its application for the thermal compensation in electron beam dosimetry.

Experimental setup and reader unit modifications. The thermal characterization was carried out placing the devices into a climate chamber model VCL4006 Vötsch and obtaining the I-V curves with an Agilent B1500 semiconductor analyzer. The transistors were irradiated with a LINAC Mevatron KDS (Siemens, Germany) that produces electron beams of 6, 8, 10, 12 and 15 MeV with a radiation field of 10x10cm^2 and without buildup layers. The response of two types of commercial DMOS was studied, the BS250F and ZVP3306. During irradiation, the transistors were biased with 20V to improve their sensitivities. The reader unit presented in previous works [1][2] was modified in order to activate the parasitic diode. The anode is connected to the drain and the cathode to the source, thus it can be activated using a current sink. In our case, a current sink of 100 µA was used to measure the diode voltage (Vd), and then the real temperature of the silicon die was obtained. During irradiation, the reader unit was placed into the bunker and connected with a PC via USB cable extension. The source voltage (Vs) and Vd were measured every 4.5 s, and stored into a PC. Vs is measured at 100µA drain current, where the thermal dependence was minimal, but not zero (around 2.24 ± 0.02 mV/°C for both types). The DMOS was soldered on a PCB with two JFETs, one between the gate and drain (JFET G-D), and the second connecting the source and drain (JFET S-D) in order to short-circuit the terminals of the transistors in different situations:

- Storage state: JFET S-D ON; JFET G-D ON. Source and drain currents OFF.
- To measure Vs: JFET S-D OFF; JFET G-D ON. Source ON, sink OFF.
- To measure Vd: JFET S-D OFF; JFET G-D ON. Source OFF, sink OFF.
- Bias state: JFET S-D ON; JFET G-D OFF. Source and drain currents OFF.

Preliminary results and conclusions. The activation of the diode did not affect the response of the transistor to radiation. Concerning the two DMOS types studied, two transistors per type were irradiated, and ZVP3306 and BS250F reported very similar sensitivities with 6 MeV beams, (7.44 ± 0.15) and (7.33 ± 0.18) mV/Gy respectively. Due to statistical distribution in the set of 5 transistors per type analyzed, the thermal error in dose with electrons of 6 MeV was 1.4 cGy/°C for the ZVP3306 and 4.0cGy/°C for the BS250F. More beam energies and devices will be analyzed in following studies.

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DETERMINATION OF NATURAL CALCIUM FLUORITE TRAP DEPTHS

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Natural calcium fluorite crystal generally has four thermoluminescence (TL) glow peaks around 100°C, 120°C, 190°C and 300°C for a irradiated sample. In this study, the trap depths of natural calcium fluorite sample for 190°C and 300°C TL peaks were determined. In order to determine trap depths computerized glow curve deconvolution (CGCD), various heating rate (VHR) and peak shape (PS) method were used. All TL measurements were carried out on three aliquots of 20±0.10 mg samples by using a Harshaw QS 3500 manual type reader that was interfaced to a PC where the signals were stored and analyzed. Sample was irradiated at room temperature using the β source from a calibrated $^{90}Sr/^{90}Y$ β (≈0.04 Gy/s). TL glow curves were recorded up to 400°C at a constant heating rate of 1°C/s.

Key words: Trap depth, thermoluminescence, calcium fluorite, CGCD, VHR, PS.

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PLASTIC SCINTILLATIONS RESEMBLING LED DRIVER

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A custom LED driver producing light pulses with very low intensity and O(10 ns) length was designed and constructed. A microcontroller was employed to handle the amplitudes and the repetition rates of the output pulses. In addition, it also provided both a PC control of the system through a RS232 interface and an external trigger I/O. The LED driver was used to study and characterize scintillation photodetectors.

THE PADME TRACKING SYSTEM

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The Positron Annihilation into Dark Matter Experiment (PADME) at LNF-INFN Linac aims to perform a search for dark photons in positron-on-target annihilation process. A key component of the setup is the tracking system which allows to veto the bremsstrahlung induced background. Different solutions for the detector will be shown. An attention will be paid to the possibility to construct a hybrid tracker based on plastic scintillator fibers read out by CCD matrices. A complete study of the dark current, bias and noise of an astronomy CCD was performed at different temperatures. An analytic model describing the response of the CCD was developed. The results and the possible application of a CCD as a detector for light from plastic scintillators due to ionizing radiation will be discussed.

THE NEW EMERGING TECHNOLOGIES AND MATERIALS: GRAPHENE BASED SENSORS

Gordana Medin

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Graphene has emerged as one of the strongest candidates for post-silicon technologies. One of the most important applications of graphene in the future is sensing of particles of gas molecules, biomolecules or different chemicals or sensing of radiation of particles like alpha, gamma or cosmic particles. In this paper the focus is given to basic science understanding how ionizing radiation (gamma rays, alpha-particles, neutrons) and associated charged particles interact with nano-materials/structures based on graphene, which was reported to show extreme sensitivity to local environmental perturbations. Thus we want to bring the scientific foundation that may lead to graphene based radiation sensors. The interactions of ionizing radiations with various nanomaterials based on grapheme (hybrid materials), whose exceptional properties may enable remote detection of fissile materials with great sensitivity are explored too. Several unique properties of graphene such as its extremely small thickness, very low mass, large surface to volume ratio, very high absorption coefficient, high mobility of charge carriers, high mechanical strength and high Young's modulus make it exceptionally suitable for making sensors. We review the state-of-the-art in the application of graphene as a material and radiation detector and give proposal for a new multi detector set up based on pulse discrimination and coincidence mode.

INVESTIGATION OF RADFET RESPONSE TO X-RAY AND ELECTRON BEAMS IN REFERENCE CONDITIONS

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Radiation-sensitive field effect transistor (RadFET) has found various applications in fields such as space radiation measurements, high energy physics experiments, and radiotherapy. The advantages of these sensors over the traditional dosimeters are small size with immediate, non-destructive read-out, low power consumption, wide dose range, and compatibility with microprocessors.

As the result of the interaction of radiation with the oxide (commonly used SiO_2), number of defects/trap centres occur in the SiO_2 and at the SiO_2/Si interface. Basically, after irradiation, the electrons are very mobile and quickly move to the metal contacts, while the motion of holes is much slower compared to electrons and the holes escaping from initial recombination are trapped at these centers. Therefore, the net oxide charge is positive after irradiation and the threshold voltage of the sensor shifts towards more negative voltages.

The Monte Carlo simulation and experimental results on the average deposited energy in the gate oxide of the p-channel MOS transistors showed that sensitivity of the sensor changes depending on the radiation type and its energy. Therefore, investigation of the responses of the RadFETs to X-rays and electrons is aimed in the present study. In addition to this, the influences of fixed oxide traps, switching oxide traps (slow switching traps) and switching traps at the Si/SiO_2 interface (fast switching traps) on threshold voltage shift have been analysed and the fading characteristics of the sensors determined.

The RadFETs with 400nm gate oxide manufactured by Tyndall National Institute were used in the experiments. The sensors were protected against electrostatic charge during the experiments and characterized under zero bias condition. RadFETs were tightly placed into the water equivalent phantom (30x30x13 cm^3) and their surface was closed with the build-up layers made of water equivalent material (RW3) to ensure the charged particle equilibrium at the sensitive region. The RadFETs were irradiated with 6 MV X-rays, and 10 MeV and 18 MeV electrons by the linear accelerator (Elekta-Synergy platform) used for radiotherapy treatments. Dose verification was provided with IBA-FC65P ionizing chamber. For all the irradiations, RadFETs were located at the isocentre, at 100 cm from the source, and irradiation field was 10x10 cm^2. The distances from the surfaces of the sensors at which the maximum dose was observed were 1.6 cm for 6 MV X-rays and 2.0 cm for the electrons.

The experimental results showed that the sensitivity of the device increased with increasing electron energy due to more energy transfer to the gate oxide. The fading showed close to linear behaviour in the studied time period for all sources. It was demonstrated that the fixed oxide traps are responsible for a larger portion of the threshold voltage shift than the switching traps.

DEVELOPMENT OF IN-VIVO DIAMOND AND RADFET DOSIMETRY FOR BRACHYTHERAPY

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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 mainly single crystalline diamond detectors and RadFET switch 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. Sensors were mounted on a thin flexible hybrid circuit of small dimensions and dedicated multi-channel readers were developed for reading out the sensors in a fast and controlled way. Results from tests performed on the test bench and with the therapeutic source in phantom will be presented.

PREDICTING THE RADIATION LEVELS IN THE CMS EXPERIMENTAL CAVERN

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The Compact Muon Solenoid (CMS) experiment is a particle physics detector situated on the Large Hadron Collider at CERN. Monte Carlo Simulation codes FLUKA and MARS are used to predict potential radiation damage and background hit rates in the CMS sub-detectors, to optimise shielding designs, and make estimates of the residual radiation environment. The aim of this paper is to describe recent developments to the CMS FLUKA model, with a focus on its optimization for activation simulations. Estimates of the absorbed dose over the lifetime of the detector, the expected fluxes during nominal running conditions and the predicted activation levels during various 'shutdown' periods are presented. Measurements of the radiation levels due to the prompt radiation field and the residual activity are compared with simulated events.

SENSITIVITY OF STANDARD AND STACKED RADFET DOSIMETERS

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Radiation Sensing Field Effect Transistors (RADFETs), also known as MOSFET dosimeters, are discrete p-channel MOSFETs with the gate oxide engineered for increased radiation sensitivity. RADFETs are small, require very little or no power during operation, read-out is simple and non-destructive, and their electronic signal is suitable for integration with the electronics systems. For these reasons RADFETs have found applications in quality assurance of radiotherapy, dose monitoring in high energy physics laboratories, accidental personal dosimetry, and space. Lower dose applications, such as e.g. occupational personal dosimetry and radiology, are currently out of reach owing to inherent sensitivity limits of the standard RADFET technology.

Tyndall National Institute has been involved in RADFET research and development, fabrication, and commercialisation for several decades and has acquired significant experience in the technology and applications. This paper presents Tyndall recent efforts in RADFET manufacturing and characterisation for different applications and discusses possible approaches towards increased sensitivity of the technology, including standard and stacked RADFETs.

RADIATION EFFECTS 18

THE BODY BIAS EFFECTS ON THE SINGLE-EVENT-TRANSIENT OF SILICON-ON-INSULATOR CMOS TECHNOLOGY

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The reverse body bias increases the threshold voltage of MOSFETs, while the forward bias decreases the threshold voltage. This effect can be used to lower the standby power or increase the speed of VLSI circuits. This technique can be utilized in circuits intended for space applications, where the power is a key consideration. Few publications, however, have discussed how the body bias influences radiation-generated SETs of SOI CMOS technology.

Transistors in TCAD simulations are based on Partially Depleted Silicon-on-Insulator (PDSOI) 0.18 μm CMOS technology. The top silicon film thickness is about two times than the junction depth. So the well contacts can be utilized to control the body bias of transistors. In this study, NMOS threshold voltage increases from 0.30 V to 0.93 V with the body bias from 0.6 V to -1.8 V, while PMOS threshold voltage decreases from -0.32 V to -1.01 V with the body bias from -0.6 V to 1.8 V.

Five various particles from carbon to copper with different energies and LETs (Linear Energy Transfer) inject the transistors or circuits. The energy of injection ions ranges from 80 to 161 MeV, while the LET ranges from 1.73 to 33.40 MeV.cm^2/mg. Radiation generates electron-hole pairs in SOI devices and temporarily changes the nodal voltage level in the combinational logic circuit, which triggers SETs. The drain area is found to be the most SET sensitive region by scanning the whole device by heavy ions. Only this case is considered in the following work.

The normalized collected charge in NMOS and PMOS with different body bias induced by heavy ions is given. The collected charge Q_{col} is obtained by integrating the drain transient current with respect to time. The normalized collected charge for different heavy ions is equal to $Q_{col}/Q_{col(Vb\ =\ -1.8\ V)}$ for NMOS and $Q_{col}/Q_{col(Vb\ =\ 3.6\ V)}$ for PMOS. For NMOS, the collected charge increases with the body bias step up from - 1.8 V to 0.6 V. But the normalized collected charge peaks for Si ion injection, then decreases. For PMOS, the collected charge increases with the body bias step down from 3.6 V to 0.9 V. But the normalized collected charge relatively saturates when LET is higher than 9.6 MeV.cm^2/mg (Si ion).

Furthermore, we can negatively bias the body/source junction in off-state pull-down NMOS and positively bias the body/source junction in on-state pull-up PMOS at the same time. The collected charge in the off-state NMOS will be lowered by the negative body/source bias and the compensating current in the on-state PMOS will be increased by the positive body/source bias. In this way SET performance will be greatly improved.

For the inverter chain in TCAD simulation, the body bias effect on SET PIPB (Propagation Induced Pulse Broadening) can be observed. SET at the output terminal with different body bias condition and Cu ion injection are given. Obviously, the SETs are mitigated by proper body bias conditions which were suggested above. Detailed discussions and physical analysis will be given in the full paper later.

KINETIC STUDY OF SYNCHROTRON RADIATION INDUCED RARE-GAS CRYSTALS MODIFICATION BY EXCITON SELF-TRAPPING

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Material modification by electronic excitation is an important prerequisite for many novel technological applications in material and surface engineering, photochemistry, micro- and nanoelectronics. The basis for the electronically induced lattice modification is a localization of the excitation energy mainly during exciton self-trapping followed by the energy transfer to the material surroundings. Rare-gas crystals (wide-gap van der Waals atomic crystals) are widely used as the model systems in fundamental investigations and as the working media of particle detectors and positron moderators. Using synchrotron radiation at HASYLAB (DESY, Hamburg, Germany) the spectroscopic properties of radiation-induced processes in rare-gas crystals were well studied recently. But the methods of chemical kinetics of solids were not applied up to now to analysis of the processes of rare-gas crystals modification by irradiation. In the present study we apply these methods for numerical simulation of defect processes in irradiated crystals and harness the rich luminescence spectra of rare-gas crystals for real-time monitoring of their crystal structure.

Initial increase of the intensity of the 'defect' luminescence during irradiation reflects the accumulation of stable long-lived point defects (Frenkel pairs) in the lattice as a result of exciton creation and self-trapping in the consecutive process $E + T \Leftrightarrow MTE \rightarrow D$, where E is the mobile excitation (free exciton), which is trapped at trapping center T (lattice imperfection) and forms an excited metastable trapped center (MTE). The time dependence of 'defect' luminescence intensity under steady-state conditions may be expressed in form$I(t) = I_0 + K\cdot t\cdot(L + t)^{-1}$, where $I_0 = I(0)$ is the initial intensity; K is the saturation value of $(I(t) - I_0)$;$L \sim n_E n_T (n_{MTE})^{-1}$ is a characteristic constant of a sample, n – concentration. At high defect concentration, n_D, the exciton self-trapping near existing defects will not produce the separate point defects, but will induce the aggregation of defects in the process $MTE + D \rightarrow DD$. The time dependence in this case may be expressed in form$I(t) = K\cdot L'\cdot(L' + t)^{-1}$, where $L' \sim n_{MTE} n_D (n_{DD})^{-1}$. The best fit of our data results in values $K = 1650$ cps,$L = 2.4\times10^3$ s, $L' = 4.8\times10^4$ s for particular case of solid Xe.

FROM THE FIELD TO THE TABLE: IONIZING RADIATION AS A FEASIBLE POSTHARVEST TREATMENT FOR FRESH AND DRIED PLANT FOODS

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Food irradiation is a treatment that involves subjecting in-bulk or packaged food to a controlled dose of ionizing radiation, with a clearly defined goal. It has been used for disinfestation and sanitization of food commodities and to retard postharvest ripening and senescence processes, being a sustainable alternative to chemical agents [1]. Doses up to 10 kGy are approved by several international authorities for not offering negative effects to food from a nutrition and toxicology point of view [2]. However, the adoption of this technology for food applications has been a slow process due to some misunderstandings by the consumer who often chooses non-irradiated foods. In this study, the effects of the ionizing radiation treatment on physical, chemical and bioactive properties of dried herbs and its suitability for preserving quality attributes of fresh vegetables during cold storage were evaluated.

The studied herbs, perennial spotted rockrose (*Tuberaria lignosa* (Sweet) Samp.) and common mallow (*Malva neglecta* Wallr.) were freeze-dried and then irradiated up to 10 kGy in a Cobalt-60 chamber. The selected vegetables, watercress (*Nasturtium officinale* R. Br.) and buckler sorrel (*Rumex induratus* Boiss. & Reut.) were rinsed in tap water, packaged in polyethylene bags, submitted to irradiation doses up to 6 kGy and then were stored at 4 °C for a period of up to 12 days. Physical, chemical and bioactive parameters of irradiated and non-irradiated samples were evaluated using different methodologies; the colour was measured with a colorimeter, individual chemical compounds were analyzed by chromatographic techniques, antioxidant properties were evaluated using *in vitro* assays based on different reaction mechanisms, and other quality analyses were performed following official methods of analysis.

The irradiation treatment did not significantly affect the colour of the perennial spotted rockrose samples, or its phenolic composition and antioxidant activity [3]. Medium doses preserved the colour of common mallow and a low dose did not induce any adverse effect in the organic acids profile. The green colour of the irradiated vegetables was maintained during cold storage; but the treatment had pros and cons in other quality attributes. The 2 kGy dose preserved free sugars and favoured polyunsaturated fatty acids (PUFA) while the 5 kGy dose favoured tocopherols and preserved the antioxidant properties in watercress samples. The 6 kGy dose was a suitable option for preserving PUFA and the ω-6/ω-3 fatty acids ratio in buckler sorrel samples. This comprehensive experimental work allowed selecting appropriate processing doses for the studied plant foods in order to preserve its quality attributes and edibility.

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THE IMPACT OF GAMMA IRRADIATION ON THE CYTOTOXIC PROPERTIES AND PHENOLIC COMPOSITION OF *THYMUS VULGARIS* L. AND *MENTA X PIPERITA* L.

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Irradiation has been increasingly recognized as an effective decontamination technique, also ensuring the chemical and organoleptic quality of medicinal and aromatic plants [1]. The use of medicinal plants in the prevention and/or treatment of several diseases has revealed satisfactory results as anti-inflammatory, antimutagenic, anti-cancer and antioxidant agents [2]. The aim of the present study was to evaluate the effects of gamma irradiation on the cytotoxic properties and phenolic composition of *Thymus vulgaris* L. and *Menta x piperita* L. (methanolic extracts). Phenolic compounds were analyzed by HPLC-DAD-ESI/MS, while the cytotoxicity of the samples was assessed in MCF-7 (breast adenocarcinoma), NCI-H460 (non-small cell lung cancer), HeLa (cervical carcinoma), HepG2 (hepatocellular carcinoma) cell lines, as also in non-tumor cells (PLP2). Thirteen and fourteen phenolic compounds were detected in *T. vulgaris* and *M. piperita*, respectively, but none of them was affected by the irradiation up to a dose of 10 kGy. However, despite there were no changes in the cytotoxic properties of irradiated peppermint samples in tumor cell lines, the thyme samples irradiated with 10 kGy showed higher cytotoxicity in comparison with the samples submitted to other doses (2 and 5 kGy). This highlights that 10 kGy can be a suitable dose to ensure the sanitary treatment, without modifying the bioactive composition and properties of these aromatic plants.

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THE MODIFICATION OF SOLID NITROGEN BY AN ELECTRON BEAM

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Interest in research of radiation effects in nitrogen solids is associated with their presence in interstellar and solar systems as well as their applications as systems for energy storage, moderators, matrices in radiation chemistry. Moreover, the information on behavior of N_2 films under irradiation is of importance to ensure safe operation of particle accelerators which contain superconducting magnets operating at LHe temperature. Desorption of the condensed residual gases (mainly N_2) may affect the operation of accelerators.

Despite a long history of solid N_2 spectroscopy the problem of charged species generation and their reactions still remains to be solved. First evidence of charged centres generation in pre-irradiated solid N_2 was a finding thermally stimulated exoelectron emission TSEE [1]. Later on creation of ionic species N_3^+ [2] and N_4^+ [3] in electron-bombarded solid N_2 was reported.

Here we present our recent findings on the radiation-induced modification of N_2 solids with a focus on the generation and accumulation of charged centers and electronically induced phenomena. We used luminescence methods: cathodoluminescence (CL) and developed by our group nonstationary luminescence (NsL), as well as optical and current activation spectroscopy methods. Correlated in real time measurements of thermally stimulated exoelectron emission (TSEE) and luminescence (TSL) or optically stimulated exoelectron emission (OSEE) and luminescence (OSL) were performed. The total desorption yield was detected by pressure measuring above the sample.

Monitoring of the CL spectra temporal evolution and concurrent measurements of optical and current relaxation emissions revealed stabilization and accumulation of radiation-induced centers – ionic (N_3^+, N_4^+, N_3^-), trapped electrons and radicals (N, N_3). The neutralization reactions: $N_4^+ + e^- \rightarrow N_2^* + N_2 + \Delta E_1$ and $N_3^+ + e^- \rightarrow N_2 + N^* + \Delta E_2$ are accompanied by the energy release which is spent for defect formation and desorption. Spectroscopic evidence of the excited N_2^* molecule and N^* atom desorption was obtained for the first time. The key role of N_3^+center dissociative recombination in generation of N radicals is suggested pointing to a prominent part played by the radiation-induced charged species in the energy storage and relaxation processes.

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QUALITY OF PLANTAGO MAJOR L. SEED PROGENY GROWING WITHIN RADIOACTIVE OR CHEMICAL CONTAMINATED AREAS

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We carried out a comparative study of the common plantain *(Plantago major* L.) seed progeny from populations exposed for a long time to radioactive or chemical contamination. *Radioactive contaminated area* (East-Ural Radioactive Trace – EURT) was formed in 1957 as a result of an accident at the ''Mayak'' Production Association (Urals, Russia). Currently, ^{90}Sr is the main contaminant in this area. In addition the EURT territory was contaminated by ^{137}Cs in 1967 after the silt and fine sand transfer from the Lake Karachay shores used as open storage for radioactive waste (Nikipelov et al. 1989; Aarkrog et al. 1997).

Heavy metal contaminated area is situated nearby a large industrial center – Nizhniy Tagil Iron and Steel Works (NTMK). The plots were established at different distances from the steel-making center. Polymetallic dust and SO_2 are the main emission components. Background populations were situated beyond contaminated zones. At all sites vegetation consists of cereal and multi-herbaceous meadows of secondary origin.

Working hypotheses: 1) viability of *P. major* seed progeny, formed in the gradient of radiation or chemical exposure is lower than in the background populations; 2) adaptive potential of the seed progeny from the contaminated areas is higher than in the background samples; 3) mutability of plants from contaminated areas exceeds the background level.

It was found that the offsprings of plants from the NTMK area had low viability, but the seedlings were resistant to the influence of acute γ-irradiation (additional new factor) and heavy metals (habitual factor). In samples from the EURT area high seed viability was combined with decreased resistance to provocative heavy metal and radiation exposure. Pre-adaptation effects were not found in these samples from the contaminated areas. Experiments with growing plants from different populations in plot-culture revealed that morphosis of generative organs were inherent for the EURT samples mainly and the samples from the NTMK area were characterized by anomalies of vegetative organs.

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LOW MOLECULAR WEIGHT XANTHAN PREPARED BY GAMMA IRRADIATION AND ITS EFFECTS ON SEEDLINGS

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Low molecular weight (Mw) xanthan was prepared by gamma Co-60 irradiation at both dry and paste-like states with various doses. The viscosity average molecular weight (Mv) of irradiated xanthan gradually decreased with the increase of the radiation dose. Its Mv slowly reduced to 1.8 × 103 kDa from 1.1 × 104 kDa of non-irradiated xanthan by irradiation at 500 kGy in the solid state, and quickly reduced to 5.3 × 102 kDa by irradiation at 50 kGy in the paste-like state. However, the viscosity of the irradiated xanthan was still high enough for utilization as a bio-adhesive polymer. Therefore, the low Mw xanthan prepared by gamma irradiation was used to improve the effectiveness of foliar fertilizer, and the effects of the irradiated xanthan on the development of seedlings were also investigated with maize and soybean. The results indicated that not only the irradiated xanthan, but also the non-irradiated xanthan can promote the development of seedlings, as indicated by the increase of plant height, root length and fresh biomass.

THE IMPACT OF RADIATION ON THE FATTY ACID COMPOSITION OF PHOSPHOLIPIDS OF THE BLOOD PLASMA, MYOCARDIUM AND LIVER TISSUES OF RATS

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It is known that maintaining the structural and functional status of cellular membranes is significantly provided by the homeostasis system of membrane phospholipids that undergo changes among the first under the influence of low doses of radiation.

The aim of the study comprised an analysis of the nature of changes in fatty acid composition of phospholipids in blood plasma, liver and myocardium of rats, exposed to ionizing radiation.

Researches were conducted on the mature male rats with adherence to general ethical principles of humane treatment to experimental animals. The total exposure in rats was once performed at the dose of 2 Gy. Fatty acid composition of phospholipids was determined by the gas chromatographic method.

It has been established that radiation exposure after 24 hours leads to a significant increase in the level of saturated fatty acids of phospholipids in plasma and liver, and the tendency to an increase of their content in the myocardium. In all investigated tissues levels of short chain saturated fatty acids, such as caprylic (C8:0), capric (C10:0), lauric (C12:0), and myristic (C14:0) acid, increased to the greatest extent. The content of palmitic (C16:0) and stearic (C18:0) acids, which are dominant compounds among saturated fatty acids in membrane phospholipid composition, increases in plasma and liver, and almost has no changes in the myocardium. On the second day of post-radiation period a decrease of monounsaturated fatty acids content in plasma and liver was observed. There were also changes in the level of polyunsaturated fatty acids. In all tissues in the largest extent were reduced contents of eicosapentaenoic (C20:5) docosapentaenoic (C22:5) docosatrienoic acid (C22:3*) etc.*, that might be caused by the involvement of these and other unsaturated fatty acids in the lipoperoxidation that were confirmed previously by our studies. The tissue specificity of changes in the fatty acid spectrum was generally detected. It was established that on the 3rd day after the radiation exposure, the level of some fatty acid of phospholipids tends to recovery, in accordance with the phase changes, characteristic for typical phases of adaptation syndrome development.

Considering the received research outcomes, the effect of radiation exposure at the dose of 2 Gy after 1 and 3 days results in a modification of fatty acid composition, which is mainly associated with an increased saturation index and in the highest degree expressed in the liver tissue, and the lowest one – in the myocardium. These effects accordingly change the viscosity of bilipid layer, and ultimately the membrane-dependent functions of cellular and subcellular structures, that requires a pathogenesis-substantiated correction.

THE PERFORMANCE ASSESSMENT OF GAMMA IRRADIATED ELASTOMERIC NANOCOMPOSITES

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Elastomers based on nitrile butadiene rubbers (NBR) are generally resistant to fuel, oil, and other chemicals (the more nitrile within the polymer, the higher the resistance to oils but the lower flexibility of the elastomeric product). This materials are using in the automotive industry for the fabrication of oil handling hoses, seals, self-sealing fuel tanks, and in the nuclear industry for protective gloves, and are able to withstand a temperature range from −40 to 110°C. Materials based on chlorosulphonated polyethylene (CSM) are using for inflatable and folding kayakes, as roofing materials, for the decking of modern snowshoes, but due to its poor compression set, thus the dynamic sealing applications are not recommended. The degradation of elastomers is accelerated by the transfer of energy under chemical attack, mechanical stress, and irradiation exposure. In general the progress in oxidative degradation depends on several factors, i.e. absorbed dose, dose rate, chemistry of material, exposure environment, and previous state of ageing. Elastomer based on rubber blends are technologically important materials as they achieve the best compromise in physical properties, procesability and cost. The main focus in the study was to estimate the effect of gamma irradiation on reinforced elastomers based on two network precursors (NBR and CSM). The content of nano silica particles was varied (20, 40, 60, 80, and 100 phr). Irradiation of the vulcanisates has been performed in air in the Co60 radiation sterilization unit with the dose rate of 10 kGy h−1 and different absorbed dose (100, 200, and 400 kGy). The characterization of aged materials has been done using stress-strain measurements and thermo-gravimetric analysis (TGA). Tensile strength, modulus at 100% elongation and hardness increased, but elongation at break decreased with increasing irradiation dose. The use of nano particles improved the mechanical properties and swelling resistance in toluene after gamma irradiation for all samples. Consequences of high energy irradiation are crosslinking and chain scissions. After irradiation the elongation at break is controlled by the shortest chains in network architecture whereas the increase in the active chains average length is controlling the material modulus.

THE HIGH ENERGY IRRADIATION AGEING OF REINFORCED ELASTOMERS BASED ON RUBBER BLENDS

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Elastomers are very often used in severe environments, for instance, in nuclear power plants, where they may be degraded by high-energy radiation and heat. The ageing behaviour of materials using in different equipment is very important. Elastomers based on chlorosulphonated polyethyelene (CSM) are using for cable jacketing materials has excellent radiation resistance needed in nuclear power stations. In the current work the influence of γ-irradiation dose (100, 200 and 400 kGy) on the ageing of reinforced blends based on CSM, styrene butadiene rubber (SBR) and natural rubber (NR) has been evaluated. The content of silica in CSM/SBR and CSM/NR rubber blends was varied (20, 40, 60, 80, and 100 phr). The curing behaviour of compounds was estimated using the oscillating disk rheometer. The irradiation of elastomeric nano-composites has been performed in air in the Co 60 radiation sterilization unit with the dose rate of 10 kGy h−1 at ambient temperature. The thermal properties of materials were studied by non-isothermal thermogravimetric analysis. The mechanical properties (hardness, modulus at 100% elongation, tensile strength and elongation at break) were determined before and after g-irradiation. It has been observed the decrease in the elastic modulus and in the strain at break with an increasing irradiation. At higher doses the network chain scissions become the main degradation process and the crosslinked topology becomes irregular, and material contains more and more weak zones, which deteriorate the ultimate properties. The appearance of maximum radiation resistance in the rubber blend was attributed to the balancing of properties due to the crosslinking or the chain scission in the elastomeric networks.

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THE INFLUENCE OF GAMMA-IRRADIATION ON MECHANICAL PROPERTIES OF NANO-SILICA REINFORCED TERNARY NR/BR/SBR RUBBER BLEND

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Reinforcement of elastomers is of great importance for the structuring of materials in new technologies. Namely, adding the nano-fillers to the elastomers obtained from different types of rubber leads to an increase in the modulus of elasticity and to an improvement of key properties such as tensile strength and elongation, as well as abrasion resistance. Reinforcement of elastomers is a particularly complicated process if cross linked material contains more than one type of precursor cross linking. By creating a multi-phase system, characteristics of individual phases can be partly preserved or significantly changed due to the influence of intermolecular interactions. Therefore, the modern research and industrial practice of tire industry leaders are directed towards the use of existing starting polymers and the obtainment of new types of elastomeric materials based on new modified macromolecules. In this study the effect of radiation dose on the mechanical properties of ternary NR/BR/SBR (25/25/50) rubber blend reinforced with nano-silica (0–100 phr) has been investigated. The size of precipitated silica primary particles was 22 nm. The cure characteristics of compounds were assessed using the reometer with an oscillating disk. The mechanical properties (hardness, modulus at 100% elongation, tensile strength and elongation at break) and swelling degree were assessed before and after g-irradiation (100-600 kGy). In crosslinked materials based on NR/BR/SBR the values for tensile strength increased when the silica content increased up to 60 phr. Tensile strength, elongation at break and swelling degree are decreased, but hardness and cross linking density are increased with the increase of the irradiation dose.

GAMMA RADIATION PRESERVES CHEMICAL AND BIOACTIVE PROPERTIES OF BOLETUS EDULIS WILD MUSHROOMS

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Boletus edulis Bull: Fr. is an edible mushroom quite appreciated for its organoleptic and nutritional properties. However, the seasonality and perishability cause some difficulties in its distribution and marketing in fresh form; losses associated with this type of food during marketing can reach 40% [1]. Irradiation is recognized as a safe and effective method for food preservation, being used worldwide to increase shelf life of fresh and dehydrated products (*e.g.* fruits, vegetables and spices) [2]. In particular, gamma irradiation has already been applied to cultivated mushrooms (especially *Agaricus*, *Lentinula* and *Pleurotus* Genus) and proved to be an interesting conservation technology [3]. However, the studies with added-value wild species are scarce. In this work, the effects of gamma irradiation on chemical and antioxidant properties of wild *B. edulis*, were evaluated. Fruiting bodies were obtained in Trás-os-Montes, in the Northeast of Portugal, in November 2012. The irradiation was performed in experimental equipment with ^{60}Co sources at 1 and 2 kGy. All the results were compared with non-irradiated samples (control). Macronutrients and energy value were determined following official procedures of food analysis; fatty acids were analyzed by gas-chromatography coupled to flame ionization detection (GC-FID), while sugars and tocopherols were determined by high performance liquid chromatography (HPLC) coupled to refraction index (RI) and fluorescence detectors, respectively. Antioxidant activity was evaluated in the methanolic extracts by in vitro assays measuring DPPH (1,1-diphenyl-2-picrylhydrazyl) radical scavenging activity, reducing power, inhibition of β-carotene bleaching and inhibition of lipid peroxidation using thiobarbituric acid reactive substances (TBARS) assay. Total phenolics were also determined by the Folin-Ciocalteu assay. The nutritional profiles were not affected in high extension. Fatty acids and sugars were slightly affected, decreasing with the increasing doses. The performed assays for antioxidant activity, indicate that irradiated samples tended to have lower scavenging activity and reducing power, but higher lipid peroxidation inhibition. Despite the detected differences in individual compounds, the results of nutritional parameters, the most relevant in terms of mushroom acceptability by consumers, were less affected, indicating an interesting potential of gamma-irradiation to be used as an effective conservation technology for the studied mushrooms.

Key words: *Boletus edulis*, Chemical composition, Antioxidant activity; Gamma irradiation.

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LOW DOSE RADIATION RESPONSE: FROM LIFE SPAN STUDIES TO MATHEMATICAL MODELS

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Background: There exists vast number of studies of biological effects of ionizing radiation, mostly dedicated to radiation-induced cancers. Whereas the field of early effects is quite well understood, the low doses (below, say, 100 mGy) that may create only late or very late effects are a subject of on-going controversy between proponents of LNT and hormesis.

Methods: Estimation of a cancer risk for low doses or ionizing radiation requires not only rigorous statistical approach to mathematical analysis of already collected data. One should in parallel develop biology-based models who could take into account essential processes that take place in irradiated cells.

Results: We present rather simple approach which can show what could be expected for the dose-effect dependence in the colony of cells. The modeling starts with rather simple consideration of how many cells can transform to cancerous ones, once mutations in them starts. An influence of both, the dose and dose-rate, is considered. In order not to loose simplicity we did not consider many purely geometrical effects in cancer cells development. This is planned for the future.

Conclusions: The general pattern emerging from the modeling indicates sigmoidal shape of the dose-effect curve as the most likely one. It is well known that the hazard functions calculated for at high doses are of this type. The mathematics shows, however, the origin of such dependence irrespective of the doses considered. The sigmoidal dependence can be further modified by such mechanisms as an adaptive response and/or bystander effect.

THE IDENTIFICATION OF MICROELECTRONIC DEVICES DURING THE INCOMING CONTROL STAGE

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A technological process of microelectronic devices may sometimes be changed by a manufacturer without any notification. These changes barely affect the electrical and functional parameters, but may come out strongly under the influence of destabilizing factors such as ionizing radiation. Therefore, all the microelectronic devices obtained by the customer should be tested both within the incoming inspection using most of the electrical parameters and within the radiation test.

The process design kits (PDK) are widely used in semiconductor device fabrication. The same PDK may be utilized by a manufacturer in different electronic devices for various purposes. At the same time, PDKs are trade secrets of developers and the PDK of one manufacturer may differ from the similar PDK of another manufacturer.

Therefore, the specific electrical parameters of an IC, for example volt-ampere characteristic of input and output circuits, may be used as identification features of a certain manufacturer. Consequently, additional identification procedures, within the incoming inspection, may be performed utilizing radiation tests with monitoring of those electrical parameters.

In this work, we propose a method based on incoming inspection combined with radiation tests. This method allows us to reveal the fact of changes in the manufacturer's fabrication processing by comparison of electrical test results of several lots of the ICs. Simultaneously, the set of electrical characteristics were confirmed to be identification features of a certain manufacturer.

USE OF CYTOGENETIC ENDPOINTS TO EVALUATE INFLUENCE OF PROTON IRRADIATION ON MICE IN VIVO

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Proton therapy of tumors has a great number of advantages compared to standard beam therapy with usage of gamma rays and electrons and it is actively developing worldwide.

The aim of this work is the search for optimal conditions to irradiation of animals on proton accelerator in vivo (ways of dosimetry and narcotization, position in the beam, beam properties and dose distribution) and getting dose dependencies for cytogenetic damage in bone marrow, thymus and spleen cellularity, induction of reactive oxygen species (ROS) in whole blood.

Male SHK mice aged 2 months were irradiated by 200 MeV pulsed pencil proton beam at the therapeutic proton synchrotron accelerator “Prometeus” (Russia) in dose range from 0.1 to 2 Gy at Bragg’s peak with impulse duration of 200 ms. Sham-irradiated animals were used as controls. All animals were housed per cage with ad libitum access to water and food pellets. Proton therapy dose control is carried out by means of clinical dosimeter on the basis of diamond detector (Russia), the gafchromic EBT2 films (USA) and thermoluminescent dosimeters (Russia) that were used for beam profile verification. For comparison, other group of mice was irradiated with X-rays (1 Gy/min, Russia) at the same dose range. The cytogenetic damage in the bone marrow was assessed using the micronucleus test, the level of reactive oxygen species (ROS) production in whole blood using luminol-dependent chemiluminescence, and the cellularity of the thymus and the spleen, by mass. The survival of animals and the tumor growth rate were estimated by the standard method.

It was discovered that: 1) the level of cytogenetic damage in the studied dose range was considerably lower comparing to X-ray irradiation; 2) the usage of hypnotics for animals’ immobilization during the irradiation procedure does not influence the lymphoid organs’ index; 3) irradiation of mice in the range of 0.5, 1 and 2 Gy leads to considerable reduction of spleen index compared to not irradiated mice, however, the thymus index was not changed for certain; 4) during the X-ray irradiation of mice at the same dose range the reduction of thymus and spleen index at the doses of 1.5 and 2 Gy was discovered; 5) during the induction study ROS there were no differences found at the low and medium dose range of proton irradiation compared to X-ray irradiation.

The most optimal conditions for the experiments on animals in vivo on proton therapeutic complex “Prometeus” were found during this research and, for the first time, dose dependencies for cytogenetic damages yield in bone marrow, thymus and spleen cellularity, induction of ROS in mice’s whole blood were discovered.

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TOTAL-DOSE RADIATION RESPONSE OF HAFNIUM-SILICATE MOS CAPACITORS

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The semiconductor devices that operate in radiotherapy and space applications are exposed to a variety of radiation sources and their effects, depending on the particular application and its environment. The important problems for the devices used in irradiation environment are electrical device characteristics much more sensitive to irradiation. It is well-known that irradiation generate numbers of e-h pairs and defects in the structure. Hence, the device characteristics could be degraded. To solve this problem, the alternative materials must be investigated to improve the radiation resistance of devices used in state-of-art microelectronic technology. HfSiO4 may be a good resistant material against radiation because of their excellent thermal stability. To investigate the total dose radiation response of the Hafnium Silicate structures, Hafnium silicates were deposited by RF sputtering system onto p-type (100) Si substrate and then annealed at 1000 ^{0}C in nitrogen environment for 30 minutes. The structures were confirmed by XRD measurements. The fabricated MOS devices were irradiated using a Co-60 gamma-ray source from 1 grays to 100 grays at a dose rate of 0.015 Gy/s. The variation in capacitance and conductance with increasing in irradiation dose is very small. This means that HfSiO4 structure is resistant devices to irradiation between 1 and 100 Grays. Therefore, these devices should be good to use in radiation environment. It is well known that MOS devices are extremely sensitive to ionizing radiation but Hafnium silicates MOS capacitor is not sensitive to ionizing radiation and it is radiation hard.

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RADIATION-INDUCED SPECIES MONITORING IN NITROGEN SOLIDS

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Nitrogen is one of the most abundant elements in the Universe. Solid nitrogen is of high interest for condensed matter physics and chemistry, material and surface sciences, dosimetry and astrophysics. Nitrogen solids are used as moderators, scintillators, systems for energy storage and components of interstellar and solar systems. In view of this radiation effects induced by ionizing radiation in solid nitrogen attract special attention.

Despite detailed investigations of electronic excitations the properties and dynamics of charge states as well as accumulation of uncompensated charge remained unexplored. It was believed that charge states do not play an essential role. Energy relaxation processes in subsystems of charged and neutral species were considered separately ignoring their interconnection. The first detection of thermally stimulated exoelectron emission from solid nitrogen [1] pointed to a key role of charge species in energy relaxation in preliminary irradiated samples.

We developed special techniques for studying charge states in cryocrystals and performed correlated in real time measurements of spectrally resolved thermally stimulated luminescence and exoelectron emission in combination with cathodoluminescence.

Analysis of the cathodoluminescence spectra indicated the formation of neutral N_3 centers. Simultaneous measurements of optical and current relaxation emissions revealed the formation and accumulation of radiation-induced ionic centers N_3^+ and N_3^-. The role of these species in energy relaxation cascades is discussed.

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DEVELOPMENT OF NOVEL MURINE MODEL OF COMBINED RADIATION AND PERIPHERAL TISSUE TRAUMA INJURY

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Detonation of a 10 kiloton nuclear bomb in major urban setting will result in >1 million casualties, waste majority of whom will present with combined injuries. Combined injuries such as peripheral tissue trauma and radiation exposure trigger inflammatory events that lead to multiple organ dysfunctions (MOD) and death, in which intestines and lungs play crucial role. The objective of this study was to develop an animal model of combined peripheral tissue trauma (TBX) and total body radiation with 5% bone marrow shielding (IR) injury to probe the mechanisms leading to reduced survival.

Male C57BL/6J mice were exposed to TBX10%, 12.6Gy total body irradiation with 5% bone marrow sparing (IR) or combination (TBX10%+IR). Experiments were conducted to evaluate mortality at 7 days (7d) post-IR. Additionally, scheduled euthanasia was performed to evaluate time course of the pathophysiological processes involved in combined injury (24h, 3d and 6/7d post-IR). Functional tests were performed to assess pulmonary function and gastrointestinal (GI) motility. After euthanasia, samples of the lungs and jejunum were collected for histology to assess tissue damage.

The results indicate higher lethality and shorter survival period in TBX10%+IR group when compared to animals in TBX10% or IR groups (24h, 7d and 6d respectively). IR alone did not have effects on the lungs and significantly impaired GI function on 3d and 6d after exposure. As expected, in the animals that received severe trauma (TBX10%), we observed impairment in lung function and delay in gastrointestinal transit in first 3d, effects that were decreasing at later time points and were comparable to Sham group at 7d. When combined with radiation (TBX10%+IR) impairment of lungs and GI function was significantly augmented comparing to TBX10% and IR groups at 24h. Histological evaluation of jejunum indicates significant shortening of the villi with areas denuded from villi in TBX10% group at 3d and 7d, and in IR group at 6d similarly to TBX10%+IR group at 24h post exposure. Histological evaluation indicates that combine injury causes increase in alveolar edema with slight increase in lung cellularity.

Herein, we have for the first time described combined tissue trauma/radiation injury model that will allow for conduct of mechanistic studies in search for new therapeutic targets and will serve as platform for testing novel therapeutic interventions.

THE EFFECT OF ACUTE X-RAY IRRADIATION OF MEDICINAL PLANT SEEDS ON THE SECONDARY METABOLITE PRODUCTIVITY

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The stimulating effects of ionizing radiation on the synthesis of some biologically active compounds, which are products of secondary metabolism of plants, have been demonstrated previously by a number of authors. Our aim was to study the possibility of pre-sowing acute irradiation of medicinal plants seeds producing flavonoids, flavonoid glycosides and essential oils in order to increase the yield of the extracted pharmacological mixtures. It was expected that this problem could be solved by radiostimulation of: 1) germination, 2) accumulation of vegetative mass per plant and per unit area of land cultivation; 3) increasing of the content of the sum of pharmacologically valuable secondary metabolites (SPVSM) per 1 g of the raw material dry weight; 4) increasing of percentage of various fractions of SPVSM according to the general amount of SPVSM. We have selected plants of interest from the point of view of favorable industrial significant cultivation in the forest steppe zone. Plants were as follows: *Matricāria chamomīlla*, *Sílybum mariánum*, *Sālvia officinālis*, *Hypericum perforatum*, *Bidens tripartite*. Based on the data on relative radioresistance we have chosen the experimental doses of X-ray irradiation: 5 Gy, 10 Gy, 20 Gy, 35 Gy, 50 Gy (dose rate 1,42 cGy/s). The study of dose dependence for some vegetative and phenological indicators confirmed the possibility of using pre-sowing irradiation of medicinal plants seeds with ionizing low LET radiation to stimulate the accumulation of vegetative mass of the stem aerial part. Dose curves had a peak that meant about stimulation dose or stimulating dose interval. These dose intervals for most vegetation parameters lied in the range of 5-20 Gy depending on the plant species, variety and seed quality. Irradiation with larger or smaller doses had no effect or changed sign of the effect (inhibition instead of stimulation). A similar relationship between dose and effect is typical for such phenological parameters as day of vegetation when plants start budding or flowering, and average duration of vegetation period. At high germination of original seed material (> 90%) exposure in the dose range 5-50 Gy inhibits germination. A preliminary study of *Sílybum mariánum* and *Sālvia officinālis* resistance under adverse conditions – water and temperature stress, indicated increasing in survival rate of radiation-stimulated plants compared with plants from untreated seeds. Direct dependence between radiation dose and the number of flowers on plants *Matricāria chamomīlla* has been also found. Analysis of the concentration of the sum of flavonoids in *Matricāria chamomīlla* flowers extracts showed a trend towards an increase in the relative mass fraction of flavonoids in the dry material from seeds irradiated with dose 10 Gy. Due to radiostimulation of flowering and increasing average weight of *Matricāria chamomīlla* flowers we have achieved increased general yield of flavonoids extract per plant and per unit area of crop. The effect has been observed for all doses from 5 to 50 Gy with a maximum at 10 Gy. It is planned to test the reproducibility of the results and determine the influence of radiation to the yield of SPVSM extracted from material of other medicinal plants.

THE ROLE OF IMPAIRED MUCOSAL BARRIER FUNCTION IN IRRADIATION-INDUCED CHRONIC GASTROINTESTINAL (GI) SYNDROME

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Total body irradiation (TBI) in a murine model with sparing 2.5-5% of the bone marrow (TBI/BM) allows for assessment of mortality and morbidity associated with the acute GI-ARS induced by TBI alone while preserving sufficient active BM for survival through the hematopoietic syndrome without transfusion. Changes in the gut following high dose TBI in mice are well documented, but there is less information on the sequelae of events post TBI/BM.

Aim: To determine role of dose-related effects of TBI/BM on injury, mucosal barrier function and inflammation in the transition from acute (6-7 days) to chronic GI syndrome (≥20 days).

Methods: Male C57Bl/LJ mice were exposed to 11-13 Gy TBI as a single uniform total body dose of x-ray irradiation with lead shielding of the tibia plus femur (TBI/BM5) or tibiae alone (TBI/BM2.5). Mice were euthanized at times from 6 – 60 days post irradiation. Sections of jejunum were prepared for histological evaluation, determination of TEER (index of permeability), and real-time PCR of tissue cytokines.

Results: The LD50/15 was 13Gy for PBI/BM5 and 11.8 Gy for TBI/BM2.5. Microscopic changes were evident in jejunum at LD50/15 doses with significant injury observed at 13 Gy for TBI/BM2.5 and at 14 Gy for TBI/BM5. This included denuded mucosa, extrusion of mucus, loss of crypts and increased depth of remaining crypts. Although the microscopic appearance improved over time, these changes remained at LD50/15 doses at ≥20 days. When compared to TEER measured in small intestine taken from control mice (51± 4Ω x cm2; n = 9), TEER in irradiated mice was reduced significantly ($p<0.05$) at day 7 for doses ≥13 Gy TBI/BM5 (32 ± 6Ω x cm2; n=4) and ≥12 Gy TBI/BM2.5 (22 ± 3.5Ω x cm2; n=7). Expression of pro-inflammatory cytokines in the small intestine was unchanged in response to the LD50/15 doses of TBI/BM2.5 and PBI/BM5. In contrast, at 20 days post 12 Gy TBI/BM2.5, IFN-γ was increased 9-fold and IL-17A increased 16-fold. At day 60 post 13 Gy TBI/BM5, IFN-γ was upregulated 10-fold and NOS-2 increased 40-fold.

Conclusions: Increased intestinal permeability (“leaky gut”) appears to be a reliable indicator of survivability as reduced TEER: 1) is observed for LD50/15 doses and higher; 2) is associated with significant mucosal damage; and 3) precedes the increased expression of pro-inflammatory mediators. These data suggest that acute changes in barrier function contribute to chronic GI syndrome.

VUV PHOTOLYSIS OF CRYSTALLINE ALKALI NITRATES

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The decomposition of crystalline alkali nitrates under UV (253.7 nm) irradiation and both g and X irradiation has been studied in detail. The diamagnetic products (NO_2^- and $ONOO^-$) are formed in both cases and paramagnetic centers (NO_3, NO_2, NO_3^{2-}, O_n^-) are registered under the g and X irradiation additionally. The products formation occurs in the bulk of crystals. The goal of the present work is to determine the products formed under VUV irradiation of crystalline alkali nitrates. The absorptivity of alkali nitrate crystals at this wavelength is ~10^5 cm^{-1}therefore it can be argued that the photolysis occurs in thin surface layer.

Alkali nitrate crystals were grown by slow evaporation from saturated aqueous solutions. Crystals were irradiated by a Xe-excimer ark (172 nm). The ESR spectra of the irradiated crystals were registered by RE-1306 X-band spectrometer at 77 K and 300 K. The optical and infrared absorption spectra were registered at room temperature by means of a "Shimadzu UV-2450" and FSM 1201 spectrophotometers, respectively. To achieve good signal-to-noise ratio the results of 250 scans were accumulated and averaged.

The diamagnetic products (NO_2^- and $ONOO^-$) were formed under VUV irradiation at both 77 K and 300 K of crystalline alkali nitrates based on the optical and infrared absorption spectra. No paramagnetic centers were observed in photolysed at 300 K the samples, but O^- and O_3^- were registered in ESR spectra of sodium, potassium, and caesium nitrates photolysed at 77 K. In addition radical NO_2 is formed under VUV irradiation of crystalline rubidium nitrate.

Taking into account the fact that the band gap for all nitrates is ~8 eV it can be assumed that the energy of light quanta is insufficient for NO_3 and NO_3^{2-} paramagnetic centers formation. On the other hand, the anionic impurities introduced to alkali nitrate crystals can dissociate to result in paramagnetic centers formation. The impurities are the nitrite ion and the peroxynitrite ion formed under photolysis. It can be assumed that the paramagnetic centers are the products of their dissociation in thin surface layer. The detailed mechanism of the paramagnetic centers formation is discussed.

PARAMAGNETIC CENTERS FORMATION UNDER RADIOLYSIS OF CRYSTALLINE POTASSIUM PICRATE

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Potassium picrate – $C_6H_2(NO_2)_3OK$ is ionic high-energy material which can be used as explosives. Besides, it slowly destroys under irradiation to form both paramagnetic and diamagnetic products. The goal of this investigation is to study the formation of paramagnetic centers in potassium picrate under g-irradiation.

The crystals were grown by slowly evaporating from the saturated water solution at 60 ^{0}C. They were in the form of needles with the size 15´3´4 mm and the weight 20-30 mg.

The samples were irradiated with ^{60}Co g-rays at ~310 K. The dose rate 1.4 Gy/s was measured with a Fricke dosimeter, assuming the radiation chemical yield of Fe^{3+} to be equal to 15.6 (100 eV)$^{-1}$. The dose absorbed by the sample was calculated using the mass energy absorption coefficients. The irradiated samples were stored at room temperature and then studied. The EPR spectra of the irradiated crystals were recorded on a Bruker EPR spectrometer at 300 K. For absolute g-value determinations a calibration using DPPH (g = 2.0036) was used.

Complex spectrum is registered in EPR spectrum of irradiated crystal. It consists of the following paramagnetic centers:

- with anisotropic triplet hyperfine structure (splitting 0.15 and 0.53 mT and the intensity ratio 1:2:1) due to 2,6-dinitro-p-quinone. The dissociation of the excited picrate ion results in this radical and NO fragment;
- with two nonequivalent anisotropic triplet hyperfine structures due to iminoxyl radical. In this case dissociation occurs in nitro group to result in oxygen atom;
- with narrow line (width 0.25 mT) corresponds to $O^{\bullet -}$;
- with wide line (width 0.55 mT) due to paramagnetic center with nitrite group in p-position.

The mechanism for the paramagnetic centers formation under molecular exciton decay formed under g-irradiation of crystalline potassium picrate is discussed.

EFFECT OF CO-MUTAGENS ON RADIOSENSITIVITY OF HUMAN SOMATIC CELLS

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There is an objective assessment of the uncertainty of the influence of physical and chemical factors on the human genome. The chemical agents include co-mutagens, which have no own mutagenic properties, can essentially intensify effects of known mutagens, including radiation-induced effects of low doses as co-mutagen selected ascorbic acid. The main goal is investigate the effect of ascorbic acid on the formation of radiation-induced effects in the exposure of human blood lymphocytes at different stages of the cell cycle. Test system of human peripheral blood lymphocytes, metaphase analysis of chromosomal aberrations. Cells were cultivated according to the standard procedures with some modifications. Peripheral blood lymphocytes culture was exposed to x-ray radiation (0,3 Gy) in G_0- and S- phases of cell cycle. Immediately after the irradiation the culture was treated with ascorbic acid in concentrations of 20,0-80,0 µg/ml of blood. Cell culture irradiation in low dose (0,3 Gy) and treatment with ascorbic acid in therapeutic concentration (20,0 µg/ml of blood) resulted in radioprotective effect regardless of the the stage of the cell cycle, decreasing overall chromosome aberrations frequency as opposed to radiation effects. It has been established that post-irradiation effect of ascorbic acid upon the peripheral blood lymphocytes culture in concentrations of 80,0 µg/ml, which exceeding therapeutic concentration value 4 times correspondingly, increased overall chromosome aberrations frequency 1,4 times compared with irradiation effect in a low dose (0,3 Gy). This bears evidence of ascorbic acid co-mutagenic activity in the range of concentrations exceeding therapeutic values. Compared with G_0-phase, co-mutagenic effect of ascorbic acid (80,0 µg/ml) in S-phase reflected in increasing frequency of radiation-induced chromosome aberrations in 1,5 times. Since the S stage (synthesis of DNA) is the most radioresistant, the increase indicates damage chromosomes of ascorbic acid impact on the efficiency of repair processes. The results come as solid proof of the repair processes dominant role in some drugs co-mutagenic activity display, in this case, at the combined effect of radiation (additional) radiation levels and of ascorbic acid. The formation of co-mutagenic effects of ascorbic acid depends on its concentration and the efficiency of repair processes.

THE AMORPHIZATION OF METALLIC ALUMINIUM UNDER THE ACTION OF ^{57}CO RECOIL NUCLEI

Igor Alekseev

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For production of ^{57}Co recoil nuclei the reaction ^{56}Fe(d,n) was used. Behind the iron target (^{56}Fe, isotopic enrichment - 93%, the thickness - 20 mcm) in the course of a beam of deuterons was placed an aluminum foil (chemical purity - not less than 99.99%, the thickness - 20 mcm), which was used to collect the recoil nuclei. The maximum energy of the ^{57}Co recoil nuclei was not more than 0.2 MeV, their range in aluminum - about 0.14 mcm.

The irradiation of aluminum (number of displaced atoms within the sample - more than 2500 vacancies/ion) is accompanied by a structural disordering and amorphization of the crystal lattice near the Mossbauer atom. The Emission Mossbauer spectra is a broad doublet (Γ = 0.46 mm/s), which is responsible ^{57}Co-vacancy complexes [1].

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HETEROGENEOUS RADIATION BEHAVIOR OF DIFFERENT SAMPLES OF HONEYWELL SS495A MAGNETIC FIELD SENSOR

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A comparative study of the radiation behavior of the various parties Hall sensors SS495A (p. Honeywell). Qualitative differences of the ionization pulse response when exposed to ionizing radiation. Fixed dose reduction resistance was also studied.

ELECTRON-STIMULATED DESORPTION OF EXCITED ATOMS FROM SOLID NITROGEN

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Desorption or sputtering is among the most intensively studied radiation-induced phenomena. The term electron-stimulated desorption describes physical and chemical changes caused in the surface region of a solid by bombardment with low-energy electrons. Radiation effects in solid N_2 attract much attention in various areas of scientific researches including material and surface sciences, physical and chemical processes in interstellar space and solar system and also particle physics. Electronic desorption of solid nitrogen was studied under excitation with electrons, ions and photons [1]. Despite extensive studies the contribution of excited atoms into the desorption is still not well understood.

In the present paper radiation processes in the solid nitrogen irradiated with an electron beam were studied with special attention to the desorption of the excited atoms and its contribution to the electron-stimulated phenomena in general. The experiments were performed employing luminescence method and activation spectroscopy techniques – spectrally resolved thermally stimulated luminescence TSL and thermally stimulated exoelectron emission TSEE.

Atomic emissions were detected in the vacuum ultraviolet VUV range – the $^4P_{1/2\text{-}5/2} \rightarrow {}^4S_{3/2}$transitions. They increased with respect to the bulk molecular emissions (the $a'^1\Sigma_u^- \rightarrow X^1\Sigma_g^+$ and the $A^3\Sigma_u^+ \rightarrow X^1\Sigma_g^+$) in thin films (< 100 nm) and under irradiation by slower electrons which have less penetration depth. Moreover, the observed atomic emissions coincided with the gas phase lines within the experimental error. These findings indicate the connection of the emissions observed with the desorbing excited atoms. Analysis of the spectrally resolved TSL and TSEE suggests connection of the atomic desorption with electron-ion recombination reaction. One can expect for the azide radical cation N_3^+ strong tendency to dissociate via N_2+N channel. Formation of N radicals in the bulk of solid N_2 by this reaction was assumed in [2]. Thereby analysis of the VUV luminescence and relaxation emissions allowed us to observe formation of defects, dissociation of molecules into the atoms and the desorption of the excited atoms from the surface of solid nitrogen and also to define the electronic states of these atoms.

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MICROWAVE RADIATION AT 1800 MHZ INDUCES INCREASE OF β-TURN AND β-SHEET FEATURES IN TYPICAL PROTEINS

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Fourier Transform Infrared (FTIR) spectroscopy was used to investigate the effects of microwaves (MWs) radiation emitted by a mobile phone during a call on two typical proteins: bovine serum albumin (BSA) and myoglobin (Mb), that are characteristic in some organic functions of livings. The reason of our investigation is also related to previous studies that concluded that more studies concerning health effects by mobile phone radiation are needed [1]. Otherwise, recently it was proved that static and 50 Hz electromagnetic fields (EMFs) alter the secondary structure of proteins [2-5].

The exposure system consisted of an operational mobile phone Nokia 1208 which provided MWs at 1800 MHz at the power density at 940 mW/m^2. A Narda SRM-3000 device was used for monitoring EMF during exposure, as accurately described in [6].

FTIR spectroscopy was carried out after exposure of 4 h of BSA and Mb samples in D_2O solution at the concentration of 100 mg/ml.

The spectra exhibited an intense Amide I band centered at 1650 cm^{-1}. In this region, a vibration at 1635 cm^{-1}attributed to β-sheet structures [7, 8], a band around 1680 cm^{-1} associated with β-turn [9] and a feature at 1620 cm^{-1} assigned to antiparallel β-sheet structure [10] were highlighted, as well. Significant increases in intensity ($p < 0.05$) of these bands were observed after exposure of BSA and Mb. This result can be attributed to unfolding process of proteins and formation of aggregates [10, 11], which gives a proof that mobile phone MWs induce denaturation of proteins. Proteins' aggregation can lead to neurotoxicity and neurodegenerative disorders that can be considered as the first step to some pathologies.

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REORIENTATION OF POLYMER CHAINS CAN BE PRODUCED BY EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELD RADIATION

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In the last few years, an interest in the effects of electromagnetic fields (EMFs) radiation on the physicochemical properties of polymers has increased due to various functions attributed to these materials, often used as devices for insulation from EMFs because their dielectric properties. Indeed several polymer materials are used in reactor materials and could be used in future fusion reactors, where magnetic confinement of plasma in high induction static magnetic fields (SMFs) have to be planned [1, 2]. The necessary security conditions for these future reactors give rise to concerns about the insulation capacity of polymers.

Hence, it is important to study polymers behavior under external EMFs.

Polyethylene oxide (PEO) can be considered a prototype of polymers because of the simplicity of its macromolecule's basic forming unit CH_2CH_2O, so that we studied the response to extremely low frequency (50 Hz) EMF radiation.

PEO was dissolved at 25mg/mL concentration in bidistilled H_2O solution.

The exposure system consisted of a couple of Helmholtz coils used to generate time-varying EMFs at 50 Hz at the intensity of 1 mT by means of a AC voltage as described in [3,4].

FTIR spectroscopy was used to study PEO vibration bands changes induced by 4 h exposure to EMFs radiation.

The bands around 2850 cm^{-1} and 2925 cm^{-1}, due to CH_2 symmetric and asymmetric stretching of methylene group, respectively [5,6], decreased in intensity significantly after exposure ($p < 0.05$).

Also the strong vibration band around 1465 cm^{-1}, that can be assigned at CH_2 scissoring vibration band [5, 6], decreased in intensity after exposure as well.

In this scenario, the decrease in intensity of stretching and scissoring vibrations of CH_2 after exposure to EMFs radiation can be explained assuming that an unfolding of PEO chain occurred, due to the alignment of PEO chain along the direction of the external EMF. This result was already observed after exposure to a SMF [7].

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RADIATION EFFECTS IN SULPHUR POLYMER CONCRETE (SPC) MATRIX UNDER HIGH DOSE IRRADIATION

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The main goal of radioactive waste processing and disposal is stabilization of radionuclides against accidental releasing into environment. Current technologies for radioactive waste disposal are based on multi-barier protection systems which are able to withstand effectively both environmental factors and destructive effects of radiation interacting with waste host matrices. Particular barriers are constructed by simultaneous application of materials designed for radionuclides immobilization, incorporation of layers limiting contact of the waste matrix with external environment and careful site selection providing safe geological conditions for deposited final waste forms. Materials used for these purposes must be designed and selected taking into account possible radionuclides transport phenomena: must effectively minimize possible surface and underground water infiltration and leaching of radionuclides from the host matrix, which may occur during accidental situations, as well as must ensure negligible radionuclides diffusion rate.

As host matrix materials many different composites are being used. Selection of the waste matrix materials depends mainly on the chemical properties, physical form and activity of the radioactive waste to be disposed. In case of low and intermediate level waste very often asphalts, bitumens, polymeric resins and cementitious composites are used.

Technologies used for radioactive waste immobilization are being continuously improved. One of such new group of materials being developed are mineral-polymeric materials based on sulfur polymers – sulfur polymer concrete (SPC). Sulfur polymer composites seem to be very attractive materials due to their properties: good mechanical behavior, very good properties of radionuclides retention and very low diffusivity within the SPC matrix.

However, elaboration of effective technology of radioactive waste immobilization in SPC requires detailed investigation of processes which occur in irradiated sulfur polymer matrices in high dose irradiation conditions. For this purpose series of radiation degradation experiments with sulfur polymers were conducted, to follow the processes induced by irradiation and their effects on the sulfur polymers properties. In this work we present results on influence of radiation degradation processes on mechanical, physical and chemical properties of the sulfur polymers. Sulfur polymers were degraded using both e-beam (6 MeV) and gamma (Co-60) radiation, within the dose ranges up to 20 MGy. Sulfur polymers properties were investigated using XRD, DSC, FTIR and SEM techniques.

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CYTOGENETIC RESEARCH OF CO-MUTAGENES' ROLE IN INCREASING RISK OF CARCINOGENESIS

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The radiation-induced destabilization of human genome is potentially oncogenic and increase of radiation sensitivity comparing to its average population values is a risk factor of radiation carcinogenesis. The main goal is definition of appearance of chromosome aberrations in irradiated lymphocytes healthy donors and cancer patients at low dose of ionizing radiation and the concentration of co-mutagen. Test system of peripheral blood lymphocytes (PBL) treated *in vitro* with subsequent metaphase analysis of chromosomal aberrations has been used. Cells were exposed to x-ray radiation at low dose (0,3 Gy) and treated with verapamil (Vp) (1,0 and 4,0 μg/ml of blood).Our studies for the first time showed the effect of co-mutagen Vp on the formation of radiation-induced chromosomal rearrangements in human somatic cells. We have demonstrated that V does not essentially influence the level of radiation-induced damages of chromosomes in PBL healthy donors at therapeutic concentrations (1,0μg/ml of blood). Application of Vp in concentration of 4,0 μg/ml of blood, potentiates damaging effect of radiation due to increase of overall frequency of chromosome aberrations in ~ 1,5 times compared with effect of exposure to radiation of PBL alone. Vp at therapeutic concentrations decreases the frequency of radiation-induced chromosomal aberrations 1,3 times in cells of cancer patients. Vp at a concentration of 4.0 μg/ml also increased the damaging effect of low doses of radiation in 1,2 times in irradiated cells of cancer patients.

Formation of co-mutagenic effects of Vp in irradiated cells healthy donors and cancer patients at low dose radiation depends on their concentration. We assume that the detected co-mutagenic effect promotes the development of chromosomal instability and thus increases a of carcinogenesis risk.

INVESTIGATION OF SELECTED CERAMIC INSULATORS USING RADIATION-INDUCED THERMOLUMINESCENCE

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Electrical properties of insulators are largely determined by the energy structure of the crystal lattice defects. Lattice defects give rise to localized electronic levels inside the energy gap of the insulator. These energy levels may act as charge carrier traps or recombination centers depending on the value of the activation energy [1]. Trap structure of the ceramic insulators of medium voltage power networks were studied using thermoluminescence (TL) method in the temperature range 300 – 600 K. Prior the measurements the samples taken from the insulators were irradiated using $^{90}Sr/^{90}Y$ *beta* source with activity of 37 MBq. Various parts of the insulator were studied: core, outer core and glaze. The samples were prepared as chopped pieces of different shape but similar masses. The measurements were performed in a vacuum chamber equipped with a heating control system. Luminescence was recorded using bialkaline photomultiplier working in the photon counting mode with appropriated electronics and custom made software [2].

TL study revealed a complex structure of the measured glow curves. Usually they consist of several overlapping peaks indicating the presence of at least a few traps and several recombination centers, whose parameters depend on the type of insulator under study. TL kinetics was analysed using Randall-Wilkins (first order) equation. Nonlinear deconvolution was made using GENOR software [3,4].

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LUMINESCENCE PROPERTIES OF MG AND RARE EARTH DOPED YTTRIUM ALUMINATE BASED PHOSPHORS

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This work focuses on the characterization of various types of luminescence of a series of green emitting $Y_3Al_5O_{12}$(YSO) phosphors doped with Ga, Gd and Mg ions prepared by the gel-combustion method. The samples exhibit luminescence emissions, which depend on the sample temperature and the type of irradiation for excitation such as X-ray, laser, incident electron beam. Here we examined radioluminescence (RL), cathodoluminescence (CL), photoluminescence (PL) along with XRD for the clarification of the relationship between lattice defects and spectral luminescence emissions. The RL and CL spectra of YAG:Ce show emission band in the 300-450 nm range related to Y_{Al} antisite defects. With increasing Ga^{3+} content, the broad band in the emission spectra of the obtained garnet nanophosphors shifted from 526 nm to 498 nm while full width half of maximum (FWHM) of the band in luminescence spectra tends to be greater than the width of YAG:Ce garnet. PL three dimensional isometric plots were recorded in order to see underline the overall signal shape changes during cooling the spectral data. PL does not exhibit intrinsic UV band at room temperature but it slightly appears at low intensity from 200 K to 10 K. The deconvolution of the spectra indicates that two emission bands occur in YSO:Ce host garnet. It is found that the garnet compound has general order and second order kinetics for m_g=0.48 and m_g=0.52, respectively. In our future research, a detailed study of other aspects of these phosphors on the basis of the promising findings presented in this paper will surely prove them worthy for numerous applications.

STUDIES ON $ZnS:Mn^{2+}$ PREPARED BY MICROWAVE-ASSISTED SOLVOTHERMAL DECOMPOSITION OF SINGLE-SOURCE MOLECULAR PRECURSORS

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Nanocrystalline doped and undoped zinc sulphide (ZnS) powders have been widely studied in the last years because of their excellent luminescence properties in correlation with particles nano-dimension. Due to their quantum confinement properties, ZnS nanocrystals can be used as emitting materials in the blue-to-violet spectral range.

The physical, chemical and luminescence properties of doped and undoped ZnS powders are exceptionally dependent on the particle size, morphology and dopant amount, which depend on the synthesis methods and conditions. Nanocrystalline doped and undoped ZnS powders can be obtained mainly by precipitation, from two different reagents – one as metal ions and one as sulphide ions sources or by solvothermal dissociation, from of a single-source molecular precursor.

Herein, we report the synthesis of undoped and manganese doped zinc sulphide nanocrystalline powders by microwave assisted solvothermal decomposition in ethylene glycol of an air-stable single-source molecular precursors, i.e. zinc diethyldithiocarbamate $Zn(DDTC)_2$ and zinc-manganese diethyldithiocarbamate $(Zn,Mn)(DDTC)_2$. The single–source molecular precursors were prepared, at room temperature, in an aqueous medium, from zinc and manganese acetate and sodium diethyldithiocarbamate, using the reagent simultaneous addition technique (SimAdd).

The single-source molecular precursors as well as undoped and Mn doped ZnS nanocrystalline powders were characterized by ICP-OES, thermal analysis, SEM, X-ray diffraction and photoluminescence spectroscopy. A correlation between SimAdd preparation conditions and the photoluminescence and morpho-structural characteristics of ZnS powders was established.

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RADIATION IN MEDICINE

19

THE EVALUATION OF THE ADAPTATION EFFECTIVENESS OF THE MILITARY PERSONNEL AND PERSONNEL OF CHNPP, WHO PARTICIPATED IN THE LIQUIDATION OF THE CHNPP ACCIDENT IN 1986 AND 1987

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Purpose: The object of this work is a comparative evaluation of the efficiency of psychophysiological adaptation of military personnel and personnel of ChNPP, participated in liquidation of consequences of the ChNPP accident in 1986–1987 years.

Material and methods: The study involved 3 groups of participants of liquidation of the consequences of ChNPP accident (PLCA) – 10 people. 1st group consisted of military personnel, colonels, 4 people, aged 65-77-73-77 years old, including 4 military chemical engineers (B.A.P., R.A.I., R.P.P., T.I.I.). 2nd Group is represented by two helicopter pilots (V.O.V., Sh.V.O.) and one test engineer of aircraft (I.V.A.) at the age of 50,57,75 years old. 3rd Group – is the ChNPP personnel, who worked from may 1986, in preparation for commissioning and operation of ChNPP units 1,2,3, in the face of a nuclear-physicist (O.I.N.), chief engineer of ChNPP (J.G.F.) and the shift supervisor of the electrical shop No. 1-2 unit of ChNPP (age 78,72,75 years old). The dose of external gamma-beta radiation in the 1st group registered in the range of 9,0 – 37,6 cSv, 2nd – up to 25 cSv, 3rd – 56,0 - 25 cSv.

Results: The rise of the profile parameters of MMPI above 80 T-points were detected in persons of the 1st group on the scale 1Hs–95,38 T-points of the neurotic triad and testified to the strain of mental adaptation, due to concerns about the health, hypochondriac tendencies. The rise of parameters on a scale of 2D–68,80 and 3Hy–72,4; T-points indicated the voltage of psychophysiological adaptation, due to anxiety-demonstrative behavior. The level of the profile of MMPI in persons of 2nd group indicated the over voltage of mental adaptation, marked by the rise of parameters of higher than 80 T-points as neurotic (1Hs–94,50; 2D–77,60; 3Hy–80,83 T-points), and psychotic triad (6Pa–75,80; 7Pt–68,30; 8Sch–81,26 T-points) with a relative decrease of parameters of the scale 9Ma–61,16 T-points, that indicated the hypochondriac, demonstrative and anxious-depressive tendencies. The profile of MMPI in persons of 3rd group does not extend beyond the limits of professional and populational norms (<70>30 T-points) and indicates on the efficient physiological adaptation in this group.

Conclusions: Comparative evaluation of psychophysiological adaptation of military personnel and personnel of ChNPP, indicates the over voltage of mental adaptation of military personnel (colonels, helicopter pilots) and effective adaptation of the staff (engineers), combined the basic work in station with participation in liquidation of consequences of the ChNPP accident. The over voltage of the psychophysiological adaptation colonels were detected at the level of the neurotic triad and was due hypochondriacal tendencies. The over voltage of the psychophysiological adaptation helicopter pilots was registered as at the level of neurotic, and as psychotic triad and was attributed due hypochondriacal and anxious-depressive tendencies.

DOSIMETRY IN NUCLEAR MEDICINE (PET/CT)

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PET/CT is unique in its ability to assess at molecular level the intensity of metabolism in body tissues. For cancer cells this intensity is much higher than normal, so even tiny accumulations of them are easily detected. Rendering quality and amount of information obtained by PET/CT, far higher than by any other diagnostic methods, so it is capable to diagnose those tumor foci that can't be detected by other imaging modalities - US, X-ray, CT, MRI, monoPET. Properties of PET/CT allow detection of tumors at early stages of their growth; establishing how far tumor has spread; assessment whether cancer cells are viable or not. This information is critical when specifying the diagnosis of malignancy, operation, radiation or chemotherapy planning and monitoring of treatment effectiveness.

Radiation exposure during PET/CT is higher compared with conventional PET and CT studies. Given that the average dose of PET is about 2 mSv, the main contribution in the PET/CT falls on CT (average dose in the routine diagnostic CT - 5 mSv).

Dose of radiation during standard CT-procedure depends on many factors and can vary. Magnitude of radiation exposure during CT scans is affected by type of scanner (with one or two X-ray tubes), number of detectors, patient's constitution, choice of peak kV/mAs and scan mode (trigger or synchronized with/without modulation) – e.g., addition of diagnostic CT-protocol with intravenous contrast and calcium scoring to PET/CT studies with standard low-dose CT (5 mSv) increases absorbed dose up to 30 mSv.

The effective radiation dose from PET/CT is 10-30 mSv (in large cities background radiation exposure reaches 3-5 mSv/year), but it is still several times lower compared with confirmed negative impact on humans. Despite this, you should use an individualized approach when selecting CT-protocol for each patient in accordance with the ALARA/ALARP principles.

SERBIAN TC COHORT: 2016 UPDATE - THERAPEUTIC USE OF X-IRRADIATION DURING 1950S AND ITS DELAYED HEALTH CONSEQUENCES

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Last year we reported on our work of setting up a cohort of patients who received Tinea Capitis (TC, ringworm) treatment which included ionizing radiation during 1950s. We provide further progress on cohort recruitment, and point out to some sensitive issues concerning protection of individual identity.

Large scale outbreak of TC occurred in Former Yugoslavia during 1950s. TC is fungal disease of the scalp commonly affecting children of school ages in an environment of low sanitation and hygiene. Epidemic proportions were unprecedented, forcing the former Yugoslavia health authorities to initiate a nationwide eradication campaign. Application for assistance was also made to 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 which included X-irradiation was provided to roughly 100,000 children, at least 50,000 in Serbia alone.

Until discovery of Griseofulvin in 1958, the only TC treatment available was based on X-ray induced hair removal followed by application of topical ointments. Irradiation doses applied through standardized protocol were considered safe and represented international standard of care. Many years later it was shown that even such exposure can lead to serious delayed health consequences decades after the treatment (mean latency is now estimated to be 35 years). Health risks relate to increased incidence of benign and malignant neoplasms of the head and neck.

Discovery of protocols from the Belgrade TC hospital enabled individual identification of former patients nowadays in their 60s and 70s. So far, identity has been confirmed for 14,000 persons out of 25,000 treated.

Our last year’s progress has been significantly delayed by the Serbian judicial reforms concerning protection of individual privacy data. Identity check of hospital data is now made almost impossible at the local registry offices and through Ministry of Interior database. The same applies to uncertainty of means by which a control group of individuals from the general population is to be selected. The only unquestioned activity remains individual approach to already identified former TC patients through health care system, aimed to obtain permission to participate following individual informed consent. Not even this aspect was carried out entirely without problems due to varying levels of motivation by primary health care institutions. We believe that all this obstacles could be overcome only with more explicit support by the relevant authorities.

We also believe that as many as 18,000 former TC patients, a minimum of 1,000 general controls, and several thousand unexposed siblings could be included. Once this work is finalized, the Serbian TC cohort would represent a valuable source of information to the wider scientific community.

RADIOCHROMIC FILM DOSIMETRY IN HIGH ENERGY ION BEAMS

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Radiochromic films are widely used in dosimetry studies with different radiation types, including proton and carbon ion beams. The key issue of carbon ion beams is the variation of its linear energy transfer (LET) with the penetration depth in material. Since the response of a film depends on radiation LET, relative efficiency was evaluated to correct measured dose values.

Dosimetric film Gafchromic® EBT3 (International Specialty Products Inc, Wayne, NJ) was used as a monitor while biological systems has been irradiated with U-70 particle accelerator at IHEP (Institute for High Energy Physics), Protvino, Russia.

Carbon ions energy was 455 MeV per nucleon. Dosimetric measurements and exposure of biological objects were performed in air box within water phantom. Air box location was controlled with high-precision movement system with remote control. The absorbed dose was measured with ionization chamber TM30010. The readout of ionization chamber was normalized to carbon ions fluency. Relative effectiveness of films at a pristine Bragg peak has been determined by irradiation of the film positioned along a beam axis. So as there is no primary standard for heavy ions, the gamma radiation with 60Co was used as calibration values. Films were scanned 48 hour after irradiation with an Epson V700 Photo scanner with 300 dpi resolution.

The dose measured with ionization chamber and radiochromic films used have substantial difference at the Bragg peak. The experimental results indicated that doses determined with films were underestimated by 10% and 40% at plateau and Bragg peak regions, respectively. Work is still in progress to further explore its potential and limitations.

Radiochromic films are precise tools with high spatial resolution. Assuming all the necessary corrections and validations done the films are promising and powerful tool for both proton and heavy ion therapy.

EVALUATION OF X-RAY BEAM QUALITY BASED ON MEASUREMENTS IN SOME MEDICAL TREATMENT CENTERS

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X-rays play an important role in modern technology, especially for medical imaging purposes. Medical sources of ionizing radiation are the largest contributor to the population dose from artificial sources, and most of this radiation comes from diagnostic X-rays. The X-ray spectrum and beam quality are must-know parameters for studying the dosimetric properties of X-ray beams in diagnostic radiology.

Quality Control measurement tests on diagnostic X-ray units were carried out in sixteen medical treatment centers (MTC) during period of time 2013-2015. The measurements consisted of tube voltage (kV), half-value layer (HVL), exposure time (ms), radiation output and Entrance Surface Dose (ESD).

X-ray tube output measurements were conducted using PTW Nomex Multimeter, calibrated at the Secondary Standard Dosimetry Laboratory (SSDL). The dosimeter was positioned in central beam axis such that the X-ray tube focal spot–detector-distance (FDD) was 100 cm. The radiation field size (FS) at FDD was set just to cover the dosimeter in order to avoid the possible influence of scatter radiation to the dosimeter. The tube potential was set at more than 70 kVp and any mAs value (depending on convenient tube load conditions), an X-ray exposure made and the dosimeter reading recorded. This step was repeated for 5 times more at same kVp and mAs settings and the average dosimeter reading determined. The X-ray tube output was determined as the ratio of average dosimeter reading (air kerma) to the tube current-time product used.

The analysis of X ray units test results showed that more than 82% had acceptable deviation between nominal and measured values of X ray tube voltage within the tolerance limit of 10%, whereas 84% of the X ray units meet the recommended limits of exposure time (deviation < 10%). Measurements on the X ray tubes showed that 93.75% had adequate beam filtration (HVL > 2.3 mm.Al, 80 kVp) and in 98% exposure reproducibility had acceptable variation within the tolerance limit of 5%.

* 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

RADIOFREQUENCY ABLATION IN LIVER TUMOR THERAPY

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Radiofrequency ablation (RFA) is a medical procedure in which the part of the conduction system of the heart, tumor or other dysfunctional tissue is ablated using the heat. Ablation refers to treatments that destroy tumors without removing them. High frequency alternating current that flows through the electrodes in the range of 350-500 kiloHertz is used. The treatment is palliative and it is based on a fact that normal tissue can be exposed to higher temperature than tumor tissue. RFA may be used to treat parenhymal organ tumors, lung, liver, kidney, pancreas, and bone tumors. The success rate for completely eliminating small liver tumors is greater than 85%. Two important advantages of the radio frequency current over the previously used low frequency alternating current or pulses of direct current are that it does not directly stimulate nerves or muscle and therefore can often be used without the need for general anesthesia and that it is very specific for treating the desired tissue without significant collateral damage.

The aim of the study is to compare the treatment of the primary liver tumors by RFA with the RFA of metastastatic tumors. We would like to present which approach for the RFA has the best results in liver tumors treatment.

A multi-database online search was performed and we made a comparison of several randomized and retrospective studies. Identified articles were reviewed on description about the exact diagnosis and aproach for ablation.

The percutaneous method of RFA in which electrodes are inserted through the skin is minimally invasive procedure which often does not require hospital admission. It is less expensive and no surgical incision is needed. There are although risks from the infection, bile duct or bowel damage or abscess formation. Even though performed through skin incision it often requires general anesthesia. In the retrospective study where 29 patients were included in 13 patients RFA was not performed because of poor visibility or possible thermal damage to adjacent organs. Laparoscopic approach would be optimal solution. In the study which compares laparoscopic resection to laparoscopic RFA the morbidity rate was less in RFA group as well as hospital stay and complete response was achieved in 90.3% of thermoablated nodules. RFA is used to treat primar or metastatic liver disease. It is developed to treat recurrent small tumors. Primar liver tumors can often be large in diameter where RFA has slight therapeutic effect. RFA of 233 hepatic tumors revealed the complications in a 24.5% of tumors most of which are primar hepatocellular carcinoma.

We believe that RFA can be safe and standardized method in a liver tumors treatment. However the best results are achieved with the treatment of metastatic liver disease with the laparoscopic intraabdominal approach.

MAMMOGRAPHY IN SERBIA: IMAGE QUALITY AND RADIATION DOSE

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Breast cancer is the major cause of mortality among female population in Serbia. It is presumed that the introduction of screening programme will reduce mortality. Quality control (QC) in mammography is an essential element of the successful breast cancer screening campaign as it provides a basis for standardization of the image quality and radiation dose in mammography. The purpose of this study is to investigate the radiation dose and technical image quality in mammography is Serbia after two years of implementation of the breast screening programme. Initially, QC protocols containing list of parameters, methodology, frequency of tests and reference values for screen-film, computed radiography and full-filed digital mammography) units, were developed and subsequently implemented. During period 2013-2015, QC protocols were applied to total 186 mammography units, namely 18 full filed digital mammography (FFDM) units, 82 computed radiography (CR) units and 86 screen-film mammography (SFM) units. This work presents results of tests of the selected parameters of patient dose and image quality. Patient dose in terms of Mean Glandular Dose (MGD) was assessed for the standard breast represented by 45 mm PMMA phantom, while image quality in terms of spatial resolution and threshold contrast visibility was assessed using TOR MAS (Leeds test objects, Leeds, UK) test object. In addition, for CR and FFDM units, contrast to noise ratio (CNR) was assessed using PMMA homogenous phantom and 0.2 mm aluminum detail. Assessed mean MGD was (1.8±0.94) mGy, (1.3±0.51) and (1.7±0.64) for CR, FFDM and SFM, respectively. Spatial resolution was better than 12 lp/mm only for 3/186 (1.6%) units. In 34/186 (18%) units, spatial resolution was less than 5 lp/mm. Threshold contrast visibility was better than 1.2 in 41/186 (22%). Mean CNR for CR and FFDM units was 5.2 ±2.2. Relevant parameters of the x-ray tube and generator were within the reference values. Radiation dose in all units was in line with reference level of 2.5 mGy for a standard breast. However, insufficient image quality was noted in most of the units. Major problems are associated with lack of central data analysis, lack of clear differentiation between units used for clinical and screening mammography, deficiencies in the image receptor and mammography unit operation (automatic exposure control, compression), lack of in-hospital QC and inadequate implementation and follow up of the corrective actions. Therefore, after initial implementation at the beginning of the population-based breast cancer screening campaign, it is essential to establish an effective system of regular and periodic QC tests and to ensure high quality mammograms with minimal possible radiation dose to population included in the screening.

X-RAY IRRADIATION IN THE DIAGNOSIS OF RARE GENETIC DISEASES

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Among the rare hereditary disease there are some causes difficult to diagnose. While such diseases involve damage (mutation) of one or several genes, in some cases a molecular diagnostics is impossible, i.e. a damaged gene is long and/or has many exons or many possible places of mutations.

When some disease is caused by mutation in gene(s), the protein synthesis from that gene is hindered or totally absent, therefore formation of active form of such protein is unlikely. This fact can be used in cell diagnostics of ataxia telangiectasia (more than 100 mutations in ATM gene), Seckel syndrome 1 type (deletions in ATR gene), AT-like disease (mutations in RAD gene), Nijmegen's syndrome (mutations in NBS1 gene) and other diseases with defects in DNA repair. Such defects could be revealed by X-ray irradiation of patient's cells, because they lead to increased DNA damage. Moreover usually those diseases correspond with increased chromosomes fragility and higher X-ray sensitivity.

RADIATION PROTECTION OR WHAT IF?

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Considering the biological action of ionizing radiation, their use for the diagnosis and treatment in medicine is gaining more and more speed. With developments in contemporary science and technology hymns came increasingly on new technologies and methods using ionizing radiation for medical purposes. New generations of medical equipment using ionizing radiation, sparing the patient the radiation exposure replace outdated. With the introduction of modern equipment necessary well prepared and continuously improving medical and non-medical personnel servicing this equipment.

This trend is observed worldwide and is especially relevant in Bulgaria. The University Hospital "St. Marina" in Varna is one of the leaders in this direction. Since 2009, we have begun upgrading and introducing modern medical equipment using ionizing radiation. Almost all medical X-ray equipment was replaced, the gamma camera as well, and for the first time in Bulgaria the positron emission tomography - PET/CT (2009) was installed, the cyclotron complex for the production of radiopharmaceutical F-18s - for diagnostic with PET /CT was also the first in Bulgaria (2013), as well as three linear accelerators (2014-2015).

In every medical procedure related to sources of ionizing radiation, the patient is informed in advance about the benefits and harms of the procedure. It takes their written consent to conduct a procedure using the sources of ionizing radiation. In medical procedures using open sources, such as the injection of radiopharmaceuticals in diagnostic PET / CT gamma camera or a patient subject to such a procedure, provides detailed information on its actions in contact with others after the completion of the study. In order to reduce the exposure of people they contacted in the next few days, the patient is recommended to limit the direct contacts, especially with small children and pregnant women. If the patient is a mother who breastfeeds her baby, it is recommended that breastfeeding should be stopped. All these rules are also known as the term "informed consent" with which the patient is required to meet prior to the study and approve it by putting his/her signature on it. Observing these rules, the patient protects people from their daily environment from an unnecessary occupational exposure to ionizing radiation.

But what would happen if the patient did not comply with these rules?

OLD AND OUTDATED RADIOLOGY EQUIPMENT IN CROATIA – RADIATION SAFETY AND ECONOMICAL CONSEQUENCES

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Aims and objectives: Ionizing radiation from medical imaging today accounts for a great proportion of the radiation exposure experienced by general population. While the benefits of imaging and interventional procedures are well known, those benefits are not without risks. Technological innovations are helping us reduce the dose of ionizing radiation delivered to patients thus lowering the chance of possible adverse effects. Older radiological equipment does not represent state of the art technology and also carries a higher risk of failures. Our goal is to show the current state of Croatian radiological equipment and analyze its position especially in regards to the ESR position statement.

Materials and methods: We statistically processed data on the number and age of the devices installed in Croatia used in radiological diagnostic and therapeutic procedures (CT, angiography, mammography) and we compared them with those from other European countries.

Results: No single modality analyzed fulfils the requirements for reasonable renewal. The situation is especially alarming in mammography where 62% of equipment used is more than 10 years old. In angiography and CT scanners the percentage of equipment older than 10 years is 43.4% and 45.5% respectively. In comparison with countries with similar GDP Croatia has a much higher percentage of old equipment. To our knowledge there is not a comprehensive plan for renewal of equipment on a national level, inspite of constant efforts by Croatian Society of Radiology~~.~~

Conclusion: In the light of the radiation safety and economical principles it is an imperative to force implementation of more coherent and sustainable investment strategies for renewal of radiological equipment in Croatia.

RADIATION EXPOSURE TO PATIENTS AND INTERVENTIONAL RADIOLOGY STAFF DURING PERIPHERAL VASCULAR ANGIOGRAPHY AND INTERVENTION

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The use of digital subtraction angiography (DSA) for peripheral vascular angiography and intervention has experienced rapid growth in recent years, due to advances in C-arm imaging equipment and computing power. Due to high susceptibility to the image noise, this imaging method is often associated with high patient and staff exposure. In addition to the whole body doses, extremity and eye lens doses could be particularly high if radiation protection is not utilized. The purpose of this study was to investigate the level of radiation exposure to patients and staff during DSA procedures. Thirty eight studies performed by five different first operators were followed during period February-April 2015. All staff members used personal protective tools as lead aprons and collars, however, collective protective tools as ceiling suspended screens were not used due to practicality reasons. Protective lead glasses were used regularly by all operators. Data collected prospectively included fluoroscopy time, number of cine series, kerma–area product, cumulative dose at an interventional reference point and occupational dose in terms of $H_p(10)$ for the interventional radiologists measured using electronic dosimeters above the operator's lead apron. Mean fluoroscopy time was 5.0 (0.70-25) min and number of cine series was 10±6 (2-41). Corresponding patient doses in terms of kerma-area product and cumulative dose in interventional reference point were (55 ±36) Gycm^2 and (203 ±170) mGy, respectively. Occupational dose in term of Hp(10) was 28 μSv per procedure , with the corresponding range from 2 to 351 μSv. When use of a dedicated eye lens dosemeter is impractical, this values could be used for eye lens dose assessment, by applying a rough correction factor of 0.75. Obtained dose values are based on a local practice and may provide useful reference for planning of the individual monitoring arrangements, in particular when collective radiation protection tools as ceiling suspended screens are not used.

EXPLORING RISK PERCEPTION AND BEHAVIOR CONCERNING OCCUPATIONAL SAFETY PRACTICES AMONG THE PROFESSIONALS IN RADIOLOGY SERVICES

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Introduction. Health care workers of the Radiology Department are exposed to increased risk of adverse effects of ionizing radiation only in case of non-compliance with occupational safety procedures. At the same time, various studies suggest that medical professional are often poorly informed about the safety standards.

The aim of this paper is an assessment of the professional risk perception, in a population of health care workers from the radiology departments.

Method. This cross-sectional study included all employees (250) of the radiology department at the Center for radiology and MRI, Clinical Center of Serbia. The study instrument was a questionnaire, consisting of 35 variables, designed and validated for this research. We have constructed two composite scores: the score of knowledge (11 variables) and the score of attitudes (10 variables).The compliance with three occupational safety procedures, determined responsible behaviour (derived dependent variable). Data collection and analysis were performed using IBM SPSS Statistics 20. The univariate association between responsible behaviour and independent variables was assessed by unadjusted odds ratios (ORs) with 95% confidence intervals (95% CIs). The independent associations between responsible behaviour and relevant independent variables among variables were tested by a multiple logistic regression model in a stepwise backward manner. The variables with a $p < 0.05$ were retained in the final model.

Result. We analysed 175 completed questionnaires (the response rate was 70%). The scores of knowledge and attitudes showed good internal consistency (Cronbach's $\alpha = 0.701$ and Cronbach's $\alpha = 0.773$). The analysis revealed that half of our respondents had negative attitudes about their profession, and nearly two-thirds of them felt that they were under constant stress caused by increased professional risk. A total of 78.0% of respondents agreed that their workplace affects health, and 53.2% believed that it endangers their reproductive ability. In this research, 63.2% of respondents had no confidence in the values that dosimeters show. Only 12.1% of our respondents were satisfied with the achieved benefits. In relation to the score of knowledge, 5.1% were at a low level, 58.3% medium and 36.6% higher level of knowledge. There was no statistically significant correlation between knowledge of subjects and their behavior and perception of professional risks. The final model of multivariate logistic regression analysis, in which are entered all the features that have proven significant in individual univariate models (socio-demographic factors, attitudes and knowledge), illuminated three significant characteristics associated with responsible behavior. More responsible were married people (OR=2,32, p<0,001), older respondents (OR=3,23, p<0,001), and respondents with affirmative attitudes toward workplace (OR=1,13, p<0,001).

Conclusion. The majority of the respondents perceived exposure to high professional risk. The use of personal protective equipment, and the development and refinement of basic safety standards have an important role in protecting the radiology staff. Awareness of radiological protection and a positive attitude to the conditions and equipment in the workplace has a positive impact on their practice.

RADIOIMMUNOTHERAPY IN THE TREATMENT OF CANCER

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Radioimmunotherapy (RIT) is successful combination of radiation therapy and immunotherapy. Radioimmunotherapy uses a monoclonal antibody linked with a radionuclide in order to deliver cytotoxic radiation to target cancer cell. Monoclonal antibody recognizes and binds to the surface of cancer cells and allows a high dose of radiation to be delivered directly into the tumor. This ability of antibodies to specifically bind to a tumor-associated antigen increases the dose of radiation delivered to the tumor cells while decreasing the dose to normal tissues. RIT requires a tumor cell to express an antigen that is not accessible in normal cells. In the ideal case only tumor cells are destroyed, and usual generalized side effects of tumor therapy (nausea, vomiting, alopecia) are absent.

Murine anti-CD20 monoclonal antibodies (MAbs) conjugated to either ^{131}I (^{131}I-tositumomab) or ^{90}Y (^{90}Y-ibritumomab tiuxetan) were the first agents of radioimmunotherapy, and they were approved for the treatment of refractory non-Hodgkin's lymphoma. They are used in patients whose lymphoma is refractory to conventional chemotherapy and the monoclonal antibody rituximab. Radioimmunotherapy is very suitable for the treatment of non-Hodgkin's lymphoma (NHL) because lymphomas are tumors that are very sensitive to radiation, and with this therapy the largest amount of radiation ends in tumor tissue, as opposed to total body radiation. The agent used today is Yttrium-90 Ibritumomab Tiuxetan (Zevalin®). Iodine-131 Tositumomab (Bexxar®) is no longer on the market.

The immunogenicity of murine monoclonal antibodies led to the characterization and production of potentially less immunogenic antibody forms, including chimeric and humanized immunoglobulins. As with chemotherapy, therapeutic progress with radioimmunoconjugates has been most evident in the non-solid tumours. Several radioimmunoconjugates, some recently approved by the FDA for radioimmunodetection are consist of antibody Fab' fragments conjugated to technetium-99m, and these smaller forms may be less immunogenic. Several new radioimmunotherapy agents are under development or in clinical trials. Potential uses for RIT include the treatment of prostate cancer, colorectal cancer, melanoma, ovarian cancer and leukemia.

The cost of radioimmunoconjugate should be comparable to chemotherapy, and its selectivity should permit cost savings by minimizing side-effects such as seen after chemotherapy. Early and aggressive use of radioimmunotherapy should result in successful disease control, with minimal side-effects.

DETERMINATION OF BETA RADIATION DOSE TO THYROID FROM THE INGESTION OF RADIOIODINE (^{131}I) BY PATIENTS FOR DIAGNOSTIC AND THERAPEUTIC PURPOSES

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Radioactive iodine (^{131}I) is successfully used for the treatment of hyperthyroidism and thyroid cancer. Thyroid is the critical organ for iodine. Iodine is taken up by the thyroid follicular cells. ^{131}I simultaneously emits two types of radiation: beta minus particles used for the treatment and gamma rays used for diagnosis. Due to the short range of beta minus particles in tissue, damaging effects of beta radiation is restricted to thyroid cells. Total activities from the ingestion of ^{131}I were evaluated in different compartments of the human body of patients by using the ICRP biokinetic model for iodine. A new dosimetric model was developed for evaluating committed equivalent doses due to ^{131}I intakes in the thyroid tissue of different age groups of patients by exploiting data obtained for specific beta-dose deposited by 1Bq of ^{131}I in the thyroid. Data obtained were compared with those obtained by using the ICRP ingestion dose coefficients for iodine. The influence of the mass of thyroid and administered ^{131}I activity on the committed equivalent dose to the thyroid gland was investigated.

THE ASSESSMENT OF THE EXPOSURE OF RADIATION WORKERS IN NUCLEAR MEDICINE IN THE CZECH REPUBLIC

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During the manipulation with radiopharmaceuticals workers in nuclear medicine receive always certain exposure which is continuously monitored and strictly controlled by relevant national regulatory authorities. This exposure should be minimized following the ALARA principle and always below prescribed limits or reference levels. The paper presents some results of radiation doses of nuclear medicine personnel where special attention is paid to the exposure of extremities and to the skin of hands in particular. It has been observed that the skin dose of some workers may exceed the relevant annual dose limit and therefore some measures should be adopted to reduce these doses. The situation in the Czech Republic related to the radiation burden of workers in nuclear medicine is assessed and conclusions discussed.

RADIATION MEASUREMENTS 20

RADIOACTIVITY LEVELS IN SOILS FROM THE CAPPADOCIA REGION (NEVŞEHIR CITY, TURKEY)

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In this study, the natural and fallout radioactivity of surface (0-5 cm) soil samples collected from the center of Nevşehir city in Cappadocia region of Turkey were determined using by a gamma-ray spectrometer with an HPGe detector. The average activity concentrations of ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs were measured as 60.2, 50.1, 631 and 3.1 Bq/kg, respectively. Radiological risk to be exposed to people living in the center of Nevşehir city caused by the radioactivity in soil samples were evaluated by estimating the radiological parameters (absorbed gamma dose rate in outdoor air and the corresponding annual effective dose and lifetime cancer risk). Values measured and estimated were compared with national/international values and recommended limits or criteria.

DETERMINATION OF TRITIUM ACTIVITY CONCENTRATIONS IN NATURAL WATER SAMPLES

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The tritium activity concentrations in natural water samples (tap, well and spring waters) collected from Mersin city were determined using by distillation procedure before liquid scintillation counting (LSC) system. Also the corresponding radiological hazards due to the ingestion of water samples were evaluated calculating annual effective dose rate The tritium activity concentrations measured in water samples varied from <1.9 (detection limit) to 14.1 Bq/L (119.5 TU) with an average of 6.2 Bq/L (52.5 TU). The tritium activities in water samples examined were significantly lower than the limit of 100 Bq/L for waters intended for human consumption. The annual effective doses estimated for different age groups of the members of the public due to the intake of the tritium varied from 0.009 to 0.185 microsieverts per year.

APPLICATION OF TAGGED NEUTRON TECHNOLOGY FOR RESEARCH, INDUSTRY, AND GLOBAL SECURITY

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At the $T(d,n)He^4$ reaction each 14 MeV neutron is accompanied (tagged) by 3.5 MeV alpha-particle emitted in the opposite direction. A position- and time-sensitive alpha-detector measures time and coordinates of the associated alpha particle which allows determining time and direction of neutron escape. A spectrum of gamma-rays emitted at the interaction of tagged neutrons with nuclei of chemical elements allows identify a chemical composition of irradiated object. The recording of alpha-gamma coincidences in a very narrow time window provides the possibility of background suppression by spatial and time discrimination of events. The Nanosecond Tagged Neutron Technology (NTNT) based on this principle has great potentialities in various fields of science and industry.

The first use of NTNT was a measurement of angle correlation of products of inelastic neutron scattering and neutron differential cross-sections. It also found numerous applications in research and industry. A small radiation doze during the irradiation makes it possible to study in vivo chemical composition of biological objects, e.g. fat, protein and water content in bodies of animals. It can be used for measuring the oxygen and carbon content of ores in mining industry, for example, the search of diamonds in kimberlit samples. Thus, the rock pieces containing large-size diamonds can be identified before the crushing stage. Also the ability to examine bulk quantities of samples with elemental specificity provides for an effective detection system for explosives, mines, drugs and chemical warfare agents.

The All-Russia Research Institute of Automatics produces complete set of equipment for NTNT including neutron generators with built-in alpha-detectors, electronic hardware for recording the alpha-gamma coincidences, gamma-detectors. The main parameters of the equipment are considered. The experimental mobile and stationary systems with tagged neutrons for various applications are described.

HALF-LIVES OF THE TITANIUM ISOTOPES FROM PHOTONUCLEAR REACTIONS

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One of the important tools in understanding of the atomic nuclei is photonuclear reaction. These reactions are also interesting for realizing the element creation processes in space. The use of bremsstrahlung photons easily generated from medical linear accelerator is practical for performing these types of reactions. In this study the breemstrahlung photons with endpoint energy of 14 MeV have been used for activating Titanium target material. The photons have been used to induce photonuclear reaction on the target. After irradiation, the half-lives of the products have been determined with small uncertainties. It has been seen that the results are consistent with the present values in the literature. Besides, new measurements on gamma-ray energies of the products have been performed.

METHODOLOGICAL TRIANGULATION APPROACH FOR AGE DETERMINATION OF PLUTONIUM SAMPLE BY HIGH RESOLUTION GAMMA SPECTROMETRY

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This paper describes a methodological triangulation approach applied for the age dating of plutonium by high resolution gamma spectrometry. A metallic disk containing plutonium was measured by planar and coaxial high purity germanium (HPGe) detectors. The “Multigroup γ-ray Analysis Method” (MGA) and two additional methods were used for the determination of sample’s age. One of the methods implies the use of full energy peak efficiencies determined by Monte Carlo simulations software Gespecor for ^{241}Am and ^{241}Pu activities estimation, while the other one implies the use of three similar in energy gamma lines for the direct estimation of ^{241}Am/^{241}Pu isotopic ratio without a need of knowing the experimental setup. The data were compared and came to be in the good agreement within the uncertainties.

Key words: Nuclear forensics, plutonium, gamma spectrometry, age dating

QT-BASED CONTROL PLATFORM FOR THE RADIATION DOSE DATA MEASURED IN KOMAC

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KOMAC (KOrea Multi-purpose Accelerator Complex), the branch institute of KAERI (Korea Atomic Energy Research Institute), is a multi-user facility to provide a high intensity proton beam for a variety of user programs. A main equipment of this facility is a proton linear accelerator that is comprised of a 50 keV injector, 3-MeV radio frequency quadruple (RFQ), and 100-MeV drift tube linac (DTL). The extracted beam energy of the 350 MHz proton Linac is from 20 MeV to the 100 MeV. There are three kinds of areas decided by the radiation dose in KOMAC: High-level radiation area, Radiation worker area, and General public area. High-level radiation area includes the acceleration tunnel with the proton linac, beam lines, and target rooms. The most interesting area in the point of the measurement of the radiation dose is the radiation worker area. Thus, the radiation safety team measures the values of the radiation dose at various points in the radiation worker area every week and documents them on the recording papers. Records of the radiation dose measured in the radiation worker area of the KOMAC are buried on a pile of unsorted papers now. This unsorted information should be arranged by any systematic way and be shown as the simple shape to emphasis the fact that KOMAC is protected very well from the radiation. Qt-based control platform to arrange the values of radiation dose measured in KOMAC will be satisfied with this condition and make the radiation worker understand the level of the radiation dose in the radiation worker area by time and by place. This control platform will be implemented in C++ GUI programming with Qt 5 and worked in the window system. This platform will be also connected to the mysql data base to arrange the radiation dose data. This platform shows the procedure to measure the radiation dose used in KOMAC and the results saved in the data base are presented on the map of the radiation worker area and the several kinds of plots. The detailed description of the Qt-bases control platform will be shown in this research.

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SIZE DISTRIBUTION ASSESSMENT OF RADIOACTIVE AEROSOLS AT RESEARCH REACTOR

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Size distribution information of radioactive aerosols on a workplace is essential for personnel dose assessment. ICRP recommends using AMAD (aerosol median aerodynamic diameters) equal to 5 microns in the absence of information about particulate aerosols composition. It can lead to significant uncertainties in the assessment of internal dose inhalation.

Assessment of radioactive aerosols size distribution was performed at the research reactor. Diffusion battery with 20 capture brass mesh and cascade impactor were used for determination of aerosol size distribution.

Atmosphere in the reactor hall consists of radionuclides mainly Cs-138 and Rb-88 (inert gas progeny of Xe-138 and Kr-88) with half-lives of $T_{1/2}$ = 33.41 min, and $T_{1/2}$ = 17.78 min, respectively, and Te-132 with a half-life $T_{1/2}$= 3.2 days.

Aerosol size distribution was estimated for the general mixture of radionuclides, which deposited in the sampling devices. The obtained results with diffusion battery demonstrated the nuclear mode with AMTD (aerosol median thermodynamic diameters) ~ 0.7, 5 and 40 nm. Deposition of large particles with inertial method hasn't led to significant results.

It has been demonstrated that inert radioactive gases progeny have the same process of clusters formation as a process for the clusters formation of radon progeny.

INVESTIGATION OF REDISTRIBUTION OF ARTIFICIAL (^{137}Cs, ^{90}Sr) AND NATURAL (^{40}K) RADIOISOTOPES IN DIFFERENT USAGE SOILS

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In this study we investigated artificial (^{137}Cs, ^{90}Sr) and natural (^{40}K) radioisotopes' vertical distribution in different usage soils. Soil samples were collected in Lithuanian territory, which was, after the nuclear weapons and the Chernobyl Nuclear Power Plant (ChNPP) accident, contaminated with artificial radionuclides. For the study, three places were selected, taking into account human activities and radioactive environmental contamination (Neris Regional Park, a field near the Ignalina nuclear power plant and a field in a village in Ukmergė district).

In addition, we analysed the soil organic matter, which determines the amount of nutrients, water infiltration, ion exchange, adsorption of pollutants. Studies show that in those places the predominant soil type is sandy loam, with soil mineralization rate close to 1 that are the biggest factors to determine the mineralization of the Neris Regional Park. In village place and regional park place (Jogvilai and Paaliosė areas, respectively), ^{137}Cs specific activity decreases exponentially. However in the regional park place (Paaliosė) 10-15 cm soil depth of ^{137}Cs noticeable increase in specific activity, associated with the former nuclear weapons test contamination. ^{40}K changes the specific activity of the soil samples, taking them by the depth in all areas preset less uneven than ^{137}Cs. In the regional park place and near the Ignalina nuclear power plant observed ^{40}K specific activity decrease with increasing depth and in village place vice versa - increasing the depth of ^{40}K specific activity increases. The average ^{90}Sr radionuclides in the soil are 6,4±1,1 Bq/kg (regional park place), 6,4±2,0 Bq/kg (near the Ignalina nuclear power plant) and 11,3±1,7 Bq/kg (in the village place).

Key words: Soil, ^{137}Cs, ^{90}Sr, ^{40}K vertical distribution in soil

A PRELIMINARY STUDY OF THE DISTRIBUTION OF ENVIRONMENTAL RADIOACTIVITY IN THE URBAN AREA OF THE TIRANA CITY, ALBANIA

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This preliminary study aims to investigate the distribution of the environmental radioactivity in the urban area of Tirana city, in order to assess the exposure of the population due to the terrestrial radiation. The activity concentrations of ^{40}K, ^{238}U, ^{232}Th and ^{137}Cs in 31 soil samples collected in the urban area of Tirana city are determined by using high resolution gamma spectrometry technique. The average values of the activity concentrations of ^{40}K, ^{238}U and ^{232}Th in the urban area of Tirana are respectively 390 ± 92 Bq/kg, 36 ± 12 Bq/kg and 34 ± 12 Bq/kg, which correspond to an absorbed external gamma dose rate of 53 ± 15 nGy/h. The exposure of the population in the urban area of Tirana city is estimated to have an average annual effective dose rate from 0.07 ± 0.02 mSv/y, which is comparable to the world average effective dose rate. The activity concentration of^{137}Cs was found to vary from ^{40}K, ^{238}U and ^{232}Th are mostly lower in the northeast and east area of Tirana city. The activity concentration values of ^{40}K and ^{232}Th are relatively high in the south and southwest area perhaps due to the influence of mollasic formation composed mainly of clay. This survey permitted to highlight the necessity for a more detailed investigation in order to cover the entire territory and to include other sources of natural ionizing radiation such as indoor radon, cosmic radiation and construction materials.

* 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 RADIOCESIUM LEVELS IN FOREST SOILS OF MOUNT IDA IN TURKEY

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In this study, it is aimed to establish the Cs- 137 activity levels in forest soils of Mount IDA (Kazdagi)/Edremit restricted area. In this aspect, soils were sampled from 118 area and Cs-137 activity levels in samples were determined by using HPGe Gamma Spectrometer System. The 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. Cesium-137 deposition in the study area was estimated to be in the range of 1 - 39 kBq m^{-2}. The distributions of ^{137}Cs activities in O_L, O_F + O_H and A horizons throughout the region were mapped in detail. These findings showed that the activity levels of Cs-137 in the forest soils were still high in contrast to agricultural soils after 25 years from the Chernobyl accident.

THE NATURAL RADIOACTIVITY IN THE BEACH SAND – CANAKKALE, WESTERN ANATOLIA/TURKEY

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The survey of the natural radioactivity (^{226}Ra, ^{232}Th and ^{40}K) levels in beach sands from the coast line of Çanakkale known as high background area was performed as a part of the environmental monitoring program on radiologic impact of the granitoid areas in Western Anatolia. This study is the new comprehensive survey carried out systematically so far in beach sands of Çanakkale coast line from Güzelyalı to Gülpınar beaches along the 75 km distance. The activity concentrations of the relevant natural radionuclides in the beach sand samples ranged from 20 to 1002 Bq kg^{-1} with a mean value 211±45 Bq kg^{-1} for ^{226}Ra, from 14 to 959 Bq kg^{-1} with a mean value 220±48 Bq kg^{-1} for ^{232}Th and from 84 to 2905 Bq kg^{-1} with a mean value 1024±143 for ^{40}K. The corresponding absorbed dose rates in air from all those radionuclides were in the range of 42-1078 nGy h^{-1} with an arithmetic mean value of 273±50 nGy h^{-1}. Furthermore, mineralogical composition of some beach samples from the Geyikli region was studied in detail. It is concluded that the major contributors to the high level of radiation are zircon, monazite, and associated ilmenite and rutile.

Key words: Natural radioactivity; beach sands; heavy minerals; Çanakkale coasts.

THE USE OF A NEW GENERATION OF SILICON PHOTOMULTIPLIERS IN PORTABLE GAMMA RADIATION SCINTILLATOR BASED DETECTORS

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Currently, silicon photomultipliers (SiPM) with scintillator CsI(Tl) are successfully used as gamma radiation detectors. However, these detectors have a significant disadvantage limiting their applications, namely, a very strong dependence of the SiPM gain on temperature and bias voltage. Presence of of such dependence makes it necessary to use bias voltages with a high degree of output voltage stabilizing and devices for the SiPM gain stabilizing in operation under varying operating temperature. We manufactured and investigated parameters of scintillation detectors based on CsI(Tl) and BGO crystals and SiPM of a new generation produced by SensL. In a work parameters of detectors with scintillation crystals of different sizes up to 5 cm^3 volume and SiPM different sizes are shown. Possibilities of optimization and stabilization of the detectors parameters in a range of operation temperatures from –20 °C to +50 °C and at high count rates are discussed. Recommendations for the practical use of the SiPM gain stabilization are given.

THE FIRST VALIDATION STEP OF AN AUTOMATIC MICRONUCLEUS COUNTER: THE COMPARISON OF MANUAL AND AUTOMATIC MICRONUCLEUS X-RAY DOSE-EFFECT CURVES

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In case of a radiation or nuclear emergency workers and inhabitants may be affected by unintended and unknown radiation dose. In these situations the micronucleus (MN) assay as a major biodosimetry tool plays a fundamental role in fast estimating of exposure and the radiation injury.

In our work we wish to show the current state of the Radosys Ltd.'s automatic microscope that is developed for MN counting. The main goal of this project is to improve the speed and cost-effectiveness of MN assay method. Whole blood samples from healthy individuals were irradiated with 0, 0.5, 1, 2, 4 Gy of dose by X-rays. The cytokinesis-blocked MN assay was performed according to the protocol of the International Atomic Energy Agency.

Dealing with automatic image processing, a trade-off between statistical precision and sensitivity always has to be achieved. The leading concept in the design of the algorithm was the maximization of object detection precision. Consequently, the automatic and the manual scoring results differ. The comparison to the manual technique as the reference method is a key part during the validation process of the new automation. In order to achieve this, the dose-effect curve was determined in three different ways:

1. with manual scoring,
2. with automatic microscope and its built-in image processing software, and
3. with manual revision of the automatic scoring results (semi-automatic).

The CABAS program was used for the preparation of the dose-effect curves. The results of the statistical analysis shows 98% correlation (R=0,988; CI95%: 0,83-0,99) between automatic and manual scoring. Our deduction now is only preliminary due to the small number of samples, but we can conclude that the automatic recognition system is suitable for the acceleration of MN assay procedure.

MSV SIGNAL PROCESSING SYSTEM AND CALCULATION OF RATIO ($Q_{NEUTRON}/Q_{GAMMA}$) FOR BF_3 IONIZATION CHAMBER IN CF-252 FIELD

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In the nuclear technique and applied nuclear physics used MSV (Mean Square Value) signal processing system with BF_3 ionization chamber that has been realized on the base principles derived from Campbell's theorem.

MSV mode is especially suitable for the measurements performed in mixed radiation field, because quantities of electrical charge involved in interactions of two type of radiation are substantially different. At occasion when classic current mode is used, direct current measured depends on partial contribution regardless of existent radiation type. On MSV mode, linear dependence appears for square quantity of electrical charge per event for each radiation type apart. Therefore, MSV mode favours radiation type which yields to detector response with larger average electrical charge per interaction event (q_1). Essentially, it fulfils better discrimination for an one of radiation field components. It is important notice that undesirable component contribution in output signal of measured chain is "repressed", and this represents discrimination in broadest sense. This property of MSV mode is utilized on an uncompensated ionizing BF_3 chamber, as neutron detector, for increment yield of signal component which results from neutron in relation to yield of gamma component with less q_1.

Influence of uncorrelated gamma field for output of such BF_3 ionization chamber could be define for both of measured systems by relative ratio ($Q_{neutron}/Q_{gamma}$) of contributions in the output signal originating from neutron and gamma radiation in Cf-252 field.

Due to the experiments in the field of californium, which is both a gamma emitter, they are estimating the value of Q_{gamma} over the numerical experiment with the use of a software package FOTELP-2K12. For the calculation of $Q_{neutron}$ values considers the case of transport of thermal neutrons through the BF_3 gas, where such products of nuclear reactions occurring alpha particles with kinetic energy $E\alpha$ = 1.47 MeV and the nucleus lithium E_{Li} = 0.84 MeV. For each thermal neutron might be approved to the products of interaction leave all their kinetic energy in the active volume ionization chamber.

Based on the calculated ratio ($Q_{neutron}/Q_{gamma}$), it shows that the repressing of undesirable gamma component contribution to output signal against to neutron radiation contribution is adopted conventionally as neutron-gamma discrimination.

THE ANALYSIS OF THE RADIATION RESPONSE OF ELECTRICAL PARAMETERS OF DIFFERENT MOSFET MODELS

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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 widely investigated, using the threshold voltage shift (ΔV_t) in the saturation region of transistors as main dosimetric parameter. However, other parameters and characteristics are influenced by radiation [1]. In this work, a depth study, in transistors both commercial and specific (RADFETs), of the relation between the dose and diverse electrical transistor parameters in different regions of operation is done.

Experimental setup

Four samples per model were analysed – 3N163 (Vishay Siliconix) and CD4007 (Texas Instruments) as commercial pMOS transistors, RADFETs of 400 nm, 100 nm and 1 µm as specific transistors. All of them were manufactured by Tyndall National Institute. The samples were irradiated with all the terminals grounded with a linear accelerator Mevatrons KDS (Siemens) operated at the Hospital Universitario "San Cecilio" in Granada (Spain). The sensor responses were measured by a semiconductor parameter, B1500 (Agilent Technologies). The parameters were calculated before and after irradiation.

Test Name	**Region of work**	**Parameter**
Test 1	Subthreshold region (short range)	Subthreshold slope (ΔS)
Test 2	Subthreshold region	Subthreshold slope (ΔS)
Test 3	Charge Pumping	Current substrate-gate (Icps), Interface traps charge (Nit), Oxide traps charges (Not)
Test 4	Saturation region (short range)	Threshold Voltage Linear Fit (Vth_LE),Threshold Voltage Constant Current (Vth_CC)
Test 5	Saturation region	Threshold Voltage Linear Fit (Vth_LE)
Test 6	Triode region (short range)	Transconductance (gm), Derivate transconductance (gm'), Threshold Voltage Linear Fit (Vth_LE), Threshold Volgate Fowler-Harstein (Vth_FL), Threshold voltage Peak of transconductance (Vth_TC), Threshold voltage Park (Vth_G3), Threshold Voltage Constant Current (Vth_CC)
Test 7	Saturation-Triode region	Early voltage (Va)

Preliminary results

Some of the preliminary results are shown in Figure 1, where the CD4007 is analysed in the triode region. Our aim with this work is to provide a comparative study and discussion of the parameters calculated in each test for every transistor. We are expecting different response to the radiation of them related to the transistor fabrication process.

BIOINDICATION AS THE VERIFICATION OF FORMULAS FOR CALCULATING SR-90 DOSE IN THE SKELETON OF SMALL MAMMALS

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Adequate definition of doses irradiation ^{90}Sr at the rodents at the ecosystems, polluted by radionuclides (Urals Mountains, Chernobyl, etc.) and in natural radioactive territories (in Brazil, India, Iran etc.) is a key position of an estimation of their viability and forecast. However the comparative studying of these materials is hindered by the using of different methods of dosimetry. As a result, multiple differences of calculated doses at the same radioactivity of ^{90}Sr in the skeleton are published. Calculation formulas for mouse and for rat are offered to use (Shishkina, Lyubashevskiy, 2008):

$DR^{bone} = A^{mouse} C_{Sr}{}^{bone} = 7.0\ C_{Sr}{}^{bone}$ – for a mouse,

$DR^{bone} = A^{rat} C_{Sr}{}^{bone} = 15.0\ C_{Sr}{}^{bone}$ – for a rat, here DR^{bone} – dose rate (mGy d^{-1}) in a skeleton at known specific^{90}Sr radioactivity ^{90}Sr (kBq g^{-1}) in a bone tissue.

Independent confirmation of the adequacy of these formulas provides a method of bioindication. As the criterions can serve mortality indicators for external γ -irradiation, $LD_{50/30}$. Ideally, these values should coincide the $LD_{50/30}$ internal exposure ^{90}Sr.

At unitary entering ^{90}Sr the absorbed dose within the first 30 days increases almost linearly. That facilitates comparison the irradiations effects of external γ- and internal β-. $LD_{50/30}$ chronic gamma irradiation for the mouse – 32 Gy, for a rat – 27 Gy (Grigoriev et al., 1986). Experimentally defined $LD_{50/30}$ ^{90}Sr for the mouse and a rat are taken as averages from many works, in particular (Zakutinsky et al., 1962; Besyadovsky, 1978), and equal 263 and 93 kBq g^{-1} accordingly. It is accepted, that at both species 70% of ^{90}Sr is deposited in bones within 1 day after introduction, by 30th day in a mouse skeleton are 30%, in a rat – 40% from quantity of intravenously radionuclide injection. While using standard power model of a metabolism ^{90}Sr (Stara et al., 1971; Lyubashevskiy, 1980), it has been defined the integrated dose absorbed by animals at entering of $LD_{50/30}$ quantities ^{90}Sr: 28.5 Gy at the mouse and 24.4 Gy at a rat (difference from $LD_{50/30}$ chronic gamma-irradiation – in both cases, no more than 15%).

It is very encouraging that the results of the calculations on this formula for the mouse close more precise method. Malinovsky et al.(2014) using the voxel phantom animal (Stabin, 2006) calculated the energy absorbed in target organs with known radionuclide content: 1 kBq g-1– 2100 mGy/year compared to 2600 mGy/year discussed the formula.

Using bone (instead the body) for the analysis avoids the influence contamination by radioactive dust and defines direct assessment of bone marrow defeat. Dosages in other organs are proportional to the shown Malinovsky et al. Thus, the submissions are proof of the adequacy of proposed simple and reliable formulas for dosimetry corresponding mammalian body size.

THE MEASUREMENT OF URANIUM CONCENTRATION IN WATER SAMPLES FOR THE ASSESSMENT OF THE RADIOLOGICAL DOSE IN PATIALA AND THE FATEHGARH DISTRICT OF PUNJAB

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Uranium content in the ground water samples of Patiala and Fatehgarh District of Punjab have been determined using LED Fluorimetry technique. Radiological and chemical risks have also been calculated for the uranium concentrations in the studied water samples. Uranium concentration in 80 water samples has been calculated from 16 different villages. The uranium concentration in the studied water samples vary from 3.92 to 17.98 μg l^{-1}. The uranium content in all these samples have been found to less than the recommended safe limit of 30 μg l^{-1}(WHO, 2011). The mean value of Excess cancer risk from the ingestion of uranium is 1.0×10^{-5}. The Lifetime average daily dose (LADD) and Hazard quotient (HQ) vary from 0.004 to 0.021 μg kg^{-1} day^{-1} and from 0.01 to 0.03 respectively. The annual effective dose ranges between 2.22 and 10.19μSv a^{-1}.

ESTIMATION OF NATURAL RADIONUCLIDES HAZARDS AND ANNUAL EFFECTIVE DOSE MEASUREMENT IN SOIL SAMPLES OF NORTHERN RAJASTHAN, INDIA

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In the present study, soil samples collected from Bikaner and Jhunjhunu districts of Northern Rajasthan, India has been analyzed for ^{226}Ra, ^{232}Th and ^{40}K using gamma ray spectroscopy. The measured activity concentration ranges from 16±9 to 37±9 Bq kg^{-1}, 42±10 to 84±11 Bq kg^{-1} and 375±130 to 734±141 Bq kg^{-1} with the mean value of 26±10 Bq kg^{-1}, 57±11 Bq kg^{-1} and 572±145 Bq kg^{-1} for ^{226}Ra, ^{232}Th and ^{40}K, respectively. The radium equivalent activity of all the soil samples ranges from 119 to 209 Bq kg^{-1} with an average value of 146 Bq kg^{-1}, which is lower than the safe limit 370 Bq kg^{-1} set by the Organization for Economic Cooperation and Development. The total absorbed dose of all the investigated samples varies from 59 to 100 nGy h^{-1} with an average value of 71 nGy h^{-1}. The total annual effective dose ranges from 0.35 to 0.61 mSv with the average value of 0.48 mSv. The corresponding values of external and internal hazard index of all the soil samples ranges from 0.34 to 0.58 and 0.38 to 0.68 with an average value of 0.41 and 0.48 respectively. It was observed that the soil of Bikaner and Jhunjhunu districts is suitable for construction purpose without posing any health hazard.

A STUDY OF MONITORING HIGH FREQUENCY ELECTROMAGNETIC FIELD POLLUTION IN URBAN AREAS

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In this paper, the results of a study of monitoring high frequency electromagnetic field pollution in some residential areas of Spadafora (38°13'29"28 N Latitude, 15°22'48"36 E Longitude), a little town in province of Messina densely populated of base stations, and a statistical analysis of values recorded for these stations, were reported. The measurement values were collected by means of a NARDA SRM-3000 radiation meter with an isotropic antenna that can be used for measurements in the frequency range 75 MHz - 3 GHz. The obtained measurement levels were compared with the exposure limits, warning values and quality objectives established by [1-3] for electromagnetic fields generated in a frequency range between 100 kHz and 300 GHz. In particular, the amplitude fluctuations of the electromagnetic radiations radiated by the present base stations were recorded for a long time and statistical analyses were performed for certain spectrum ranges under far-field conditions by using an isotropic field probe and selective spectrum analyzer. The measurement results for each station were compared, and their contributions to the combined radiation were analyzed through a software packet to calculate the high frequency electromagnetic field and for the interpolation points. The data were also processed using wavelet analysis. In almost all cases the electromagnetic field values respected the established limits, but a case has proved more interesting, because of the strong vicinity of a base station near to inhabited houses and to an elementary school. In particular, in this urban area values close to 5 V/m at the frequency of 900 and 2300 MHz were measured, very near to the limits indicated in [1-3]. Further research is underway to assess the effects on health of people who live there.

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FRICKE GEL DOSIMETER LAYERS OPTICALLY ANALYZED FOR QUALITY ASSURANCE IN STEREOTACTIC RADIOSURGERY

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Stereotactic radiosurgery is a highly precise form of radiation therapy to treat brain abnormalities that requires accurate treatment verification. This work investigates the use of Fricke gel dosimeter layers as a valuable tool for quality assurance in stereotactic radiosurgery by clinical linear accelerators.

Dose distributions in radiosurgery were verified by Fricke gel dosimeter layers, radiochromic films and Monte Carlo simulations. Dose measurements and calculations were performed using an adapted head-like phantom scanned by computed tomography for further planning with the Blue Frame SRS - FiMe treatment planning system. Dedicated Monte Carlo subroutines were developed for stereotactic radiosurgery using physics packages of PENELOPE main code. Radiosurgery plan consisted of two small targets irradiated with a 10 MV photon beam. Dose distributions were compared by means of the Gamma index.

Dose distributions were directly measured with film dosimeters and Fricke gel layers analyzed by visible light transmission, while treatment planning and Monte Carlo simulations were based on tomography images. Results from exhaustive evaluation of dose profiles and two-dimensional maps showed good performance when comparing treatment planning system with Monte Carlo simulation, film and Fricke gel dosimeters. Additionally, three-dimensional dose distributions were obtained by Fricke gel stack layers and further image processing with the toolkit. Both qualitative and preliminary quantitative comparisons with Monte Carlo of three-dimensional dose distributions indicated promising performance for Fricke gel dosimeter layers.

This work presents investigations regarding the feasibility, reliability and accuracy of Fricke gel dosimeter layers for stereotactic radiosurgery. Good agreement was found between experimental and calculated dose distributions in different regions close to the target. The capability of the developed system for three-dimensional dose mapping was shown, obtaining promising results when compared with well-established dosimetry methods. This supports the viability of Fricke gel dosimeter layers analyzed by optical methods for stereotactic radiosurgery.

ASYMMETRY IN EXPERIMENTS TESTING CPT IN ORTHO-Ps DECAYS

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In this paper we consider *asymmetry* in the CPT test experiments performed using polarized ortho-positronium atom decay. Ortho-positronium, a triplet state of Ps, annihilates dominantly into three gamma rays with the continuous energy spectrum in the range (0-511) keV. In searching for decays of ortho-Ps which violate CPT symmetry, the correlation $\boldsymbol{S}*\boldsymbol{k_1}\mathbf{x}\boldsymbol{k_2}$ was tested, where $\boldsymbol{S}$ is the ortho-Ps spin, and $\boldsymbol{k_1}$, $\boldsymbol{k_2}$ are momenta of the two most energetic annihilation photons ($E_{g1}>E_{g2}>E_{g3}$). The experimental tests consisted in comparing the number of asymmetric decays of polarized ortho-Ps in two identical reflection-symmetric geometries, and the angular correlation coefficient was calculated from the *asymmetry* (A). Using our previous results, as well as results of the other researchers, we particularly discuss the tests carried out at the three and seven-detector system ($A=0.0017\pm0.0017$ and $A=0.0008\pm0.00091$, respectively), together with their measuring errors.

ON THE USE OF A PARALLEL PLATE ION CHAMBER FOR FFF PHOTON PDDS MEASUREMENTS

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The international code of practice for dosimetry IAEA TRS-398 recommends the use of parallel plate chambers to measure photon percentage depth doses (PDDs). This code of practice was written at a time when the standard kind of photon beam was flattened, providing uniform dose at a certain depth. Since that time clinical dosimetry has shifted to a paradigm consisting on the combination of remarkably non uniform beams. Flattening filter free linacs offer higher dose rates at the expense of field uniformity, taking into account that state of the art treatments (such as VMAT) combine multiple fields, lack of uniformity is not an issue. Their profiles tipically show a peak on the central axis, therefore, ion chambers used to measure central axis PDDs can experience partial volume averaging. Since the dimensions of a parallel plate are larger than the dimensions of typical scanning chambers, a volume averaging effect could affect the PDDs measured with a parallel plate chamber.

PDDs for 6 FFF and 10 FFF (Varian TrueBeam) were measured with a scanning type chamber (PTW 31010 Semiflex), two small volume chambers (Scanditronix CC04 and PTW 31016 Pin Point 3D), PTW 34001 Roos and Scanditronix Roos parallel plate chamber. PTW MP3 water tank, PTW Tandem electrometer and PTW Mephysto were used for all these measurements.

PDDs were measured at 100 cm SSD, for different field sizes (5x5, 10x10, 20x20, 30x30, and 40x40 cm^2), they were corrected for recombination factors at all depths, and measurements were carried at two different polarities.

It was found that parallel plate chambers show the best PDD coincidence for both polarities, differences are below 0.1% at all depths, whereas cylindrical chambers show differences that can reach 0.6% at 350 mm deep.

Using one single polarity, and correcting for recombination, the largest difference in PDD among different detectors was found at 350 mm deep for all field sizes, which would amount to: 0.6% for 6 FFF and 0.4% for 10 FFF for a 40x40 cm^2 field measured with a PTW Pin Point 3D chamber.

For absolute dosimetry purposes, IAEA TRS-398 reference conditions for the determination of absorbed dose to water are SSD = 100 cm, 10x10 cm^2 field at 10 cm deep. Hence, the accurate measurement of the value of PDD(10) is of paramount importance. Our results show that the maximum difference in PDD(10) measured with all different detectors, for the same polarity, is 0.3% for 6 and 10 FFF.

PTW Roos and Scanditronix parallel plate chambers can still be recommended for PDD measurements in Varian TrueBeam FFF beams, and TRS-398 recommendations can then be followed. Besides, they show an interesting and important property, which is a very small polarity dependence.

THE DEVELOPMENT AND CHARACTERIZATION OF A NOVEL POLYMER GEL DOSIMETER BASED ON ITACONIC ACID FIXED TO A GEL MATRIX WITH GLUTARALDEHYDE

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This work presents the development and characterization of a new polymeric dosimeter based on itaconic acid and N, N'-methylenebisacrylamide. The preparation method, compositions of monomer and crosslinking agent and the presence of oxygen in the dosimetric system are carefully analyzed.

The radiosensitive material is inserted in standard vials and they are irradiated with photon beams from clinical linear accelerator and conventional X-ray tubes. The effect of photon energy and dose rate is investigated.

The samples are read out using different techniques, like optical methods including standard spectrophotometry and visible light transmission imaging, Raman spectroscopy and nuclear magnetic resonance. The different dose-responses are compared.

The obtained results demonstrate that this system shows linear dose-response for high dose levels, namely 50 to 1000 Gy.

THE DOSE RATE INDUCED DANGER PARAMETER DETERIORATION OF THE LOGIC LEVEL CONVERTERS IN THE SWITCHED-OFF MODE

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Often found delusion on dose firmness consists that IC in the switched-off or passive status are less subject to degradations subject from TID behavior. We have many results which are indicating the opposite. On the example of one of the devices, in article it is shown degradation parameters the logic level converter (FXL4TD245BQX) in switched-off status which can not take into account the ordinary research.

RADIATION DOSE RATE MEASUREMENTS AROUND A NUCLEAR INSTALLATION

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Various organizations and in some cases governments, apply nuclear technology for peaceful purposes in facilities such as the construction and mining industries, medicine, agriculture and energy. However, the military antecedence of nuclear technology, the Hiroshima and Nagasaki episodes coupled with the willingness and competence of some groups to cause severe havoc and harm to the public and the environment by whatever means possible creates fear amongst the public.

In order to productively and sustainably continue to use nuclear technology given the diverse and evolving nature threats to the use of nuclear and radioactive materials, there is the need to put in place a very robust and effective regulatory regime which incorporates assessment, monitoring and evaluation.

Radiation monitoring is done with the view of preventing radioactive effluent discharge from being released into the environment either as liquids or gases. An effective monitoring programme must have aspects that deal with the type of radiation being monitored, the human exposure pathways, as well as the various groups in the population that are exposed.

These pieces of information when analyzed qualitatively and quantitatively will provide a basis for sound decision making in nuclear safety and security. For example, the nuclear forensic analysis of the data may provide information that can attribute and link the type and levels of radiation monitored within and around a nuclear facility to legitimate, malicious or unintended activities relating to the nuclear and radioactive materials being used, stored or transported to and from the facility.

An area within and immediately around a facility utilizing nuclear materials and radioactive sources requires constant monitoring for radiation. This regular monitoring apart from assuring that there are no unintended releases or leakage of radiation into the environment, ensures that any malicious activities involving nuclear and radioactive materials are detected promptly for the necessary response. Environmental radiation monitoring therefore, is a useful tool that guarantees nuclear safety and security during the peaceful use of these materials.

Environmental radiation has been measured around the residential flats and the School of Nuclear and Allied Sciences (SNAS) campus on the Ghana Atomic Energy Commission (GAEC) premises. This was done to comply with best practice around nuclear installations and also to obtain data that will serve as a baseline to which further environmental radiation surveillance would be compared. The results obtained in the study showed that the average radiation doserate for the whole study area was $0.11 \pm 0.017 \mu Sv/h$ which is equivalent to 0.96 mSv/y. This result compares well with works in literature and is lower than reported values elsewhere in the world.

ROBOT-BASED SYSTEM FOR MONITORING OF IONIZING RADIATION IN NUCLEAR ENVIRONMENT

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Nuclear science plays a vital role in the rapid development of industry, agriculture and medical sciences. Radiation is problematic in nuclear facilities for rescue worker in radioactive contaminated or high level radiation area. Robots are being widely used in the nuclear facilities. The first significant efforts to introduce mobile robotics to the US commercial nuclear industry began in the early 1980's. One of the earliest efforts was to develop surveillance and sampling vehicle to work in the accident affected areas at Three Mile Accident (TMI). Their main application is to perform automated and repetitive work or to execute hazardous tasks that are dangerous to human beings. To prevent the human worker from unwanted radiation exposure, it is therefore, necessary to develop equipment, tools and particularity robots or robotic devices to assist radiation workers in radiation-environment. In nuclear science, radiation protection of workers became a catalyst for the development of robotics. Robotics in the nuclear industry should be able to replace human operator not only to comply with the ALARA (As Low As Reasonably Achievable) principle applied to radiation protection but also to comply the nuclear regulatory limit (20 mSv/year). Therefore, the use of robots and robotic devices in nuclear industry can play a vital role in reducing the risk of hazardous radiation exposure to meet the concept of ALARA. With the rapid depletion of the fossils fuel resources, the demand of nuclear energy is increasing. For instance, Bangladesh has planned to introduce nuclear power generation by 2024/2025, which may cause the risk of repeated radiation exposure to radiation workers. Such problems can be eliminated by the use of devices such as Robot in nuclear facilities. In case of Fukushima nuclear accident, Packbots (iRobot) were used for post disaster analysis (detect temperature, gamma radiation, explosive gases and vapours and toxic chemicals etc.) and cleaning up wreckages. These robots are highly specialized and are designed to work in rugged and high level radiation areas. However, these robots are very expensive (as much as US$120,000. In this study, the objective is to design and develop a simple and inexpensive mobile robotic device capable of assisting radiation workers in a medium level of ionizing radiation environment where human can't perform for longer durations. Its intended use will be to pick and carry the accidentally dropdown irradiated sample and handling of liquid and dispersible solid waste such as contaminated ion-exchanger resin etc. It is hoped that with the help of this robot, radiation workers can accomplish a task without having any exposure to hazardous environment for longer durations. This paper presents preliminary results on design and development of simple and inexpensive robotic system for monitoring of nuclear radiation in real time.

MEASUREMENTS AND EFFECTS OF MICROWAVE RADIATION EMITTED BY WIRELESS COMMUNICATION DEVICES

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The achievement of electronics in all technological sectors has produced an enormous increase in the use of wireless communication devices such as mobile telephony, cordless phones, bluetooth and more. In spite of the great number of studies performed, knowledge about the effects of radiofrequency (RF) and microwave (MW) radiation on human health or biological responses to their exposure is still limited [1-2]. However, it was found that RF-MW radiation produce a response in many types of neurons in the avian Central Nervous System [3], oxidative damage in brain tissues [4] and changes in heat-shock proteins expression of human neuronal-like cells [5]. Other studies focused on the danger of MW radiation for health in humans and animals [6]. These effects have suggested accurate measurements of MWs radiation to check that the exposure limits suggested by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) are not exceeded [7]. To this aim, measurements of MWs radiation emitted by typical wireless communication devices were carried out by means of a SRM-3000 instrument of Narda Safety Test Solutions, linked through a cable to a three axis antenna covering the frequency range from 75 MHz to 3 GHz. The spectrum analysis mode was chosen as preliminary analysis to detect and quantify the frequencies values relative to the electromagnetic waves impinging the three axis antenna. In time analysis mode, selective and continuous measurements at a fixed frequency are provided, allowing temporal check of power density of radiation. Spectral analysis of power density of MW radiation emitted by a typical working cordless device (model Brondi DC3010) evidenced exposure within a narrow frequency range from 1880 and 1890 MHz at the intensity of 89 mW/m^2. Measurement of MWs power density of a mobile phone Nokia 1208 emitted at the frequency of 905 MHz was carried out during a call, providing larger intensity values (around 2 W/m^2) but within the limits reported in [7]. Nevertheless, at this security level of intensity of MWs radiation, increase of HSP in neuronal-like cells was observed [5].

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ESTIMATION OF ANNUAL EFFECTIVE DOSE DUE TO RADON AND THORON LEVEL IN INDOOR AIR OF NORTHERN RAJASTHAN, INDIA

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Radon causes lung cancer when it is trapped inside the lungs. In the present work, indoor radon and thoron measurements have been carried out from 20 different locations of Bikaner and Jhunjhunu districts of Northern Rajasthan, India using RAD7, a solid state alpha detector. The radon and thoron concentration in indoor air varies from 8.75 to 84 Bq m^{-3} and 16.35 to 180 Bq m^{-3} with the mean value of 25.2 and 68.21 Bq m^{-3} respectively. The observed indoor radon concentration values are well below the action level recommended by International Commission on Radiological Protection (200-300 Bq m^{-3}) and Environmental Protection Agency (148 Bq m^{-3}). The calculated total annual effective dose due to radon level in indoor air varies from 0.85 to 5.64 mSv y^{-1} with the mean value of 2.35 mSv y^{-1} which is less than even the lower limit of action level 3-10 mSv y^{-1} recommended by International Commission on Radiological Protection (2005). The effect of the factors related to building material characteristics in relation to radon measurements was also examined.

THE MEASUREMENT OF ^{238}U AND ^{232}TH IN PETROL, GAS-OIL AND LUBRICANT SAMPLES BY USING NUCLEAR TRACK DETECTORS AND RESULTING RADIATION DOSES TO THE SKIN OF MECHANIC WORKERS

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Workers in repair shops of vehicles (cars, buses, trucks...) clean carburetors, check fuel distribution and make oil change and greasing. To explore the exposure pathway of ^{238}Uand ^{232}Th and its decay products to the skin of mechanic workers, these radionuclides were measured inside petrol, gas-oil and lubricant material samples by means of CR-39 and LR-115 type II solid state nuclear track detectors (SSNTDs), and corresponding annual committed equivalent doses to skin were determined. The maximum total equivalent effective dose to skin due to the ^{238}U and ^{232}Th series from the application of different petrol, gas-oil, and lubricant samples by mechanic workers was found equal to1.2mSv $y^{-1}cm^{-2}$.

ALPHA RADIATION DOSES TO THE EYES OF INDIVIDUALS WEARING OPTICAL GLASSES

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Optical glasses are presently utilized by a great number of individuals to correct vision weakness. Two types of solid state nuclear track detectors were used for measuring uranium (^{238}U), thorium (^{232}Th), radon (^{222}Rn) and thoron (^{220}Rn) contents in various optical glasses as well as radon and thoron in air. Radiation doses to eyes of individuals due to alpha-particles emitted by the ^{238}U and ^{232}Th series inside the studied optical glasses and those emitted by the radon and thoron series in air were evaluated. The influence of the nature of the optical glasses as well as radon concentration in air on radiation doses received by individuals wearing optical glasses was studied. Radiation doses were found higher for persons wearing mineral optical glasses than for those wearing organic optical glasses.

THE ANALYSIS OF ^{238}U, ^{232}Th AND ^{222}Rn IN VARIOUS FISH SAMPLES AND RESULTING RADIATION DOSES TO THE CONSUMERS

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Naturally occurring radionuclides existed since the creation of the earth some 4.5 billion years ago. They are present in rocks, soils, water, air, plants, and animals and even in the human body. According to the Food and Agriculture Organization (FAO), Morocco produces about 1.5 million tons of fish per year. Morocco is the first producer of sardines (sardine pilchardus) in the world. In the present work,^{238}U, ^{232}Th ,^{222}Rn and ^{220}Rn concentrations were measured in different fish samples collected from different fishing zones in Morocco by using a solid state nuclear tracks detectors method. Alpha radiation doses due to ^{238}U, ^{232}Th , and ^{222}Rn from the ingestion of different fish samples was evaluated. The influence of the consumption rate and fish nature as well as pollution on the radiation doses received by individuals was studied.

^{238}U AND ^{232}TH CONCENTRATIONS MEASURED IN DIFFERENT MEDICAL DRUGS BY USING SOLID STATE NUCLEAR TRACK DETECTORS AND RESULTING RADIATION DOSES TO THE SKIN OF PATIENTS

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Urban populations in Morocco receive free medical drugs as prescribed by doctors in district health centres. To explore the exposure pathway of ^{238}U, ^{232}Th and their decay products to the skin of patients, these radionuclides were measured in various medical drugs by using solid state nuclear track detectors (SSNTDs).The measured concentrations range of ^{238}U and ^{232}Th in the medical drug samples of interest vary from (4.3±0.3) mBq l^{-1} to (11.1±0.7) mBql^{-1} and (0.49±0.03) mBql^{-1} to (1.3±0.1) mBql^{-1}, respectively. A new dosimetric model, based on the concept of specific alpha-dose and alpha-particle residual energy, was developed for evaluating radiation doses to skin following the application of different medical drugs by patients. The maximum total equivalent effective dose to skin due to the ^{238}Uand ^{232}Th series from cutaneous application of different medical drugs by patients was found to be 2.8 mSv $y^{-1}cm^{-2}$.

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

AIRBORNE GAMMA-SPECTROMETRY MAPPING

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If you want to perform a macroscopic gamma-survey, one of the best ways is to perform an airborne gamma-spectrometry survey. It allows you to investigate a large area in a short time and at a reasonable cost. Gamma mapping has some limitations caused by the atmosphere shielding for the gamma ray. In this manner and to balance between efficiency and precision we have to use an aircraft flying at 60 to 120 meters height. For an accurate measurement, we should do several calibration flights which allows us to calculate the cosmic background correction and intrinsic background correction. In order to save flying time, for differentiation of the industrial and NORM radionuclides we need to use spectrometry dose meter with high sensitivity and quick response. It is also important to know the terrain specifics to choose a model that describes it best. How far we can go using the known methods and technology and what to research for the future?

COMPARATIVE STUDY OF RPL GD-301, TLD-100 AND AL2O3:C DETECTOR RESPONSES BY MONTE CARLO SIMULATION

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Introduction: For the monitoring of patient dose in external radiation therapy, the luminescent dosimeters are widely used, where the physical processes of their three types (thermoluminescence (TLD), radiophotoluminescence (RPL) and optically stimulated luminescence (OSL) are very similar.

Purpose: The purpose of this work was to compare the dosimetric proprieties of three kinds of luminescent detectors, RPL glass dosimeter, commercially known as GD-301, lithium fluoride TLD-100 (LiF:Mg,Ti) and carbon-doped aluminum oxide (Al_2O_3:C).

Methods and Materials: In our study, a Monte Carlo simulation with MCNP5 was carried out to estimate the responses of these dosimeters in terms of the absorbed dose, output factor, as well as the angular and energy dependence.

Results: In this work, we found that the difference between the output factors was less than ±4.2 % for the three dosimeters. The variations in sensitivity for angles up to ±80° from the central axis of the beam were approximately 1% and 1.5 % for the GD-301 and Al_2O_3:C, respectively. The energy dependence of the RPL and OSL dosimeters was found to be within 1% and 3.1 % for 6 and 15 MV X-ray beam, respectively, whereas, for the TLD, it was less than 1.1% for both beams.

SPECTRAL PROPERTIES OF ULTRA-WEAK THERMOLUMINESCENCE IN SELECTED DETECTORS

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Thermoluminescence (TL) is a two-stage luminescence phenomenon. TL can be found only in insulators and wide band-gap semiconductors. Each crystalline insulator contains a number of imperfections related to lattice defects and/or dopants which produce additional energy states within the band gap. These states may act as electron and hole traps and recombination centers. To detect TL the material under study has to be irradiated. High energy ionizing radiation produces band-band transitions filling empty traps and recombination centers.

These metastable excited states may last for many years. Luminescence is triggered by thermal stimulation. We observe TL while heating the sample usually with the constant rate. In most cases the emitted luminescence is proportional to the dose of radiation absorbed by the material. Hence, it is frequently used in dosimetry of ionizing radiation as well as in luminescence dating applications.

Typically, TL is measured using a photomultiplier in the photon counting mode. Unfortunately, it does not provide information related to spectral distribution of the luminescence. Spectrally resolved measurements are very difficult in the case where the luminescence is week.

This paper presents two spectrally resolved measurement techniques for TL. The first one uses cooled CCD camera coupled to a spectrograph. The other one is based on a scanning monochromator with a custom-made software. Spectrally resolved TL glow curves are presented for several luminophors exhibiting very week TL signal. Irradiations were done using two $^{90}Sr/^{90}Y$ beta sources with activities of 37 MBq and 2,8 GBq, respectively. In the case of signal fading the dose rate plays important role.

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THE MEASUREMENT OF URANIUM CONCENTRATIONS IN WATER SAMPLES FOR THE ASSESSMENT OF THE HAZARD QUOTIENT

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Uranium content in the ground water samples of Patiala and Fatehgarh districts of Punjab have been determined using LED Fluorimetry technique. Radiological and chemical risks have also been calculated for the uranium concentrations in the studied water samples. Uranium concentration in 80 water samples has been calculated from 16 different villages. The uranium concentration in the studied water samples vary from 3.92 to 17.98 $\mu g\ l^{-1}$. The uranium content in all these samples have been found to less than the recommended safe limit of 30 $\mu g\ l^{-1}$(WHO, 2011). The mean value of Excess cancer risk from the ingestion of uranium is 5.5 x 10^{-4}. The Lifetime average daily dose (LADD) and Hazard quotient vary from 0.22 to 1 $\mu g\ kg^{-1}\ day^{-1}$ and from 0.36 to 1.66 respectively.

RADIATION ONCOLOGY 21

HYPOFRACTIONATED SUPERFICIAL HIGH DOSE RATE BRACHYTHERAPY IN TREATMENT OF NON-MELANOMA SKIN CANCERS

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Introduction. In the last several decades there has been a reported increase in skin cancers on the global level. Despite the emergence of new treatment modalities and techniques, radiotherapy remains the main conservative treatment. Given the advances and benefits of the early detection, lesions are diagnosed in their earlier stages, thus enabling localized high effective treatments, such as superficial high dose rate brachytherapy. It is sometimes preferred by patients when confronted with surgical interventions and it has rather poor cosmetic effects, especially on some skin lesion locations. The fractionation varies from single one to multiple fractions administered once or twice per week. Patients prefer hypofractionated regimens because they relieve patients from obligatory everyday radiation treatment.

Material and methods. In total, 12 patients were irradiated with the diagnosed non-melanoma skin cancer, 8 (66.67%) of which were basocelular and 4 (33.34%) were of the squamous type. The gender distribution was 9 (75%) males and 3 (25%) females, with their age ranging from 48 to 83 years, with the average of 66.3 years.

We used GammaMed Plus^{tm} after loading the apparatus, using Ir-192 isotope source. We used a contact surface applicator set with Leipzig-style cone. Depending on the lesion diameter, we used applicators with the diameter range from 10 to 45mm.

Applied doses were hypofractionated: Treatment brachytherapy dose of 28Gy with a single week fraction of 7Gy was administered in 4 weeks to 10 (83.34%) patients. The dose of 30Gy with a single week fraction of 5Gy was administered in 6 weeks to 2 (16.67%) patients respectively regardless of the histology type. The dose was prescribed on 5mm skin depth. The estimated surface $EQD2_{\alpha/\beta=10}$ for the whole brachytherapy treatment ranged from 69Gy to 76Gy.

Results. The beginning of skin defect sanation (from peripheral margins propagating inwards towards the center of the defect) was evident after the second or third brachytherapy application, which gradually increased towards the end of the treatment. Defects were usually healed at the first checkup. The local control was visible and confirmed in 11 patients (91.67%). In 1 patient (8.34%), the disease recurred after 10 months from the last treatment (7Gy/4fr./28Gy). Patients are still being followed on regular ambulatory basis.

Adverse events were seen, such as inflammatory skin reactions (skin redness and mild local swelling). Skin reactions were manifested in all patients (100%), most visible in the second half of the treatment, increasing as the treatment progressed. Telangiectasia was visible at the end of the treatment in 4 patients (33.34%). Local anti-inflammatories and antibiotics were prescribed.

At the first checkup, the inflammatory reactions of all patients subsided or completely disappeared.

Conclusion According to preliminary results and current patient checkups, we can conclude that using hypofractionated superficial high dose brachytherapy is both clinically successful in local tumor control and in providing good cosmetic results.

THE MOLECULAR MECHANISM INVOLVED IN RADIATION-INDUCED ERECTILE DYSFUNCTION (RIED)

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Prostate cancer is one of the most prevalent cancers diagnosed in men in the USA. Five-year survival by stage in patients is almost 100% local and regional and 28% distant cases. More than half of prostate cancer patients after diagnosis undergo radiation therapy as a standard care of treatment. Among these patients, Radiation-induced Erectile Dysfunction (RiED) is a common late side effect after radiation therapy (RT). 50% of patients develop RiED within 3-5 years of radiotherapy. This illness and treatments affect patients' quality of life severely. The precise molecular mechanism of RiED is still poorly understood and treatment options are extremely limited. Hence, definite curative treatment for RiED remains an unmet need. Normal erection depends upon three processes: (1) neurologically initiated increase in arterial flow into the penis, (2) relaxation of cavernosal smooth muscle and (3) restriction of venous outflow from the penis. Our hypothesis is that the pelvic radiation causes significant damage to nerve, prostate and microvasculature at the field of radiation leading to RiED. During RT, the prostate, cavernous nerve (CN), major pelvic ganglion (MPG), and part of the urinary bladder and rectum is in the radiation field. Our previous reports showed that the increased involvement of reactive oxidative stress (ROS) and nitric oxide (NO) dependent pathway by RT playing an important role in the development of RiED. Our recent data in our established rat model are indicating RT induced significant neural injury by decreased nNOS, increased tyrosine hydroxylase, caspase 3 mRNA expressions in MPGs compared to normal rats. Similarly, we measured the mean arterial pressure (MAP) and intracavernous pressure (ICP) which showed significantly low MAP/ICP ratio in RT rats compared to non RT rats signifying the impaired erectile function and development of RiED. We also observed increased mRNA expressions of inflammatory cytokines and M1 macrophages at the site of RT which is strongly indicating a possibility of RT induced chronic inflammation which further aggravated the damage. Interestingly, involvement of Rho-Kinase signaling pathway in corporal fibrosis has been reported in non RT rat models by several investigators in their CN crush injury rat models. We have found similar preliminary results in MPG of cavernous nerve for the first time in our RT treated rats. Moreover, we have recently improved our RiED rat model by more targeted prostate confined radiation by using SARRP irradiator with cone beam CT scan as a translational model. Therefore, it is supportive to our hypothesis that it is necessary to identify the markers of cavernous nerve injury by RT more precisely and involvement of Rho-ROCK pathway is intensively associated with the pathogenesis of RiED even after 10 weeks of RT. We postulate that the inhibition of both ROS/NO and Rho-ROCK pathway could potentially ameliorate the RiED and open the door for new drug development against RiED.

SINGLE INSTITUTION EXPERIENCE OF TWO-DIMENSIONAL VERSUS TRI-DIMENSIONAL INTRACAVITARY BRACHYTHERAPY IN LOCALLY ADVANCED CERVICAL CARCINOMA

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Introduction. Cervical carcinoma is the third most present malignancy at women worldwide. Beside the screening program for early cancer detection, locally advanced disease is still present, thus requiring specific therapeutic approach. Intracavitary high dose rate (HDR) brachytherapy is one of the most efficient radiotherapy techniques in cervical cancer treatment which builds up upon the external beam radiation (EBRT) dose. Limited two-dimensional (2D) planning in ICRU points is moreover replaced by more sophisticated tridimensional (3D) volumetric planning.

Materials and methods. 22 patients with diagnosed inoperable locally advanced cervical carcinoma were treated in 5 month period. Median age was 51 years, planocellular carcinoma was dominant histological type with 81% (18) and according to the clinical stage of disease 77% (17) were in IIB stage. EBRT chemo-radiation was applied to all patients, followed by 3D HDR intracavitary brachytherapy given in 3 applications (one/weekly), with prescribed dose of 7Gy to point A.

Brachytherapy planning was made in 2D and 3D setting for dosimetric comparison purpose.

2D planning utilized 2D radiography with C-arm or 2D simulator, while 3D used CT scans. For 2D plans there were used ICRU 38 defined reference points, while 3D plans were calculated upon delineated volumes of interest and organs of risk. Doses were calculated and reported according to ICRU 38.

Brachytherapy itself was performed on GammaMed Plus apparatus, using Ir-192 source.

Total treatment time was evaluated which encompassed the period from the first external beam fraction till the last brachytherapy application.

Results. 2D vs 3D dosimetric comparison showed no significant difference in point A (2D) vs reconstructed point A (3D). However, 3D planning showed the isodose coverage of the whole target volume with average value of 56.9% covered with 100%, while 63.3% received 90% of the prescribed dose. Generally organs of risk (OR) in 2D planning had significantly lower ICRU dose values compared to 3D planning where maximal dose points and absorbed dose in volume of 2ccm were higher than ICRU points. Volumetric doses showed more realistic view of isodose projection in surrounding tissues and organs, thus reducing the adverse events rate and potential later complications such as fistulae and strictures. However, OR related results were not the main aim of this study.

Total Treatment time averaged 69 days (57 to 89) showing a 23.2% deviation (extending) of the treatment optimum of 56 days. 12 (55%) patients finished their treatment in 57-70 days range, 7 (31%) in 71-80 days, while 3 (14%) finished in timeframe of 81-89 days.

Conclusion. 3D planning offers the option for treatment individualization and volumetric dose presentation which results in better local disease control and surrounding tissues preservation. In our clinic 2D planning was a decades-long tradition, but now planning is being shifted towards the 3D approach.

RADIOTHERAPY IN LITHUANIA - FROM COBALT TO LINAC

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Introduction. Lithuania is one of the post-Soviet country and after independence in 1990 had to biuld their new oncology system: infrastructure, legislation, education and training system, etc. The number of people with cancer in Lithuania per 100 thousand populations has increased twice during the last two decades. Radiotherapy (RT) has a major role to play in reducing deaths from cancer but has no chance of doing so if the patients have not access to high quality treatment because of lack of equipment and staff. The aim of this study was to review the evolution of Lithuanian radiotherapy infrastructure over the last twenty five years.

Methods and methodology. In 2015 electronic questionnaire was made and sent to all RT centers in Lithuania. Earlier data regarding RT infrastructure was received during participation in ESTRO projects such as pan-European Radiation Quality Assurance (EURAQA), Quantification of Radiation Therapy Infrastructure and Staffing Needs (QUARTS), Health Economics in Radiation Oncology (HERO-project).

Results. In 1990 9 cobalt units were used for external beam RT treatment in Lithuania. RT situation has changed dramatically during the recent decades – in 2015 the country owned 12 units of linacs; the number of linacs per million population was 4.1. The last cobalt unit was dismounted in 2010.

The first treatment planning system in RT centre was introduced in 1995 and in 2015 there were 7 units. Currently RT centres perform 3D conformal RT, IMRT, IGRT, VMAT, stereotactic RT, gated RT. Notably, a major part of the modern RT equipment was bought using EU Structural Funds and IAEA support.

According the requirements of Council Directives, International Atomic Energy Agency Safety and other international legal acts in 1996-2001 in Lithuania were approved most of the documents relating to the radiation therapy. The Radiation Protection Centre and other regulatory authority were established and within their competence are responsible for state supervision and control of implementation of radiation protection requirements of laws and legal acts.

In 1993 was approved the list of medical staff, but neither radiation oncologists, neither medical physicists was not included. The professions of medical physicist and radiation oncologist were approved by Ministry of Health of Republic Lithuania in 2001 and in 2004, respectively. Currently the study programs of radiation oncology and medical physics have two universities and radiological technology – one university.

Conclusion. It can be seen how much has changed in Lithuanian RT over the last twenty five years and how much still needs to be done. Due to a lack of advanced technologies, only a part of the oncology patients receive high quality RT services. Therefore, it is essential for each country to define its RT baseline situation and make future plans according to its burden of disease in order to have a successful cancer control program.

SECOND PRIMARIES (SP): IMPACT OF HDR ^{252}CF BRACHYTHERAPY NEUTRON IRRADIATED VOLUME AND DOSE

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Introduction. The carcinogenetic effect of therapeutic ^{252}Cf neutron-gamma irradiation is still unclear. The aim of this study – to evaluate incidence of second primaries for two different groups of irradiated patients – Ca cervicis uteri group – C53 – (large volume and high neutron dose) and Ca corporis uteri group – C54 – (small volume and low neutron dose).

Methods. During 1990-2000 period the 402 pts with Ca cervicis uteri and 168 pts with Ca corporis uteri received combined treatment: external ^{60}Co beam gammatherapy and ^{252}Cf neutron brachytherapy.

Results. 5, 10, 15, 20 yr survival was 53.2% and 76.8%; 44.0% and 65.5%; 36.7% and 52.2%; 28.8% and 35.3% respectively. After 4 yr latency period the 41 SP were diagnosed: 24 (6.0%) in C53 and 14 (10.1%) in C54 groups (p=0.238). According irradiation dose: heavily irradiated sites – 10 vs 6; moderately irradiated sites – 3 and 0; lightly irradiated sites 8 and 11; respectively SP in C53 and C54 groups. The incidence of SP presented at Fig. 1 show no statistical difference between these pts groups (p=0.238).

<table>
<tr><th></th><th>N</th><th>SP</th><th>5y</th><th>10y</th><th>15y</th><th>20y</th><th>p-value</th></tr>
<tr><td>C53</td><td>402</td><td>24</td><td>0.46</td><td>3.94</td><td>8.53</td><td>20.43</td><td rowspan="2">0.238</td></tr>
<tr><td>C54</td><td>168</td><td>17</td><td>0.76</td><td>7.31</td><td>13.08</td><td>42.92</td></tr>
</table>

Figure 1.

It is interesting to note the high incidence of breast tumors in C54 (small volume, low dose) group (23,4% vs 4,2%) and gynaecologic (16.7% vs 5.9%) as well as haematological (12.5% vs 0%) malignancies in C53 (large volume, high dose) group.

Conclusion. The neutron dose value and irradiated volume have had no effect on the incidence of SP after combined radiotherapy treatment (EBRT by ^{60}Co units and brachytherapy by HDR ^{252}Cf after loading device). The incidence of individual types of cancer after therapeutic use of neutron irradiation is the subject of future studies.

COMPARISON OF DOSES AND VOLUMES OF TARGETS AND ORGANS AT RISK IN PATIENTS WITH HIGH GRADE GLIOMA IRRADIATED WITH TWO DIFFERENT TECHNIQUES

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Purpose: Purpose of this study is to evaluate radiation dose in target volumes and volumes of organs at risk (OAR) in patients with high grade glioma treated with two different techniques, one phase treatment or cone down technique.

Patients and methods: Patients have been treated with 3D conformal radiotherapy up to dose of 60 Gy with daily dose per fraction of 2 Gy. Analysis of dosimetric data of 66 patients with high grade glioma (WHO grade III or IV) has been done. Dose volume parameters were analysed in following treatment volumes, brain stem, whole brain, volume which receives dose of 57 Gy (V57Gy) or more of brain, and ration between volume of contoured brain volume and the V57Gy (BrainV/V57Gy). 32 patients were treated with one phase technique (first group) and 34 were treated using cone down technique (second group)

Results: Mean value of maximal dose in brain stem was 56,27 in the first group versus 55,05 in the second group of patients, mean values of V57Gy was 642,42 in the first versus 553,70 in the second group and mean values of BrainV/V57Gy was 2,23 in the first group versus 2,56 in the second group. There was marginally significant difference (p= 0.04899) of maximal dose in the brain stem. Other compared dose/volumes and volumes ratios were not statistically significant.

Conclusion: Decreasing of dose in brain steam is possible with utilization of cone down treatment techniques, which could lead to decreasing of treatment related toxicity.

ADJUVANT RADIOTHERAPY OF MALIGNANT TRITON TUMORS (MTT)

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Aim of report: *To evaluate how radiotherapy influences local recurrence/progression and overall survival (OS) in the case of Malignant triton tumors (MTT).*

MTT are a subgroup of Malignant peripheral nerve sheath tumors (MPNST) - sarcomatous tumors thought to arise from Schwann cells or nearby cells with perineural differentiation. MPNST incidence is one per 100 000. Approximately 50% of cases arise in patients with neurofibromatosis type 1 (NF1). NF1 is a clinically heterogeneous, neurocutaneous, genetic disorder characterized by café-au-lait spots, iris Lisch nodules, axillary and inguinal freckling and multiple neurofibroma. MTT are a rare but aggressive subgroup of MPNST.

Case report: *A 39 years old male has NF1 established since childhood. NF1 is caused by mutations in the tumor suppressor neurofibibromin 1 NF1 gene (17q11). The patient is with MTT, established histologically and immunohistochemically. At the beginning of 2014 multiple tumor formations in the left hip area have appeared. The cell population has been dominated by elongated cells with sharp ends, organized in beams of rabdomioblasts, IHC-Desmin positively marked rabdomioblasts, and G3 sarcoma.*

Therapy: *The patient has undergone two operative interventions, after which the tumor has recurred within two months in average. Consecutive staging did not find any distant metastases; palliative radiotherapy with photons has been carried out on an Electa accelerator with two opposite AP and PA fields, a radiobiological dose of 30 Gy being administered. Nine months after radiotherapy there is necrosis in tumor's bed and no progression in tumor's dimensions. Currently patient is alive, 19 months after establishment of diagnose.*

Conclusion: *In our case radiotherapy has contributed to ceasing tumor progression and stabilization of decease. Up to now, the relationship between radiotherapy administration and survival, local reccurence/progression in MPNST/MTT has not been clearly defined by scientific research. Mortality was found to be lower in patients with small tumors (<10 cm) and those who received adjuvant radiotherapy after surgery.*

Key words: *Malignant triton tumor, radiotherapy, survival, local recurrence/progression*

THREE-DIMENSIONAL MICROTISSUES AS PHENOTYPIC MODELS TO CATEGORIZE ACTIVITY OF RADIATION MODIFIERS

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Radiation- or chemo- therapy resistance is a common treatment problem. Overcoming the mechanisms responsible for this phenotype is an ongoing challenge. Options include repurposing established chemotherapeutics and the discovery of new radiosensitizing molecular players.

Three-dimensional (3D) microtissues are widely accepted as being more physiologically relevant than conventional 2D monolayer cell cultures, and can therefore help to generate more predictive data. Validation of the phenotypic screen using breast cancer 3D microtissues was performed by HER2_shRNA knockdown. Following lentiviral knockdown of HER2, we compared growth rate alterations using 2D monolayers, 3D microtissues and mouse xenografts. Additionally, to model combined therapeutic strategies, we treated HER2-depleted T47D cells and 3D microtissues using trastuzumab (anti-HER2 antibody) in combination with irradiation. Comparison of HER2 knockdown with corresponding controls revealed growth impairment due to HER2 knockdown in T47D 2D monolayers, 3D microtissues and xenografts (after 2 days, 12 days and ≥ 40 days, respectively). We show that regarding tumor growth analyses, 3D-microtissues are highly comparable to outcomes derived from xenografts.

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). The compound treatment in combination with irradiation is changing the shape of non coding RNA (ncRNA) response using different cell types, classifying them in radiation resistant and sensitive groups. Phenotypic 3D microtissue models were used for exposure to ionizing radiation, miRNA overexpression / knock-down (ex. miR-21, miR-221) and treatment with a panel of selected chemotherapeutic compounds. 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. Expression changes of specific ncRNAs in combination with irradiation decelerated growth, as proven by measuring the area of the cell spheroids after treatment. We have shown that simple miRNA expression has some ability to predict outcomes, such as miR-21 or miR-221 characterisation as biomarkers for breast cancer correlation with distant metastasis. Furthermore, we have shown that suppressive epigenetic influence of specific long non coding RNA (*PARTICLE)*implicates an expanding role for such non coding RNAs in global cellular methylation and intercellular communication in response to low dose irradiation exposure.

Consequently we have begun to follow individual regulatory pathways responding to radiation in order to establish which of them will have a functional relevance in a systems model. The roles of ncRNAs in the DNA-damage/repair response are only beginning to be unravelled. While their crucial existence is now un-disputed, no doubt the long non-coding genome will continue to surprise and reveal unexpected layers of cellular regulatory complexity describing new molecular players in response to radiation.

RADIATION PHYSICS 22

PHOTONUCLEAR REACTION CROSS SECTIONS FOR Xe-131

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^{131}I is one of the radioisotopes in nuclear medicine procedures for diagnostic and treatment purposes. It decays to ^{131}Xe by emitting beta particles. In this study, we have investigated the reproduction possibility of ^{131}I from ^{131}Xe by using different reactions include a photonuclear reaction step. We have used TALYS computer program for calculating cross-sections of the reactions. It was seen that, it is not an easy task to reproduce ^{131}I from its decay product ^{131}Xe since low reaction cross section values. According to the results, we have seen that the calculations are in harmony in the TENDL 2014 database.

Key words: Photonuclear reaction, Iodine, Xenon, cross section, TALYS

INELASTIC SCATTERING, ENERGY LOSS AND CHANNELING OF PHOTOELECTRONS IN N_2 DOPED SOLID KR

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In Rare Gas Solids the energy loss rate of photoelectrons with energies above the band gap energy, E_g, is mainly determined by electron-electron scattering. The scattering of a hot photoelectron by a valence electron results in the formation of an additional electron-hole pair which can be bound or free. Such processes of multiplication of excitations with well-defined thresholds lead to prominent structures in the photoluminescence excitation spectra. Solid krypton doped with N_2 was extensively used to investigate intra- and intermolecular energy relaxation into the impurity subsystem. Because of the fast electronic relaxation by the intersystem crossing to the lowest excited state and the pronounced Vegard-Kaplan bands emission, N_2 can be used as a sensitive luminescent probe to detect electronic relaxation at an impurity. This paper reports the observation of the influence of inelastic photoelectron scattering on luminescence of N_2 doped solid Kr.

The photoluminescence experiments were carried out at the SUPERLUMI experimental station at HASYLAB, DESY, Hamburg. Solid krypton exhibits strong effects of neutral and charged defect formation induced by electronic transitions. Therefore all measurements were carried out after saturation of dose effects at steady concentration of point defects and ionic centers. Under selective excitation by synchrotron radiation the threshold energies for multiplication of electronic excitations were measured. The data obtained suggest that in N_2 doped solid Kr three types of photoelectron scattering exist: (i) long-range photoelectrons are scattered inelastically by the impurity molecules, (ii) short-range photoelectrons with energies about $E_g + E_{exciton}$ form electronic polaron complexes, (iii) photoelectrons with energies above $2E_g$ can create intrinsic ionic centers as a result of formation of secondary electron-hole pairs during scattering. The influence of mean free path of photoelectrons on scattering process is discussed.

EXPERIMENTAL NANODOSIMETRY OF 25 MeV PROTONS AT DNA SCALE

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Nowadays, it is widely recognized that the biological effect of ionizing particles is closely related to the number and distribution of initial interactions in critical biological targets such as the nuclear DNA. The pattern of these initial interactions at nanometric scale forms the particle track structure, which is specific of each radiation type (particle and energy).

Both for medical applications and radiation protection, the definition of new measurable quantities is needed, in order to link the initial track structure description at nanometric scale with a given biological effect.

The so-called Startrack-counter, installed at the TANDEM-ALPI accelerator complex of the Legnaro National Laboratories of INFN, allows to measure the frequency distribution of ionization cluster size – that is, the number of ionizations produced by single ion tracks in a specified target volume, both in the core and in the penumbra region of the particle trajectory. The sensitive volume of the device simulates subcellular structures of dimensions between 1 nm and 5 nm, if the detection efficiency is taken into account.

An extended study for several light ions of therapeutic interest has been already performed at 5 nm [1]. However, in order to optimize the quantitative correlation between measurable properties of the particle track structure and radiobiological cross sections available in literature, it results that the equivalent size of the critical target must be reduced from 5 nm to about 1 or 1.5 nm, depending on the specific biological end-point which is considered.

First measurements performed with 25 MeV protons in a target volume of about 1.5 nm water-equivalent size will be presented and compared with ionization-yield distributions determined by Monte Carlo simulations. The consistency with data measured at 5 nm will also be discussed.

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ALLOWED AND FIRST-FORBIDDEN UNIQUE BETA DECAY STUDY OF ^{16}N TO ^{16}O IN RANDOM PHASE APPROXIMATION FRAMEWORK

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A systematic study of the β^--decay of ^{16}N to ^{16}O has been carried out through a progressive method based upon particle-hole representation called random phase approximation (RPA). The used theoretical framework starts from a mean-field calculation with a phenomenological Woods-Saxon potential included spin-orbit, coulomb terms obtaining single-particle energies and wave functions. A schematic residual surface delta interaction (SDI) was then defined on top of the mean-field and treated via a random phase approximation. The parameters of this residual force were optimized at each individual state reproducing the experimental excitation energies. Finally, the beta-decay properties were calculated for the possible allowed as well as the first-forbidden unique transitions. In fact, the Q-value, comparative, partial and total half-lives of theoretical possible transitions would be calculated in this approach.

The obtained results of the approximation framework of energy states and beta transitions were perfectly in consistent with those of the experimental data.

NEUTRINO RESONANT INTERACTION AS A POSSIBLE REASON OF NUCLEAR OBJECT ACCIDENTS

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At first, the neutrino emission was postulated as extremely high-penetrating, practically non-reactive to the matter. However, the capture cross sections of neutrinos, 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. Neutron, too, has a high penetrating capacity and often a low capture cross sections, but, nevertheless, its cases of resonant interaction processes that have sections many orders larger than normal are well studied.

The possibility of resonant interaction of neutrino with the matter is discussed. The thesis proposed in 1970 by academician Pontekorvo B.M. [1,2] - beside the fact that the interaction of neutrinos with the matter is among the weak interactions, the interaction between the particles themselves can proceed according to the mechanism of the strong interaction – is developed.

It is proposed that the presence of two or more neutrino fields close to each other can lead to a strong interaction between them, precisely: 1) to a sharp acceleration of the inverse beta process, which will lead to a large release of additional energy, and 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 regime in the reactor to a undercritical state. It is assumed, that the factors mentioned earlier may be dangerous for working of nuclear power plants (NPP) with many power units. For the detection of interaction according to neutrino mechanism, it is assumed to carry out the systematic statistical analysis of cases of uncontrolled spontaneous power fluctuations in the work of NPPs being located close to each other, and find out the correlations between fluctuations.

The possibility of influence of astrophysical phenomena on the safety of nuclear objects is discussed. It is noted, that the accidents on the NPPs have been taken place in the close time intervals with known supernovas (SN). Usually, the accidents on the NPPs took place before optical registration of SN, which can be explained by the higher speed of neutrinos in comparison with photons since the photons interact with the real cosmic matter, but neutrinos do not. It is necessary to carry out the analysis of cases of uncontrolled spontaneous power fluctuations in the NPPs, located at the different places of the Earth before the supernovas SN-1993, 2006, 2013, and during the accidents at the Chernobyl and Fukushima.

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PLATFORM DEPENDENT EFFICIENCY OF A MONTE CARLO CODE FOR TISSUE NEUTRON DOSE ASSESSMENT

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Efficiency of a Monte Carlo algorithm for neutron dose calculation is compared in two implementations: a standard C++ code executed sequentially, and a CUDA C/C++ code which utilizes GPU resources for highly parallel processing. Both versions of the algorithm, developed specifically for this investigation, are based on the same physical model for the assessment of neutron dose in tissues, including lung, cortical bone and adipose tissue. The model treats emission and interaction of neutrons stochastically, utilizing cross-sections for relevant interaction types. Several intentional simplifications have been introduced into the physical model used for simulations, which have allowed parts of the two codes to be related to one another in a straightforward way. A neutron's history is terminated when it leaves the outer ellipsoid (representing the human body), experiences any of the absorption interactions (inside one of the inner geometrical regions, representing tissues or organs), or if its energy falls below the cut-off limit set at 0.0001 eV. The two approaches to algorithm implementation are compared according to execution speed, at various neutron source energies and for an increasing number of neutron histories. The fact that particle histories in a Monte Carlo simulation are independent from one another makes this kind of calculation suitable for implementation on parallel processing platforms. CUDA framework offers higher speeds of code execution, allowing more particle histories to be processed within a set time frame, and thus yields lower statistical uncertainty and higher reliability of the calculated neutron dose values. Appropriating standard C++ codes for CUDA is faced with specific challenges, which are described in the investigated case of neutron dose assessment. Despite the physical representation of neutron transport being somewhat simplified, comparison of both implementations to results obtained from MCNP shows a good agreement in a wide range of neutron energies.

RADIATION-INDUCED DEFECTS AND DICHROISM IN $La_3Ga_{5,5}Ta_{0,5}O_{14}$ CRYSTALS

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Lanthanum - gallium tantalate ($La_3Ga_{5,5}Ta_{0,5}O_{14}$, langatate, LGT) belongs to a class of symmetry 32 and is one of the isomorphic compounds to $La_3Ga_5SiO_{14}$. The presence of defect centers in the crystals has prevented their application in the field of laser physics.

Therefore the study of the origin of defects in LGT is an important problem. One of the ways to determine the origin of defects is to investigate the influence of growth conditions and postgrowth treatment. We studied the optical and luminescent characteristics of LGT crystals depending on their growth atmospheres and electron irradiation.

All investigated samples were cut from crystals grown in Fomos-Materials using Czochralski method in iridium crucibles, growth atmosphere – Ar, Ar + (2%) O_2.

Electron irradiation (EI) was performed using a linear accelerator of the LU type which emits electrons with a narrow-band energy spectrum (~ 6 MeV) in a short-pulse (~ 5 ms). The electron radiation doses were 10^{11}, 10^{12}, 10^{13}, 10^{14} and 10^{15} cm^{-2}. **Optical transmission** spectra were measured using UV-Vis-Nir spectrophotometer «Cary-5000» with the accessory UMA (Agilent Technologies) at non-polarized light, p- and s- polarization and at different angles of sample. **The luminescence** was excited at T=300 K and T=95 K by second (λ_{ex}=532 nm) and third harmonic of YAG:Nd^{3+} (λ_{ex}=355 nm). Investigation of the defects were carried out by the **X-ray diffuse scattering** (XRDS) method using the X-ray diffractometer D8 Discover (Bruker-AXS, Germany) in three-crystal scheme.

Growth atmosphere significantly affects the coloration of crystals and, as a consequence, absorption spectra of LGT: colorless crystals are obtained in oxygen-free Ar atmosphere, while colored crystals – with adding of oxygen. In absorption spectra of LGT we observed three absorption bands in UV –VIS regions in the colored crystals (290, 370 and 480 nm) and only one band in the colorless crystals (290 nm) at T = 300 K. Also in the absorption spectra of all investigated samples there were two bands in NIR region - 1850 and 2920 nm.

After irradiation, all samples changed color, become more intense orange color with a grayish tint. A lesser degree color change is observed of the crystal LGT (Ar). With an increase of oxygen concentration in the growth atmosphere, the centers responsible for attenuation bands at 290 nm and 360 nm are more resistant to the effects of ionizing radiation.

The effect of irradiation shows only changing the intensity of the characteristic attenuation bands of LGT, new attenuation bands, and the new defect centers are not formed.

Studies of luminescence in irradiated LGT crystals at T = 300 K revealed influence of growth conditions on their luminescent characteristics. Luminescence in langatate crystals is provided by a large number of different luminescent centers and mechanisms.

^{14}C ANALYSIS OF THE GRAPHITE DISPOSAL FROM RBMK-1500 REACTOR

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Graphite is widely used material to moderate neutrons in nuclear reactors. Management of irradiated graphite after end life of the reactor is an important task both to graphite moderated reactors in operation or decommissioning (Magnox, AGR, HTR, RBMK) and to new HTR reactors designs (generation IV reactors VHTR or MSR). The graphite recycling opportunity for re-use is technically challenging because of the high specifications of graphite required but also it is one of solution of irradiated graphite management instead of disposal. For graphite treatment, disposal or recycling concentration of radioactive contaminants in spent graphite should be identified. Activity of radionuclides in irradiated graphite depends on concentration of impurities in virgin graphite and on characteristics of neutron flux [1,2]. ^{14}C isotope is one of the limiting radionuclides for low- and intermediate-level radioactive waste of the RBMK-1500 reactor and graphite itself. Nowadays it is believed that significant concentration of radiological contamination in irradiated graphite exists in the surface layer of the graphite [3]. The greatest long-term radiological concern of this contamination is ^{14}C ($t_{1/2}$ = 5730 yrs.). Removal of ^{14}C from large irradiated graphite reactor components may reduce disposal cost, while also allowing the possibility of recycling this very pure nuclear grade material. An understanding of the bonding characteristics, functional groups, location, and concentration of ^{14}C would contribute to optimizing its removal from irradiated graphite. The experimentally observed ^{14}C activity in the RBMK-1500 graphite samples is about 130kBq/g, the calculated part form $^{13}C(n,\gamma)^{14}C$ is about 37%. This demonstrates the importance of nitrogen activation path and demands comprehensive investigation on it distribution on graphite surface and in graphite matrix. The obtained results are important for further decommissioning process of the Ignalina NPP and other RBMK type reactors and further decision which graphite utilization method will be applied.

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OPTIMIZATION OF THE HPGE DETECTOR SHIELD BY MONTE-CARLO SIMULATIONS

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Selection of appropriate materials, as well as their thicknesses and order of arrangement from outer toward inner layers of shield for germanim spectrometers is important and complex task with aim to reduce contribution of background events to detector spectra. These background events have origin in radioactive decay of environmental radionuclides, in addition with cosmic-ray muon induced secondary particles within shielding materials.

In this work we simulated emission of gamma quanta arising from members of U-238 and Th-232 series distributed in the vicinity of cylindrically-shaped shield, together with 2 GeV muons interacting with shield. Different types of materials (Pb, Hg, Fe, Cu, Sn) and their combinations, including variations of layers thickness were included in simulations. The simulated spectra registered by germanium detector were analyzed and compared, providing thus the optimal shield for germanium detectors regarding to external irradiation of the shield by cosmic-ray muons and environmental gamma quanta.

THE EFFECT OF FFF FOR PATIENTS RECEIVING PELVIC RADIOTHERAPY USING VOLUMETRIC MODULATED ARC THERAPY (VMAT) TECHNIQUE

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In this study, dosimetric data of 10 patients with prostate cancer receiving radiotherapy using intensity modulated radiation theraphy (IMRT) as Volumetric modulated arc therapy (VMAT) technique were studied. Treatment plans were created in ECLIPS treatment planning system (TPS) using 2 arcs VMAT, 10MV energy, 600MU/second dose rates for FF plans and 800MU/second dose rates for FFF plans, in Truebeam-STx linac. Target volumes were PTV1 (prostate), PTV2 (Seminal Vesicle) and PTV3 (pelvic Lymph node) and rectum and bladder were accepted as organ at risk (OAR). For each patient, 2 different plans as used FF and not used FF (FFF) were made and dose distributions were obtained. Maximum dose within targets and OAR, dose homogeneity and conformality for PTV1 target, used MU values for FF and FFF plans were compared. Dmax values were found higher in FFF plans than FF plans, 1.74%, 0.61% and 0.58% for PTV1, PTV2 and PTV3 respectively. Difference was significant for PTV1 (p=0,00) only. Both homogeneity and conformality for PTV1 were more successful in FF in comparison to FFF; difference was significant and 17.6% for homogeneity (p=0,00) and 2.54% for conformality (not significant). Max OAR doses were less FF than FFF, difference was 1.17% for rectum and 0.51% for bladder; difference was significant for rectum (p=0,039) while not significant for bladder. MU values 40% higher for FFF than FF (p=0,00). In conclusion, better conformality, homogeneity and OAR protection were achieved for FF plans in comparison to FFF plans while higher MU required for FFF plans.

A STUDY OF GAMMA-IRRADIATED POLY-L-LACTIDE BY DYNAMIC THERMAL TECHNIQUES

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Various macromolecular materials and the effects of high-energy radiation on their structure were widely studied in the past using conventional Differential Scanning Calorimetry (DSC) measurements. In this work, in order to obtain more information about the influence of the initial structural differences and gamma radiation on the evolution in structure and thermal properties of different poly-L-lactide (PLLA) samples, dynamic thermal techniques were deployed: Temperature Modulated Differential Scanning Calorimetry (TMDSC) and Photoacoustic (PA) technique. For this reason, low crystalline PLLA and high crystalline PLLA were exposed to gamma radiation, in air, to a wide range of absorbed doses (up to 1200 kGy). Our results indicate that dynamic thermal characterization could improve the understanding of radiation-induced effects in polymers.

Keywords: Crystallinity, photoacoustics, TMDSC, PLLA, thermodynamics, radiation

CdTe NANOPHASE FORMATION USING SWIFT HEAVY ION IRRADIATION

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Irradiation by energetic ion beam at 100 MeV/amu (Swift Heavy Ion) is a versatile technique for material modification. In the present work, swift heavy ion irradiation induced mixing effects followed by nanophase formation have been investigated in Te/Cd/Te trilayer films. The Te/Cd/Te trilayer films prepared by thermal evaporation method are irradiated by 100 MeV Ni , Ag and Au ion beam at a fluence of 5 ´ 10^{12} ions.cm^{-2}**.** The structural changes induced by SHI irradiation are studied by X-ray diffraction (XRD) technique. The XRD studies indicate that irradiation results in Te/Cd/Te layer mixing and CdTe phase formation for all the ion beams. The observed layer mixing is attributed to the interfacial reaction taking place within the molten zone created in the wake of energetic ions. The elemental composition before and after irradiation is studied by Energy Dispersive X-ray Analysis (EDAX). The surface morphology is studied by Scanning Electron Microscopy (SEM). The optical characterization is carried out using UV-VIS spectroscopy. The band gap values of all the irradiated films are found to be more than the reported value of 1.5 eV. The nanophase formation in Te/Cd/Te trilayer films is inferred from increases in band gap value.

ELECTRON-BEAM DAMAGE FROM SEM TO LIPID-(GRAPHENE, MoS2, WS2) HETEROSTRUCTURES

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Interfaces of lipids with its surroundings are important in defining the physical properties of lipid films supported as mono- bi- or multilayers on solid surfaces [1]. These assemblies are usually engineered by means of chemical or mechanical processing, which allow them to be tailored to a specific application, either as a coating of a nano-particle for drug delivery or a multilayer heterostructure for biochemical sensing. Among most convenient materials used as solid support for lipid heterostructures are the 2D-materials, such as graphene and transition-metal dichalcogenides that may be used as a mechanical scaffold or a base for an electrical biochemical sensor nano-device. As these devices may often be required to function in an environment where radiation from space, nuclear reactors, or scientific instruments may interfere with their operation, it is important to asses the potential damage that radiation causes to all the materials comprising these devices.

The imaging technique that is routinely used in scientific research, Scanning Electron Microscopy (SEM) employs an intense high-energy electron beam that is participating in elastic and inelastic collisions within the thin lipid films and the solid substrate that supports them. Recent studies of electron damage to WS2 nanosheets [2] show that the electron beam can cause considerable morphological and structural changes in these materials. Also, a previous study [3] on the damage of low-energy electrons on DPPC monolayer films supported on silicon demonstrated that even sub-keV electrons can degrade the lipids.

In order to study an overall effect of keV-energy focused electron beams from SEM on our heterostructures consisting of DPPC, DPHyPC, sphingomyelin and cholesterol supported on graphene, MoS2 and WS2 thin films, we performed the AFM, KPFM, FT-IR and Raman spectroscopy measurements.

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VARIATION OF MUON COSMIC RAY FLUX RECORDED BY BELGRADE COSMIC RAY STATION DURING DECEMBER 2015 AND COMPARISON WITH EUROPEAN NEUTRON FLUX MONITORS

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The Solar activity in rather quiet 24th Solar cycle had it’s maximum in 2014. The year 2015 is the year of declining Solar activity, and still interesting variation of Cosmic ray flux are evident. In this paper we present the results of measurements of muon flux variations in the second part of year 2015, especially December’s variations. The Cosmic ray flux is continually monitored at the Belgrade Muon Cosmic Ray station in the Low background Laboratory in the Institute of Physics Belgrade. The measurement of Muon flux is compared with measured neutron flux, also originating from Cosmic rays, which was recorded at several European Neutron monitor stations. The Belgrade data correlates very well with Neutron monitors measurements. The significant variations in Cosmic ray flux are discussed. Additionally, December event was discussed in the light of Solar activity during the current 24th and previous two Solar cycles.

DOSIMETRIC BEHAVIOR OF RARE EARTH DOPED PHOSPHATE GLASSES AND POLYTETRAFLUOROETHYLENE COMPOSITES

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Development of radiation and nuclear technologies from the early beginning required elaboration and implementation of reliable and accurate dosimetric methods. Dosimetry is essential branch of science due to necessity of measurements of ubiquitous radiation of natural (radionuclides, terrestrial and cosmic radiation) and technical origin (medical diagnostics, radiation processing). Dosimetric methods must provide information about absorbed doses in a very wide dose ranges which vary from µGy (equivalent dose in case of living organisms in µSv) in case of human radiation exposure control, up to dozens and even hundreds of kGy for control of doses delivered in materials radiation processing technologies. Both medical and industrial processes utilizing ionizing radiation require precise dose control in very wide dose and dose rate ranges.

For last few decades many different dosimetric systems have been elaborated. One of the most accepted is thermoluminescence dosimetry (TLD). This method uses effects of radiation on solid state materials, and is based on energy accumulation within irradiated material followed by its releasing as a luminescence photons induced by controlled heating. TL signal intensity is dependent to the dose absorbed within the material.

In our work we present results of possible application of rare earth doped phosphate glasses for dosimetric purposes. The samples of phosphate glasses (PPG) doped with REE oxides (REE: Eu, Gd, Ce, Sm, Tb, Dy) were synthesized by the melt-quench technique. The materials used for synthesis were of highest available purity: ammonium dihydrogen phosphate ($NH_4H_2PO_4$), sodium carbonate (Na_2CO_3), aluminum oxide (Al_2O_3) and respective REE oxide. The batch components were accurately mixed in an agate mortar, placed in $Al_2O_3/ZrO_2$95/5 composite crucible and subsequently heated at 800°C for 3 hours. After this time, bubble free melt was further heated to 1200°C. The melt was quickly poured on a stainless steel plate. After cooling and crushing, samples were grinded in ZrO_2 planetary ball mill. Two steps synthesis process was applied to ensure homogeneity of the glasses. For evaluation of the thermoluminescence signal pellet type dosimeters were prepared using PTFE powders as agglutinator. Polymer-glass composite pellets were irradiated with Co-60 gamma source in Institute of Applied Radiation Chemistry. TLD measurements were performed with TL RA-94 thermoluminescence reader.

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APPLICATIONS OF POSITRON ANNIHILATION SPECTROSCOPY FOR INVESTIGATIONS OF ORGANIC LIQUIDS

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Positron annihilation spectroscopy (PAS) is an effective probe to study the electronic structure and heterogeneities of liquid media [1]. Using both positron annihilation lifetime spectroscopy (PALS) and the angular correlation of annihilation radiation (ACAR) techniques, one may obtain information about the orientation of molecules of the medium at the interface and determine the ionization potentials of complex molecular compounds by example of water and complex organic compounds containing C–H and O–H groups (alcohols, saturated hydrocarbons etc.) [2], since positron annihilation in a material can occur both in free collisions with electrons of the medium and through the formation of bound states of positrons with electrons, atoms, molecules, or various defects, with each annihilation route making a specific contribution to the experimental annihilation spectrum. Basing on the parameters of annihilation spectra and on the concepts of the "positronium (Ps) bubble" and the intratrack reactions of positron and Ps, we can determine of free-volume sizes, in which the Ps atom is localized.

So, with the ACAR method, we found the energies of annihilating pairs and calculated radii for the "Ps bubble" in pure liquids, such as water, heavy water, ethanol, benzyl alcohol, glycerol, octane, acetone, toluene (for example, the energies of annihilating pairs in toluene are $E1 = 0.36$ eV, $E2 = 3.84$ eV, $E3 = 7.03$ eV; the electron and positron energies are $Ee = 3.66$ eV, and $Ep = 3.4$ eV). The Ps bubble radii are 5.4, 5.6, 7.1, 6.4, 6.6, 6.9, 6.9, 7.2 Å respectively. We supposed that C–H groups of complex molecules containing both C–H and O–H groups are primarily localized on the surface of the "Ps bubble" in these media [1].

In frames of these concepts, we learnt the PAS methods are widely usable to study biological tissues, including polymers, lipid membranes, micelles, vesicles, etc. to determine, for instance, the size of voids and mesophase's aggregations [3-6].

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MONTE CARLO SIMULATIONS TO OPTIMIZE THE SETUP FOR THE DETECTION OF AU NANOPARTICLES IN TUMORS

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This works investigates the performance of different setups for the detection of gold nanoparticles in tumors using X-ray fluorescent emissions following irradiation with conventional X-ray tubes.

Geometric and physical issues regarding detection system are studied by means of two different dedicated Monte Carlo subroutines based on the the FLUKA and PENELOPE main codes. Additionally, these tools allow to study the effect of Au concentration, tumor size and shape, among others relevant parameters.

Optimal configurations are evaluated in terms of signal-to-noise ratio for the K-lines in the recorded spectra. Although each specific situation has its own optimal detection configuration, some important issues are common to all cases.

BIOCHEMISTRY 23

THE VIEWS AND THOUGHTS OF PRIMARY SCHOOL STUDENTS ABOUT RADIATION

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Background: Radiation is a kind of energy that comes from both natural sources, and manmade sources that provide many advantages of modern living. Radiation is a matter in which we come across a lot in our lives and something that students find difficult to understand.

Purpose: This study reports the views and thoughts of primary school students about radiation.

Sample: In this study, a total of 222 students from 3 different primary schools in Erzurum, Turkey. The students were aged between 12-15, with 108 of them being girls and 114 being boys.

Design and methods: Students were asked 7 open ended questions. The answers of the students were recorded and then are evaluated.

Results: Results of the study led to the following conclusions: that students lack an adequate knowledge of radiation, and because of this, 88% of them are frightened of radiation and they have negative views about radiation since they think it's dangerous and harmful. Sources of great trust and accuracy should be used while studying radiation. This study suggests that important topics, an example of one such topic are radiation, should be inserted into the educational program and introduced to the students at an early age.

Conclusions: We recommend the construction of educational activities that introduce and familiarize students with radiation at specific time periods and suggest methods/techniques that will enable teachers to support these ideas.

THE DEVELOPMENT OF GAMMA-TOCOTRIENOL AS A RADIATION COUNTERMEASURE FOR THE ACUTE RADIATION SYNDROME

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The search for treatments to counter potentially lethal radiation injury has been underway for the past several decades, resulting in muliple classes of radiation countermeasures. However, to date only granulocyte colony stimulating factor (G-CSF) has been approved by the United States Food and Drug Administration (US FDA) for the treatment of acute radiation syndrome (ARS). Gamma-tocotrienol (GT3), a vitamin E isoform, has demonstrated strong radioprotective efficacy in the mouse model suggesting its evaluation in a large animal model. We evaluated pharmacokinetics (PK) and efficacy of GT3 against different doses of cobalt-60 gamma-radiation (0.6 Gy/min) using a non-human primate (NHP) model. PK results demonstrated increased area under the curve and half-life of GT3 with increasing drug dose. GT3 treatment was able to reduce group mean neutropenia by 3 - 5 days and thrombocytopenia by 1 - 5 days. The capability of GT3 to reduce severity and duration of neutropenia and thrombocytopenia was dose dependent; 75 mg/kg dose was more effective than 37.5 mg/kg post 5.8 Gy irradiation. A single injection of GT3 without supportive care was comparable to a recently published report using multiple doses of G-CSF with supportive care in terms of improving hematopoietic recovery in the NHP model. Although GT3 treatment of irradiated NHPs caused no significant difference in animal survival in our study, low mortality was observed in untreated control groups as well. Our data from this study further demonstrates the hematopoietic recovery after irradiation and PK of GT3 in NHP. GT3 could serve as an ideal radioprotective agent for use in humans, specifically for first responders and military personnel. Our pilot study with NHPs demonstrates that GT3 is an ideal radioprotectant meriting further development for the ultimate use in humans.

THE RISK AND PROTECTION FROM IONIZING RADIATION AT WORK AND IN EVERYDAY LIFE

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This paper is devoted to the prevention and precaution in the struggle against ionizing radiation contamination. According to the world standards, out of the total number of people suffering from malignant diseases, the ionizing radiation in responsible for approximately 5-10% of the cases. Legal regulation of the issues of ionizing radiation protection is expanded by issuing of detailed technical rules and standards. Each society fights against the possibility that modern technologies cause catastrophic consequences for people by making and application of legal regulation, equipment and organization of the protection management. For enforcement of regulation of environmental protection, there are extremely important and already known principles: integration, prevention and precaution, natural values preservation, sustainable development, application of motivation measures. Besides these principles, the principles whose application contains the concrete action of preventing measures of pollution control - principle of information and participation of public and principle of protection of the right on healthy environment and access to justice, as well as repressive measures for the case of the determined pollution. The need for education of population on danger of ionizing radiation, as well as manners of protection is of crucial importance for preservation of health of population and protection of environment.

Question is what percentage of employees is endangered on the job? The first report on increased number of leukaemia(s) in radiological workers was published back in 1911. The importance of informing of public of the dangers of ionizing radiation brings is stressed, as well as the role of “strengthened attention“ of employees that are especially exposed to ionizing radiation at their working place.

Informing of public on ionizing radiation coming from nature and taking steps for its reduction should be one of the priorities of our society in the next long-term period. Around 75% of total irradiation dose that world population receives is of natural origin. It has just recently been understood that radon is the most important of all sources of natural radiation. Scientific Committee of United Nations on the effects of atomic radiation estimates that radon, together with products of its decay polonium, contributes around 68,8% per year to effective equivalent dose that individuals receive from all sources together.

Recognition and application of the right on access to information on environment is one of the main goals of the environmental protection law. The availability of information on the condition of environment or projects which influence it is the pre condition for effective participation of citizens in the decision making processes.

Key words: Radiation, protection, environment, law

PERFORMANCE CHARACTERISTICS OF A HOME-MADE TLD READER; PRELIMINARY RESULTS

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Model of 7200 hot gas automatic TLD card reader has been designed and manufactured in Iran. This study assesses some performance characteristics of the reader including the linearity of response, stability of readouts during a period of time as well as reproducibility of TLD readouts. Furthermore, the coefficient of variations (COV) of the parameters have been studied and compared with those of standard criteria.

The obtained results show that the TLD reader can be used reliably in dosimetry laboratories.

THE HORIZONTAL FUEL CHANNEL PRESSURE TUBE DECOMMISSIONING IN THE CANDU 6 NUCLEAR REACTOR

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The scope of this study is to design a device for the decommissioning of the pressure tube, to achieve a possible dismantling method for the fuel channel components in the CANDU 6 nuclear reactor, to realize the logic functional diagrams and operator panel screens, which are on the basis of the Programmable Logic Controller (PLC) and the HMI operator panel software. The most important characteristic of the Cutting and Extraction Device (CED) is to ensure the environmental protection and totally operator's protection against the nuclear radiation. In the structure of the Cutting and Extraction Device (CED) are several modules: guiding-fixing module, traction modules, cutting module, guiding-extracting module. All of them are connected, one by one with flexible elements. The Cutting and Extraction Device (CED) it's a modular and flexible device, designed to work inside the fuel channel and equipped to perform the dismantling, cutting and extraction of the fuel channel components using the following functions: unblock and extract the channel closure plug (from End Fitting - EF), unblock and extract the channel shield plug (from Lattice Tube - LT), moving inside of the fuel channel with variable speed, block in the working position, monitoring temperature and video surveillance inside the pressure tube, block in the middle or at the end of the pressure tube and cut it, 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 by a operator panel type Human Machine Interface (HMI). The operations of the Cutting and Extraction Device (CED) are performed by functional logic diagrams, which are on the basis of the Programmable Logic Controller (PLC) software and are monitored and controlled from the HMI operator panel screens. The end of each dismantling step requires the confirmation of its finalization, in order to perform the next operation step. In case of error, the process is automatically stopped, the operator receiving an error message and the last sequence could be reinitialized or aborted due to safety reasons.

THE HORIZONTAL FUEL CHANNEL PRESSURE TUBE DECOMMISSIONING IN THE CANDU 6 NUCLEAR REACTOR PART I: CUTTING AND EXTRACTING DEVICE PRESENTATION

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The paper presents a solution for a Cutting and Extraction Device (CED) in order to achieve the decommissioning of the horizontal fuel channels pressure tube in the CANDU 6 nuclear reactor. The Cutting and Extraction Device (CED) is the most important execution element of the decommissioning device of the horizontal fuel channels in the CANDU 6 nuclear reactor. The very important characteristic of the Cutting and Extraction Device (CED) is the capability of totally operator's protection against the nuclear radiation in time of pressure tube decommissioning. In the structure of the Cutting and Extraction Device (CED) are several modules: guiding-fixing module, traction modules, cutting module, guiding-extracting module. All of them are connected, one by one with flexible elements. The guiding-fixing module is provided with elastic guiding rollers and fixing claws, the traction modules are equipped with variable pitch rollers for allowing travel speed change. The cutting module is equipped with three roll knives for pressure tube cutting. The cutting module has a system for video surveillance and temperature sensor for cutting place monitoring. The design of the Cutting and Extraction Device (CED) shall be achieved according to the pressure tube features of the fuel channel to be dismantled and to ensure radiation protection of workers.

THE HORIZONTAL FUEL CHANNEL PRESSURE TUBE DECOMMISSIONING IN THE CANDU 6 NUCLEAR REACTOR PART II: CUTTING AND EXTRACTING DEVICE FUNCTIONING PRESENTATION

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The scope of this paper is to present the Cutting and Extraction Device (CED) functioning for the decommissioning of the horizontal fuel channels pressure tube in the CANDU 6 nuclear reactor. One important part of the decommissioning device, which performs the dismantling, cutting and extraction of the fuel channel pressure tube, is the Cutting and Extraction Device (CED). The Cutting and Extraction Device (CED) it's a modular and flexible device, designed to work inside the fuel channel and equipped to perform the dismantling, cutting and extraction of the fuel channel components using the following functions: unblock and extract the channel closure plug (from End Fitting - EF), unblock and extract the channel shield plug (from Lattice Tube - LT), moving inside of the fuel channel with variable speed, block in the working position, monitoring temperature and video surveillance inside the pressure tube, block in the middle or at the end of the pressure tube and cut it, block and extract the half of pressure tube. After each step of dismantling is necessary the confirmation its finalization in order to perform the next operation step. The dismantling operation steps of the fuel channel components are repeated for all the 380 channels of the reactor, from the front of calandria side (plane R) as well as the rear side (plane R'). The design of the Cutting and Extraction Device (CED) shall be achieved according to the particular features of the fuel channel pressure tube to be dismantled and to ensure the environmental protection and radiation protection of workers.

THE HORIZONTAL FUEL CHANNEL PRESSURE TUBE DECOMMISSIONING IN THE CANDU 6 NUCLEAR REACTOR PART III: OPERATING THE CUTTING AND EXTRACTING DEVICE

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The subject of this paper is the Cutting and Extraction Device (CED) operating presentation for the dismantling of the pressure tube and the fuel channel components in the CANDU 6 nuclear reactor. The most important characteristic of the Cutting and Extraction Device (CED) is the capability of totally operator's protection against the nuclear radiation. To assure this totally operator's radiation protection and the environmental protection against the nuclear radiation, the Cutting and Extraction Device (CED) is fully automated, connected by wires to a Programmable Logic Controller (PLC) and controlled by a operator panel type Human Machine Interface (HMI). The operations carried out by the Cutting and Extraction Device (CED) to the 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. Each operation of the Cutting and Extraction Device (CED) is performed by a functional logic diagram, which is on the basis of the Programmable Logic Controller (PLC) software. Also, the dismantling operations are monitored and controlled from the HMI operator panel screens. The end of each dismantling step requires the confirmation of its finalization, in order to perform the next operation step. In case of error, the process is automatically stopped, the operator receiving an error message and the last sequence could be reinitialized or aborted due to safety reasons.

THE HORIZONTAL FUEL CHANNELS IN THE CANDU 6 NUCLEAR REACTOR PART IV: DISMANTLING MAIN STEPS WITH THE DECOMMISSIONING DEVICE

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The authors' contribution to this paper is the concept presentation of the decommissioning device main steps for the horizontal fuel channels decommissioning in the CANDU 6 nuclear reactor. The design of the fuel channel decommissioning device was achieved so that to perform the dismantling and extraction of the fuel channel components. At the fuel channel decommissioning, the device shall ensure, during the stages of dismantling, all security aspects for the environmental protection and the radiation protection of the workers. The major steps of the decommissioning operation are the following: the mounting of the device on the moving platform and their positioning to the fuel channel to be dismantled; coupling and locking the device at the fuel channel; unblock, extract and store the channel closure plug and the channel shield plug; cutting at the middle and at the end of the pressure tube; block, extract and store the end fitting; block, extract and store the half of pressure tube; mounting of the extended closing plug. The dismantling steps are carried out by the extraction actuator and by the cutting and extraction device from the handling elements assembly of the decommissioning device. The end of each dismantling step requires the confirmation of its finalization, in order to perform the next operation step. The dismantling operation steps of the fuel channel components are repeated for all the 380 channels of the CANDU 6 nuclear reactor, from the front of calandria side (plane R)as well as the rear side (plane R').

THE HORIZONTAL FUEL CHANNELS IN THE CANDU 6 NUCLEAR REACTOR PART V: DECOMMISSIONING DEVICE OPERATING PRESENTATION

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This paper presents a proposed solution by the authors in order to achieve a operating panel for decommissioning device of the horizontal fuel channels dismantling from the CANDU 6 nuclear reactor. The decommissioning device is designed to be automated, controlled by a Programmable Logic Controller (PLC) and operated from a Human Machine Interface (HMI). The decommissioning device performs the following dismantling operations: unblock and extract the channel closure plug (from End Fitting - EF), unblock and extract the channel shield plug (from Lattice Tube - LT), moving tool with variable speed, cutting the middle and the end of the pressure tube, block and extract the half of pressure tube, temperature monitoring and video surveillance inside the pipe. All operations can be monitored and controlled from the HMI operating panel. The PLC fully command the device in automatic or manually mode, to control the internal sensors, transducers, electrical motors for monitoring the status and position of control element, video surveillance and pyrometers for monitoring cutting place temperature. The device controller has direct access to the measured values with these sensors, interprets and processes them, preparing the next action after confirming the action in progress. The design of the decommissioning device shall be achieved according to the particular features of the fuel channel components to be dismantled and to ensure the environmental protection and radiation protection of workers.

DEPENDENCE OF RADIATION PROTECTIVE EFFECTS OF EXTREMELY HIGH-FREQUENCY ELECTROMAGNETIC RADIATION ON EXPOSURE PARAMETERS

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In modern radiobiology the role of non-ionizing electromagnetic radiation (EMR) in changes of the non-specific resistance and implementation of radiobiological effects is not clearly understood. It is assumed that non-ionizing EMR through the generation of reactive oxygen species can alter the resistance of cells to ionizing radiation and modify the DNA damage caused by them in the cells. To test this hypothesis we studied the combined effects of extremely high-frequency EMR (EHF EMR) with different exposure parameters and X-rays on the induction of DNA damage in mouse peripheral blood leukocytes.

Peripheral blood of male random-bred white Kv:SHK mice was collected in cuvettes with an anticoagulant, diluted 10 times, and the resulting suspension was used to prepare microscopic slides with viable leukocytes immobilized in 0.5% low melting point agarose. The cells in agarose slides were exposed to EHF EMR for 20 minutes at various exposure parameters before or after X-ray irradiation at a dose of 4 Gy. 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 found that the exposure of blood leukocytes to pulse-modulated EHF EMR (carrier frequency of 42.2 GHz, incident power density of 0.1 mW/cm^2, SAR of about 1.5 W/kg, exposure duration of 20 min, modulation frequencies of 0.1, 1, 16, 32 and 50 Hz) before X-ray irradiation at a dose of 4 Gy reduced the level of DNA damage in cells on the average by 25%. Continuous or amplitude modulated EHF EMR with the same modulation frequencies were inefficient. If the cells were exposed to pulse-modulated EHF EMR in five minutes after X-ray irradiation, the radiation protective effect was reduced on the average to 15%. Thus, it was shown that the pulse-modulated EHF EMR has both a protective and therapeutic effects. It was found that the radiation protective effect of EHF EMR depends on carrier frequency and an intensity of the radiation. The effect had a characteristic S-shaped dependence on the intensity of the radiation, the half effect was reached at the intensity of about 0.05 mW/cm^2. The effect value of EHF EMR was independent on the dose of X-rays in the range of 1-8 Gy. In a special series of experiments, it was found that the radiation protective effect of EHF EMR is maintained for 30 min after the exposure. The results obtained show that the radiation protective effect of EHF EMR depends on carrier frequency, frequency and type of modulation, radiation intensity, aftereffect interval, and a sequence of exposures.

Using a method of enhanced chemiluminescence, we found that pulse-modulated EHF EMR causes the production of hydrogen peroxide at nanomolar concentrations in physiological saline. The concentration of hydrogen peroxide formed depended on the intensity of EHF EMR, duration of the exposure, carrier and modulation frequencies. These results suggest that the mechanisms of radiation 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 electromagnetic radiation.

RADIOACTIVE WASTE MANAGEMENT AT THE NUCLEAR SCIENTIFIC AND EXPERIMENTAL CENTRE OF INRNE-BAS

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The paper gives an overview of the management of radioactive waste (RAW) generated during the operation and maintenance of the facilities at the Nuclear Scientific Experimental and Educational Centre (NSEEC) of the Institute for Nuclear Research and Nuclear Energy at the Bulgarian Academy of Sciences. It covers the basic procedures adopted at the NSEEC for collection of solid and liquid RAW, their categorization, classification and storage as well as the chain of command for RAW tracking, transportation and reporting. The accumulated solid RAW is stored according to the international and Bulgarian regulations in separate safe boxes (in the designated premise of every laboratory on the site of NSEEC), in monitored storage rooms (for the I Class Radiochemical Laboratory and the premises of the dismantled neutron generator) and in a separate building (Reactor Equipment Storage). At present the largest inventory of discarded sources of ionizing radiation is stored in the Gamma Irradiation Facility. In 2009 the low and medium activity liquid RAW stored in the underground tanks of the IRT-2000 research reactor were shipped for final utilization to the reprocessing facility of Kozloduy NPP and at present there are small amounts of low activity liquid RAW stored mainly in the II Class Radiochemical Laboratory. Among the main steps during the implementation of any RAW treatment activities is the detailed assessment of the doses accumulated by the personnel as well as providing the admissible work conditions - devices and accessories, personal means of protection, measuring appliances for overall dosimetry control, conduct of personnel instructions, etc., so that the collected doses are in the permissible limits determined by the legislation in force in Bulgaria and the internal regulations of INRNE for work with sources of ionizing radiation. The radiation measurements and site monitoring prior, for the period and after completion of all the RAW related activities conducted in long term at the NSEEC provides evidence that the RAW management as developed and adopted, meets all the requirements for radiation safety of personnel and prevents any radiation consequences to the environment.

ESTIMATION OF INDIVIDUALIZED RADIATION RISK OF CHRONIC OCCUPATIONAL EXPOSURE DUE TO INHALATION INTAKE OF U^{234}

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This study describes a methodology of radiation risk assessment for occupational exposure of nuclear industry workers. Chronic exposure due to inhalation intake of U^{234} in normal service conditions of radiation sources was considered. It was shown that the committed equivalent dose in lungs makes main contribution (99.7%) to the committed effective dose per unit intake by inhalation; dynamics of the accumulation of equivalent dose in the lungs is uneven.

The methodology for calculating lifetime attributable risk (LAR) of the lung cancer incidence under the influence of internal exposure, which was obtained as a result of inhalation intake, developed on the basis of ICRP models. The risk is calculated as a weighted average between the additive and multiplicative components of the total risk model of the lungs.

As received by inhalation aerosol at standard conditions of irradiation used 234U aerosol with AMAD=1 µm and dispersed phase type M.

For the calculation of radiation risk should use the risk assessment method multiple exposure.

If the value of lifetime attributable risk of the lung cancer incidence after a single exposure is known, it is possible to calculate LAR after multiple exposure by addition of single lifetime attributable risks by age at the time of exposure with an appropriate radiation dose.

As an example in the article was calculated LAR of the lung cancer after internal exposure for men who had the annual dose of 5 mSv through inhalation intake of radionuclides in age from 20 to 50 years. The maximum risk of a single irradiation was $2.5 * 10^{-4}$, which exceeds the acceptable risk for the staff – $2 * 10^{-4}$ (Standarts of radiation safety 99/2009). Lifetime attributable risk from multiple exposures for this staff is equal of $7.88 * 10^{-3}$.

CALCULATION OF RADIATION SHIELDING FOR MEGAVOLTAGE GAMMA RAY FACILITY USING MONTE CARLO CODE EGS_{NRC}

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This research applies the Monte Carlo simulation method EGSnrc Electron Gamma Shower (EGSnrc) Code with two codes: BEAMnrc code is used to simulate the beam emitted from the accelerator head and DOSXYZnrc code is used to calculate the dose emitted from the accelerator. From there, we evaluated the beam attenuation of radiation emitted from the accelerator through the layers of shielding material in the staff area and public area.

The accelerator used in this study was the Primus linear accelerator, and it emited the photon beam energy of 6MV. The Accelerator Head included 9 parts: Vacuum envelope, Target, Filter, Chamber, Mirror, the Collimater (Jaw X, Jaw Y), Mica and Air layer. Use BEAMnrc code, declare the components of the engine speed. (Fig.1)

Phantom used in this study was the accelerator room with a water phantom (dimensions 50x50x50cm^3) located at the distance of 100cm from the source to Phantom surface. The accelerator room size in the x, y, z coordinates was 1100x1007x708cm^3. Use DOSXYZnrc code, declare the components of the engine speed. Phantom is divided into 11x11x11 voxels are presented.

Case 1: Dose at the area staff

Table 1: Dose array in staff area

Position (cm)	Dose value (Gy)	Error
-5 → 5	1.10E-14	0.00%
5 → 25	4.93E-18	0.00%
25 → 390	7.54E-19	0.10%
390 → 445	1.37E-19	0.00%
445 → 520	4.45E-22	0.40%
520 → 550	1.23E-24	59.60%

D_{staff} = 0.11 (mSv/week)

Case 2: Dose in the public

Table 2: Dose array in the public area

Position (cm)	Dose value (Gy)	Error
-5 → 5	3.97E-18	0.0%
5 → 25	1.43E-18	0.0%
25 → 390	4.05E-21	1.0%
390 → 445	8.41E-23	0.6%
445 → 520	1.44E-24	3.0%
520 → 550	9.05E-26	5.0%

D_{puplic} = 1.1 (mSv/week)

Table 3: Comparison of measured and simulated results

Area	Simulationby EGSnrc	Measurement at People's Hospital 115
Public	1.1 (mSv/year)	< 1 (mSv/year)
Staff	5.5 (mSv/year)	< 6 (mSv/year)

Radiation dose in the public area of simulation case was higher than 10% compared with the actual results at the 115 People's Hospital, which can be explained as follows:

- The presence of radiation leakage.
- The radiation scattered from the patient, angle, direction of the slide projector, ...

In this work, the author and colleagues have successfully applied the EGSnrc simulation program with two dedicated codes – BEAMnrc and DOSXYZnrc. The initial results of the study showed that the dose limit in the area is 0.11 staff mSv/ week (5.5 mSv/year) and in the public area is 0.022 mSv/ week (1.1 mSv/year). These results are lower than 8.3% in the staff area and, in the public area, they are 10% higher than the regulations of the IAEA, the ICRP [2] allow. However, these results need to be verified further through further research.

OIL EXTRACTS OF WILD APPLE FRUIT AS ACTIVE SUBSTANCES IN UV PROTECTION PREPARATIONS

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Permanent exposure of the skin to the sun may cause a lot of side effects due to the action of UVA and UVB rays. Several studies have shown that polyphenols inhibit the reactive oxygen species formation as their "scavengers", reduce the penetration of UVB rays to sensitive tissues, neutralize free radicals, and because of their antioxidant and anti-inflammatory properties, participate in the prevention and treatment of many diseases caused by UVB rays. The use of cosmeceuticals rich in polyphenolic compounds represents a good basis for health improving and prevention of UV-related-chronic diseases. Apple fruit contains a large number of biologically active antioxidant substances, and their extracts can be potentially used for prevention and/or treatment of many skin's diseases caused by oxidative stress. The aim of our study was to estimate the antioxidant activity of wild apple fruit oil extracts obtained by different extraction methods using olive and sunflower oil in order to investigate possibility of their use as active substances with antioxidant effects for use in cosmeceuticals/dermocosmetic products which are used for UV skin protection.

Two extraction methods were applied. Method 1 comprised the maceration of the wild apple fruit in olive or sunflower oil on a water bath for 4 hours (Samples S1 and S2). Method 2 comprised the maceration dry wild apple fruit in 96% ethanol followed by maceration with the olive or sunflower oil extraction, heating up on the water bath and removing the ethanol thoroughly at same time (S3 and S4). All extracts were prepared in drug: extract ratio 1:5. Antioxidant activity was determined by two methods: DPPH test and test with linoleic acid and expressed as %RSC (Radical Scavening Capacity) and %AOA (AntiOxidant Activity), respectively.

Type of used solvent didn't have significant influence on antioxidant activity of oil extracts, but the used method of extraction was an important factor. %RSC of S1 and S2 were 14.94% and 18.11%, and %AOA were 62.20% and 61.21%, respectively. The use of 96% ethanol additionally increased the antioxidant capacity (S3 and S4), compared to the extraction with oil solvents only (more in DPPH test). %RSC of S3 and S4 were 20.63% and 35.20%, and %AOA were 63.48% and 66.48%, respectively. All extracts showed better ability to prevent lipid peroxidation, and low to neutralize free radicals. Oil extracts of wild apple fruit have good antioxidant possibilities and they can be used as active substances for UV protection.

Key words: Wild apple fruit, oil extracts, antioxidant activity, UV protection

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REGIONAL EAST EUROPEAN AND CENTRAL ASIAN ALARA NETWORK (RECAN): NETWORKING FOR IMPROVING THE OCCUPATIONAL RADIATION PROTECTION

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Occupational radiation exposure, as exposure of workers incurred in the course of their work, is regulated by national regulations and international basic safety standards. According to basic radiation protection principles, it should be justified, optimized and in line with occupation dose limits. Optimization of all types of occupational exposure trough dissemination of good ALARA (As Low As Reasonably Achievable) is an essential tool for improving the occupational radiation protection arrangements. Networking is an opportunity to share the knowledge and experience, to harmonize the approaches for using tools for occupational radiation protection, and to create new strategies to improve the radiation protection systems. The Regional East European and Central Asian ALARA Network (RECAN), which was established in 2005 with the support of the IAEA, has been supporting the countries of the region to facilitate information exchange and to promote integrated approach for practical and cost-effective implementation of the ALARA principle for the optimization of protection in the region. RECAN is focused on the maintenance, enhancement and development of competences in occupational radiation protection with special emphasis on the implementation of the ALARA principle for occupational exposure both in routine operations and emergency situations, on work towards harmonisation of radiation protection policies and practices, particularly concerning ALARA, both at regulatory and operational levels, as well as on exchange of information and experience in relation to the integrated approach to practical implementation of the ALARA principle. RECAN activities include newsletters, workshops, website maintenance and other activities of common interest to the network members. Whiting its scope, the RECAN provides the possibility to share new knowledge and experience, to harmonize regulatory requirements and approaches for occupational protection, to disseminate relevant information and to set links with different organizations within the region, both on regulatory and operational level.

RADIATION EXPOSURE OF NUCLEAR MEDICINE STAFF WORKING WITH RADIONUCLIDES ^{99m}TC AND ^{131}I

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Radioisotopes play an important role in medicine, where they are used routinely in the clinics for the non-invasive diagnosis and treatment of various diseases, including some of the most important and frequent ones, like cancers and cardiovascular diseases. Exposure to radiation during a medical procedure needs to be justified by weighing up the benefits against the detriments that may be caused. In the case of optimisation, practitioners need to ensure that the minimum amount of radiation is used to achieve the intended diagnostic objective.

Because of the physical nature of the radionuclides used and the activities required for diagnostic and therapy, the processes of preparing and dispensing therapeutic radiopharmaceuticals have a greater potential to expose operators to radiation. Dose to the staff can be minimised in multiple ways, mainly by training them in applying basic radiation principles such as maintaining distance from the radiation source or patient, performing operations in a shortest possible time and using shielding whenever practicable. Laboratories and other areas in which unsealed radioactive materials are used should be monitored, both for external radiation and for surface contamination, using a survey meter on a systematic basis.

The aim of the present work is to provide an overview and analyse the magnitude of radiation exposure of nuclear medicine staff working with radinuclides ^{99m}Tc and ^{131}I in Oncology Institute of Vojvodina, Serbia.

SHIELDING REQUIREMENTS FOR PET/CT USING THE AAPM TASK REPORT 108

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Whether installing PET/CT in an existing department or building a new facility, shielding for PET/CT is complicated and expensive [1]. The energy of positron annihilation radiation is greater than the energy of radiation used with other diagnostic imaging modalities. National regulatory limits dictate the annual radiation exposures for uncontrolled and controlled areas, and it is necessary to consider not only areas immediately adjacent to the PET/CT, but also areas above and below the facility. Barrier shielding must be determined for floors, ceilings, and adjacent walls. The short half-life of PET radionuclides and movement of injected patients within the department are also factors that must be considered when planning a PET/CT installation. Various materials can be used in order to shield positron annihilation radiation, and choices should be cost effective and practical. Effective planning for the installation of a PET/CT will include a medical physicist, workers from the nuclear medicine department, an architect, and the PET/CT manufacturer. Methods for estimating the shielding required for PET/CT take into consideration decay of the radionuclide, attenuation in the patient, and the examination protocol.

[1] Madsen MT, Anderson JA, Halama JR, Kleck J, Simpkin DJ, Votaw JR, et al. PET and PET/CT shielding requirements AAPM Task report 108, Med Phys2006;33:4–15.

ORGAN DOSE RATES DUE TO $^{137}Cs/^{137m}Ba$ CONTAMINATION OF SOIL DEPEND ON DEPTH OF RADIONUCLIDE DEPOSITION AND AGE OF A PERSON

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In 1949-1956 the releases of the liquid radioactive waste by the Mayak Production Association (Southern Urals, Russia) into the Techa River have become the cause of the chronic radiation exposure of about 30000 riverside residents. The purpose of the long-term follow-up of the population health status is the evaluation of the risk factors of the chronic radiation exposure. For the evaluation of the risk factors reliable dosimetric estimates are required. The individual dose calculation is performed by the instrumentality of the Techa River Dosimetry System (TRDS). Particularly the doses from the external exposure due to ^{137}Cs contamination of the soil are calculated on the basis of dose coefficients converting radionuclide concentration deposited in soil to the dose in the organ. The previous TRDS version utilized the dose coefficients which were calculated for ^{137}Cs uniformly distributed in the surface layers of the reference soil and a hermaphrodite mathematical phantom according to Eckerman and Ryman (1993).

In the network of the present study the regularities of dose formation in the organs with a glance at the Urals region specificity were analyzed and described. It is supposed that radionuclides are able to deposit at different depths into the alluvial soil (the density is equal to 1.5 g·cm^{-3}) typical of the middle and the lower Techa. The new hybrid phantoms were used which had the anatomical accuracy and anthropometrically appropriated by Urals residents for five ages corresponding to 1-year-old, 5-year-old, 10-year-old, 15-year-old and 22-24-year-old. Dose coefficients were calculated for 23 organs: active marrow, stomach wall, brain, breast, skin, lung, small intestine wall, liver, kidneys, pancreas, spleen, adrenals, bladder wall, rectosigmoid, esophagus, thymus, thyroid, right colon wall, left colon wall, endosteum, testes, uterus and ovaries. In addition the dose coefficients in tooth enamel were calculated for the analysis of EPR measurements of the tooth enamel. The method Monte Carlo was used, it was realized in the MCNP program. The uniform distribution of $^{137}Cs/^{137m}Ba$ in the thin layers of the soil at different depths corresponding to 5, 7, 9, 11, 13 and 15 cm were simulated. The results of the numerical experiments were smoothed by the analytical functions which described the dependences of the dose coefficients on the depth of $^{137}Cs/^{137m}Ba$ deposition and the age of the person. These dependences are easy-to-use and are able to applicate for the dosimetry on the Techa river as well for the population dosimetry in the uncontrollable radiation conditions (in case of the contaminated alluvial soils).

USE AND ANTIOXIDANT CHARACTERISTICS OF COFFEE

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Coffee is the second most consumed beverage by the people after water of course. The only competition to it is the tea.

Until recently, the effect of coffee was mainly assigned to the presence of caffeine in it. In the past years, however, scientists increasingly recognize the role of antioxidants in it.

This study is an overview analysis of the antioxidant properties of coffee and use among students from two universities in Bulgaria.

The time of the study spans over the period from September 30, 2014 to May 30, 2015.

Research approaches used:

- systematic approach and critical analysis of the available scientific periodicals;
- mathematical and statistical, combined methods;
- poll-interview method.

As the most commonly used caffeine drink, the students indicate coffee - 51 of respondents, followed by tea - 20 respondents, Coke (19) and Pepsi - 6 respondents.

The distribution within the parents of the students, surveyed, is identical. Greatest is the use of coffee - 53 parents, followed by the use of tea - 11 people, followed by Coke - 10 and three prefer Pepsi.

The coffee is in a leading position among caffeine containing drinks. Preferred drink for 66.67% of respondents.

AIR KERMA-TO-ORGAN DOSE CONVERSION COEFFICIENTS FOR HUMANS STAYING ON THE CONTAMINATED SOIL

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Uncontrolled radiation incidents can lead to soil contamination and as a result to exposure of people residing in the polluted areas (the Chernobyl accident, the Southern Urals contamination due to “Mayak” industrial activity and so on). The aim of this study was to estimate the conversion factors from air kerma to organ doses for human standing in the soil depend on age and depth of deposition of gamma-emitters. To achieve this goal the following tasks were resolved: (1) modeling of air kerma depend on penetration of radionuclides in different soil types (swampy or alluvial); (2) calculation of the dose coefficients as a function of depth of radionuclide penetration into soil and age for men and women; (3) evaluation of air kerma–to-organ dose conversion factors. Age dependent organ-specific dose coefficients were calculated by simulation of electrons and photons (Monte Carlo) using MCNPX program based on new hybrid phantoms of men and women and children of various ages (15, 10, 5 years and 1 year), which were developed at the University of Florida (phantoms UF). The gamma emitting radionuclides such as ^{137}Cs/^{137m}Ba, ^{95}Zr, ^{95}Nb, ^{144}Ce/^{144}Pr/^{144m}Pr, ^{106}Ru/^{106}Rh and ^{91}Y were considered.

As a result the data on soil contamination can be converted into air kerma and then into age-dependent organ doses for any vertical distribution of radionuclides in the soils, which allows reconstructing of a realistic picture of external exposure. Obtained results were applied to the Techa River dose reconstruction taking into account village-specific radionuclide shoreline profiles and lateral extents and depth profiles as well as village-specific soil compositions and densities.

The simulations of air kerma on the Techa riverside territory were compared with the results of measurements performed in the 1951-1970. The good agreement is found. The main factor of influence on air kerma-to-organ dose ratio is the human age. Soil type, gender and the radionuclide deepening in the soil and the difference in the spectra of gamma-emitting radionuclides are not significant for these ratios.

THE REASONS FOR THE FEASIBILITY OF OUTPATIENT RADIONUCLIDE THERAPY

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The possibility of use in the ambulatory therapeutic radiopharmaceuticals facility labelled one of the 19 β-γ-emitting radionuclides or 6 α-β-γ-emitting radionuclides was identified. A criterion for admissibility of outpatient regime is effective dose in individuals of the population that occasionally or permanently in contact with the patients after the radiopharmaceutical introduction. Based on the dose limits established by the NRB-99/2009, maximum allowable activity of these radionuclides for various geometries and exposure scenarios were calculated. It is shown that even for the most conservative irradiation conditions hospitalized patients to be passing courses radionuclide therapy only with ^{111}In and ^{131}I.

DIFFERENT METHODS FOR ^{90}Sr DETERMINATION IN WATER

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^{90}Sr is one of the important fission products likely to be found in the environment of a nuclear power plant or a fuel reprocessing plant. Because of its long physical and biological half-life the longest-lived radiostrontium isotope, ^{90}Sr is of major concern in environmental contamination and nuclear processes. Thus, it is important that effective monitoring techniques exist for ^{90}Sr in water samples, both as part of the regular monitoring program at nuclear sites and in the case of a radiological emergency.

Three laboratories participated in this study: Laboratory for low radioactivity at the Department of Physics, University of Novi Sad (UNS), Serbia, Laboratory for Radioecolgy of the Ruđer Bošković Institute (RBI) in Zagreb, Croatia and Radiation and Environmental Protection Department at the Vinča Institute of Nuclear Sciences (VINS). Each laboratory used different method for ^{90}Sr sample preparation and measurement. UNS used direct method for ^{90}Sr screening in water via Čerenkov radiation detected by a liquid scintillation counter PerkinElmer Quantulus 1220™ without any chemical pre-treatment. In RBI, EiChrom extraction chromatographic Sr resin (50–100 μm, 100–150 μm) Fluka Amberlite IR- 120 (16–45 mesh) cation-exchange resin and Amberlite CG-400 anion-exchange resin (100–200 mesh) were used for strontium isolation. ^{90}Sr is detected via Čerenkov radiation by a liquid scintillation spectrometer Packard Tri-Carb 3180 TR/SL and proportional counter (in equilibrium with ^{90}Y). In VINS, the determination of ^{90}Sr content in environmental water samples is based on the radiochemical analytical separation of ^{90}Y from the sample and measuring its activity after the establishment of radioactive equilibrium with^{90}Sr; the content of ^{90}Sr in the samples was determined by α/β low level proportional counter.

The analytical procedures and measurement techniques were confirmed by participating in the IAEA-TEL-2015-03 world-wide proficiency test on determination of ^{90}Sr in water sample and in interlaboratory comparison. The reported results were compared with the IAEA reference value and were acceptable in terms of accuracy and precision.

DEVELOPING A CULTURE OF RADIATION PROTECTION IN THE HOSPITAL ENVIRONMENT

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The responsibility of the radiation protection coordinator is to help ensure that radiation safety at the hospital is safeguarded in accordance with applicable laws and regulations. In practice, this means equipment registration and maintenance, personnel dosimetry, and ensuring the competence of all who work with ionizing radiation. This work describes the oppositions met and improvements made during one year of work as radiation protection coordinator in a regional hospital with locations in five cities in Østfold County, Norway.

The position of radiation protection coordinator was long absent at Sykehuset Østfold, and bringing the topic of radiation protection into focus was met with resistance. Communication of a central coordinator to contact people in all departments is vital, and the first challenge of the job was to establish consistent and authoritative communication. This task was initially hindered by the organisational placement of the coordinator within the radiology department. Although radiation protection is a respected theme in radiology, ionizing radiation is unwittingly used in many departments, particularly in the form of c-arm equipment. The coordinator was perceived as having no authority in departments outside radiology. Changing the organisational structure of the hospital and placing the coordinator under the administrative director improved the status and thereby the message of radiation protection and the requirement of personal dosimeters in the daily workflow outside radiology.

Consistent communication was established with at least one designated radiation protection contact person in each department, and it was thereby possible to address the issue of competence. Norwegian law is clearly requires documented, yearly refreshment of basic radiation safety and regular intervals of equipment specific training. Adhering to the law requires a central coordinator who is consistently in place to drive an internal educational system. This was accomplished by creating e-learning classes, giving classroom lectures to every department, and educating contact people to give equipment specific training in their departments.

Of central importance in any work is documentation, and a central file was created in the internal computer system of the hospital in order to store classroom lectures, educational articles of interest, and equipment maintenance records.

COLLECTIONS OF RADIOACTIVE MINERALS IN GEOLOGICAL MUSEUMS

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Of the thousands of known minerals about 200 shows a natural high radioactivity. A number of unique objects with extremely high radioactivity was discovered in Poland. These include abernatyt activity 81 000 kBq / kg (containing U 46%) Sabugalite a specific activity of 95 000 kBq / kg (53% U) Saleeit a specific activity of 91 000 kBq / kg (50% U), Samarskit- 28 000 kBq / kg (16% U) Torbernite 86 000 kBq / kg (48% U) cuprosklodowskite 98 000 kBq / kg (55% U) and many others. Availability of minerals carries the risk of easy to distribute among the local population as well as through online auctions across the country. At the same time knowledge of Poles about ionizing radiation and legal aspects of its use is low. A good source of information are the English-language portals online database forming minerals, ie. Webmineral.com, mindat.org, and the other containing full information on the composition of the material, structure, physico-chemical or occurrence of minerals in the world. Such databases contain images of minerals, as well as radiological classification in the five-point scale and comprehensive information on the necessary radiation protection commensurate with the radiation levels of the mineral.

Exhalation of radon gas is a spontaneous process, and a high share of ^{226}Ra, usually in equilibrium with ^{238}U radionuclide can increase the radiological exposure. The internal exposure is an important factor in quality of radiation, which for alpha radiation is many times greater than other types of radiation. According to the new directive ^{222}Rn concentration in the air in a residential building has been limited to 200 Bq/m^3, while in work condition to 300 Bq/m^3. In most Polish geological musemums activity concentration of ^{222}Rn radionuclide in storage air exceed limit 300 Bq/m^3.

SURFACE RADIOACTIVE DECONTAMINATION BY MOLTEN SALT STRIPPING

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Large amounts of radioactive waste are generated in dismantling and decommissioning operations. Significant part of the waste is generally constituted by superficial contaminated carbon steel structures. The reduction of the radioactive waste volume has a significant impact in the decommissioning costs. Nevertheless, some traditional decontamination methods, such as acid pickling, alkaline washing and ultrasonic baths have failed to promote effective decontamination. The use of solvents for paints removing has a undesirable environmental impact. However, removal of paints, corrosion and coatings is extremely important to reach effective decontamination, since the main objective is the unconditional releasing of all the waste as iron scrap. In this paper is described a new, innovative and efficient method for surface radioactive decontamination of contaminated steel structures, even corroded and with complex shapes, by immersion in molten salt baths of different compositions.

THE DETERMINATION OF ALPHA RADIATION DOSE TO SKIN DUE TO THE APPLICATION OF DIFFERENT RADIOPHARMACEUTICALS

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Artificial alpha-emitting radionuclides are significantly utilized in nuclear medicine. So, the skin of practitioners as well as patients in nuclear medicine and workers in the industry of radiopharmaceuticals may be accidentally contaminated even for a very short time by these radionuclides. Natural radionuclides such as those belonging to the uranium and thorium series are deposited on the human skin from the application of various material samples. The basic concepts of a Monte Carlo computer code for evaluating the mean absorbed dose in skin due alpha-particles emitted by these radioisotopes were described and discussed. Committed equivalent dose to skin from the deposition of different material samples were evaluated. The influence of the application time, alpha disintegration ratio, half-life of the radionuclide, and contaminated skin surface on committed equivalent dose was investigated.

EDUCATION IN RADIATION PROTECTION AND RADIATION RISK COMMUNICATION WITH THE PUBLIC

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The paper summarizes basic radiation protection aspects important for the communication with the public in the case of radiological emergency or radiological attack. The present system of radiation protection quantities and units as well as the associated terminology is too complicated for those who are not professionally engaged in the field but who need to have some basic understanding how to protect themselves and others against harmful effect of ionizing radiation. The emphasis are laid on the education and training of members of the general public in order to achieve better cooperation and coordination during radiation or nuclear emergency situations where the main gaol relies on the minimization of consequences of such events in terms of the personal exposure and the radioactive contamination of the environment.

THE STUDY OF THE RADIATION SCATTER IN INTERVENTIONAL CARDIOLOGY THROUGH MONTE CARLO SIMULATIONS: THE EURADOS WORKING GROUP NO.12 APPROACH

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In interventional cardiology and radiology workplaces the medical staff remains near the patient during the examination and receive doses due to the scattering field produced by the X-ray beam, impinging on the patient. In that condition the eye lens, particularly if no shielding is provided, can easily reach the new annual dose limit proposed by ICRP (20 mSv). For such reason, in the recent years, various investigations have been carried to determine the effect of the shielding for the eye lenses. In the present study the work performed in the framework of Working Group 12 "Dosimetry in medical imaging" of EURADOS (European Radiation Dosimetry Group) is presented. The main objective of this work, on the basis of previous studies we performed, was to perform detailed analysis of the scattered radiation field surrounding the operator's head for some selected X-ray beam projections, which are commonly used in these practices. We employed anthropomorphic analytical models, representing the patient, the operator and various scattering/shielding structures, using the Monte Carlo codes (MCNP5/X). The general approach and methodology are discussed and some preliminary results related to the scattered radiation that reaches the operator's eyes are given.

STRUCTURAL SHIELDING DESIGN FOR RADIOGRAPHIC ROOM BY SCATTERED RADIATION MEASUREMENT

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The purpose of radiation shielding is to limit radiation exposures to employees and members of the public to an acceptable level. The objective of a shielding calculation is to determine the thickness of the barrier that is sufficient to reduce the air kerma in an occupied area to a value $\leq P/T$, the weekly shielding design goal modified by the occupancy factor for the area to be shielded. This paper presents a method for determining the thickness requirements for barriers against scatter and leaking radiation in a radiographic room. The measurements were performed by RTI Barracuda equipment and R100B detector which are very suitable for scattered radiation measurements because of the high sensitivity and the minimal energy dependence. Obtained thickness of the barriers was compared with calculated values according to NCRP report No. 147 which contains recommendation and technical information related to the design and installation of structural shielding for facilities that use X-rays for diagnostic imaging.

A STUDY OF RADON CONCENTRATIONS AND RADIATION DOSE LEVELS IN SALT SAMPLES EXTRACTED FROM THE SAMAWA SALTERN – IRAQ

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The radon concentration in the environment and food concern all people involved in radiation protection. Because the salt is used in food and industry, radon (R_n^{222}) activity measurements in the salt samples from Samawa Saltern- south of Iraq, were carried out from radiation protection point of view of the occupational workers and general public. For the measurements, Radon Alpha Detector (RAD-7) was used. Results of various measurements of the radon activity, exposure to radon daughters, the annual inhalation dose received by the workers, and the excess lifetime cancer risk (ELCR) have been reported. The radon activity concentrations were found to vary from (7.2 Bq/m^3) to (52.3 Bq/m^3) with a mean value of (24.99 Bq/m^3). It was found that the As-salt workers are exposed annually to (0.058) Working Level Month (WLM) from radon gas and its short – lived daughters. The annual inhalation dose in the environment of Samawa Saltern was found to vary from (0.127 mSv/yr) to (0.898 mSv/yr) with an average of (0.429 mSv/yr). The excessive lifetime cancer risk due to radon in the Samawa Saltern was found to vary from (0.06%) to (0.43%) with an average of (0.21%). The results have revealed that the radon concentration and the associated inhalation radon dose do not pose any kind of health hazard to the occupational workers, consumer of salt and or when it used in the industrial purpose.

OUR EXPERIENCE IN DOSIMETRY AND RADIATION PROTECTION IN PEDIATRIC CHEST X-RAY DIAGNOSTICS

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Wilhelm Roentgen’s discovery of x-rays in 1895 opened a way to vast array of applications in medicine.

The enthusiasm was followed by a lack of concern regarding radiation damage. One of the first warnings came from Thomas Edison and Nikola Tesla who reported that x-rays experiments caused eye irritation. In the early days, radiologists and radiology technicians were the ones most exposed to radiation.

In the 1940s, and increased mortality caused by cancers, leukemia dominantly, was observed in radiology staff. After the development of atomic bomb, researchers realized that working with radioactive materials required a better knowledge about radiation protection. As a result a group of scientists began to work in this new field of protection and in 1965. International Radiation Protection Association (IRPA) was founded with the primary objective of providing the protection from the hazards caused by ionizing radiation.

First attempt at establishing a radiation dose limit was in 1920 when scientists defined a “Skin Erythema Dose”, a dose which caused skin reddening. 2 mSv/day (200 mrem/day) dose limit was established in 1931 and during World War II the year dose limit was reduced to 250 mSv (25 000 mrem) while today it is 20 mSv/year for professionals and 1 mSv/year for public excluded medical irradiation. The highest contribution of artificial ionizing radiation exposure to the public is caused by medical irradiation. Permanent efforts are done for improving the radiation protection of patients and medical staff.

In spite of development of sophisticated and often high dose diagnostic treatments (CT) the standard X-ray diagnostic of thorax is the most often procedure in pediatrics. For radiation protection purposes doses were measured on different body parts of children patients and on phantom in thoray and sinus x-ray diagnostic with thermoluminiscence (TL) and radiophotoluminiscence (RPL) dosimeters. The aim was to estimate the risk from irradiation and to propose some radiation protection measures taking into account several aspects such as: effectiveness of every day work, human factors , and image quality. However, the doses were low (0.06-0.85 mSv in primary beam on the back measured on more than 150 patients) in thorax diagnostics, the cytogenetic monitoring commet assay and micronucleus test on 20 patients demonstrated that there is significant potential of inducing genetic instability. After more than 25 years of experience in pediatric respiratory system radiology it is clear that dosimetry and low dose procedures are very important but they should not reflect on diagnostics (superposition of dosimeters on radiograms, image quality, etc.).

In conclusion, our long team work shows the importance of permanent dosimetry in x-ray diagnostics, continuing education and good teamwork for dose reduction to minimize the potential damage and maintain optimal benefit for medical staff and patients, especially children.

PREVENTION OF MEDICAL CONTRAINDICATIONS AT WORK / NEW ASPECT OF OCCUPATIONAL HEALTH SYSTEM

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Enterprises of the Russian nuclear industry is stably maintained a low level of occupational diseases during last years: not more than 120 cases per year - less than 1.5% of occupational diseases in the Russian Federation. Occupational diseases from exposure to ionizing radiation are rare among workers of the nuclear industry (0.8% of total occupational diseases in this group of workers) and they are the result of working conditions in the early period of the development of the industry.

Today, Russian occupational health system is providing measures to prevent not only occupational diseases, but also diseases that hinder the continuation of professional activities with the sources of ionizing radiation.

Were studied the results of obligatory medical examinations of 70 000 nuclear workers engaged in work with ionizing radiation sources, including the rate of medical contraindications (number of employees with medical contraindications per 100 employees, who have undergone periodic medical examinations).

The study shows that, from 2011 to 2014, the frequency of medical contraindications ranged from 2.5 to 3.22 cases per 100 workers of the nuclear industry. Identified major groups of diseases that hinder continuation of work with sources of ionizing radiation were: cardiovascular diseases, diseases of the respiratory system and the musculoskeletal system were major groups of diseases that hinder the continuation of work with the sources of ionizing radiation.

The results allow us to formulate targeted measures to identify risks and prevent the development of the main types of medical contraindications that would ensure the prevention of disability qualified and experienced specialists and, consequently, will prevent economic losses associated with the loss of these professionals.

Calculations showed that the economic losses of the nuclear industry associated with the need to train new workers to replace suspended from work of highly skilled professionals could achieve $ 200 million a year. The prevention of medical contraindications among professionals of the nuclear industry, working with ionizing radiation sources, can prevent up to 30% of these economic losses.

NUCLEAR SECURITY CULTURE: EVALUATION OF CONCEPT AND IMPLEMENTATION *(CASE STUDY: TWO FACILITIES AT THE GHANA ATOMIC ENERGY COMMISSION PREMISES)*

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The new trend of threat has changed so much so that we can no longer rely on the perception that radioactive materials are self-protecting and therefore may not be easily accessible by terrorists. With the increase in application of nuclear technology in Ghana, there is a need to put pragmatic and prudent measures in place to adequately and effectively protect the facilities and their materials from all kinds of adversaries. Physical Protection Systems for facilities and sources are not the only way to detect and/or prevent possible malicious acts.

"The assembly of characteristics, attitudes and behaviour of individuals, organization and institutions, which serves as a means to support and enhance nuclear security" is crucial in enhancing nuclear security at a facility. This implies that the Human factor plays a crucial role in the entire nuclear security architecture of a country. A facility that has its staff naturally and positively practicing security culture is bound to limit the facilities vulnerability to threats.

The study evaluated the security culture concept and its implementation of two facilities at the Ghana Atomic Energy Commission where radioactive sources are mainly used. This was done by the use of a developed questionnaire. The questionnaire was developed using the World Institute of Nuclear Security (WINS) Best Practice Guide 1.4 on Nuclear Security Culture and the IAEA Draft Document NST026 on Self Assessment of Nuclear Security Culture in Facilities and Activities that Uses Nuclear and/or other radioactive Materials.

The evaluation showed that staff was aware of the potential risk that the facility poses and the risk poses to the facilities and the radioactive materials. The evaluation also revealed how and extent to which security culture is implemented at the facilities.

RADIOBIOLOGY 24

THE IMPAIRMENT OF DNA DOUBLE-STRAND BREAK REPAIR IN PRESENESCENT HAMSTER FIBROBLASTS AFTER BLEOMYCIN ACTION

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Studies of DNA damage response are critical for the comprehensive understanding of age-related changes in cells, tissues and organisms. Syrian hamster cells halt proliferation and become presenescent after several passages in standard conditions of cultivation due to what is known as “culture stress”. Using proliferating young and non-dividing presenescent cells in primary cultures of Syrian hamster fibroblasts, we defined their response to the action of radiomimetic drug bleomycin (BL) that induces DNA double-strand breaks (DSBs).

The effect of the drug was estimated by immunoblotting and immunofluorescence microscopy using the antibody to phosphorylated histone H2AX (gH2AX), which is generally accepted as a DSB marker. At all stages of the cell cycle, both presenescent and young cells demonstrated variability of the number of gH2AX foci per nucleus. gH2AX focus induction was found to be independent from BL-hydrolase expression. Some differences in DSB repair process between BL-treated young and presenescent Syrian hamster cells were observed: (1) the kinetics of gH2AX focus loss in G0 fibroblasts of young culture was faster than in cells that prematurely stopped dividing; (2) presenescent cells were characterized by a slower recruitment of DSB repair proteins 53BP1, phospho-DNA-PK and phospho-ATM to gH2AX focal sites, while the rate of phosphorylated ATM/ATR substrate accumulation was the same as that in young cells.

Our results demonstrate an impairment of DSB repair in prematurely aged Syrian hamster fibroblasts in comparison with young fibroblasts, suggesting age-related differences in response to BL therapy.

KINETICS OF UV-INDUCED GENE AND STRUCTURAL MUTATIONS

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To study the kinetics of UV-induced gene and structural mutations in the yeast *S. cerevisiae*, several genetic assays were used. They included a forward mutation rate assay that detects mutations inactivating the arginine permease gene (Can^R mutations), frameshift reversion assays detecting mutations that revert a 4-base insertion in the *LYS2* gene (*lys2-Bgl*) or a +1 T insertion in a stretch of 6 T's in the *HOM3* gene (*hom3-10*), and a collection of six isogenic *trp5*-strains that is specifically diagnostic for all possible base-pair substitutions. Assays for intrachromosomal and interchromosomal homologous recombination (HR repair) based on the 5'trancated *lys2* sequence and the *LEU2* gene integrated into chromosome II as a direct repeat with the *lys2::HS-D* allele in the first case and two truncated *lys2* sequences located in nonhomologous chromosomes II and III in the second case. The [YCpL2]-plasmid assay was used to detect extent deletions (two or more genes) arising during NHEJ repair.

We have treated yeast cells with UV light up to 130 J/m^2. UV irradiation induced all types of base substitutions, although transitions — in particular, GC-AT events — were predominating. Frameshift mutations were induced at the same frequency as a base pair substitution, while forward mutations in the *CAN1* gene exceeded base pair substitutions by about an order of magnitude. Structural mutations were the most efficient. The kinetics of the induced gene and structural mutations is represented by a linear-quadratic function. Such curves have been reported for UV mutagenesis in bacteria and were explained by induction of SOS error-prone repair. Similar biphasic kinetics have been described in yeast. These data suggest the occurrence of several factors forming the mutagenic response of eukaryotic cells to UV light, which is discussed in the report.

THE CYTOGENETIC DOSE EVALUATION AFTER NON-UNIFORM IRRADIATION

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Analysis of chromosome aberrations in cultured peripheral blood lymphocytes is a conventional method of biological dose indication after an acute relatively uniform irradiation. It allows us to evaluate the average dose to the whole body. However this approach is not very effective at non-uniform irradiation. A detection of non-uniformity of acute external irradiation as soon as possible is very important for prognosis of acute radiation diseases course. The agreement between dicentric distribution per peripheral blood lymphocytes and theoretical distribution of Poisson is used for qualitative cytogenetical confirmation of irradiation uniformity fact (Dolphin suggestion). Also the IAEA recommendation suggests two approaches (advanced Dolphin's method and Qdr method) that enable quantitatively to estimate exposed body part volume and absorbed dose in it only after partial irradiation. The fourth approach consists in the evaluation of dose distribution on hemopoietic tissue by cytogenetical investigation results of bone marrow punctates taken from regions available for a puncture: sternum, anterior and posterior iliac spines at each side, thoracic vertebrae spines. The detection of local doses to hematopoietic tissue can be performed bycytogenetic investigations of bone marrow punctates from areas available for puncture: the sternum, the anterior and posterior iliac spines at each side, thoracic vertebrae spines. However this method has a dose and time limitations. Dilution punctates of peripheral blood interferes with the use of bone marrow lymphocyte cultures for the same purpose. In our Center a special computer program was proposed by to restore lymphocyte distribution by dose from dicentric distribution by lymphocytes after non-uniform irradiation. Apparently the dose distribution by lymphocytes reflects dose distribution by the body mass. In addition our experiments with cultures of irradiated lymphocytes and mixed cultures of non-irradiated and irradiated lymphocytes after in vitro gamma-irradiation of blood of healthy donors (1 to 8 Gy) permitted to determine quantitatively influence of interphase death and mitotic delay on dicentric yields for non-uniform irradiation. It was found after non-uniform irradiation it is necessary to correct not only the values of exposed lymphocyte fractions but also the values of dose estimations. This approach can be used for any type of dose distribution on body. It is evident what as a whole dose distribution by body mass can not reflect dose distribution by bone marrow mass. In spite of this the comparison of real curves of postirradiated dynamic of blood neutrophils number with analogous curves reconstructed from estimations of dose distributions by body mass on basis of results of the computer analysis of dicentric distributions was realized for several of patients exposed by acute external nonuniform gamma-irradiation. As a whole satisfactory results were received.

RADIATION SENSITIVITY OF BACTERIA CONTAMINATING FOOD

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Purpose: The purpose of the study is to determine how nanosecond electron beams affect the survival of the bacteria contaminating food and establish threshold doses for these types of bacteria.

Material and methods: 500 and 650 keV electrons from nanosecond-pulsed electron accelerators (URT-0.5, URT-1) were delivered at an average dose per pulse of 0,8 kGy/pulse and 1,8 kGy/pulse, at a repetition rate of 200 and 50 pulses per second, with a pulse width of 50 and 60 ns, respectively. The absorbed dose in the experiments was determined by varying the number of pulses. At the same pulse repetition frequency and their duration were constant. In this study the bacteria Kebsiella, Citrobacter, Salmonella, Staphylococcus, Aspergillus were irradiated in vitro. The dose was assessed by means of film dosimeters. Survival of the bacteria was estimated by counting the colony forming units per ml of solution.

Results: We found that at doses of 25 kGy survival for Klebsiella decreases by 21% and at doses of 30 kGy survival for Citrobacter decreases by 15%, at the electron energy of 500 keV. Accuracy of microbiological studies was 5%. For the electron energy of 650 keV, we got the following results:

1) At the doses of 11 kGy survival for Staphylococcus decreases by 40%. The number of staphylococcus changed irregularly, at a dose of 11 kGy survival decreased in the center of the Petri dish (5 cm diameter circle), but along the edges - the number of bacteria did not change.

2) The number of Salmonella changed uniformly. Moreover cells changed its shape and color. At the doses of 6 kGy, the survival of Salmonella decreases by 40% and, at the doses of 11 kGy, the survival of Salmonella decreases by 95%.

3) At the doses of 6 kGy survival for Aspergillus decreases more than 90% and at a dose of 11 kGy was showed effect of stimulating the growth of the colonies. However, these results should be checked by the following experiments.

Conclusions: We investigated the effect of nanosecond electron beams on bacteria and establish threshold doses at which survival of the bacteria vary by more than 10%.

TOWARDS ACCURATE SIMULATION OF RBE AND RADIATION-INDUCED DAMAGE IN CARBON ION BEAMS USING GEANT4

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The estimation and accurate prediction of the Relative Biological Efficiency (RBE) both for normal and tumor cells is the most essential part in radiation therapy with carbon ions. The actual RBE value for both microbiological objects (i.e. cell cultures) and macro biological objects (e.g. tumours) are not constant along Bragg curve and this fact is considered while implementing Spread-Out Bragg Peak at patient treatment.

In this study, we try to implement a highly accurate RBE simulation of the first (i.e. physical) stage of radiation-induced damage for macro biological objects based both on Geant4 simulations and our previous experience with X-rays, neutron, proton and carbon ion radiation fields performed with cell cultures. The Geant4 model was used to simulate different characteristics we estimate as model parameters. These includes the carbon ion-driven fragmentation, and Linear Energy Transfer (LET) function along Bragg curve for a primary and every type of secondary particles both in terms of dose-weighted LET and dE/dx probabilistic distribution at a certain point of the biological object. In addition, the number of ionization events occurring while carbon ion beam transfer its energy along the path was considered. The results of our previous radiobiological studies were used for fine tuning of the RBE simulation model.

The results derived from RBE simulation model will be used in future studies as the Proof-of-concept work in forthcoming carbon ion beam radiotherapy programme now implementing in cooperation of A. Tsyb MRRC, Obninsk, Russia and SRC IHEP of NRC “Kurchatov Institue”, Protvino, Russia. The next aim will be the accurate simulation of radiation-induced chemical factors preventing cell repair processes after irradiation.

Keywords: RBE simulation, Geant4, carbon ion beam

EFFECTS OF EXPERIMENTALLY IRRADIATED PITUITARY GLAND ON SOME MORPHOLOGICAL PARAMETERS OF RATS' HEAD, BODY AND TIBIA

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Studies on the effects of X-rays on biological systems are still meaningful and actual. The aim of present study was to examine the effects of pituitary gland irradiation on rats grow and develop, and the impact of pituitary gland protection during cranial irradiation. During the experiment rats were divided into tree groups. Animals in first group (control group) did not irradiate. In the second and third groups animals received cranial irradiation with 240 kV X-rays at doses of 27.92 Gy (n=10 per group), applied during 8 sessions, in the period from 8 to 63 days of age. In the second group rats had the pituitary gland protection in the form of lead plate set below the projection of the pituitary. Animals in the third group were irradiated without the lead plate protection of pituitary gland.

After the cranial irradiation without pituitary protection (second group) animals showed significant retardation of physical growth which was manifested in the reduction of pituitary gland mass as in body and tibial mass and length. In third group where rats during the cranial irradiation had the pituitary gland protection no significantly harmful effects of radiation were observed.

STUDY OF DNA DAMAGES INDUCED BY UV RADIATION

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UV radiation induces single or double strand breaks on DNA molecules, leads to the changes in DNA conformation and structure. As a consequence, some potentially harmful mutations in the cell's genome, which affect the survival of its daughter cells after it undergoes mitosis, can be occurred. Fortunately, the DNA repair process is constantly active as it responds to damage in DNA structure. In the present study, DNA damages in Escherichia coli (*E. coli*) exposed to UV radiation have been investigated. After 30 min of exposure to UV radiation of 5 mJ/cm^2, the growth of *E. coli* in LB broth medium was about only 10% in compared with non-irradiated one. This results suggested that the UV radiation caused the damages for *E. coli* genome resulted in reduction in its growth and survival, and those lesions can be somewhat recovered. For both solutions of plasmid DNAs and *E. coli* cells containing plasmid DNA, this dose also caused the breakages on single and double strands of DNA, shifted the morphology of DNA plasmid from supercoiled to circular and linear forms. The formation of pyrimidine dimers upon UV radiation significantly reduced when the DNA was irradiated in the presence of *Ganoderma lucidum* extract. Thus, studies on UV-induced DNA damage and repair mechanisms at molecular level are very essential to determine the UV radiation doses corresponding to the DNA damages, especially for creation and selection of useful radiation-induced mutants, as well as elucidation the protective effects of the specific compounds against UV light.

CYTOGENETIC EVIDENCE OF HRS/IRS EFFECTS IN CHINESE HAMSTER CELLS FOLLOWING CARBON-12 IONS IRRADIATION

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Biological consequences of cell irradiation with low-doses of carbon ions and their secondaries resulting from carbon ion therapy were investigated in terms of LET modification and hyper-radiosensitivity and induced radioresistance (HRS/IRR) using cytogenetic test. Chinese hamster CHO-K1 cells were irradiated with unmodified ^{12}C ion beam (initial energy 454 MeV/u) in a water phantom either in the plateau region of the Bragg curve (LET_d ~10 keV/µm) or in the tail region (1 cm behind the peak, LET_d ~18 keV/µm). Cell monolayers were irradiated with doses of 0.09–2 Gy in the late stationary growth phase. Therefore, chromosome type aberrations (deletions, dicentrics, centric and acentric rings) contributed mainly to the total chromosomal aberration (CA) yield, 85–95%.

For both radiations dose-effect curves demonstrated, in general, the same shape. Namely, the sharp rise of CA at doses of 0.09–0.12 Gy (HRS) followed by a (quasi)plateau (IRR) up to 0.28–0.35 Gy, and, finally, transition to a regular linear-quadratic dependence. Those patterns of dose-effect curves have been observed for total aberration frequencies and for yields of the major type of CA, deletions in the case of Chinese hamster cells. Experimental data were reasonably well fitted using Induced Repair Model by B. Marples and M.C. Joiner. The data obtained confirmed the suggestion that HRS/IRR is a response universal to low levels of radiation injury in repair competent cell lines after low- and medium- LET irradiation.

Despite the overall likelihood of dose curves for both radiations a small LET-modifying effect was observed. The doses of HRS was up to 0.09 Gy in the case of irradiation in the plateau region and 0.12 Gy in the case of irradiation in the tail region while in the case of irradiation with standard ^{60}Co gamma-rays it was 0.08 Gy. The dose range where IRR was observed was 0.09–0.3 Gy at the plateau region, 0.12–0.35 Gy at the tail region and 0.08–0.6 Gy for gamma-rays. It suggests that despite general mechanisms of both effects (HRS/IRR) some features of their performance are LET-dependent. One reason of possible discrepancies may be the different spectra of radiation damages induced with various radiations: primary carbon ions in the plateau region and set of secondary particles (n, p, alpha, Li, Be, B) in the tail region. So, in carbon ion therapy it is necessary to report and take into account also physical doses delivered to normal tissues at the beam entrance and beyond the spread-out Bragg peak because at the doses less than 0.8 Gy the irregular shape of dose-effect curves hampers straightforward RBE assessment.

ATP-DEPENDENT STEPS OF RADIATION-INDUCED APOPTOSIS

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Apoptosis is considered the main way of cell death after ionizing radiation exposure. But the intracellular events that mediate apoptosis are only partially characterized. Apoptosis is an active ATP-dependent process and the modulation (for instance, depletion after X-ray exposure) of intracellular ATP level can cause the development of radiation-induced cellular metabolism disorders. So we investigated the biochemical regulation of apoptosis (ATP-dependent steps) in lymphocytes upon X-ray irradiation (1.0 and 7.78 Gy). The results indicated the decline of ATP level after X-ray exposure which was accompanied by the DNA lesions and defects in ATP-dependent DNA repair machinery (30 minutes and 3 hours postirradiation). According to modern concept another main source of ATP application is an apoptosis pathway associated with the mitochondria-mediated caspase-9 activation at the apoptosome: procaspase-9, Apaf-1, ATP (deoxy-ATP), cytochrome c. Our investigations demonstrated dose-dependent changes in caspase-9 activity upon X-irradiation (both studied doses). And finally energy-dependent proteolysis by ubiquitin/proteasomes system plays a major role in radiation-induced response and is pivotal in degradation of many key regulatory molecules involved in apoptosis: p53, IκBα, BCL-2, Bax, and XIAP. To elucidate these processes we estimated the influence of proteasome activity on the regulation of instrinic radiation-induced apoptosis path. Our results suggest that the ATP- dependent part of apoptosis processes is an important and irreversible stage of lymphocyte cell death after ionizing radiation exposure.

OPTIMIZING THE EFFICIENCY OF THE SEQUENTIAL THERMORADIATION THERAPY IN ONCOLOGY

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The effectiveness of malignant neoplasms treatment usually increases when the combined treatments are applied. The sequential use of two different types of treatment affecting different cellular targets can lead to an increase in the total damaging effect due to the synergistic interaction of agents. Optimization of combined interactions that provide maximum therapeutic impact can be achieved using the regularities of synergistic effects.

The aim of the study was to adapt a previously developed mathematical model of simultaneous action of two agents to the conditions of the sequential thermoradiation action on the cells survival and test it using the experimental data.

A simple mathematical model of synergism proposed to describe the action of two agents on cell survival has been modified and adapted for optimization and prediction of sequential actions of agents on malignant tumour cells inactivation. The model postulates that detected synergistic effect occurs due to the formation of additional efficient lesions arising from the interaction of sublesions induced by each of the applied agents. Those sublesions do not induce any registered damage when agents applied separately. The degree of synergy enhancement of the registered effect was determined by the thermal enhancement ratio (TER).

To test the adapted model we used the experimental data published by other researchers. It should be noted that those researchers didn't use any mathematical model to predict the results of combined actions. The possibility to optimize and predict the malignant tumor and mammalian cells sensitivity increase after sequential action of two high temperatures or ionizing radiation and hyperthermia was tested. It was shown that there is a limit of cells sensitivity modification when two agents act sequentially. The model predicts that hyperthermia doesn't enhance the other agent action by any temperature. The model predicts the value of the thermal enhancement ratio depending on the duration of thermal exposure, its greatest value, and the condition under which it can be achieved. A comparison between the theoretically predicted increase in TER's and the experimentally determined increased value shows good correspondence in all cases.

Thus, the ability to predict and optimize the results of synergistic sequential interaction of two agents wildly used in clinical cancer therapy on tumour and mammalian cells was demonstrated.

ON THE MECHANISM OF BIOLOGICAL ACTIVATION BY RADIONUCLIDE SOLUTIONS

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The effects of alpha- and beta-emitting radionuclides (americium-241, uranium-235+238, and tritium) on marine microorganisms under conditions of chronic low-dose irradiation in aqueous media are summarizes. Luminous marine bacteria were chosen as an example of microorganisms; bioluminescent intensity was used as a tested physiological parameter. Non-linear dose-effect dependence was demonstrated. Three successive stages in the bioluminescent response to americium-241 and tritium (alpha- and beta-emitting radionuclides, respectively) were found: 1 - absence of effects (stress recognition), 2 - activation (adaptive response), and 3 - inhibition (suppression of physiological function, i.e. radiation toxicity). Hence, the response of bacterial cells to alpha and beta low-intensive emission is unified.

The nonlinear dose-effect dependencies are ascribed to the hormesis phenomenon. 'Hormesis' is a term for generally favorable biological responses to low exposures to toxins and other stressors, with the ionizing radiation involved. Activation of vital functions of various organisms is a well-known effect, common to all living organisms. It is attributed to triggering of cell defense response under the influence of low concentrations of toxic compounds, low dose radiation, and other stressors.

There exist two models explaining mechanism of radiation hormesis; they consider the adaptive response as related with (1) DNA damage or (2) cell membrane processes. Sequence analysis did not reveal mutations in DNA of the bacterial exposed to tritium. Experiments with tritiated water and tritium-labeled films (liquid and solid course of beta-particles, respectively) resulted in conclusion that activation of the intracellular bioluminescence process can take place without penetration of tritium atoms into the cells. The results give preference to a "non-genomic" mechanism of bioluminescence activation. Probably, the activation effects result from ionization of aqueous media followed by the intensification of cellular membrane processes. Hydrated electrons and reactive oxygen species can be considered as biologically active particles in aerated water solutions. Biological role of reactive oxygen species, secondary products of the radioactive decay, is discussed. The study suggests an approach to evaluation of non-toxic and toxic stages under conditions of chronic radioactive exposure.

The results of the study are considered in respect of the novel approach based on "exposome" concept of complementing the genome. The "exposome" encompasses the totality of environmental (i.e. non-genetic) exposures (Wild, 2012; Rappaport and Smith, 2010). Though this term was initially introduced for human exposures, the study of simple model organisms might provide fundamental molecular, physicochemical, biochemical, and cellular bases for human exposure science.

INFLUENCE OF MUTAGENS ON DECORATIVE PLANTS

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Through a relatively easy-to-apply technology novel characters in plant form, leaf and flower colour and shape can be induced. Induced mutagenesis through the application of physical and chemical mutagens remains an important part of ornamental and floricultural plant breeding. The tulip is an important ornamental bulb crop in the world being extremely popular for landscaping, but also as garden plants and cut flowers. Due to the constant or even increasing interest for this flower species, continuous and consistent efforts have been made to develop improved breeding methods. The induction of mutations with chemical and physical mutagens on the tulip bulbs was undertaken to make possible the growth of blossom period (blooming), the increase of heights and also of the number of petals in the treated plants. Also it is important to obtain resistant plants, since bulbs often are infected with Fusarium. In our study we treated the tulip bulb with chemical mutagens as dES and EMS, and with physical mutagens as gamma rays of Cs – 137, with three doses for each mutagen. During this year we achieved to obtain the first generation of the coloured mutant plant with these characteristics: the duration of blooming was extended 3 days, the root system was enlarged, the high of tulip plant as increased 6 – 10 cm, the number of petals changed from 6 to 8 petals in the EMS treatment. A considerable increase of the numbers of bulbs (more than 50 %) was observed.

INDUCED MUTAGENESIS APPLIED IN BEAN SEEDS

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Legume represent a high genetic variability and important for agricultural production. Among legumes cultivation is shown interest in soybean, groundnut, bean and pea. The use of induced mutagenesis techniques is on most important methods for the creation of new varieties. Besides the economic benefits, induced mutagenesis techniques also play an important role in the study of genetics and plant development. For this study bean seeds and were treated with gamma irradiation of Cs-137 with three doses 50Gy, 100Gy and 150 Gy, and chemical mutagen dES also in three doses. The seeds after treatments were implant in green house and experimental field. The temperature stress treated plants, have reacted positively being more resistant compare with control plants. Results obtained in the first generation of mutant M1 indicate change compared to control for the both treatments. Changes have been noted in the amount of Chlorophyll pigments a, b and (x+c), related to the acceleration of flowering, where the first doses of dES has given more and fast flowers compared to the control. There were changes in the maturity period for the two gamma rays doses (100 Gy and 150 Gy).

GENETIC IMPROVEMENT BY MEANS OF γ RAY TECHNIQUES IN *TRITICUM AESTIVUM*: RESULTS ON DAVID X MEC VARIETY

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Wheat is an agricultural plant deeply linked with a state's economy. It is extensively utilized in food and other light industries while its usage as a fuel is being increased step by step. As such, the genetic improvement is a duty for each country. Aiming at the genetic change induction and screening further for the positive changes amongst, radiation techniques with gamma rays are applied in some wheat varieties. To serve this purpose, 1000 seeds of each variety have been radiated with gamma rays in three different doses and have been sown for two continuous years. The radiated seeds and one group of un-radiated ones were planted on a complete randomized block design. Key physiological, morphological and yield features were analysed in each group of plants in order to evaluate the changes induced by the radiation applied to them. Flag leafs were analyzed for their photosynthetic system as well as their area and dry weight. Furthermore, plant height was measured and averaged in each group. In the end of the vegetative period the kernel weight, their number in the spike was evaluated. The changes were statistically assessed by LSD test using SPSS 17 software. Moreover the correlation between the traits is analysed by the Person coefficient. The paper shows the results revealed on the radiated plants of DxM variety. The radiation has induced several improvements on the analysed features, which are mostly observed in groups of low and high doses application. It should be emphasised the melioration of the photosynthetic system in the plants of low doses application what seems to be reflected in the analysed yield elements.

PLANT HEIGHT REDUCTION BY MEANS OF γ-RAY TECHNIQUES IN THREE GENOTYPES OF TRITICUM

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Seeds of some Triticum aestivum L. and Triticum durum varieties were treated by gamma rays from Cs137 source, in order to induce mutations in their gene band aiming the selection of improved genes. The seeds were irradiated in three different dosage levels. They were planted for the two first generations in bulk without being screened for any improvement. The selection was undergone in the end of second generation plants (M2). The selected seeds of M2 were planted for three following generations in the experimental plot of QTTB in Lushnje where are going to be monitored by agrospecialists.

The paper will present the revealed results in the third and fifth generation (M5) in lines selected for reduced height. It is well known that plant height is a feature highly correlated with the loadging phenomena in cereals, which causes high loses in cereals yield.

The third generations some of the short lines selected in M2 revealed with a significant reduced stem, moreover, yield elements revealed as improved or unchanged as compared to control plants. Lines DXM-K3, LB7-K1 and STF4-B4 were reduced in height respectively with 21%, 16% and 20% whereas. The fifth generation which is going to be presented is planted in the autumn 1015 and is going to be analysed in the beginning of May 2016 for their height and yield features.

CLINICAL RADIOBIOLOGY OF INFILTRATIVE LOW-GRADE GLIOMAS (GRADE II)

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Objectives: Estimate radiobiological parameters of infiltrative low-grade gliomas using available clinical data.

Materials and methods: In our study 5 clinical studies were analyzed [1, 2, 4, 5, 6], as well as a data from our database. We used the following radiobiological parameters in our calculations: dose per fraction, total dose of radiotherapy, total number of treatment days, 5-year progression-free survival. The method proposed by Pedicini Piernicola et. al. (2014) [3] was used to estimate the radiobiological parameters of low-grade gliomas.

Results: In total, our study included 870 patients. All patients received surgery (1-phase treatment) and radiotherapy (2-phase treatment). Following radiobiological parameters of tumor were calculated: α, β, α/β, T_d, D_{prolif}, T_k, N(clonogens). Following values were calculated (95% Cl): α(Gy-1) = 0,096 (0,08-0,11), β(Gy-2) = 0,014 (0,012-0,018), α/β(Gy) = 6,8 (4,3-9,2), Td(days) = 21,3 (18,3-26,4), Dprolif(Gy) = 0,27 (0,21-0,35), Tk(days) = 44 (34-55), N(clonogens) = $2{,}18\cdot10^3$ $(1{,}2\text{-}5{,}3)\cdot10^3$.

Conclusion: The calculated values of radiobiological parameters give a better idea of the biological properties of the low-grade gliomas and estimate as accurately as possible of the total dose of radiotherapy using a linear-quadratic model.

Keywords: Low-grade gliomas (LGG) (grade II), α/β ratio, linear-quadratic model (LQM), clinical radiobiology

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CORRELATION BETWEEN PHYSIOLOGICAL AND BIOCHEMICAL STATUS OF *SILENE LATIFOLIA* SEEDLINGS FROM KYSHTYM ACCIDENT (RUSSIA, URALS)

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We investigated the quality of seed progeny and biochemical status of white campion (*Melandrium album* (Mill.) Garcke = *Silene latifolia* Poirt), which grows at the East-Ural Radioactive Trace (EURT, impact populations) and outside contamination (background samples). The collection of samples was conducted in similar geobotanic conditions from 8 plots of the background area and 4 plots of impact one. The total absorbed doses estimated by ERICA Tool varied from 0.090 to 0.092 $\mu Gy\ h^{-1}$ for the *Silene latifolia* background populations, and from 0.195 to 38.39 $\mu Gy\ h^{-1}$ for the impact samples. In general, dose rates in the EURT area exceeded background levels in 2-417 times. These values apply to low level radiation doses for plant organisms.

The seeds of white campion were germinated in roll culture at +24°C using 12 hours light/dark cycle for a period of 3 weeks. After which all the measurements were taken. We estimated the germination rate, survival of seedlings and root length. All experiments were repeated 4 times, and there were a total of 1200 seeds (25 seeds per each experimental container). The activity of superoxide dismutase (SOD) and catalase (CAT), lipid peroxidation (LPO) were determined by standard methods in dry seedlings using the SpectraMax Plus 384 (Molecular Devices, USA).

The SOD and CAT activities and level of lipid peroxidation of white campion seedlings varied at the gradient pollution of EURT area similarly (R=0.32-0.79; p=0.00001-0.028). It was shown the activity of enzymes in *Silene latifolia* seedlings minimal under maximum absorbed radiation dose (R= -0.93; p=0.021). We detected the significant negative correlation between the all viability parameters of white campion seed progeny (except for root length) and SOD activity (R=(-0.43)–(-0.29); p=0.0025-0.048).

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EFFECTS OF SPONTANEOUS γH2AX LEVEL ON GENE EXPRESSION IN HUMAN SOMATIC CELLS

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Phosphorylated histone H2AX (γH2AX) foci are well-known markers of DNA double-strand breaks in human cells. Spontaneous γH2AX foci form on unrepaired DNA double strand breaks, shortened telomeres and sites with altered chromatin conformation. The presence of such permanent γH2AX foci in cell is an important component of epigenetic background and potentially leads to the activation of DNA repair system. The objective of this study was to analyze the effects of spontaneous γH2AX level on radiation-induced response in human somatic cells.

Spontaneous γH2AX foci and radiation-induced micronuclei were analyzed in peripheral blood lymphocytes of 54 healthy individuals after exposure to 2 Gy ionizing radiation *in vitro*. An inverse correlation was found between the spontaneous level of γH2AX foci and the frequency of micronuclei after irradiation ($R=-0,37$, $p=0.025$). However, no such correlation between the spontaneous level of γH2AX foci and the frequency of micronuclei after irradiation was found in 18 lines of primary human extraembryonic fibroblasts. Further, a transcriptome analysis was performed using gene expression microarrays in lymphocytes of two sub-groups of individuals: 1) individuals with low spontaneous level of γH2AX foci (n=3) and 2) individuals with high spontaneous level of γH2AX foci (n=3). After gene expression analysis with microarrays, several differentially expressed genes were identified, which are associated with an efficiency of DNA repair and radiation sensitivity. Differential expression of several genes (THBS1, WHSC1, RBFOX2, ADAMTS1) was confirmed in lymphocytes with different level of spontaneous γH2AX foci by qRT-PCR. THBS1 gene, well-known radiosensitizer, was down-regulated, and WHSC1, RBFOX2, ADAMTS1 genes were up-regulated in lymphocytes with high spontaneous level of γH2AX foci. Moreover, expression of WHSC1, RBFOX2, ADAMTS1 genes directly correlated with the level of spontaneous γH2AX foci in primary human extraembryonic fibroblasts.

The obtained results indicate that spontaneous γH2AX foci significantly affect gene expression profile in various human somatic cells. Some of identified genes are associated with DNA damage response in human somatic cells and apoptosis. Identification of other genes, like RBFOX2 and ADAMTS1, provides opportunities to clarify their role in the formation of spontaneous γH2AX foci and radiation-induced response in human somatic cells.

A MATHEMATICAL APPROACH TO THE COMPOSITION OF TUMOUR CONTROL PROBABILITIES FOR HYPOFRACTIONATED SCHEDULES AND REPLANNED TREATMENTS

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Modern radiotherapy practice has evolved towards the use of a greater proportion of hypofractionated treatments. Although fractionation patterns could be different, these treatment schedules make external treatments similar to multifraction brachytherapy applications: fractions can be seen as instant actions on the tumor, followed by a long period when tumor dynamics govern repopulation mechanisms. This work presents a mathematical framework to obtain the overall tumor control probability for a hypofractionated treatment, which offers flexibility for the introduction of refined developments. The equation has been derived from first principles; it is straightforward and allows the handling of different schedules and replanning.

A basic dose-response curve can be interpreted as fraction of clonogens surviving the action of the absorbed dose **d**. If each voxel is treated as a region of homogeneous dose, the set of all voxels receiving the same dose has the volume described by the differential DVH at **d**. The cell density can be worked out from this volume assuming constant density within the PTV.

For every voxel, and, therefore, for every set of voxels with the same dose, each treatment fraction results in interactions with a fraction of clonogens. The only interactions that still can cause progress in the treatment are those occurring in surviving clonogens. Therefore, as the treatment progresses every additional treatment fraction is less effective, even if the dose distribution is exactly the same.

The mathematical method to deal with this situation consists of a two compartment model for each voxel, each session causing a number of clonogens to leave the set of active cells and enter the inactive set. Hence, TCP can be defined as the probability of emptying the active compartment at the end of the course of treatment for every voxel in the PTV.

The modeling of the two compartments with Poisson statistics leads to a compact formula for TCP in *n* fractions and a given dose distribution. Transition functions can be computed from the dose distribution, its DVH and the dose-response relationship. TCP computed within this framework can be decomposed in groups of treatment fractions: $TCP(n)=TCP_1^m * TCP_{m+1}^n$ (all terms are matrices), so that new plans, or plans for repeated implants in brachytherapy, can be treated in a simple way. More complex schedules could be modeled as well, and assessments of patient radiation protection can be likewise obtained with a modified formula.

EFFECT OF X-RAY ON PLANTS AND HAIRY ROOTS OF DIGITALIS PURPUREA L.

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Plant response to radiation exposure, as well as other negative effects on the factors, includes adaptive activation processes of an organism. Studying this mechanism is interesting. The aim of our study was to investigate the formation of radioadaptive response Digitalis purpurea, both in vitro plants and hairy roots, after exposure to low doses of radiation.

In the present study, we have used X-ray 1, 2, 3, 5, 10, 20 Gy and analyzed by influence of radiation on the photosynthetic apparatus, biosynthesis of phenolic compounds, a change of DNA methylation pattern and mitotic index in a week and month after the irradiation in the two passages.

As a result, it was found that such irradiation improves the morphological characteristics of the plants. Growth processes and plants and hairy roots are activated. A week after exposure to the stressor changes in the number of chlorophylls, carotenoids and flavonoids are observed. A month later, the amount of carotenoids, the ratio of chlorophyll a / b decreases, which indicates a decrease in the photosynthetic capacity of the irradiated plants. Synthesis of flavonoids reduced as well.

But in the second passage we have seen an increase in all the parameters studied in relation to the non-irradiated samples. It shows the development of long-acting adaptive response of plants. The amount of flavonoids in the culture «hairy roots» the contrary increased week after irradiation, and in a month has decreased almost twice. An analysis of the mitotic activity of the cells of the root apical meristem allowed to establish a 2-fold increase in the mitotic index in the irradiated plants in the first passage and the alignment of indicators in subsequent transplant. The hairy roots exposed significant differences from control were observed. DNA-analysis by methylation-sensitive PCR did not reveal a clear change in methylation pattern after irradiation either in plants or in the hairy root.

ADAPTATION MECHANISM OF SMALL MAMMAL POPULATIONS TO ACUTE AND LOW LEVEL CHRONIC EXPOSURE

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Small mammal's natural populations are heterogeneous. Individuals of the same species living in the same community differ in many traits and may be divided into groups with respect to age, size, developmental rate (type of ontogeny). Comparison of the resistance achieved by bank voles (*Clethrionomys glareolus)* of different ontogeny types (natural population) to acute gamma-radiation (laboratory experiment) showed that immature yearlings (specimens representing ontogeny type II) are significantly more resistant than the mature yearlings (ontogeny type I). Their lethality was 3.7 times lower at the same dose, but average lifespan was significantly longer during the 30-day long period of observation than in specimens of type I. Besides, the dynamics of quantitative hematologic parameters (blood, bone marrow, and spleen) are also indicative of the radioresistance in type II based on the depth and degree of decrease and on the rate and intensity of their recovery up to the initial level as well. Differences in the Radioresistance of animals using various demographic and reproductive strategies are primarily determined by their level of metabolism.

Radionuclide (90Sr) accumulation was studied in the skeleton of pygmy wood mice (*Sylvaemus uralensis*) representing different ontogeny types that were captured in the head part of the East Urals Radioactive Trace zone (Urals, Russia). The initial density of soil pollution with 90Sr is 18.5 MBq/m2 (500 Ci/km2). In was found, the specific activity of 90Sr accumulation in immature yearlings (type II) was two times higher than that in mature yearlings (type I). These differences depend on bioenergy, morphophysiological state of rodent's bone tissue, because, as known, cellular activity has a complex influence on the behavior of radioisotopes in the skeleton of vertebrates, mainly through growth modification and bone tissue remodeling. Thus low level chronic radiation can be considered as the mechanism of switching of life history of small mammals.

In summary, the response of murine rodent's population to acute and low level chronic irradiation is specific. Bivariance of small mammal's ontogeny development is a main mechanism of adaptation and protection strategy of population in radiocontaminated environment for decreasing the damaging action of radiation on non-human biota. Functional approach makes it possible to significantly reduce errors in assessing the radiological consequences and hence, can provide a reliable methodological basis for organization of biological monitoring.

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MICRODOSIMETRIC SIMULATIONS FOR TESTING CELL RADIOSENSITIVITY

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Microdosimetric approach takes into account the discontinuous nature of energy deposition in a medium exposed to ionizing radiation. This is of prime significance when biological effects of radiation are analyzed at the cellular level. Monte Carlo simulations of radiation transport allow microdosimetric quantities and their statistical distributions to be calculated for geometrical models of real tissues. The geometrical system investigated in the present study consisted of micrometer-sized spheres (termed *targets* in the paper) arranged in a cubical lattice. Target volume can represent either a whole cell, in which case the space between the targets represents the extracellular matrix, or just a particular part of the cell known to be especially sensitive to radiation. Two types of radiation have been investigated: alpha particles from a source distributed uniformly throughout the space between the targets, and neutrons forming an isotropic external field. Parameters that have been varied in the simulations include: target size and spacing, material composition within and around the targets, alpha particle and neutron energy, as well as total absorbed dose in tissue. Simulations have been performed in MCNPX, with the absorbed dose set by changing the number of alpha particles emitted or of neutrons constituting the external field. The output of each simulation run is a histogram showing the distribution of radiation energy deposited in targets, i.e. the probability distribution function (PDF) of the specific energy. These graphs show how shape and position of PDFs change with increasing absorbed dose. They also indicate the range of values for specific energy within which an energy threshold for cell death lies. Based on the data obtained from simulations, survival curves are plotted for different values of energy threshold and presented in the paper. The procedure is then outlined on how comparison of these theoretical survival curves with the ones obtained for real irradiated samples can yield the value of the threshold energy for cell death in an investigated type of tissue.

THE EFFECT OF IONIZING RADIATION ON THE EMBRYO AND FETUS: REAL CASE STUDIES

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The developing embyo and fetus are extremely sensitive to ionizing radiation. The main effects for the human embtyo and fetus are: growth retardation, prenatal or neonatal death, congenital malformations and mental retardation. The incidence of these radiation effects depend on the absorbed dose and stage of gestation. The threshold dose, which pregnancy termination can be considered must be flexible, in a large tolerance, depending on other possible risks of the pregnancy as well as the personality of the future parents and ethical aspects. Conceptus doses of less than 100 mGy are not recommended to be considered a reason for terminating a pregnancy. Radiation exposure from dianostic radiooy roedures rarely reaches this dose levels.

In this work we preset three actual cases of prenatal exposure held at the lumbar spine radiogapy, computer tomography of pelvis and abdomen, and X-ray of stomach and duodenum in the presence of contrast material. In all three cases the exposure was conducted in early stage of pregnancy before the patient knew she was pregnant. It is known, that embryos in the pre-implantation stage are very radiosesitive. However, the radiation damage inevitably would lead to death of the conceptus and early abortion. Those embryos that survive develop normally.

A careful analysis of radiation dose to the uterus, in particular after abdominal CT examination, as well as medical anamnestic estimation were performed. A recommendation of termination of pregnancy because of possible radiation injury was not given in these cases because radiation occurred shortly after conception and radiation dose to the uterus from those radiological procedures were well bellow 0.1 Gy.

The outcome of pregnancy of these monitored cases was the birth of a normal child.

PROTON INDUCTION OF GENE MUTATIONS

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Space radiation is hazardous to long-duration space crews because it may cause cancer and damage DNA, blood cells, and platelets. The problem of protection from chronic exposure to cosmic radiation, which is primarily composed of protons (95%), in future manned missions to Mars has not yet been solved. To model the effect of cosmic radiation on living cells, we used a proton accelerator beam at JINR (Dubna) and the eukaryotic unicellular yeast *Saccharomyces cerevisiae*. Based on the conservation of fundamental molecular processes, including DNA repair, in the eukaryotic cells from yeast to humans, the data gained from studying model systems, such as yeast, can be directly applicable to studies of higher eukaryotic systems.

A comparison of different ionizing radiations showed that charged particles produced a greater number of DSBs compared to abasic and oxidized base clusters than ionizing photons, with protons generating the highest ratio of DSBs to abasic and oxidized damage (*Hada, Sutherland, 2006*). DNA strand breaks induced by protons were predominantly repaired by homologous recombination and postreplication repair pathways (*Rostel et al., 2008*). There are two branches of postreplication repair: template switching (error-free) and translesion synthesis (error-prone). In this study, we describe the results of our investigations of the effect of low-LET proton irradiation on gene mutations.

DNA lesions were caused by acute exposure of the cells to 150 MeV proton irradiation (liner energy transfer of 0.539 keV/μm) and ^{60}Co γ-rays at doses up to 20 Gy. Cells responded similarly to proton and γ-irradiation. The survival rates were exponential and comparable. To detect the gene mutations, we used a forward mutation rate assay that detects the mutations inactivating the arginine permease gene (Can^{R} mutations) and reversion assay detecting the frameshift mutations that revert a 4-base insertion in the *LYS2* gene (*lys2-Bgl*). The dose responses can be described by a linear relationship for both types of gene mutations. Different radiation sources that induce mutations have the relative biological effectiveness values of 0.89 for frameshift mutations and 1.63 for forward gene mutations Can^{R}. So, the damage induced by proton irradiation of cells appears to be more serious than the damage induced by γ-irradiation, which is indicated by an increase in the yield of not only DSBs (*Antocia et al., 2002; Di Pietro et al., 2006*) but also gene mutations.

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EFFICACY OF YTTERBIUM SOURCES TO INDUCE LETHAL AND CYTOGENETIC DAMAGES IN HUMAN CELLS IN CULTURE

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169 Ytterbium (Yb 169) due to its radiation properties (relatively soft radiation spectrum, high specific activity) is a radionuclide with great potential for the use in cancer brachytherapy. Although there is no experience of ytterbium practical application, it is considered by some radiopharmaceutical companies as a clinical radionuclide. We studied ytterbium sources developed by LLC "Delis" and INR (patent number 131302 -RU). These sources are composed of a dense ceramic core of enriched ytterbia in the hermetic titanium container. In this work we present an assessment of some properties of the nuclide that may be clinically relevant. We study the effect of ytterbium radiation on the proliferation and progression of the cell cycle, as well as on the apoptotic death and the level of chromosome aberrations in carcinoma (HeLa G63) and endothelial (ECV304) of human cells in culture. It has been shown that the exposure of cells by Yb-169 with doses 0.33- 1.2Gy leads to cell blocking in G2 / M phases of the cell cycle. We found that the blocking of the cell progression is dose-dependent and become irreversible, resulting in repopulation changes. The ytterbium radiation also inhibited the growth of cells in a dose-dependent manner. We found that the level of the chromosome aberrations in HeLa cells induced by the ytterbium exposure of 1.1 Gy was close to the same level induced by X-rays exposure of 1 Gy. Morphological analysis of the cells showed that the apoptotic form of cellular death is less significant for irradiated cells, than for their descendants. In the latter case we also recorded an abnormal mitosis, a damage of the mitotic apparatus of cell division. The necrotic form of cellular death was registered only after a prolonged exposure of ytterbium irradiation. Observation of the irradiation effects for several cellular generations after exposure indicates that low doses of radiation induce a systemic change of cellular metabolism, which was accompanied by activation of mechanisms of "check-point" control and apoptosis. The observed manifestation of the damaging effect late after the irradiation by ytterbium sources may significantly contribute to the total effect of treatment, which is important in clinical practice.

NATIVE REGULATION OF MICRO RNA mmu-miR1195 IS NECESSARY FOR RADIATION RESISTANCE IN MOUSE THYMIC LYMPHOMA CELL LINES

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Our preliminary studies with archival animal tissues showed differential expression of different micro RNAs including mmu-miR1195. Our laboratory hosts a large collection of irradiated animal archival samples and uses them to investigate micro RNA expression in spleen samples from animals that have lived out their “natural” lifespan after irradiation. A limited, custom made 40 micro RNA (miR) array was used for this initial screening. Several types of comparisons were done and screening included healthy mice (non-irradiated or irradiated) and mice with developed spleen disease (again non-irradiated or irradiated). Among the differentially expressed miRNAs mmu-miR1195 had the most interesting expression pattern, suggesting involvement in support of normal tissue homeostasis.

Next, we observed that mmu-miR1195 is differentially expressed and modulated in response to ionizing radiation in mouse thymic lymphoma cell lines differing by their degree of radiosensitivity. Upregulation of miR1195 was found both in sensitive cells (LYS) and resistant cells (LYR) in response to radiation but the extent of mmu-miR1195 expression differed significantly. Next, radiation response was evaluated at different radiation doses in LYS and LYR cell lines transduced with mmu-miR1195 precursors and antagomirs. Interestingly, increasing doses of radiation combined with mmu-miR1195 precursor and inhibitors led to different outcomes in LYR and LYS cells. Upregulation of beta 3-integrin, PARP1 and Caspase 3 occurred in LYR cells expressing mmu-miR1195 antagomir, while upregulation of p53, p21, Caspase3, JNK1 and p38 MAPK and downregulation of beta-catenin followed irradiation in these cells. All of these changes could be associated with increased apoptosis and disturbances of cell cycle. Surprisingly, cells tranduced with mmu-miR1195 precursor also showed an increase in apoptosis and a change in cell cycle dynamics. These data suggest that mmu-miR1195 modulates radiation response in lymphomas by a tight regulation of cell cycle, however, involvement of mmu-miR1195 in radiation resistance depends on native regulation of expression of this miRNA.

THE DOSE RATE EFFECTIVENESS FACTOR CALCULATIONS USING ANIMAL ARCHIVE DATA

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National and international committees on radiation protection are tasked with establishing approaches to evaluate cancer risks associated with exposure to ionizing radiation (IR). Unlike chemical toxins, IR causes damage to living organisms relatively uniformly throughout the body by inactivation and modulation of cellular processes. While cell and tissue culture studies may be informative about radiation effects, questions pertaining to whole organism effects of total dose and dose rates at which IR was delivered require whole organism studies. Increased risk of life shortening in animals exposed to IR provides an easily measurable endpoint suitable for statistical analyses.

Dose protraction, in delivery of large total doses of IR, has long been known to be life-saving; similarly, protraction when IR is used for cancer therapy spares the normal tissue some toxic effects of IR. The effects of dose protraction when the total dose delivered is non fatal and falls into medium or low dose range, however, remain a subject of dispute. The factor, by which a total dose could be increased, if protracted, for the same final biological effect, is known as dose and dose-rate effectiveness factor (DDREF). Estimates of DDREF are made based mostly on non-protracted human exposure data (atomic bomb survivors data, specifically) and models including a linear quadratic (LQ) formula developed originally for high dose protraction calculations relevant for medicine. Human exposure data are not the only data on effects of IR exposures used in these studies, and similarly, the LQ formula is not the only approach that can be considered for DDREF evaluation. Animal radiation data archives (ERA in EU, NURA in USA etc.) provide wealth of IR data, with accurate dosimetry and IR delivery following multitude of clearly defined patterns. Until recently, no effort has been made to incorporate all world-wide animal irradiation data that exist in the public domain, nor to use “best fit” approaches to evaluate these data using formalisms other than LQ. In our recent publication Haley et al., 2015 we have used all publically available animal irradiation archives to re-evaluate DDREF and found that a dose rate effectiveness factor – DREF can be evaluated with more accuracy.

We have now extended our work to intra- and inter-species comparisons, and extended the range of doses under consideration to 4Gy, which matches skin dose maximum considered for human A-bomb survivor studies conducted by RERF.

EVALUATION OF ENDOCRINE DISORDERS IN LIQUIDATORS OF CHERNOBYL NUCLEAR POWER PLANT

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The accident at the Chernobyl Nuclear Power Plant was a global radio-ecological catastrophe. About 3000 residents of Armenia have participated in the liquidation of its consequences. The control of health status of these people is carried out at the Scientific Center of Radiation Medicine and Burns for 30 years. During these years, an increase in levels of endocrine diseases is observed in liquidators (12.8% incidence in 2015). The dynamics of changes in levels of T3, T4 and TSH showed that after the increase of the functional status of the thyroid gland in first years following the accident, a decrease in these levels was observed by the end of the study. According to the results of our regression analysis, a decrease in these parameters is expected.

The changes in thyroid system are a result of an impact of both radiation and non-radiation factors (endemic goiter, non-specific stress, immune and metabolic-immune deficiency, age etc.). Applying variance factor analysis for T3, T4 and TSH, we found that radiation factor prevailed over age factor until 1992.

We found that in liquidators with increased biological age, average values of the parameters of the thyroid system were lower than those in liquidators with normal biological age, which suggests that thyroid pathology is a catalyst for early aging processes.

Another evidence of premature aging of liquidators with hypothyroidism was the low value of prostate-specific antigen as compared with liquidators without hypothyroidism. These individuals were also at greater risk of developing osteoporosis.

According to the results of multiple regression analysis for: TSH, glucose and cholesterol in liquidators with thyroid disorders, in the late period, the coefficient of interdependence of TSH-cholesterol had increased almost 3 times, and the coefficient of TSH-glucose had increased almost 10 times, in comparison with the late period. Moreover, a decrease in one of these 3 parameters will result in a decrease in the remaining 2. This fact suggests that the increasing thyroid disorders significantly affect the energy supply system of the organism, especially at a state of tension of adaptation and compensatory systems.

In the early and late post-accident periods analyses were done for the following hormones: ACTH, somatotropin, prolacin, follicle stimulating, luteinizing, calcitonin and parathyroid hormone, cortisol and testosterone. In the early post-accident period, each of these parameters underwent changes that can be interpreted as one of the signs of endocrine disadaptation after radiation influence. And in late period, the changes in their levels were a consequence of aging.

The use of the methods of system analysis allowed revealing the connection between the complex changes in the endocrine system and the changes in immune system in case of radiation influence on the organism.

THE PETKAU EFFECT IS A WAVE PHENOMENON

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Depleted uranium that has been used as armor-piercing ammunition in international military conflicts caused mixed radio-chemical exposure. Repeated use of significant amounts of depleted uranium over a longer period of time could significantly influence the balance of all natural resources and undermine the human health inducing the early and delayed health effects. Artificial discharge of large amounts of ionizing alpha particles emitted from the decay of uranium, can seriously misbalance the nature equilibrium conditions.

The depleted uranium repeated military use, every four years (1991-2011) and recently in numerous conflicts to now days) has some peculiarities: the low doses (air pollution easy transferable to the remote distances from the place of explosion) and the slow doses (depleted uranium ammunition remnants can be fully oxidized into corrosion products twenty-five to thirty-five years after impact) has ensured further prolonged contribution to the maintenance of alpha particles radiation with consequent disastrous Petkau effect in the biosphere. There is a remarkable parallelism between the use of depleted uranium ammunition and records of unusual environmental physical and climate phenomena (Zunic and Rakic, 2013). In the environment, as well as in living tissues, α-particles induce ionization. Rapidly increasing of positively charged α-particles in atmosphere, may induce changes in the electromagnetic field and changed coupling mechanism between the Lithosphere-Atmosphere-Ionosphere.

Very fine particles of depleted uranium are easily transferable from battlefields and detected as far away as thousands of miles. Depending on aerosol speciation, inhalation may lead to a protracted exposure of the lungs and other organs. Alpha particles emitted by depleted uranium, with their high ionization potential, induce alpha particles' bystander effect in the living tissues what was claimed to contribute to health problems, known as the Gulf War Syndrome and recently as the Balkan Syndrome. Pathogenesis of diseases caused by repeated exposure to low radiation doses assumes that the lowest doses did not trigger the repair mechanism of the cells. Direct exposure of cells to a low dose of ionizing radiation can induce a condition of enhanced radioresistance, i.e., a "radioadaptive" response. These statements, together with the Petkau effect clearly indicate missing links in understanding of time-dependent biological effects of depleted uranium (Zunic, 2013 [1, 2]).

Under the conditions of exposure to radiation originating from depleted uranium, biological effect of depleted uranium particles in the body was manifested like "ideal killer". Except biological predisposition, physicochemical characteristics of radioactive particles are substantial for understanding of "hot" or "cold" sequels of depleted uranium, too.

With the possibility to observe non-particle, or better to say wave phenomenon in the atmosphere, with the high impact to the biosphere, we conclude that Petkau effect is a wave phenomenon, generated mainly at the membrane level disorganization. Focusing of our attention "back" from macro plan on the micro world or *in vitro* conditions, we believe that small doses of radiation are more harmful than high doses because high doses lead to mainly irreversible harmful effects on cells and subcellular structures. Small doses originated from charged particles or photonic radiation can interfere with biofrequencies of cell structures, primarily cell membrane or endomembranous system, which is resulting in higher cytotoxicity. In higher mammals including the humans, Petkau effect represents long term, but timely-framed integrative adaptive response of biosystem which includes whole metabolome and changed signaling pattern of regulatory mechanisms in horizontal, as well as in its vertical organization.

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IMMUNE SYSTEM ASSESSMENT OF CHERNOBYL NUCLEAR POWER PLANT DISASTER CONSEQUENCE LIQUIDATORS

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The observation of the liquidators of the Chernobyl accident has shown that as time goes on, they have different pathological processes and chronic illnesses. Increased level of chromosome aberrations, immune and endocrine disorders, clastogene factors etc., requires active treatment and rehabilitation measures. We have studied the changes in the immune system of the liquidators in combination with the other vital systems of the organism activity and not in isolation.

In addition to the routine peripheral blood test, relative and absolute quantity of T-lymphocytes and rosette-forming cells, serum immunoglobulin (IgG, IgA, IgM), phagocytic and complementary activity were studied.

The condition of cell-mediated immunity was assessed based on the relative and absolute quantity of T- and B- lymphocytes. The assessment of the humoral immunity condition was carried out by the estimation of Ig G, Ig A, Ig M class immunoglobulin concentration in the serum. Non specific defense factors are the complement content in the serum and phagocytic activity of the neutrophils. Statistical analysis of the data was carried out with the help of such methods of system analysis as correlation, variance factor and cluster analysis.

Leukocyte cell rejuvenation was noticed in the early post disaster period, the evidence being the increase in stab and segmented neutrophil and eosinophil content. The observed deviations are obviously the result of the disorder of balanced condition and is a consequence of proliferation disorder and marrow cell maturation.

Making use of the factor analysis we managed to detect the influence of radiation and age factors on the change of immune indices. In the early period, the radiation factor mainly prevailed. By the end of the study the part of influence of the age factor was growing.

Making use of the method of the assessment of human immune system suggested by L.V. Kovalchuk and A. N. Cheredeev, based on the pathogenetic principle, we developed an algorithm of assessment of humoral component of immune system in case of immunodeficiency. In spite of the seemingly good condition of the immune system in the early post-accident period, which can be accounted for by adaptation mechanisms, in most cases, recurrence of inflammatory processes is observed which is probably explained by displacement of the immune system component provoked by radiation influence 20-25 years ago, with non radiative factors connected with the way of life.

PROLONGED ADMINISTRATION BIOKINETICS OF Ag NANOPARTICLES IN MAMMAL ORGANISMS

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Silver has been known as an antiseptic agent from the ancient times. Thus, the Hospitallers used silver dishes and paid a lot of attention to hygiene. Nevertheless, Malta Island, the place of their dislocation, was often attacked, but this important knowledge has been the base of the knight's survival.

Today antibacterial, antiviral ad fungicidal properties of silver are used in various medical and industrial applications. As a rule, such commercial production is based on silver in nanoform. First of all, nanosilver is less toxic than silver ions and more sufficient than silver in the bulk. It is widely spread in Alternative medicine to use nanosilver as daily food supplement, which is especially important problem.

From the other point of view, there are many scientific works demonstrating negative effects of nanosilver. It is shown that such nanoparicles can be toxic for mammal organisms as well. Inducing reactive oxygen species they lead to cell metabolism disturbance, genetic changes and finally to apoptosis on necrosis of mammal cells. Moreover, silver nanoparticles can accumulate in different organs and tissues having long-time effects.

Biokinetic studies are much more complicated and less common in Nanoscience than toxicological investigations of such nanoparticles. In the present work the most sensitive and precious Nuclear Physical technique, namely Instrumental Neutron Activation Analysis, was used to study prolonged up to 6 months daily administration biokinetics and elimination processes of silver nanoparticles performed by commercial food supplement in white mice organisms.

Activity normalization to average neutron flux in active zone of nuclear reactor was suggested in order to obtain statistically valid data. The main idea of such normalization is in averaging of neutron flux over activities of biophilic element selenium, which is constantly redistributed among the mice of the same age grown under the same conditions. Half-life of the key silver and selenium radioactive isotopes are quite long, which gives a possibility to conduct gamma spectrometry measurements in a proper time.

Thus, in this work experimental data of prolonged administration biokinetics as well as biokinetics of the elimination processes of silver nanoparticles were obtained which is in an excellent agreement with Analytical Chamber Model proposed here either.

The main result of this work is the discovery of accumulation of silver in mice brain in quite cytotoxic amounts. This fact demonstrates that food supplements based on nanosilver may lead to unknown hazardous effects for humans and the environment. The next step will be in study of cognitive changes of such mice exposed to nanosilver for a long period, which is also highly important to know as a possible long-time effect of nanosilver.

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SELENIUM BIOKINETICS STUDY BOTH BY TERMS OF NUCLEAR-PHYSICAL METHOD AND NUMERICAL MODELING

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When the food is depleted by selenium, some complex immune deceases could be developed. A relatively fast repair of a normal Se content in a living organism can be in principle done with a reception of biologically active supplements (BAS) in the form of Se salts (sodium selenite, for example). But some mandatory precautions shall be taken into account because of significant Na2SeO3 toxicity even in not very high dose, which actually can vary depending on a current state of organism.

To fix this problem, we examine the two groups of laboratory linear rats Wistar, one of which is normally supplied with Se, and other is appeared to be a model of selenium deficit animals. Both groups had accepted a single oral dose (by a probe) of 20 ug of radioactively labeled Na^2SeO_3 (with ^{75}Se, Kurchatov Institute nuclear reactor IR-8) in water solution per animal. The rats were decapitated in 3, 12, 24 and 48 hours after oral administration, and their organs and tissues were analyzed by terms of gamma-spectroscopy. It was anticipated that in the group of animals normally supplied with Se the majority of labeled ^{75}Se will be excreted with the urine and the lesser part will retain in organs in comparison with Se deficit rats. Nevertheless, the difference was not strongly pronounced.

To explain the experimental data, the quantitative phenomenological model of Se biokinetics was developed. It conceptually accounts for the possible metabolism of Se in organs and redistribution between some significant organs and tissues (“chambers”). The numerical parameters (kinetic constants) of chamber model were got from fitting the empirical data. The results of numerical experiments showed that, probably, a redistribution in each organ with Se metabolism between two pools of Se takes place. Those pools are so-called conservative-labile pool of selenium (Se-proteins + selenite + hydrogen selenide and its derivatives) and the products of Se catabolism (methylated forms of Se). The total content of 75Se in both pools of each chamber changes little between two groups of animals. That is why likely the experimental data do not differ significantly from each other.

These results also say about possible higher toxicity of Na_2SeO_3 in the same dose for animals with normal ration than for selenodeficit model. Indeed, the pool of methylated forms of Se for the former is bigger than for the latter, and this pool is in quasi-equilibrium with hydrogen selenides which are highly toxic when in excess. So, there some reasons are shown to take into account a level of current supply with Se of a living organism when calculate the dose of Se-consisting BAS. Also, the need of looking for and development of other Se-consisting BAS (for example, in the form of nanoparticles) with lower activity than of Se salts but higher than of tissue Se-proteins is again shown.

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RADIOCHEMISTRY AND RADIATION CHEMISTRY

25

THE NATURE OF HIGH SOIL RADIOACTIVITY IN THE CHINESE PROVINCE OF GUANGDONG

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Soil is a basic component of biosphere and its important natural resource. The article deals with the analysis of soil radioactivity in Chinese province Guangdong.

The character of soil radioactivity varies from pure radioactive (U > Th, which is typical for soil of New Island) to mixed uranium-thorium (Th/U > 2.5-5) and thorium (Th/U > 5, as it is in the soil of Guangdong Province). For the latter, it is suggested that its radioactivity is explained by the presence of monocyte.

In the course of the analysis, it was stated that highly radioactive soil of China had been formed due to deep chemical weathering of highly radioactive potassium granites. High uranium and thorium contents in them are caused by specific conditions of weathering crust formation and subsequent pedogenesis. High dose loads for a man are formed in the development fields of such rock types.

The experiments in uranium leaching from clay fraction showed that uranium is a part of highly soluble compounds and a part of close connection with the clay component in the form of isomorphic impurity in accessory minerals.

As a current hypothesis, it can be suggested that in our case we are dealing with the sorption concentration mechanism of U, Th, rare-earth elements in kaolinite-gibbsite soil aggregate. In this case one cannot exclude the fact that proper rare-earth nanominerals are formed on this catalytic barrier that can explain the presence of iron - neodymium phase in them. The high natural radioactivity of soils in Chinese Guangdong Province is associated with a high content of radioactive elements in the predominantly fine clay fraction.

In the clay fraction phosphates, heavy and light rare earths, monazite, thorite and rare earth cerium phase with thorium were identified. The most common minerals are iron and titanium oxides, copper and zinc compounds (such as brass), zircon, and barite. Besides, silver gray trace minerals in the form of sulfide silver (it is not possible to state accurately), micromineral formation of bismuth and sulfur dioxide, zirconium (baddeleyite), copper-nickel compound are likely to be present.

The content of organic hydrogen in soil was low, only 0.14 %. 24.6 % of its total amount was accounted for as fulvic acid hydrogen.

The research of mineral composition of silt-loam fraction by the X-ray structure analysis show that kaolinite dominates in it ($Al_2[OH_4]Si_2O_5$), there are a great deal of hydrargillite ($Al[OH]_3$), chlorite and quartz as well as insignificant admixtures of mica, K-feldspar, illite-chloritic aggregates, and hematite.

The given rock can be classified as a ferrallitic soil group of humid tropical and subtropical regions in terms of the set of chemical indicators. The region is characterized by high degree of soil-forming material weathering.

THE SYNTHESIS OF HYDROUS (Zr-Si)O_2 SPHERES BY THE SOL-GEL METHOD AND THE INVESTIGATION OF COLUMN PARAMETERS FOR SIMULATED WASTE SOLUTIONS

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In the present study, ZrO_2-SiO_2 mixed gel spheres were prepared via sol-gel process. The source sols of Zr and Si with 1:1 molar ratio were prepared by the ammonia addition method starting from $ZrCl_4$ and Na_2SiO_3 solutions. A simple method, using a gelation column containing two phases (methyl isobutyl ketone and ammonia) as sphere forming and gelling medium, allowing to direct preparation of mixed oxides gel spheres suitable for column operation, was developed. The adsorption behaviours of adsorbent towards strontium were determined for dynamic conditions using column technique by the experimental design method for the possible application to its removal from radioactive waste solutions. The basic parameters such as flow rate, initial strontium concentration and bed height were investigated. It was determined that all the parameters of flow rate, initial strontium concentration and bed height are affecting the adsorption, so the surface graphics showing the strontium adsorption dependency to the related parameters were constructed. As a result of the experimental studies, the maximum adsorption (74 %) was obtained at a flow rate of 0.5 $mL.min^{-1}$, initial strontium concentration of 55 ppm and a bed height of 2.55 cm.

INVESTIGATION OF DIFFERENT RADIOCHEMICAL PROCEDURES USING ANION EXCHANGE RESIN COLUMN FOR DETERMINATION OF LEAD-210 BY LIQUID SCINTILLATION COUNTER

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In this study, we investigated a few chemical preparation procedures suitable to determine ^{210}Pb by liquid scintillation counter. The methodology of ^{210}Pb analysis is based on sequential separation of ^{210}Pb and ^{210}Bi using an anion exchange resin in Cl^- form (Eichrom). The steps of chemical procedures are checked in order to ensure the accuracy of Pb separation conditions for the adequate operation of liquid scintillation counting. For this purpose, tested samples from lake bottom sediment core were analyzed. According to proposed procedures, Pb^{2+} carrier and ^{210}Pb tracer are added to sediment and digested using wet acid combustion. Following by Pb elution, sulfuric acid is added to form a $PbSO_4$ precipitate. The precipitates are dissolved with sufficient of EDTA/NaOH and ammonium acetate mixtures, optional. Afterwards the dissolved source is mixed with scintillation cocktail (Optiphase HiSafe 3, Perkin Elmer) in a 20 ml container vial and the sample activity is determined using a liquid scintillation spectrometer (Quantulus 1220, Perkin Elmer).

Results of the analysis performed by using proposed procedures are compared on the chemical yield, solvent suitability, homogeneity of suspended cocktail and counting efficiency. The chemical yield of ^{210}Pb is determined gravimetrically. The counting efficiency is evaluated with a known activity of ^{210}Pb tracer, which is in secular equilibrium with the ^{210}Pb daughter ^{210}Bi.

Keywords: ^{210}Bi, ^{210}Pb, anion exchange resin, $PbSO_4$, liquid scintillation counting.

NUCLEAR-CHEMICAL METHOD – NEW WAY FOR SYNTHESIS OF TRITIUM LABELED RADIOTRACERS WITH FLUORINE SUBSTITUTED HETEROCYCLIC STRUCTURE

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Nuclear-chemical method gives unusual generation of free nucleogenic (formation by decay processes) carbocations. Elaborated method is based on tritium beta-decay in hydrocarbons. In our previous investigations we have applied generation of nucleogenic phenyl cations (generated from *p*-ditritiobenzene) and their ion-molecular reactions with different nitrogen containing six-ring heterocycles. The achieved advances of this method concerns the opening of the unknown reaction of nitrogen atom direct phenylation together with the one-step synthesis of tritium labeled biomarkers [1-3].

In this work, we have presented a new way for synthesis of tritium labeled radiotracers with fluorine substituted heterocyclic structure. *p*-Difluoroditritiumbenzene was used as the source of nucleogenic fluorosubstituted phenyl cations. Investigations of ion-molecular reactions of fluorinated phenyl cations with nucleophilic centers of quinoline derivatives (quinoline and 2-methylquinoline) revealed the reaction of direct nitrogen atom phenylation and one-step synthesis of tritium labeled *N*-(*p*-difluorophenyl)quinolinium derivatives with the radiochemical yields more than 20%.

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INVESTIGATION OF PU (III) SORPTION BY MINERALS (WUSTITE/MAGNETITE AND HEMATITE) AND SOIL FROM AQUATIC SOLUTIONS USING AM (III) AS AN ANALOGUE

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Assessment of migration of radionuclides in the environment requires the understanding of its behavior influenced by various factors. Plutonium exhibits a complicated redox behavior that permits transformation of one oxidation state into other states under different conditions [1]. Pu exposed to certain factors may change its oxidation state from +3 to +7 depending on the redox conditions in the environment [2]. Plutonium (III) assessment is complex because it quickly changes the oxidation state therefore the trivalent americium can be used. Am (III) is a more stable element and its properties are similar to those of plutonium, therefore it can be used as an analogue of the trivalent plutonium to evaluate its behavior.

The present study focuses on Am sorption to minerals (wustite/magnetite and hematite) and soil from aquatic solutions. Laboratory-scale sorption experiments were carried out using a static batch method and a dynamic flow column method. Sorption experiments of ^{243}Am (III) sorption onto minerals and soil were performed using 10 and 20 mL 0.1 mol/L $NaNO_3$ solution spiked with 0.502 Bq ^{243}Am. Concentrations of micro- and macroelements (Cu, Mn, Co, Pb; Na, Fe, Ca, Mg, K) in soil were determined by using the atomic absorption spectrometer with the flame atomizer (AAnalyst 800, PerkinElmer, USA). Solid and aqueous samples were analyzed for ^{243}Am using a CANBERRA γ-spectrometric system with an HPGe detector (model GC2520, 26.2% relative efficiency). Influence of solution pH (2.15; 4.00; 6.95; 9.01) on the ^{243}Am/Pu(III) sorption onto minerals (wustite/magnetite and hematite) and soil was evaluated.

The highest amount of ^{243}Am was sorbed in the upper 0-1cm layer irrespective of the solution pH and the geosorbent type. Batch experiments with hematite have shown that the amount of sorbed ^{243}Am increases with increasing pH values from 2.15 to 6.95. Results of the investigation demonstrated the identical ^{243}Am sorption process at pH values of 2.15 – 9.01 for both soil and wustite/magnetite under studied conditions.

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NATURAL RADIOACTIVITY IN DRINKING WATER FROM GALATI AND VRANCEA AREAS, ROMANIA

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Pollution and contamination of drinking water grow rapidly due to industrial growth and urbanization. They potentially cause severe problems to health so the water quality management addresses both national and international action to assess and prevent associated threats. Drinking water is the most important food for human beings and its quality must be strictly controlled. The aim of the study was to assess the radioactvity of ^{210}Po, ^{210}Pb, ^{226}Ra in drinking water. The occurrence of ^{210}Po and ^{210}Pb has been determined by spontaneous deposition onto a nickel disc and the gross alpha activity has been measured. ^{226}Ra has been measured after 30 days of storage; this period of time assured that ^{222}Rn in water samples reached secular equilibrum. Water samples were collected from a total of 17 sites, which serving 556125 persons, in Galati and Vrancea areas of the East part of Romania. Samples were collected during March and April of 2015. The monitoring of drinking water samples indicated the presence of ^{210}Po, ^{210}Pb, ^{226}Ra at a concentration from 1.90 to 12.48 mBq/L, 3.21 and 15.90 mBq/L, 8.00 and 30.00 mBq/L, respectively. These values were compared with the maximum contaminant level, according to national legislation. The average annual committed effective dose from the intake of water ranged between 4.15×10^{-3} and 18.80×10^{-3} mSv, for adults, which is lower than the recommended reference value of 0.1 mSv in drinkable water in the current EU legislation.

UV-INDUCED ONE-PHOTON IONIZATION OF DNA AND OXIDATIVE DAMAGE

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Electron abstraction from DNA bases, produced either via redox reactions with other molecules present in the cell, or under the effect of various types of radiation, may damage the genetic code. For long, it was considered that UVC radiation at 266 nm provokes electron ejection from DNA bases only via multophotonic processes. However, a recent study of our laboratory has shown that, contrary to its monomeric constituents, single and double strands of DNA can be ionized by absorption of one single 266 nm photon [1]. Subsequently, we have undertaken a systematic investigation of the factors that govern the UV-induced ionization of DNA and of the final photoproducts resulting from this process. To this end, we combine time-resolved spectroscopy, HPLC coupled to mass spectrometry and theoretical calculations (molecular dynamics and TD-DFT).

We determined the monophotonic ionization quantum yields of several single, double and quadruple DNA strands by detecting the transient absorption signals of hydrated electrons using nanosecond flash photolysis. The highest quantum yields (ca. 4×10^{-3}) were found for G-quadruplex structures. The results of this spectroscopic study, associated with previous studies on the relaxation of the electronic excited states [2], suggest that electron ejection correlates with the population of charge transfer excited states.

We also showed that the UV-induced adenine radicals in A_{20} single strands and $AT_{10}{\cdot}AT_{10}$ double strands survive for several milliseconds. In contrast, the radicals of mono-nucleosides evolve on the sub-microsecond timescale toward reaction intermediates leading, among others, to 8-oxoadenine.

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INTERACTION OF SUPERHEAVY ELEMENTS (COPERNICIUM AND FLEROVIUM) WITH SELENIUM SURFACE: RELATIVISTIC DENSITY FUNCTIONAL STUDY

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Long-lived isotopes of the superheavy elements (SHE) with atomic numbers $Z \geq 104$, can be produced in fusion reactions between heavy actinide targets and neutron-rich projectiles at only very low rates: from single atoms per minute ($Z = 104$) to single atoms per week ($Z = 114$). Since the thermochromatography on gold has proved a unique method for chemical detection of heaviest elements, the description of SHE – gold interactions has recently been of prime concern. It has been shown experimentally that the desorption temperatures and energies of Cn ($Z = 112$) and Fl ($Z = 114$) atoms on gold surface are close and lower than those for their closest homologues Hg and Pb, respectively. This confirms the theoretical predictions concerning the electronic stucture of the Cn and Fl atoms: due to strong relativistic stabilization of *s* and $p_{1/2}$ shells, both Cn $(6d^{10}7s)^2$ and Fl ($6d^{10}7s^27p^2{}_{1/2}$) ground states are of closed-shell character. Theoretical data on the interactions of Cn and Fl with various elements [1] encourage the search for surfaces other than a gold one may lead to finding a better adsorbent for chemical separation of these elements. We suppose that amorphous selenium surfaces can serve such purpose. Though there are various allotropes of amorphous selenium, we focus on the red (Se_n rings) and gray (Se chains) forms only [2]. The results of our electronic structure calculations for the MSe_n complexes, M=Hg, Cn, Fl, suggest that the complexes of Fl and Hg are more stable than their analogues with Cn. Adsorption energies of Cn, Fl and Hg atoms on grey selenium surface are estimated using the cluster model. The adsorption energies of Fl and Hg atoms both on red and on grey selenium surfaces should differ significantly. For Hg, this observation is in agreement with the experimental data by the Eichler group (PSI, Switzerland). The calculations were performed within the two-component shape-consistent small-core pseudopotential model and employed the non-collinear version of relativistic density functional theory to treat electronic correlations.

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DETERMINATION OF ^{90}SR VIA CHERENKOV RADIATION ON QUANTULUS 1220 LIQUID SCINTILLATION COUNTER AFTER MICROWAVE DIGESTION PREPARATION OF MILK SAMPLES

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In this work we performed innovative experiments in which ^{90}Sr is determined via Cherenkov's radiation on Liquid Scintillation Counter Quantulus 1220™ after microwave digestion preparation of milk samples. ^{90}Sr is created in nuclear fission processes and it has been released to the environment with global fallout following atmospheric nuclear explosions, by nuclear waste discharges and by the nuclear power plant accidents. It's determination in milk has a important role especially for infants.

Until relatively recently, sample digestion methods were largely limited to the conventional techniques of wet digestion, dry ashing and fusion techniques. Such methods are often time consuming, may be the source of contamination and losses of analyte and generally require a great deal of operator attention, skill and experience in order to gain accurate and precise results. As a consequence, sample preparation is often regarded as the weak link in sample analysis, an area which provides much scope for improvement. The advantages of microwave digestion technique has gradually gained widespread acceptance as an effective method of sample preparation. Using this technique not only have digestion times been dramatically reduced (by factor of 2-5) but also other benefits such as reduction in the contamination, less reagents and sample usage, a reduction in the loss of volatile species and improved safety have been reported.

A procedure for the determination of ^{90}Sr in milk samples using Cherenkov's radiation on low–level liquid scintillation counter Quantulus 1220 was applied and optimized. The sample channel ratio (SCR) method has been applied to correct color quench effect.

SYNTHESIS AND STUDY OF POTASSIUM URANATE

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The method of synthesis of potassium urinate $K_2U_4O_{13}\cdot2.2H_2O$ is proposed. The chemical and functional composition of this compound has been studied; its crystallographic characteristics have been determined; the process of dehydration and thermal decomposition has bean researched.

The investigated compound is synthesized by reaction of shoepite $UO_3\times2.25H_2O$ with aqueous solutions of potassium nitrate (pH of 10, KOH) under hydrothermal conditions at 200°C. The chemical analysis results correspond to the following empirical formula of potassium uranate: $K_2O\cdot4UO_3\cdot2.2H_2O$. The results of X-ray diffraction measurements show that the synthesized compound is an individual crystal phase. The set of the X-ray diffraction maxima of this compound contains a strong peak at small angles (2θ= 13.76°), suggesting the layered type of the structure.

To estimate the nature of functional groups and and role of H_2O molecules in the structure of $K_2U_4O_{13}\cdot2.2H_2O$, we performed its IR study in combination with methods of thermal analysis and X-ray diffraction. The IR spectrum contains three groups of bands of independent vibrations: H_2O vibrations, vibrations of hydroxy groups UOH, and uranyl $UO_2^{\delta+}$ vibrations. The H_2O vibration bands include the ν(HO–H) stretching band splitted into ν_{as} and ν_s components at 3580 and 3490 cm^{-1}, and also the bending vibration band $\delta(H_2O)$ at 1605 cm^{-1}. The stretching vibrations of the uranyl fragment appear in the spectra as a single band $n_{as}(UO_2^{d+})$ of strong intensity at 923 cm^{-1}. The bands of stretching ν(UOH) and bending δ(UOH) vibrations of hydroxy groups are at 3330 and 1153 cm^{-1}, respectively.

Heating of $K_2U_4O_{13}\cdot2.2H_2O$ to 102°C leads to the weight loss equivalent to 0.4 mol of H_2O per formula unit. This is the total amount of H_2O in the compound. The X-ray diffraction pattern of the dehydration product, $K_2U_4O_{13}\cdot1.8H_2O$, remains unchanged. In the process, all the bands of molecular H_2O disappear from the IR spectrum, but the bands of ν(UOH) and δ(UOH) are preserved. Such situation is possible if the dehydration product $K_2U_4O_{13}\cdot1.8H_2O$ contains no H_2O molecules but contains instead an equivalent amount of hydroxy groups. In this case, the formula unit of the initial potassium uranate can be presented in the following form: $K_2U_4O_{11.2}(OH)_{3.6}\cdot0.4H_2O$. The formula unit of potassium uranate can be written using integer stoichiometric coefficients in the form $K_5U_{10}O_{28}(OH)_9\cdot H_2O$, or $K_5(UO_2)_{10}O_{28}(OH)_9\cdot H_2O$.

On the whole, the crystal lattice of the potassium uranate has layered structure. It can be assumed that the uranium hydroxide layers $[(UO_2)_{10}O_8(OH)_9]_{2\infty}^{\delta-}$ in this structure are combined in a 3D cell by potassium ions compensating the layer charge and by hydrogen bonds formed by hydroxy groups of the neighboring layers.

A SEPARATION PROCEDURE FOR THE DETERMINATION OF NEPTUNIUM AND PLUTONIUM ISOTOPES BY EXTRACTION CHROMATOGRAPHY

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The subject of this study was to develop, respectively modify and implement these analytical methods for the determination of long-lived radionuclides, namely ^{237}Np and ^{241}Pu in environmental samples. We examined the separation of Np from Pu and from other interfering radionuclides, such as U, Am and Th. A separation procedure was developed for the determination of Pu isotopes (^{238}Pu, $^{239,240}Pu$ and ^{241}Pu) and ^{237}Np using co-precipitation and separation of radionuclides by using extraction chromatography and commercially available sorbents TEVA® resin and TRU resin supplied by Eichrom Technologies, LLC. ^{239}Np a ^{237}Np were selectively captured on the sorbent TEVA® resin in oxidation state IV. TRU resin was used for purification of plutonium fraction from interfering americium radionuclide. ^{242}Pu and ^{239}Np radionuclides as tracers have been used to monitor the radiochemical yields of separation. Before every radiochemical separation tracer radionuclide ^{239}Np was obtained by separation from the parent radionuclide ^{243}Am, which is in radioactive equilibrium to ^{239}Np. Radionuclides ^{242}Pu, ^{238}Pu, $^{239,240}Pu$ and ^{237}Np were determined by alpha-spectrometry by using low background semiconductor detector with silicon surface barrier (Alpha 576a-ORTEC, 919, USA), ^{241}Pu was determined by liquid scintillation spectrometry (Tri-Carb 2900 TR, PerkinElmer, USA) and gamma-spectrometric system (Gamma-spectrometer ORTEC with HPGe detector ORTEC, USA) was used to determine activity of tracer ^{239}Np. Sources for alpha-spectrometric counting were prepared by co-precipitation with Nd carrier and hydrofluoric acid. The method was applied to determine plutonium and neptunium radionuclides in reference materials IAEA-375 and IAEA-414, as well as in samples of contaminated soils from the area of Nuclear power plant AI Jaslovské Bohunice which is stored temporarily before disposal.

TOTAL REFLECTION X-RAY FLUORESCENCE ANALYSIS OF ADVANCED OXIDE NANOMATERIALS

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Nanomaterials based on ZnO and SnO_2 oxides can be used as components of piezoelectric transducers, as sensitive materials for gas sensors and for transparent electrodes. Several modifiers (Au, Pd, Ru, Ga, In) are introduced to obtain desirable properties of materials. The determination of elements is very important for understanding the dependence between conditions of synthesis, composition and physical-chemical properties of materials. In our work we have suggested to use Total Reflection X-ray Fluorescence (TXRF) for the express determination of elemental composition of nanomaterials based on ZnO and SnO_2 oxides. There are several approaches for the sample preparation: analysis of solution after acid digestion, analysis of milled solid particles and analysis of slurries. Nanomaterials based on SnO_2 oxide are hard to digest, so last two approaches can extremely reduce complexity and duration of analysis. Digestion and slurries preparation allow using the internal standard quantification. In case of powder samples only standardless quantification by internal normalization can be used. For nanomaterials relation between matrix and modifier metals is significant, so internal normalization is also applicable.

Acid digestion was performed using 63% nitric acid. ZnO materials were simply washed from a glass substrate. Dissolution of SnO_2 based materials was carried out under the microwave radiation in high pressure vessels. Milling of samples was made in an agate mortar. Particles with 10-30 µm size were weighted on an analytical balance with 0.1 mg accuracy, then placed into a vial, filled with surfactant solution and homogenized to obtain slurry. Internal standard (Ga) was added into solution and slurry samples. The drops of solutions (3-5 µl) and slurries were placed onto quartz carrier and dried. Solid particles were fixed on the reflector by vaseline grease. The measurements were carried out with energy dispersive TXRF spectrometer S2 PICOFOX (Bruker Nano, Germany). Mo Kα (17.48 keV) radiation was used for X-ray fluorescence excitation. Acquisition time was 650 s.

In SnO_2 nanomaterials Au (1-3%) or Ru (0.7%) modifiers were determined by TXRF method. In ZnO based nanomaterials Ga (1%) and In (5-10 %) modifiers were determined by the same technique. It was shown that the results of elemental composition determination are the same in all cases up to accuracy of analysis which is 0.1-0.2% abs. So, the matrix effects do not significantly affect the process of TXRF analysis. All samples were characterized using ICP-MS. The good coincidence between TXRF and ICP-MS results was shown.

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SYNTHESIS AND STUDY OF PLUMBUM URANATE WITH GENERAL FORMULA $PB(UO_2)_2O_2(OH)_2 \cdot H_2O$

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Method of synthesis of the plumbum uranate with general formula $Pb(UO_2)_2O_2(OH)_2 \cdot H_2O$ has been proposed in this work. The composition and structure of the synthesized compound have been established by mean of high-temperature X-ray diffraction, IR spectroscopy, thermography, chemical analysis. The dehydration and thermal decomposition process have been studied.

The studied compound was synthesized by the reaction of schoepite UO_3 $2.25H_2O$ with an aqueous solutions of $Pb(NO_3)_2$ under hydrothermal conditions at 200°C. The results of chemical analysis and X-ray diffraction demonstrate that the plumbum uranate is individual crystalline phase with general formula $PbU_2O_7 \cdot 2H_2O$.

An IR spectroscopic study was carried out in order to evaluate the functional composition of studied compound. The IR spectrum of the plumbum uranate contains three groups of absorption bands. There are vibrations of H_2O molecules, UOH groups and uranyl vibrations among these bands. The bending vibrations $\delta(H_2O)$ are slightly shifted from 1595 cm^{-1}, which is characteristic of H_2O molecules in the gas phase, to the region of 1621 cm^{-1} as a result of H-bonds formation. For the same reason the stretching vibrations $\nu_{as}(H_2O)$ and $\nu_s(H_2O)$ are not resolved. They form wide and intensive band with maximum at 3372 $см^{-1}$. There is the middle intensity shoulder on this band at 3202 cm^{-1} which can be assigned to the stretching vibrations ν(UOH). Corresponding band of the bending vibrations δ(U-O-H) is intensive one at 1078 $см^{-1}$. The uranyl vibrations appear in spectrum as a two bands $\nu_{as}(UO_2^{d+})$ and $\nu_s(UO_2^{d+})$ at 833 cm^{-1} and 740 cm^{-1}, respectively. This indicates the uranyl group O⩶U⩶O has unequal bond lengths and nonlinear configuration.

The thermographic investigation has been carried out for detailed determination of the uranate structure and its resistance to high temperatures. One H_2O molecule is removed from the $Pb(UO_2)_2O_2(OH)_2 \cdot H_2O$ according to the first endotherm effect at 155°C. A new crystalline phase of $Pb(UO_2)_2O_2(OH)_2$ is formed as a result of these processes. The process of the $Pb(UO_2)_2O_2(OH)_2$ thermal decomposition occurs in one stage according to the second endotherm at 248°C. Condensation of the hydroxyl groups and chemical crosslinking opposed layers occur in this process. The dehydration product with formula $Pb(UO_2)_2O_3$ formed. Further heating of the compound $Pb(UO_2)_2O_3$ leads to formation of the plumbum monouranate at 888°C.

Thus, the chemical composition of the plumbum urinate synthesized by us can be written as $Pb(H_2O)[(UO_2)_2O_2(OH)_2]$ taken into account the functional groups. Its crystal lattice has pseudo layered structure. Cationic forms of Pb^{d+} and the H_2O molecules are located between the layers and they participate in binding of layers along with the uranium hydroxide groups UOH. The products of dehydration and thermal decomposition of the $Pb(H_2O)[(UO_2)_2O_2(OH)_2]$ are the compounds having following composition: $Pb(UO_2)_2O_2(OH)_2$, $Pb(UO_2)_2O_3$ and $Pb(UO_2)O_2$.

RADIOPROTECTIVE TECHNOLOGY TO PRODUCE CONSTRUCTION MATERIALS FOR NUCLEAR POWER BASED ON THE SULFUR BINDING

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The inventory of radioactive waste in Kazakhstan contains 529 of the storage and disposal of radioactive waste, including:

- 127 - of uranium mining and processing industry;
- 76 - on non-uranium mining branches;
- 16 - in places of nuclear explosions;
- 5 - on nuclear power plants;
- 305 - for businesses that use radioisotope production.

Kazakhstan is one of the first places in the world in proven reserves of uranium (15% of the world and about 50% of uranium reserves of the former USSR).

The production and use in industrial, civil and road construction high corrosion resistant construction composites based on thermoplastic binder sulfur can dramatically improve the technology and reduce the time of construction, improve reliability facilities, the construction process to involve large-technogenic raw materials - sulfur and sulfur-containing wastes and to provide for replacement of broken stone screenings. The prerequisites for the production of sulfur-binding and its application in the technology of the construction industry and road construction is an extensive resource base in the form of technical sulfur and sulfur-containing wastes, as well as the great need of the economy in durable, chemically resistant and radioprotective materials. Currently, cement is one of the most common materials in construction, and its production - the most energy-intensive and expensive process. Development and implementation of sulfur binding is an important energy materials saving techniques dramatically reduce the cost of manufacturing products and designs for the construction of the radioprotective materials. Materials based on a "sulfur binding" on their physico-chemical, mechanical and radioprotective properties have a better performance than materials obtained on the basis of cement. Materials based on a “sulfur binding” have the ability to absorb gamma radiation and protect from ionizing radiation. The scientific basis, patterns, dependencies, methods of analysis and the nature of the new process: the transition of elemental sulfur from the α-form in the β-form, i.e. sulfur in the polymer, which is stable in corrosive environments, especially in the radiation environment. The regularities of the transformation of elemental sulfur by the addition of various modifiers (compound olefin series, natural shungite, polyelectrolytes, and the so-called) into the molten sulfur. The optimal condition of the process by examining the process of experimental factors: temperature, time, initial concentration of sulfur additives, plasticizers, fillers, aggregates and other factors, as well as the processes of phase transition: solid - liquid - gas and vice versa. Conduct thermal analysis and the establishment of the kinetics of the transition process and to obtain sulfur-based materials of elemental sulfur (lump) - oil and gas waste. Unlike previously conducted similar research is the use of various modifiers of sulfur, which give the sulfur composites is radioprotective properties, which can be used as building material in the field of nuclear energy, where there is increased radiation or the action of radionuclides.

SYNTHESIS OF SUPERABSORBENT XANTHAN-REDUCED OXIDE GRAPHENE HYDROGELS USING ELECTRON BEAM IRRADIATION

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In this paper superabsorbent hydrogels based on Xantan gumm and reduced graphene oxide (rGO) with the addition of potassium acrylate and N'N methylene bis acrylamide have been synthesized with accelerated electrons while in liquid state. Samples with and without rGO were used in the experiments. The reduced graphene oxide was obtained by reducing thin films of graphene oxide (GO) with the aid of a continuous wave laser diode (with a power of 80 mW). The polymeric solutions were irradiated with doses of 5, 10 and 20 kGy, in the absence of oxygen. The hydrogels that were later obtained were characterized from a physical and chemical point of view by determining the gel fraction, sol-gel analysis, swelling ratio determination and conductivity measurements. The structure of the hydrogels was studied using FT-IR spectroscopy, SEM, thermal analysis (TG and DSC). For the hydrogel samples that contained rGO the gel fraction increases with the irradiation dose while for the samples without rGO the gel fraction decreases as the radiation dose increases. Sol-gel analysis has determined that the minimum radiation dose required is 3.3 kGy for the samples containing rGO and 4.89 kGy for the samples without rGO. Also the scission ratio was smaller for the samples containing rGO. The obtained results illustrate the formation of a superabsorbent hydrogel with the water absorbing capacity of 3000 % at room temperature. For both sample types irradiated at 20 kGy the scission of the polymeric chain is advanced.

THE RADIATION SYNTHESIS AND CHARACTERIZATION OF THE NETWORK STRUCTURE OF COLLAGEN-PVP SUPERABSORBENT HYDROGELS

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In this paper, the electron beam radiation synthesis and the characterisation of the network structure of polyvinilpyrrolidone (PVP)-collagen/acrylic acid sodium salt/N'N methylene-bis-acrylamide (NMBAm) superabsorbent hydrogels were investigated. Three hydrogel systems were prepared by varying the polymers' ratio, acrylic acid and NMAAm concentration. The influence of the radiation dose on the swelling and the network properties was examined. It was observed that the gelation processes and the superabsorbent properties depend on the PVP ratio and the NMBAm concentration.

The network parameters (molecular weight between crosslinks, crosslink density and the mesh size) were calculated from rheology tests. The swelling experiments revealed obtaining of a gel with an absorbency capacity of 10000 % at 5 kGy and the oscillatory frequency sweep shows gels with a G' value (elastic modulus) up to 800 Pa.

DETERMINATION OF PLUTONIUM SORPTION CAPACITY IN DIFFERENT TYPES OF SOIL

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Plutonium isotopes are present in the environment as a result of nuclear weapon testing, nuclear fuel reprocessing and nuclear facility accidents such as the Chernobyl and Fukushima accidents [1]. Much attention has been paid to the evaluation of the radiation risk of Pu in the environment due to its strong radiological toxicity and long-term persistence (half-lives of ^{239}Pu and ^{240}Pu are 24100 y and 6561 y, respectively). Other studies have been focused on its migration behavior in the environment. The activity ratios of $^{238}Pu/^{239,240}Pu$ and$^{240}Pu/^{239}Pu$ atom were about 0.45 and 0.40 in the Chernobyl fallout and 0.03 and 0.18 in the stratospheric fallout, respectively [2]. Plutonium was extracted by acid leaching from the sample matrix and purified using the unified anion-exchange chromatography method. From the purified fractions the plutonium isotopes were electrodeposited on stainless steel discs [3].

Sorption capacity is one of the most significant parameters in predicting the fate of a radionuclide in the environment.

The amount of Pu (IV) adsorbed per unit dry weight of treated soil qe (mg/g) was calculated using the following equations:

$$qe=(C_0 - C_e)V/m \qquad (1)$$

where Co (mg/L) and Ce (mg/L) are the initial and final Pu (IV) ion concentrations in the solution, respectively. V (L) is the solution volume and m (g) is the dry mass of the soil [4].

To determine sorption capacity of ^{236}Pu, we conducted laboratory experiments with loam, clay, peat and two types of sand samples. Samples contained different concentrations of tested micro and macroelements, different color and texture, as well as different pH_{KCl} values. The dynamic flow method was used in the investigation of the sorption and transport of plutonium (^{236}Pu) in soils from distilled water. The ^{236}Pu uptake from aquatic medium by tested soils was evaluated following the radiochemical analysis of the sorbent and effluent. The plutonium analyte of each studied aliquot was electrochemically deposited onto the stainless steel disc and measured with alpha spectrometer. Finally, the sorption capacity values were calculated and compared.

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ANTIBACTERIAL Ag-POLY(VINL ALCOHOL)/WS CHITOSAN HYDROGEL SYNTHESIZED BY GAMMA IRRADIATION

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Hydrogels have been used successfully in many biomedical applications including scaffolds for wound healing applications. They facilitate autolysis and may be beneficial in managing ulcers containing necrotic tissue. For example, debridement using hydrogel is more effective than standard wound care for healing diabetic foot ulcers. Potential problem for biomedical application of hydrogels is that microorganisms may grow in hydrogels due to their natural biocompatible properties. Therefore incorporation of antibacterial agents is required. However, the emergence of antibiotic-resistant bacteria as a result of the excessive use of antibiotics has led to a demand for newer antibacterials. Silver nanoparticles are rampantly used in many medical procedures and devices as antibacterials, but they have their drawbacks due to nanotoxicity. These challenges have led to restrictions in the availability or complete withdrawal. The antibacterial efficacy and reduced toxic effect can be improved by introduction of chitosan, as a nontoxic, biodegradable, biocompatible and antibacterial natural polysaccharide. In addition, chitosan and Ag/Ag^+ would be suitable for application in diabetology because both were elucidated as anti-diabetic agents.

Here we report synthesis strategy of formation of silver nanoparticles (AgNPs) and crosslinking of polymer matrix consisting of poly(vinyl alcohol)/ ws chitosan blend, using radiation technology platform which allows synthesis by environmentally friendly and biocompatible radiolytic products of water and sterilization in one technological step. In addition, using the same technology, we have developed the procedure to process chitosan to water soluble form (ws chitosan) which has antibacterial properties. The antibacterial activity of Ag-poly(vinyl-alcohol)/ws chitosan hydrogels show enhanced antibacterial potential in comparing with Ag-poly(vinyl alcohol) hydrogel or poly(vinyl alcohol)/ ws chitosan hydrogel matrix only. It is known that chitosan soluble in physiological acceptable pH values posess high efficacy against bacteria and fungi. The target site of this cationic polymer is the cytoplasmic membrane of bacterial cells. For investigated hybrid hydrogel, zone of inhibition is grater against *Staphylococcus aureus* as compared to *Escherichia coli*, which is important for the treatment of the wound infections in diabetic patients which are mainly caused by aerobic gram-positive *cocci*. These promising results give possibility for development and optimization of antibacterial Ag- delivery system through therapeutic window.

CHEMICAL EVOLUTION: AN APPROACH FROM RADIATION CHEMISTRY

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Chemical evolution encompasses the physical and chemical processes involved in the formation of organic compounds before the appearance of life. Many of these abiotic reactions were not spontaneous and required the input of energy. UV light from the sun is considered the most important source due to its abundance.

Ionizing radiation may play a significant role in chemical evolution because it is a very efficient source of energy for prebiotic synthesis, its way of energy deposition, and the effectiveness of its reactions via free radicals. The use of this source in prebiotic synthesis is substantiated by calculations of the energy available for the decay of radioactive elements with a long half-life. Cosmic radiation is an external energy source that also could have contributed to chemical evolution processes, especially in extraterrestrial environments. In the context of chemical evolution, radiation chemistry can be a very precise and useful tool to simulate the changes that suffered organic molecules exposed to high-energy radiation. This work highlights the importance of ionizing radiation in prebiotic synthesis reproducing both terrestrial and extraterrestrial environments.

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RADIOLYSIS OF AQUEOUS GLYCERALDEHYDES AT DIFFERENT IRRADIATION TEMPERATURES

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Studies in chemical evolution are intended to demonstrate the generation of compounds of biological importance from substances that could have found in abiotic conditions on the primitive Earth and extraterrestrial environments. In this context, the aim of the present work is to examine the behavior of D, L-glyceraldehyde in aqueous solution under irradiation, in particular, to study the effect of irradiation temperatures. Glyceraldehyde is related to biochemical processes, and it may be the starting material for the synthesis sugars in prebiotic conditions. The experiment was performed using gamma rays of the same LET (linear energy transfer) of the most abundant protons in the cosmic rays (Draganic et al., 1984).

The experiments attempt, by using high-performance liquid chromatography and liquid chromatography- mass spectroscopy for the analysis of aqueous suspensions glyceraldehyde irradiated in different doses and temperatures with a 60-Cobalt gamma source. Many compounds sugars-like were found.

RADIOECOLOGY 26

THE QUANTITATIVE ASSESSMENT OF THE PERORAL INTAKE OF TRANSURANIUM ELEMENTS BY THE WILD HOOFED ANIMALS INHABITING THE POLESSIE STATE RADIATION-ECOLOGICAL RESERVE

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Analysis of long-term radiobiological consequences of the Chernobyl disaster is impossible without an adequate assessment of doses of internal and external exposure of biota inhabits the contaminated territories. Currently, the main dose-related radionuclides here are ^{137}Cs and ^{90}Sr. However, relative role of transuranic elements (^{238,239,240}Pu and ^{241}Am) with half-lives of hundreds and thousands of years are gradually increasing. ^{241}Am activity continues to increase as a result of the beta-decay of ^{241}Pu.

Assessment of doses for large animals in the natural environment is a difficult problem because of their high mobility, diversity of feed supply and specificity of the behavior.

Low adsorption coefficient of plutonium and americium in the gastrointestinal tract of animals allows us to offer a relatively simple method for estimating the ingestion of radionuclides by animals on the population level. This method is based on determining the content of plutonium isotopes and ^{241}Am in the feces of the animals collected in their habitats. The daily intake of the radionuclides is a base for assessing doses of internal exposure.

Thus, the aim of this work was the quantification of the ingestion of plutonium isotopes and americium-241 by the wild hoofed animals (Alces alces and Sus scrofa) on the basis of scatological analysis.

Daily intake of plutonium isotopes and ^{241}Am in the body of elk is much higher compared to the wild boar -- 1.5—252.6 Bq day^{-1} and 1.3—182.1 Bq day^{-1} correspondingly (lower—upper quartiles). In some cases intake of ^{241}Am by elk 10 times higher than by wild boar. Daily intake of plutonium isotopes by elk and wild boar are 0.0—120.8 Bq day^{-1} and 0.7—26.8 Bq day^{-1} correspondingly. It should, however, bear in mind the significant differences in daily weight of feed and body weight for investigated animal species.

In the autumn season daily intake of transuranic elements by elk is increasing, but for the wild boar the tendency is opposite.

The analysis of collected data revealed no significant dependence of transuranic elements intake by elk and wild boar on density of soil contamination.

To assess the adequacy of the method used the available information about the activity of plutonium isotopes in the tissues and organs of the wild boars from population inhabit the territory of the exclusion zone of the Chernobyl NPP and a reverse calculation from biokinetic model of plutonium behavior in the body of an adult (ICRP, Publication 67). This result is comparable with the estimation of daily intake of plutonium isotopes calculated on the basis of scatological analysis. Both approaches yield values of the same order, the differences between them are not statistically significant. Therefore we have the reason to believe that the assessment method of daily per oral intake of plutonium and americium isotopes by wild hoofed animals based on scatological analysis is adequate.

THE ENVIRONMENTAL STANDARDIZATION OF RADIATION FACTORS FOR THE BIOTA ECOSYSTEMS

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The literature discusses the problem of environmental regulation of radiation exposure through the reference radiosensitivity species characteristic of different types of ecosystems. In the report suggest a different approach, which is based on the assessment of the environmental standards through the biota of the ecosystem, which is experienced the highest radiation doses. Using we obtained in field trials data assessment speeds the transition between boxes slope ecosystem, consider evaluating radiation exposure to certain types of biota in considered slope ecosystem (forest, edge, meadow, terrace, floodplain, lake).To calculate our estimates using the reliability transport of radionuclides on basis of developed box models. Therefore, at this stage of development of ideas about environmental regulations for allowable radiation dose to biota are invited to set as acceptable value for plants and aquatic organisms as a limit dose of 4Gy/year and 0,4 Gy/y for animals (i.e. their radiocapacity). B. Amiro model calculations have shown that pine forest is not critical dose in 4Gy/y.The dose of a geer in the forest havt dose in 0,9 Gy/y.The dose for people does not exceed more1 mSv/y. Dose of frogs in this lake is 0,2 Gy/y.But the dose to bentic organisms as a minimum 0f 16Gy/y, much more than the critical dose. It threatens the withering away of bentic biota, and thus serious environmental consequences for entire ecosystem.

RADIOECOLOGICAL RELIABILITY AND RADIOCAPACITY OF DIFFERENT ECOSYSTEMS

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Reliability-is ability of a biological systems with a certain probability to function considerable time in the real environment. The use of radioecological analysis situation in different types of ecosystems, using models of radiocapacity and reliability theory has proved to be an effective tool and heuristic evaluation and simulation of radioecological and environmental conditions and can be used with success in further studies Experimental and theoretical research we found that the higher the parameter radiocapacity biota in ecosystem the greater the level of well-being and reliability of biota in this ecosystem. It is found that the decline in plant radiocapacity biota ecosystem, under influence of chemical and gamma irradiation plant clearly shows the decline in well-being and safety of biota. It can be argued that the parameters radiocapacity able to represent as a measure of the reliability each element ecosystem and ecosystem as a whole. Irradiation plant clearly shows the decline in well-being and safety of biota. It can be argued that the parameters radiocapacity able to represent as measure of reliability of each element ecosystem and the ecosystem as whole.

ISSUES OF SYNERGY AND ANTAGONISM OF RADIATION AND CHEMICAL FACTORS

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An important task of modern radiobiology, radioecology and general ecology is the study of the effects caused by the combination of the various stress factors impact on living organisms and the processes of restoration and adaptation to stressful influences. In polluted environments, it is important to know the features of the joint impact of various harmful factors on organisms, their interactions with each other. The phenomenon of synergies in the interaction of different stressors in nature - it is a topical issue that attracts the attention of many biologists, radiobiology, ecologists.

To assess the effect of exposure to radiation alone, and in combination with the introduction into the medium of toxic metals salts on the state of the model plant ecosystem (aquatic plant culture), we proposed to use a sensitive indicator - radiocapacity factor. The radiocapacity of ecosystem, as mentioned above, is defined as the limit of radionuclides deposit in the ecosystem and its components, which can occur above oppression, suppression and destruction of the ecosystem biota. Radiocapacity factor is calculated as a percentage of radionuclide tracer (for example- ^{137}Cs) in the components of ecosystem.

For example, for water culture of maize plants, when the observation time is large, it is possible to calculate and estimate a radiocapacity factor of biota and water as follows: (a_{12} – tracer absorption rate, a_{21} – the outflow velocity of tracer): $F_b \approx a_{12}/(a_{21}+ a_{12})$; $F_w \approx a_{21}/(a_{21}+ a_{12})$. The formula for radiocapacity factor comparing these equations can be obtained: $a_{12}/a_{21}= F_b/F_w=(1-F_w)/F_w=Z$ (denoted by the parameter- Z).

We performed a quantitative analysis of the role of systems recovery and adaptation to the effects of the interaction of various factors, through their influence on the parameters radiocapacity water culture of maize plants. The effects are not additive (synergistic) with different modes of action of the combined stressors. In general, the -n pollutants that act on the ecosystem, the formula for estimating synergy through radiocapacity parameters is as follows:

$S_n = (Z_{\Sigma} \cdot Z_{n-1}) / (\Pi Z_i)$, where Z_{Σ} – the parameter of relationship F_b / F_w, while the action to biota of the ecosystem - n factors, Z_{n-1} – setting F_b / F_w for control (n -1) - degree, ΠZ_i - the product of parameters F_b/F_w subject to action individual factors of -n. Thus, we have a model of assessment of the combined effects of several pollutants on the ecosystem, introduced the necessary parameters to assess synergies and formulas are based on experimental data.

RADIOECOLOGICAL INVESTIGATION IN THE ENVIRONMENT OF BELGRADE CITY, SERBIA

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Activity concentrations of ^{40}K, ^{238}U, ^{232}Th and ^{137}Cs in samples of soil (cultivated and uncultivated), mosses, mushrooms and game meat (wild rabbit, pheasant and wild boar) are measured by gamma-spectrometry technique. The samples were collected from suburban areas of Belgrade city, Serbia, over 2008–2014. Naturally occurring radionuclides in the soil are present at the level characteristic for Serbia. An artificial radionuclide ^{137}Cs is detected in the samples of soil, mosses and mushrooms, which indicates that almost 30 years after the nuclear accident in Chernobyl, this radioisotope is still present in the environment. Since the measured activity concentrations of primordial radionuclides and ^{137}Cs in game meat are below detection limit, these samples can be classified as safe for consumption.

RADIOACTIVITY IN ENVIRONMENT OF STARA PLANINA MOUNTAIN IN AREA OF SUMMER SCHOOL FOR MOUNTAIN ANIMAL BREEDING

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The aim of this paper was to investigate the specific activity of natural radionuclides ^{40}K, ^{238}U, ^{226}Ra, ^{232}Th and the anthropogenic radionuclide ^{137}Cs in the samples of soil, moss, hey, corn, yarrow, houseleek, milk and cheese. Samples were collected on Stara planina mountain, near the summer school for mountain animal breading, Faculty of Veterinary Medicine during July 2014 and June 2015. The specific activity of natural radionuclides in soil ranged from 393-543 Bq/kg (^{40}K), 29.7-56.8 Bq/kg (^{238}U), 25.2-50.9 Bq/kg (^{226}Ra) and 27.9-69.5 Bq/kg (^{232}Th). The highest activity concentration of ^{137}Cs in environment of Stara planina mountain was measured in soil (22 Bq/kg) from the area of Smilovci and moss (26 Bq/kg) from the area of Kamenica. Radiocesium was also detected in houseleek (5.7 Bq/kg), while in animal feed and dairy products the specific activity was below the detection limit.

THE IMPACT OF RAPID WARMING ON THE BIOACCUMULATION OF RADIONUCLIDES AND THEIR TRANSFER WITHIN THE FOOD CHAIN

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Rapid changes of the environmental temperature can alter the soil characteristics and influence the migration ability and bioavailability of the radionuclides. Elucidation of the effects of the extreme weather conditions on the transfer factors of radionuclides in different soil types is especially important for adequate risk assessment after radioactive contamination.

This study presents the impact of rapid increase of environmental temperature for a period of one month on the bioaccumulation of ^{60}Co, ^{137}Cs and ^{54}Mn from three soil types to orchard grass. The obtained results were applied to perform a prognostic risk assessment of radionuclides transfer within the food chain by using data for transfer coefficients and food processing retention factors, published by the IAEA. The determined transfer factors were used to calculate the maximal specific activities of the radionuclides in the investigated soils, at which the food products (milk and meat) are harmless to be consumed.

The experiment was performed by soil samples, taken from the surface soil layer 0-10 cm of a fluvisol, a cambisol and a chernozem soils from Bulgaria. The samples were contaminated by a radioactive solution of ^{60}Co, ^{137}Cs and ^{54}Mn, separated into two subsamples and stored during one month at two temperature regimes: 15°C and 40°C by using of a climate chamber.

Afterwards the soils were planted with orchard grass and stored at 15°C during two weeks until growing. The specific activities of the radionuclides in the grass and the soil samples were measured by gamma-spectrometry. HPGe detector Canberra 7221 coupled to a 16000-channel analyzer DSA-1000 was used and the gamma spectra were processed by Genie-2000 Basic Spectroscopy Software.

The results showed that rapid warming during one month after radioactive contamination influences the transfer of ^{137}Cs, ^{60}Co and ^{54}Mn from the soil to orchard grass. The temperature increase before the growing season was found to cause:

- Decrease of radiocaesium transfer from soil to grass, which was stronger expressed for soils with higher content of micaceous minerals;

- Decrease of the transfer of ^{60}Co and ^{54}Mn to grass from in soils with high cation-exchange capacity and

- Increase of the transfer of ^{60}Co and ^{54}Mn to grass from in soils with low cation-exchange capacity.

Further studies on the influence of rapid changes of basic climatic parameters on the radionuclide transfer from different soil types within the food chain would contribute for more adequate risk assessment after radioactive contamination.

THE IMPACT OF SHARP TEMPERATURE SHIFT ON THE WATER-SOLUBLE FORMS OF TECHNOGENIC RADIONUCLIDES IN DIFFERENT SOIL TYPES

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This study presents the impact of the sharp increase or decrease of environmental temperature on the water-soluble forms of ^{241}Am, ^{60}Co, ^{137}Cs and ^{54}Mn in four soil types from Bulgaria. The aim of the investigation is to evaluate the influence of freezing and sharp warming on the mobile forms of the radionuclides and to identify the importance of main soil characteristics (e. g. soil texture, cation-exchange capacity (CEC), pH, mineral content) for the water-solubility of the radionuclides of interest. The experiment is a case study, based on a scenario where the radionuclides have entered the soil in the form of aqueous solution (e. g. in case of flooding or heavy precipitation), followed by rapid change of environmental temperature.

The study was performed by soil samples, taken from the surface soil layer 0-10 cm of Calcaric chernozem, Gleyic fluvisol, Salic fluvisol and Vertisol soils. The samples were contaminated by a radioactive solution of ^{241}Am, ^{60}Co,^{137}Cs and ^{54}Mn, separated into three subsamples and stored during one month at different temperature regimes: -18°C, 18°C and 40°C by using of a climate chamber and a freezer. The water-soluble forms of the radionuclides in the investigated soils were determined by single extraction and gamma-spectrometric measurements. 1:10 (mass:volume) ratio was applied for extraction of the soil samples with distilled water. End-over-end extraction was performed by shaking at about 20°C for 2 h, followed by vacuum filtration of the leachates through 0.2 μm cellulose nitrate filters. The radionuclide content was measured in the supernatant, and the extraction yield was determined in respect to the initial radioactivity of the sample.

The radioactivity of solid samples and leachates was determined using an HPGe detector Canberra 7221 coupled to a 16000-channel analyser DSA-1000. The spectra were processed using Genie-2000 Basic Spectroscopy software. The crystal structure of the soil samples was studied by X-ray diffraction method (powder diffractometer Siemens D500) using CuKα radiation filtered by a secondary monochromator. The phase identification and quantitative phase analysis of the soil minerals were performed by X'Pert HighScore Plus software.

The obtained results showed highest water-soluble forms of the studied radionuclides in the Salic fluvisol soil, which has acidic pH, very low CEC and loamy-sand texture. The sharp temperature shift led to decrease of the water-soluble forms of ^{241}Am, ^{60}Co, ^{137}Cs and ^{54}Mn in this soil. Increase of water-soluble radiocobalt after sharp warming was determined in the alkaline soil with loamy-sand texture.

GAMMA RADIATION FROM "RADON PEAKS" / ASSOCIATION WITH FACTORS RELATED TO GEOGENIC RADIATION SOURCES AND METEOROLOGY

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During precipitation events (rain, snow, fog), gamma-ray-emitting Rn progenies (^{214}Pb, ^{214}Bi) are concentrated on the ground and can cause significantly elevated ambient dose rate. Due to short half-lives of these progenies, the peaks are short-lived and disappear quickly with physical decay, but are easily measurable if dose rate time series are sufficiently highly resolved in the temporal domain.

We show how the Rn peaks can be separated from ambient dose rate, which is continuously measured by the stations of the EURDEP system, which consists of networks of dose rate monitors in addition to other monitoring devices. Its purpose is to issue early warning in case of anthropogenic radiation from nuclear accidents and the like, but the signals also contain the contributions of Rn peaks.

Although the Rn peaks are prominently visibly in time series of ambient dose rate, they contribute relatively little, mostly below 3%, to total ambient dose rate. However, the local long-term averages of this dose component are subject to a geographical trend, since they are partly controlled by factors which themselves have a geographical trend. Candidates are geogenic factors such as U concentration in the ground, the geogenic Rn potential, outdoor Rn concentration and mean precipitation intensity.

We investigate the geographical dependence of dose due to Rn peaks and its association with some of the possible control factors.

TOWARDS A EUROPEAN MAP OF TERRESTRIAL GAMMA RADIATION

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Terrestrial gamma radiation (TGR) contributes to exposure of humans to ionizing radiation. TGR is one component of ambient dose rate. Its sources are natural radionuclides in the ground and anthropogenic gamma emitting fallout. As part of early warning monitoring networks against anthropogenic radiation, contributing to the EURDEP system, about 4500 dose rate stations distributed over Europe continuously measure ambient dose equivalent rate and transfer the data to a central server of the JRC of the European Commission in almost real time. While the purpose of the system is to warn against accidental or other radiation releases, the dose rate signals also contain a contribution from natural terrestrial radiation. Since the Chernobyl accident in 1986, no anthropogenic event has occurred that has led to detectably increased ambient dose rate on a regional scale. (Local events are being recorded from time to time, originating in material testing using radioactive sources and the like.) The EURDEP values are still being stored, but so far they have hardly been used for any purpose.

As part of the European Atlas of Natural Radiation, a project which is ongoing since 2006, creating a European map of TGR is planned which will exploit the information from EURDEP. Since the TGR is only one of several components which contribute to ambient dose rate, it has to be estimated by decomposing the total signal. We show how this can be done and discuss uncertainties associated with the procedure. Not all dose rate monitoring stations are equally suited for estimating TGR; we discuss criteria for filtering stations according to their location, for our purpose.

As results, we show first regional TGR maps of some European countries. We show association with U, Th and K concentrations in soil, which are the sources of TGR, and with geology as a categorical control factor. It is shown how these quantities can be used to improve local TGR estimation. A difficult issue is to separate the existing anthropogenic component, i.e. ^{137}Cs from global and Chernobyl fallout, which is low in most of Europe but can still contribute significantly in other regions.

Further, we discuss the relationship between TGR and the geogenic radon potential (RP), and whether TGR can be used as its proxy and possibly as predictor for indoor Rn concentrations. Since TGR and RP have partly the same source (U in the ground), such relations exist, albeit being statistically weak.

Finally, we suggest how estimation results obtained from EURDEP could be validated against ambient dose rate measurements collected independently from EURDEP.

BERYLLIUM-7 SPECIFIC ACTIVITY IN SURFACE AIR AND ITS CORRELATION WITH METEOROLOGICAL VARIABLES, SOLAR ZENITH ANGLE, AND NUMBER OF SUNSPOTS

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This analysis presents linear correlations of the beryllium-7 specific activity in surface air with several variables measured in Helsinki, Finland, over 1987-2011. The beryllium-7 data are stored by the online Radioactivity Environmental Monitoring (REM) Database. Daily measurements of beryllium-7 are linearly correlated with the daily values of the following 10 variables: tropopause height; mean, minimum and maximum temperature; precipitation; atmospheric pressure; potential vorticity at 300 hPa and 200 hPa; solar zenith angle; and number of sunspots.

A time lag is also introduced into the calculations of Pearson's linear correlation coefficients, i.e. the beryllium-7 specific activity measured on a day is correlated with a value of a given variable measured on some preceding day. In particular, the time lag is allowed to vary between 0 and 7 days for tropopause height, meteorological parameters and potential vorticity, and between 0 and 31 days for solar zenith angle and number of sunspots. In this way, we obtain sets of correlation coefficients for each pair of analysed variables, in which we look for the maximum correlation coefficient as well as for the time lag on which this value is reached. In addition to investigating all of the available measurements, the time series are further split into seasonal subsets.

Weak to moderate maximum correlation coefficients, ranging between 0.29 and 0.44, are found for the beryllium-7 specific activity with the tropopause height, temperatures and atmospheric pressure. These correlations are reached with a time lag of 0–2 days. Seasonal correlation coefficients show that the strongest linear relationships are obtained in summer. Similarly, a moderate correlation (0.48) with the solar zenith angle is reached with a time lag of 0 days, but the seasonal correlation coefficients in this case show a weaker relationship during different seasons. On the other hand, our analysis suggests that the correlations of beryllium-7 with precipitation, potential vorticity and number of sunspots are not statistically significant.

ANALYSIS OF EXTREME BERYLLIUM-7 SPECIFIC ACTIVITIES IN SURFACE AIR

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The maxima in a large dataset of the beryllium-7 specific activities measured in surface air in Helsinki, Finland, over 25 years (1987-2011), are analysed. The measurements at this station were performed with a varying temporal resolution: weekly until 1999, and daily, or once in two days, in the subsequent years, with a final dataset consisting of more than 4000 measurements. These data are stored by the online Radioactivity Environmental Monitoring (REM) Database.

The beryllium-7 extremes in this dataset are defined as events with the beryllium-7 specific activity above the 95thpercentile, or in other words, as the maximum 5 % of the measured values. Specifically, for the Helsinki data set, this threshold is $4.82 \cdot 10^{-3}$ Bq m^{-3}. The beryllium-7 specific activity in Helsinki shows a seasonal pattern with the monthly means above $2.00 \cdot 10^{-3}$ Bq m^{-3} during the warm season (April–September), and below $2.00 \cdot 10^{-3}$ Bq m^{-3}during the cold season (October–March). The analysis of the extremes shows that 90 % occurred in the warm season, and the remaining 10 % in the cold season. The occurrence of the extreme beryllium-7 events during the cold season is therefore of particular interest, and these "cold extremes" are analysed in more detail.

Amongst the cold extremes, three extreme episodes are identified. These episodes, which occurred in March 1999, February 2003 and February 2005, show extremely high berrylium-7 specific activities measured over several consecutive days. Potential vorticity and surface temperature maps over Europe are investigated in attempt to find underlying mechanisms that cause high concentrations of beryllium-7 in surface air during the cold season.

ACCUMULATION OF Cs ISOTOPES BY DIFFERENT ABOVE-GROUND-VEGETATION AFTER THE FUKUSHIMA DAIICHI NPP ACCIDENT

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As the proximate estimate of the radionuclide deposition density on the ground surface, the result of measurements of fallout on the surface of flat stumps could be considered if trees were cut before the radioactive accident. Wood samples of the ~5 cm thickness were collected from stumps of pine trees, which were cut before the FDNPP accident in the forest openings in some places in Lithuania. The comparative accumulation coefficient (K_{ca}) was identified as the ratio of the total radionuclide deposition density (A_s) in the samples of the above-ground vegetation collected from the sampling square of 1 m^2 to that in the respective square samples of tree stumps (A_T) – $K_{ca}=A_s/A_T$. The average ^{134}Cs deposition density of stump samples was 0.23±0.02 Bq m^{-2}. ^{134}Cs concentration in the deeper layers of stumps was below the detection limit, which confirms the Fukushima's origin of ^{134}Cs. The samples of moss, litter and last year's perennial grass were collected during the 2011-2012 period.^{134}Cs activity concentrations of moss ranged from 0.70 to 2.45 Bq kg^{-1} (d.w.), those of grass – from 0.21 to 0.92 Bq kg^{-1} (d.w.), and those of litter – from 0.54 to 1.49 Bq kg^{-1} (d.w.), respectively. The comparative accumulation coefficient of vegetation related to the residual (or fixed) fraction of ^{134}Cs was 1.8 for grass, 4.9 for litter, and 3.9 for moss, i.e. above unity for all the studied media. Consequently, the use of moss and litter samples seems to be suitable for biomonitoring after the nuclear accidents or non-radioactive events. However, in spite of the maximum value of the comparative accumulation coefficient of litter samples, the use of moss samples is more preferential in estimating the radionuclide deposition densities after radioactive accidents because of a rather little weight of samples, convenience of sampling and sample preparation, as well as an insignificant effect of soil on the moss composition.

CS-137 VERSUS STABLE K IN ROOT UPTAKE FROM RADIOACTIVELY CONTAMINATED SOILS: FIELD OBSERVATIONS

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Analogies and differences between Cs-137 and stable K (K-39) bioavailability for crops growing on radioactively contaminated lands are still under discussion. To clarify the peculiarities of Cs-137 and K root uptake and the elements distribution over the parts of plant biomass the field observations within post-Chernobyl Plavsky radioactive hot spot (Tula region, Russia) have been examined. Total Cs-137 and non-exchangeable K were analyzed in soils that resulting in comparability of their bioavailability for plants. 4 agricultural crops of field rotation (spring barley, maize, potatoes, and rape) and semi-natural vegetation of dry and wet meadows were selected for the study. Above- and belowground parts of biomass were separated for the detailed examination. To avoid the difference in Cs-137 and K content in soils of different plots and to appreciate the biological peculiarities of individual crops the transfer factor (TF) values (the ratio of the activities for Cs-137 and concentrations for K between vegetation and in soil) were calculated.

Determined current activities of Cs-137 in arable and native chernozems of the area taking into account initial level of contamination and the relief position varied from 450 Bq/kg to 700 Bq/kg (170-280 kBq/m^2). The amount of non-exchangeable K in rhizosphere represented 0.09-0.14% without mineral fertilizers and 0.40% after soil fertilization (for maize).

Root uptake of the elements was characterized by different peculiarities. As a whole TF_K were several orders more than $TF_{Cs\text{-}137}$ that stressed the biogenic nature of potassium and the xenophobic nature of caesium. Among the investigated agricultural crops and meadow plant communities TF_K were minimal for maize and barley (5.1-5.7), middle – for rape, and dry and wet meadows (6.5-7.2), and maximal – for potatoes (17.4). $TF_{Cs\text{-}137}$ were minimal for rape (0.01), middle – for wheat, barley and potatoes (0.05-0.06), and maximal – for maize, dry and wet meadows (0.11-0.19).

An accounting of Cs-137 and stable K distribution among above- and belowground parts of plant biomass clearly demonstrated the importance of biological characteristics in root uptake of the elements: wheat, barley and maize (*Gramíneae* family) were characterized by elevated Cs-137 activities in belowground parts (12-14 times higher than in shoots), and rape (*Brassicaceae* family) and potatoes (*Solanaceae* family) were characterized by homogenous distribution of the radionuclide over plant biomass, whereas K concentrations in aboveground parts of plants were 1.5-10 times greater than in belowground parts of plants for all investigated crops.

Thus, Cs-137 and stable K were difficult if not impossible to consider as biochemical analogists in root uptake from radioactively contaminated soils.

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ASSESSMENT OF AIR POLLUTION BY ^{137}Cs DURING FOREST FIRES

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One of the most important environmental issues of nowadays is the problem of forest fires. The threat of forest fires revealed after numerous fires in the Chernobyl exclusion zone (CEZ) in 1992 on the border with Ukrainian part of exclusion zone (Hao et al., 2009). The large amount of wildfires in Belarus has also been registered in 1996, 1999 and 2002.

During the forest fires in areas contaminated with radionuclides, the smoke particles are released in the air. The activity concentration of radionuclides deposited in these particles is able to exceed the allowable levels of radioactivity in the air. The emission containing radionuclides deposited on the fine aerosol fractions is particularly dangerous. ^{137}Cs and ^{90}Sr are especially dangerous and have relatively high dose coefficients for external exposure pathways (Zibtsev et al., 2012). Inhalation of radionuclides (especially ^{238}Pu, $^{239,\ 240}Pu$,^{241}Am) can generate additional internal doses both for firefighters, near the source of ignition, and for citizens, at a distance from the source.

Methods. The objective of this study is to analyze the air pollution by ^{137}Cs and to estimate a potential threat for human health. The estimation process based on empiric data obtained from the fire experiment. The experiment was carried out in controlled conditions using the smoke chamber. For radioactive aerosols sampling an aspirator with an output of 200 l · min^{-1} was used. During the experiment 3 cycles of combustion for materials from the each site was made. The values of airborne activity concentration (A_V) of ^{137}Cs was calculated (Yoschenko et al., 2006).

Results. Airborne activity of ^{137}Cs increase with increasing of activity concentration of this isotope in combustible materials. Activity concentration of radionuclides in aerosols depends on several factors: the contamination density of fuel materials, combustion intensity and time of this process. According to the radiation safety standards allowable average volume activity for the workers and the population is 1.7 Bq m^{-3} and 27 Bq m^{-3}, respectively. Airborne concentration of ^{137}Cs produced by the combustion of forest fuel materials with contamination density over 400 kBq m^{-2} can exceed the allowable activity levels of ^{137}Cs in air for the population, and in some cases the allowable activity levels of ^{137}Cs for workers and firefighters.

Key words: forest fires, fire experiment, air pollution.

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CHANGES IN FRACTAL DIMENSION OF *PHRAGMITES AUSTRALIS* LEAVES UNDER CHRONIC RADIATION EXPOSURE

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The article compares the fractal dimension of the common reed leaves collected in the Chornobyl exclusion zone under different levels of chronic radiation exposure.

The common reed leaves and water samples were collected in 2011-2012 in aquatic ecosystems with different levels of radionuclide contamination. The leaf samples were used to measure the content of ^{90}Sr and ^{137}Cs in the common reed. Based on the results of radionuclide measurements, the internal irradiation level in the leaves was calculated. The concentration of dissolved vegetative chemicals – ammonia and nitrate nitrogen, potassium, phosphorus – was measured in the water samples.

The common reed leaves were examined for transparency to the light scanning for the morphometric study of the leaves venation. Besides, micro-images of the leaf surface were made using a scanning electron microscope. The fractal dimension of venation was calculated and thickness of the veins was measured on the scanned images. Morphological parameters of the conducting bundles were measured on the micro-images.

Using the methods of correlative and regressive statistical analysis, the connection of fractal dimension of venation with other studied parameters of the leaves and water was assessed. As a criterion of correlation dependency in the studied parameters, the coefficient of determination (R^2) was used.

The results showed the average non-linear connection of fractal numbers in venation of the common reed leaves with internal irradiation from ^{90}Sr and ^{137}Cs incorporated in the leaves. Mineral nutrients dissolved in the water oppose the radionuclides and are associated with average fractal numbers of leaf venation by inverse linear relationship.

At the microscopic level, the morphological parameters of venation and conducting bundles are related to average fractal numbers in the leaves and to close linearly dependencies.

The results indicate morphological violations of venation in the common reed leaves under chronic radiation exposure. At the same time, the fractal number of venation in the leaves increases proportionally to the dose of radiation exposure received by the plant.

The dependency of fractal numbers of venation in the common reed leaves on their morphological parameters allows applying the fractal analysis data as an integral indicator of the stability of plant development under chronic radiation exposure.

APPLICATION OF ZONALITY CONCEPTUAL MODEL OF CHRONIC EFFECTS OF IONIZING RADIATION FOR STUDYING BEHAVIOR OF SR-90

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Behavior of Sr-90 radionuclide in the system of «soil-plants-mollusc shells» was investigated on the example of biotope of regional radioactive waste storage facility. The purpose of the study was to examine the possibility of applying the conceptual model of zonality of chronic effects of ionizing radiation in natural populations in the investigation of behavior of radioactive strontium in terrestrial ecosystems and to identify radioecological zones of biological effects of chronic exposure to ionizing radiation of the mollusc population based on of the bio-geochemical regularities of technogenic migration of Sr-90 within the "soil-plant-mollusc shells" system. The study was conducted on the experimental site which represented the biotope of the regional radioactive waste storage facility. Analysis of samples of soil, vegetative matter (Urtica dioica) and molluscs (bush snails) was implemented by the method of radiochemical separation followed with measuring the activity of the radionuclide using scintillation spectrometer "BETA-01C". Annual exposures to external beta-radiation received by tissues of molluscs irradiated by Sr-90 and its daughter radionuclide Y-90 contained in the shells were calculated using Levinger and Marinelli formula.

It was discovered that dose rates of irradiation of molluscs *Bradybaena Fruticicola fruticum* are within 0.03-1.60 Gy/year. Structuring of experimental data was implemented based on the obtained data on the specific activity of Sr-90 in the system under study in accordance with model by G.G.Polikarpov. Three ecological zones were identified on the experimental site with regular variation of specific activity of Sr-90 in mollusk shells. In the zone of physiological masking concentration of radionuclide in mollusk shells can be by one order of magnitude and even more higher than in the vegetation. In the zone of ecological masking and the zone of pronounced environmental effects specific activities of the radionuclide are reduced as compared to its concentration in vegetation by 8 and 40 times, respectively (no decrease of specific activities of the radionuclide in the vegetation is registered). The implemented studies allow formulating the conclusion on the possibility of adaptation of indicators of Sr-90 migration in terrestrial ecosystems.

ADAPTATION OF HYPHOMYCETES TO CHRONIC IONIZING RADIATION

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Radionuclides in the environment are one of the major concerns to human health and ecotoxicology. The explosion at the Chernobyl nuclear power plant and Fukushima I renewed interest in the role played by fungi in mediating radionuclide movement in ecosystems. To study the behavioral adaptations of hyphomycetes that were formed under exposure of chronic ionizing radiation and possible mechanisms of its realization two model systems were created; one of them imitated the influence of "hot" particles, another – the radioactivity of the contaminated soil of the alienation zone ChAES. It was established that the adaptation of hyphomycetes to relatively high doses of radiation isn't a unique property of some species but there are frequent occurrences of the adaptive feature in a lot of taxon that formed under exposure of chronic radiation and it has the maximum rate in areas with radioactivity background up to 500 mRh^{-1}. It was established that in all the studied hyphomycetes in oligocarbotrophic conditions radioadaptive properties correlate with the high efficiency of substrate utilization (2.0–3.5 times higher than that of the control strains). It is shown that under the exposure of chronic radiation each of the investigated species or strain hyphomycetes was characterized by unique changes in profile of the activity of antioxidant enzymes, which provide their adaptation to ionizing radiation. It was found that one of the mechanisms for realization of radioadaptive properties in *Cladosporium cladosporioides* and *Aspergillus versicolor* is a significant (5 to 8 times) increase of their melanin pigments antioxidant capacity.

THE BIOACCUMULATION FACTOR OF HEAVY METALS IN MARINE ORGANISMS FROM THE KOREAN COAST

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The concentrations and bioaccumulation factor of 14 heavy metals in marine organisms at the neighbouring sea of Korea were measured and investigated, respectively. The concentrations of heavy metals were measured in 162 seawater samples, 189 fish samples, 13 Cephalopods and 12 Crustaceans. The bioaccumulation factors in 162 sampling locations were analyzed in the concentration of seawater and marine organisms.

The concentrations of heavy metals in seawater increased in the order of <mn<cd<co<cr<pb<ni<cu<zn<mo<p<fe<rb<sr<na.< span=""></mn<cd<co<cr<pb<ni<cu<zn<mo<p<fe<rb<sr<na.<>

Metal concentrations were the highest in Crustaceans, except for P and the lowest in the squid muscle of all the fish species, except for Cu. Highest concentrations of Na (6300 $mg \cdot kg^{-1}$), P(4600 $mg \cdot kg^{-1}$), Fe (200 $mg \cdot kg^{-1}$) and Sr (71 $mg \cdot kg^{-1}$) were measured in shrimp, respectively. The concentrations of muscle in fish showed strikingly high levels of Na (1500 $mg \cdot kg^{-1}$), P(3200 $mg \cdot kg^{-1}$), Sr (21 $mg \cdot kg^{-1}$) and Fe (23 $mg \cdot kg^{-1}$). The concentrations of muscle in Cephalopods were the following – Na (640 $mg \cdot kg^{-1}$), P (110 $mg \cdot kg^{-1}$), Fe (5.9 $mg \cdot kg^{-1}$) and Sr (4.9 $mg \cdot kg^{-1}$). The results indicated that the concentration of metals in Cephalopods was higher than the concentrations in fish and Crustaceans.

The mean bioaccumulation factor of heavy metals, except for Zn, Pb, Mn, Cd, Ni and Fe, were similar to the recommended values from IAEA (2004), but they were not similar to the values reported from KAERI(1989).

ISOTOPE CONTENTS AND TRANSFER FACTORS OF ^{137}CS AND ^{90}SR IN BIOGEOCENOSIS OF YENISEI 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. In 2004, 2011, 2013 and 2015 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 35-40 μR/h in 2013, but it increased to 60 μR/h in 2015. 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 and it increased to 40-50 μR/h in 2015.

Data of ^{90}Sr and ^{137}Cs isotopes content obtained in different years show notable increase of the specific activities in the upper parts of plants compared with earlier observation. Thus, in 2004 ^{137}Cs specific activities range from 34 to 240 Bq/kg, and ^{90}Sr specific activities – from 2 to 26 Bq/kg depending on the distance from KMCC. For background site the transfer factors (TF) were 0.258 for ^{137}Cs and 0.714 for ^{90}Sr. In short distance from KMCC the transfer factors were 0.758 for ^{137}Cs and 1.970 for ^{90}Sr; for more remote sites TF decreased to 0.429 for ^{137}Cs and 1.905 for ^{90}Sr. For the outermost site (Balchugovskaya channel) TF were 0.027 for ^{137}Cs and 0.488 for^{90}Sr. The excess of the specific activities of ^{137}Cs and ^{90}Sr in plants above background values also has changed over time. Thus, in 2004 in the nearest point to the KMCC the specific activity of ^{137}Cs exceeded background values in 309 times, ^{90}Sr – in 13 times. However, in more recent years, these excesses have been less significant (40-120 times for ^{137}Cs, 30-74 times for ^{90}Sr). Apparently, this was due to global fallout from the Fukushima nuclear accident in March 2011, because in 2011 and 2013 background contents of radiostrontium and radiocesium increased in 1-2 orders of magnitude (maximum increase in 134 times in 2011).

Despite obvious reduction of man-induced impact on floodplain biogeocoenoses of KMCC near impact zone, 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 ^{90}Sr 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.

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DETERMINATIONS OF GAMMA EMITTING RADIONUCLIDES IN SOIL SAMPLES FROM THRACE REGION, TURKEY

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The aim of the present study is to analyze the activity concentrations of terrestrial (^{238}U, ^{226}Ra, ^{232}Th and ^{40}K) and anthropogenic (^{137}Cs) radionuclides in surface soil samples collected from different locations in Thrace Region province using the gamma spectrometer. The mean values of the activity concentrations of ^{238}U, ^{226}Ra,^{232}Th, ^{40}K and ^{137}Cs in the soil samples were analyzed as 55.4, 32.0, 22.9, 1318.9 and 20.9 Bq kg^{-1}, respectively.

The absorbed gamma dose rate in air at 1 m above the ground surface, annual effective dose rate, the values of the radium equivalent activity and the external hazard index associated with all the soil samples in the present work were evaluated. The data obtained in this work cover a wide area along the Thrace Region, and can be considered as a baseline for the region.

PLUTONIUM ISOTOPIC RATIOS ANALYSIS IN ENVIRONMENTAL SOIL SAMPLES - A TECHNIQUE TO DETECT ARTIFICIAL NUCLEAR CONTAMINATION

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Plutonium is the artificial radionuclide produced and spread over int ecospheedring nuclear weapon tests and severe meltdowns of nuclear power plants and nuclear facilities. Due its significant radiotoxicity plutonium is important from the radioecological point of view. Plutonium isotopic composition assessment gives the possibility to be able to determine the artificial radionuclide source. To demonstrate this, alpha- and mass-spectrometric techniques were used for this radionuclide isotopic determination. The set of soil samples were taken from the Southern and Southwestern part of Lithuania from undisturbed grasslands and mature forests. Each sample was taken from the depth of 0-5 cm. A double step ion exchange and ion chromatography techniques were used to separate plutonium from environmental matrix. It is shown that plutonium $^{238}Pu/^{239+240}Pu$ atomic and $^{240}Pu/^{239}Pu$ isotopic ratios reveal fall-out plutonium origin; whereas, some sampling points in the Southern part of Lithuania show substantial Chernobyl accident impact. The first results of nuclear contamination inhomogeneity in nearby sampling locations are revealed and discussed, too.

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THE PROBLEM OF MOBILITY OF INDUCED RADIONUCLIDES IN CONTAMINATED ALLUVIAL SOILS OF THE YENISEI RIVER

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Level of long-term influence of ionising radiation on environment components, contaminated by induced radionuclides (IRN), is defined not only by activity of the IRN and physical nature of the induced radiation (α, β, γ), but also by migration ability and speciation of the IRM in natural conditions.

For the purpose of determination of mobility degree of the IRN in the contaminated alluvial soils of island system of the river Yenisei, located in a near-field influence zone of the Krasnoyarsk Mining and Chemical Combine (KMCC), a study of highly mobile fractions of the suspended matter ingressed in the interstitial waters was carry out. Fractions were localized from the interstitial water sampled from the lower watered horizon of soil of the left bank of Island Atamanovskaya. The volume of the sample was 10 liters. Specific activities of the IRN in the circumjacent soils were as much as ^{152}Eu-1320 Bq/kg, ^{137}Cs-2470 Bq/kg, ^{241}Am-360 Bq/kg. After separation of the low mobile material, which is precipitating within the first 10 minutes after sediment detachment, the following mobile and highly mobile fractions were allocated: I - the particles which were precipitated during 4 hours; II - 24 hours; III - on the 3 μm membrane; IV - on the 0.45 μm membrane; V - Fe and Mn oxides and hydroxides precipitated on the inner surfaces of the water sample package; VI - colloids and the ions precipitated in the form of the solid residue after evaporation of all initial volume of the filtered water sample. The mass concentration (g) of the allocated mobile fractions and their contribution (%) to the total weight and activities of some IRN (^{241}Am, ^{152}Eu, ^{137}Cs) in suspended matter of the interstitial waters are as follows: I fraction - 4,55 g, 52,1%, 64,8%, 48,3%, 82,1%; II - 0,42 g, 4,8%, 5,0%, 4,2%, 7,9%; III - 0,16 g, 1,8%, 2,6%, 2,8%, 4,0%; IV - 0,02 g, 0,2%, 0,7%, 0,9%, 0,7%; V - 1,87 g, 21,4%, 26,7%, 43,3%, 5,0%; VI - 1,72 g, 19,7%, 0,2%, 0,5%, 0,3%. Total weight is 8,74 g. Total activities (Bq) are 2,4, 13,11, 22,2, correspondingly.

Evidently, the average specific activities the highly mobile fractions of the suspended matter of the interstitial waters (^{152}Eu-1502 Bq/kg, ^{137}Cs-2536 Bq/kg and ^{241}Am-273 Bq/kg) are close to values for the circumjacent soils. The received results show, that radionuclides, deposited in the contaminated alluvial soils of the Yenisei River, can be involved in the secondary migration in the structure of highly mobile fractions and be transported thus on considerable distances.

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RADIATION-EPIDEMIOLOGICAL STUDY OF THE INCIDENCE AND MORTALITY OF CARDIOVASCULAR DISEASE AMONG EMERGENCY WORKERS OF THE CHERNOBYL ACCIDENT

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Author presents results of retrospective cohort study of the incidence and mortality of cardiovascular disease among emergency workers of the Chernobyl accident, for the follow-up period 1986-2012. Cohort selected for analysis consists of more than **100,000** Russian emergency workers registered in the National Radiation Epidemiological Registry (NRER) 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. According to WHO data identified codes of ICD-10 which cardiovascular diseases contains. During the follow-up period 1986-2012 more than **50,000** cases of cardiovascular diseases were diagnosed, and more than **9,000** deaths from cardiovascular diseases in the study cohort were reported. Using WHO mortality data were analyzed standardized mortality ratio (SMR) of two main diseases of cardiovascular disease: Ischemic heart disease (ICD-10: I20-I25) and other heart diseases (ICD-10: I30-I52). This analysis of standardized mortality ratio (SMR) has shown no statistically significant decrease of mortality of Ischemic heart disease in the cohort as compared with baseline non-cancer mortality among males of Russia (for 1992-2012 follow-up) (SMR = **0.99**, 95% confidence interval (CI): **0.96; 1.01**). Diabetes, hypertensive diseases, overweight and obesity and alcohol consumption were used as risk factors for cardiovascular diseases. The statistically significant (p-value <0.05) relationship between cardiovascular diseases incidence and mortality and external radiation dose was estimated in terms of excess relative risk and relative risk.

NATURAL RADIONUCLIDES IN THE SOIL OF SUBOTICA, SERBIA: THEIR DISTRIBUTION AND CORRESPONDING GAMA DOSE RATES

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The knowledge of activity concentrations and distribution of the radionuclides in soil provides useful information in the monitoring of environment radioactivity. The activity concentrations of ^{40}K, ^{226}Ra and ^{232}Th from 50 locations of the territory of Subotica were determined by gamma ray spectrometry. Based on the results the value of absorbed gamma dose rate in air was calculated. Mean values of activity concentrations were found to be 29 Bq/kg for ^{40}K, 20 Bq/kg for ^{226}Ra and 18 Bq/kg for ^{232}Th. The total absorbed gamma dose rate varied between 21 and 45 nGy/h. The mean value of 32 nGy/h is lower than the world average value.

THE USE OF LUMINOUS BACTERIA PHOTOBACTERIUM PHOSPHOREUM AS A BIOINDICATOR OF GEOMAGNETIC ACTIVITY

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Daily changes of the Earth's ionosphere sun-illumination cause regular variations in the geomagnetic activity, mainly due to the currents in the Earth's ionosphere. These variations have an impact on the biological objects. It is possible to perform the assessment of geomagnetic activity using microbial cells-based biosensors. The biological sensors based on luminos bacteria have attracted the special attention among all types of biosensors. Bacterial luminescence is an enzymatic process associated with the general metabolism of the cell. These bacteria contain the luciferase enzyme system responding to the environmental changes.

The aim of this work was to study the geomagnetic activity effect on *Photobacterium phosphoreum* IMV B-7071 luminescence intensity.

The luminescent marine bacterium *P. phosphoreum* strain IMV B-7071 from the culture collection of the Zabolotny Institute of Microbiology and Virology of the National Academy of Sciences of Ukraine was used in this study. Bacterial biomass was grown for 24 hours at 21˚C. The bacterial suspension of the 3 ml volume and 10^7cells/ml was used to evaluate specific luminescence intensity at photomultiplier FEU-115. The geomagnetic activity was assessed by the values of the K-index using the data of space weather prediction center of the National Oceanic and Atmospheric Administration (http://www.swpc.noaa.gov). The daily measurements were carried out during September-October 2015.

Calculated basic statistics data for analyzed period showed a statistically significant inverse relationship between geomagnetic activity and the specific luminescence intensity with a correlation coefficient $R = -0.40$ ($p < 0.001$).

CYTO- AND GENOTOXICITY OF NATURAL WATERS IN THE VICINITY OF RADIOACTIVE WASTE STORAGE FACILITIES

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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 a mixture of radionuclides is often supplemented by other potentially hazardous substances (e.g. heavy or alkali metals). There is still a large lack of knowledge on actual hazard of such combined contamination for biota and human health. Special attention is attracted to a problem of radioactive waste (RW) storage and treatment and possible consequences of their impact on the environment.

Here comparative findings are presented from two bio-assay studies carried out in a vicinity of two RW facilities.

The first one is situated 100 km from Moscow (RW Facility 1), the other one – in the Far East of Russia (RW Facility 2). In both cases water samples were collected from monitor wells within an industrial site and nearby a fence. Measurements of chemical and radionuclide composition in waters were carried out following a routine procedure. To assess a hazardous potential of the complex contamination in the study sites, cyto- and genotoxicity of sampled water was estimated with *Allium cepa* plant system, a sensitive and simple bioassay validated in international collaborative studies and proven to be efficient test system to genotoxic monitoring of environmental pollutants. 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* root tips.

An analysis of aberration spectrum shows an important role of chemical toxicants in mutagenic potential of waters collected in a vicinity of the radioactive waste storage facilities. The *Allium*-test application allows reveling sample points where natural waters have got an enhanced mutagenic potential. Dependencies between biological traits and pollution levels, including an integral pollution index, are analyzed and discussed. Biological effects are not always possible to explain from the knowledge on water contamination levels, which show limitations of physical-chemical monitoring in providing an adequate risk assessment for human and biota from multicomponent environmental impacts. Finding obtained could be used for monitoring optimization and decision making on rehabilitation measures to decrease negative influence of the enterprise on the environment.

ACCUMULATION OF CESIUM AND STRONTIUM BY MYCELIA OF *PLEUROTUS ERYNGII* IN THE PRESENCE OF ALUMINA NANOPARTICLES

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Nanoparticles (NPs) may be up to 100 nm large; compared to other materials, they have unique physicochemical properties resulting from a high ratio of surface area to volume or weight, and exhibit unusual interactions with media. Because of their exceptional properties, NPs are increasingly produced and used in diverse commercial products (agriculture, cosmetics, energy, electronics, paint, medicine). Nanoparticles find application, inter alia, in water treatment – to reduce concentrations of toxic components (e.g. metal ions, radionuclides, organic and inorganic compounds, as well as bacteria and viruses). In fact, surface characteristic of nanoparticles, can enhance their sorption properties and separation of many pollutants. Additionally nanoparticles can interact with the chemical and physical properties of water components. They are able to modify uptake of metal ions and other substances. It can be caused by direct NPs-metal ion reaction (i.e. adsorption of ions on the NPs surface). The second possibility is that NPs can influence the uptake and transport systems in organisms. NPs may induce the formation of new and large-size pores and routes (causing possible increase of compounds uptake) or on the contrary, adsorb on the surface (what can inhibit compounds uptake).

The aim of undertaken studies was examination of: 1) sorption of cesium and strontium ions on the alumina (Al_2O_3) nanoparticles; 2) accumulation of cesium and strontium by mycelia of *Pleurotus eryngii* in the presence of Al_2O_3-NPs. Previously we have found an excellent ability of biotechnological cultures of mycelium of *P. eryngii* to efficient accumulation of alumina NPs from a contaminated environment.

It was shown, that cesium and strontium adsorb on the alumina nanoparticles; the sorption efficiency was ~ 42% and 17%, respectively. *Pleurotus eryngii* mycelia accumulated 30% of strontium form medium while addition of Al_2O_3-NPs increased the accumulation efficiency to 56%. Cesium accumulation by fungus was much less effective and independently on the alumina nanoparticles presence was ~ 26%.

The obtained results document an ability of biotechnological cultures of mycelium of *P. eryngii* to efficiently remove of strontium ions from a contaminated environment. We have shown that alumina nanoparticles enhance the strontium accumulation efficiency. Combination of fungi and nanoparticles is a promising method for radionuclides detoxification.

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POPULATION DOSES FROM TERRESTRIAL EXPOSURE IN THE VICINITY OF THE KOSTOLAC THERMAL POWER PLANT, SERBIA

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In this study, the specific activities of ^{40}K, ^{232}Th, ^{226}Ra in 32 soil samples collected from locations in the vicinity of the Kostolac Thermal Power Plant in 2015 were determined by gamma-ray spectrometry. Based on the obtained data the radiation risk for the population was assessed. Mean values of specific activities of radionuclides were found to be 287 Bq/kg for ^{40}K, 20 Bq/kg for ^{232}Th and 23 Bq/kg for ^{226}Ra. The mean value of the total absorbed dose due to mentioned radionuclides is 35 nGy/h (worldwide average value 58 nGy/h). The estimated radiation risk factors have shown the following: the mean value of radium equivalent activity of 74 Bq/kg is significantly lower than the value which corresponds to the dose of 1 mSv for the population (370 Bq/kg); the mean value of external hazard index is 0.20; the mean value of annual effective dose of 42 µSv is significantly lower than the maximum allowed dose of 1mSv for the population and corresponds to the worldwide average value; the mean annual gonadal dose is 245 µSv; the mean excess lifetime cancer risk due to terrestrial exposure is 1.6 x 10^{-4}. The values of these factors suggest that there is no significant radiation risk to the population in the vicinity of the Kostolac Thermal Power Plant due to terrestrial exposure to radiation from natural sources outdoors. These are the results of preliminary research.

A STUDY ON NATURAL RADIOACTIVITY OF VARIOUS ENVIRONMENTAL SAMPLES FROM THE VICINITY OF THE OBRENOVAC POWER PLANT

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A series of measurements were carried out to determine activity concentration levels from the naturally occurring radionuclides in the various environmental samples. The collected samples include soil and plant samples taken from different sites in the vicinity of the Obrenovac Power Plant, nearby Belgrade, Serbia. It was also investigated if there might be an increase in activity, following the heavy flooding in the area in 2014.

GENETIC ANALYSIS OF *ASPERGILLUS VERSICOLOR* GROWING AT CHERNOBYL ZONE

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All living organisms inhabiting Chernobyl Nuclear Power Plant are affected by chronic irradiation that can lead to various changes of morphological, physiological and genetic features. Sustained exposure of microfungi to radiation appears to have resulted in formerly unknown adaptive features, such as directed growth of fungi to sources of ionizing radiation and stimulation in spore germination.

In our study genome variability among *A.versicolor* microfungi isolated from regions with different radiation contamination, $12x10^{-6}$ R/h (used as control sample) and 70-100 R/h (inside the former reactor room), was evaluated. Besides, microfungi from chronic irradiated regions were divided according to their possession of positive reaction to high level radioactivity (spore germination and hyphal growth response). For this purpose ISSR-PCR with two primers to dinucleotide repeats was performed. The total number of PCR-products amplified with both primers was 10, their size varied from 500 to 2000 bp. The comparative analysis showed slight differences between amplicon patterns of control and exposed to chronic irradiation fungi. There were two minor fragments detected after amplification with $(AG)_8T$ primer and DNA extracted from irradiated microfungi. There were no changes revealed in amplicon fragments between samples exposed to chronic irradiation.

Thus, results obtained in our study suggest that exposure to chronic radiation caused some *A.versicolor* genome reorganization but differences in growth and developmental characteristics were possibly the result of epigenetic changes.

DECOMPOSING RADIOACTIVE HOT PARTICLES FOUND IN THE CHERNOBYL EXCLUSION ZONE BY MICROSCOPIC FUNGI *CLADOSPORIUM CLADOSPORIOIDES*

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Small fragments of nuclear fuel (hot particles) fall into the environment as a result of radiation accidents.

Objective of the given work was a studying of capacity micro fungus *Cladosporium cladosporioides* to transformation of hot particles with high specific activity of α-radiator ^{241}Am.

In this work were used hot particles isolated from soil of exclusion zone of Chernobyl NPP. First hot particle had concentration activity of ^{241}Am – 364 Bq and 3420 Bq of ^{137}Cs. Second hot particle had concentration activity of ^{241}Am –

908 Bq and 6590 Bq of ^{137}Cs. Investigation of interaction fungi and hot particles were in liquid Chapek's medium, which consisted 1g/l glucose.

Fungal accumulation of ^{241}Am and ^{137}Cs released from first intact hot particles was shown to consist 0,165Bq and 0,465Bq, accordingly.

The part of releasing activity from first hot particle was shown to be greater for americium – (6,3±0,5)10^{-2} Bk/g than cesium – (1,8±0,2)10^{-2} Bk/g.

Fungal accumulation of ^{241}Am and ^{137}Cs released from second intact hot particles was shown to consist 1,28Bq and 0,35Bq, accordingly.

The part of releasing activity from second hot particle was shown to be greater for americium – (2,4±0,2)10^{-2}Bk/g than cesium – (1,2±0,2)10^{-2} Bk/g.

We would like to note that in the liquid activities of cesium and americium were in the same ratio as in the hot particles.

It was established that *Cladosporium cladosporioides* was shown capacity to decomposition investigated hot particles. In spite on that in structure of particles prevails ^{137}Cs releasing activity under exposure of fungi to be greater for ^{241}Am.

Thus the capacity to acquire radionuclides in these fungi is determinate by an interaction between physical nature of radioactive source and fungal species.

Americium is one of the most dangerous to the person and an environment radionuclide, in connection with its high toxicity, carcinogenicity and thus a great half-life period. In this connection the special attention is deserved with studying character of interoperability of americium with micro fungi since microbiological processes can play a crucial role in decomposition and migrations of radionuclide in an environment.

DOES NANOMOLAR PLUTONIUM CONCENTRATION GENERATE OXIDATIVE STRESS IN *SOLANUM TUBEROSUM* L. (POTATO) PLANTS?

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Plutonium, mainly the isotopes Pu-238, 239, 240, 241 and 242 were released in a number of severe nuclear accidents and deposited in the environment. In soil, Pu migrates rather slowly and becomes plant available mainly after oxidation to Pu^{V} (e.g. PuO_{2+x}). Chelation by naturally occurring soil organic constituents was proposed as an additional and mechanism of mobilizing Pu and allowing for subsequent plant uptake. Low molecular weight ligands are expected to mobilize Pu and promote plant uptake. Plutonium associated with higher molecular weight molecules was presumed to be non-mobile and not plant available. In our present study, we gave treatments of [Pu-242]=100 and 500 nM respectively to *S. tuberosum* plants in amended Hoagland medium for 21 days and studied whether or not this rather low Pu concentration causes oxidative stress in the plants. For the confirmation of oxidative stress, we explored the production of NO and H_2O_2 by epifloroscence microscope and also checked some oxidative stress markers like lipid peroxidation and superoxide radicals ($O^{\cdot}_2$) through histochemical analysis and also checked biochemical parameter like chlorophyll and carotenoids to check the cellular damage in the tested plants.

Our observation suggest that a decrease in NO production occurs in [Pu]=500 nM 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 case of the [Pu]=500 nM treatment in comparison to control. It was also noticed that there was a significant increment in lipid peroxidation as well as generation of superoxide radicals in leaves. From our present results we conclude that increment of H_2O_2 may create oxidative damage to root and leaf membranes of *S. tuberosum* plants, suggesting that oxidative stress is involved in the toxic mechanism of Pu. Therefore, the reduction of NO induced by Pu in the present work could contribute to the accumulation of ROS and oxidative stress. 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 Pu could be manifested in the plant tissues. The detail of this work is going to be discussed in the meeting.

THE EFFECT OF RADIOACTIVE PARTICLES ON THE YENISEI RIVER ECOSYSTEM

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The Mining-and-Chemical Combine (MCC) of Rosatom, which previously produced weapons grade plutonium, is located at Zheleznogorsk in the Krasnoyarsk Territory, on the bank of the Yenisei River, 60 km downstream of the city of Krasnoyarsk. The combine has been in operation for about 50 years and has contaminated the Yenisei River floodplain with radionuclides. From 1995 to 2015, researchers of the Institute of Biophysics and Institute of Geology and Mineralogy found radioactive “hot” particles in floodplain soils and sediments of the Yenisei River in the area affected by the operation of the MCC. All radioactive particles of the Yenisei River can be divided into two main classes (fuel particles and particles dominated by activation radionuclides) and several subclasses. Radioactive particles with the activity of ^{137}Cs (or another radionuclide) between several kBq/particle and several tens of MBq/particle are a serious hazard to people and biota. Radioactive particles are both a source of the secondary contamination of the ecosystem by artificial radionuclides released by degrading particles and point sources of high-dose external g-radiation to aquatic and terrestrial organisms.

Potential effects of radioactive particles on the River ecosystem were evaluated in laboratory experiments with submerged plant Elodea canadensis (elodea) irradiated with gamma rays from radioactive particles. The experiments showed that low-dose gamma radiation produced an unfavourable effect on the growth of roots and cytogenetic characteristics of elodea plants. The elodea parameters examined in the experiments did not vary significantly when particles with different radionuclide composition were used. Results of the toxicological experiment with radioactive particles as sources of radioactivity showed high sensitivity of elodea to low-dose radiation exposure.

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THE INFLUENCE OF THE SOIL ORGANIC MATTER ON THE MIGRATION ABILITY OF TECHNOGENIC RADIONUCLIDES IN DIFFERENT SOIL TYPES UNDER A SHARP TEMPERATURE SHIFT

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This study presents the influence of soil organic matter on the leaching of ^{241}Am, ^{60}Co and ^{137}Cs by 0.01M $CaCl_2$and 1 M NH_4NO_3 from eight soil types, conditioned at two temperature regimes. The investigation aimed to examine the migration ability of the radionuclides in soils with removed organic substances and in untreated soils, stored at 18^{o}C and 40^{o}C during one month after radioactive contamination. The experiment was carried out by Haplic chernozem, Chromic cambisol, Haplic luvisol, Eutric fluvisol, Calcaric chernozem, Gleyic fluvisol and Vertisol soils, taken from the surface soil layer 0-10 cm. The soil organic matter was removed from aliquot of the samples by treatment with 6 % NaClO and heating at 96^{o}C.

The radioactivity of solid samples and leachates was determined using an HPGe detector Canberra 7221 coupled to a 16000-channel analyser DSA-1000. The spectra were processed using Genie-2000 Basic Spectroscopy software.

Different effects of the removal of the soil organic matter on the leaching of radiocobalt in the studied soil types were observed. Decrease of the leaching of ^{241}Am and ^{137}Cs by 0.01 M $CaCl_2$ as a result of removal of organic matter was found in soils with high sand content. Sharp temperature increase led to decreased leaching of ^{137}Cs by 1 M NH_4NO_3 in all soil samples, excluding the soil with removed organic matter, which had alkaline pH, high sand content, high CEC and low clay content. Further studies on this topic might help to identify the soil types, which can be used as natural sorbents of radionuclides, released in the soil during nuclear accident under sharp temperature shift.

THE IMPROVEMENT OF FOOD SHELF LIFE WITH IONIZING IRRADIATION

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Since 1960 till nowadays, the facility in the field of food irradiation is actively used all over the world. Irradiation can serve many purposes:

- reducing the risk of intestinal diseases and infectious diseases transmitted through food;
- reducing the risk of parasitic and epidemic incidents associated with infection with the larvae of parasites;
- reducing the risk of toxicosis as a result of failure of fumigants, pesticides, repellents, etc. tools used in the processing of products and the laying on storage;
- reducing the risk of infection in the case of bioterrorism;
- declining in the proportion of spoiled food due to the activity of putrefactive microorganisms and parasites;
- declining in the proportion of damaged agriculture product due to sprouting;
- economic incentives to increase the shelf life (preservation of the freshness of the product, taste, color, expanding the range of supply in the trade, especially international);
- failure after radiation treatment excerpts from quarantine fresh fruits and vegetables, some spices, reducing the intensity of quarantine measures for packaged meat products (reduces the costs, the ripening period).

The spheres of using food irradiation:

- pasteurization of meat (including poultry) and seafood, vegetables, fruits;
- decontamination of spices, dried vegetables, herbs, coffee, etc.;
- extending the shelf life of freshly harvested fruits, berries and vegetables;
- radiation disinfestations of cereals, grains, pulses, pest control, pests and their larvae;
- preventing of fodder root-crops germination.

Some studies showed that gamma irradiation system can successfully compete with traditional methods of preserving fishery products. The treatment efficiency increases when irradiated with absolutely fresh fish with a low level of contamination microflora. It reduces the dose of radiation, thus increasing the quality and economic efficiency of the method and increases the shelf life of the fish.

SPATIAL DISTRIBUTION OF RADIONUCLIDES AND HEAVY METALS IN BOTTOM SEDIMENTS OF THE YENISEI RIVER

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For decades, the Yenisei River has received artificial radionuclides and heavy metals from the Mining-and-Chemical Combine (MCC) ROSATOM and industrial facilities of the city of Krasnoyarsk. Bottom sediments (BS) of the River accumulate radionuclides and heavy metals from water. Thus, BS both store information on the range of contaminants present in the water and provide habitat for many species of living organisms, which may be adversely affected by high concentrations of these contaminants. Therefore, it is important to obtain the data on the distribution of radionuclides and metals in BS. Sediment layers located downstream of the MCC discharge point contain a wide range of artificial radionuclides: Eu isotopes, ^{137}Cs, ^{60}Co, ^{90}Sr, and transuranium elements. The vertical distribution of radionuclides in bottom sediments is rather complex, with a number of extrema. Different radioisotope methods have been used to calculate sedimentation rates in several regions of the Yenisei River and date the maxima of radionuclide concentrations. In addition to artificial radionuclides, heavy metal concentrations have also been determined in the layers of sediments of the Yenisei River. For the metals studied, no significant concentration increases or consistent effects of industrial facilities on the chemical composition of bottom sediments have been revealed. In some parts of the River, Cd and Ni concentrations were higher than their threshold values, above which these metals may adversely affect the biota. Downstream of Krasnoyarsk, U and Th concentrations were increased. Thus, in some parts of the Yenisei River, aquatic organisms may be subjected to the joint adverse effects of contaminants, under increased concentrations of both radionuclides and heavy metals in bottom sediments.

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TO THE PROBLEM OF THE MOBILITY OF INDUCED RADIONUCLIDES IN CONTAMINATED ALLUVIAL SOILS OF THE YENISEI RIVER

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Level of long-term influence of ionising radiation on environment components, contaminated by induced radionuclides (IRN), is defined not only by activity of the IRN and physical nature of the induced radiation (α, β, γ), but also by migration ability and speciation of the IRM in natural conditions.

For the purpose of determination of mobility degree of the IRN in the contaminated alluvial soils of island system of the river Yenisei, located in a near-field influence zone of the Krasnoyarsk Mining and Chemical Combine (KMCC), a study of highly mobile fractions of the suspended matter ingressed in the interstitial waters was carry out. Fractions were localized from the interstitial water sampled from the lower watered horizon of soil of the left bank of Island Atamanovskaya. The volume of the sample was 10 liters. Specific activities of the IRN in the circumjacent soils were as much as ^{152}Eu-1320 Bq/kg, ^{137}Cs-2470 Bq/kg, ^{241}Am-360 Bq/kg. After separation of the low mobile material, which is precipitating within the first 10 minutes after sediment detachment, the following mobile and highly mobile fractions were allocated: I - the particles which were precipitated during 4 hours; II - 24 hours; III - on the 3 μm membrane; IV - on the 0.45 μm membrane; V - Fe and Mn oxides and hydroxides precipitated on the inner surfaces of the water sample package; VI - colloids and the ions precipitated in the form of the solid residue after evaporation of all initial volume of the filtered water sample. The mass concentration (g) of the allocated mobile fractions and their contribution (%) to the total weight and activities of some IRN (^{241}Am, ^{152}Eu, ^{137}Cs) in suspended matter of the interstitial waters are as follows: I fraction - 4,55 g, 52,1%, 64,8%, 48,3%, 82,1%; II - 0,42 g, 4,8%, 5,0%, 4,2%, 7,9%; III - 0,16 g, 1,8%, 2,6%, 2,8%, 4,0%; IV - 0,02 g, 0,2%, 0,7%, 0,9%, 0,7%; V - 1,87 g, 21,4%, 26,7%, 43,3%, 5,0%; VI - 1,72 g, 19,7%, 0,2%, 0,5%, 0,3%. Total weight is 8,74 g. Total activities (Bq) are 2,4, 13,11, 22,2, correspondingly.

Evidently, the average specific activities the highly mobile fractions of the suspended matter of the interstitial waters (^{152}Eu-1502 Bq/kg, ^{137}Cs-2536 Bq/kg and ^{241}Am-273 Bq/kg) are close to values for the circumjacent soils. The received results show, that radionuclides, deposited in the contaminated alluvial soils of the river Yenisei, can be involved in the secondary migration in the structure of highly mobile fractions and be transported thus on considerable distances.

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INFLUENCE OF MICROBIOLOGICAL PREPARATION EM1 ON STATE OF ^{137}Cs IN SOIL

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The objective of the research was to study the effect of microbiological preparations on the state and migration of ^{137}Cs in the soil. Experiment was conducted under field conditions. The density of soil contamination was 860 kBq / m^2. The soil was treated with the 1 and 10% solutions of the EM1 6 times at the period from May to August. The pH of the soil, the distribution of ^{137}Cs in the soil by chemical forms, with varying degrees of bioavailability, and the transfer of ^{137}Cs in plants were evaluated. Isolation forms of ^{137}Cs was carried out according to the method [A. M. Ure, C. M. Davidson, 2002].

State of ^{137}Cs in the soil varies on the vertical profile 0 to 20 cm. Percentage of movable, exchangeable and fixed on oxides of Fe and Mn forms of ^{137}Cs increases in the deeper soil layers. Stock of available plants ^{137}Cs increases and percentage of unextractable form decreases.

Applying of EM1 had an ambiguous effect on soil pH. Particularly strong it impact on in the process of acidification of the upper soil layer (0-5 cm). The acidity of the soil in a layer 0-5 cm was reduced on 10% after spraying 1%-solution of EM1.

A similar effect EM1 has on the transfer of ^{137}Cs in plants. Applying of EM1 in the concentration of 1% leads to a decrease in the concentration factor for plants on 38%, but at a concentration of 10% applying EM1 increase concentration factor on 30% compared to the control.

During the growing period, the percentage of available for the plants forms of ^{137}Cs decreas. Spraying by microbiological preparation enhances this process. Further, EM1 leads to the reducing the fraction of ^{137}Cs, associated with the iron and manganese oxides and fixed on organic matter (II-III form) on the background of increasing the proportion of hardly- and unextractable physical-chemical forms (IV-V forms).

THE ESTIMATION OF THE TOXICITY AND GENOTOXICITY OF WATER, SEDIMENTS AND SUBMERGED MACROPHYTE *ELODEA CANADENSIS* OF THE YENISEI RIVER IN THE PRESENCE OR ABSENCE OF AMERICIUM-241

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Toxicity and genotoxicity of one of the most widely spread species of aqueous plants of the Yenisei River –*Elodea canadensis* and bottom sediments of the Yenisei River containing ^{241}Am have been evaluated for the first time. It is shown that the control suspensions and extracts of plants or bottom sediments which do not contain ^{241}Am, inherently decrease the survival of bacterial cells of specific strains as compared to the control without these samples. In the experiments the increased cell death of *E. coli* in the studied aqueous plants accumulating^{241}Am was observed to be higher, which is consistent with the toxicity of the control samples of aqueous solutions of ^{241}Am salts. Non-radioactive suspensions of the control samples of the plants and bottom sediments also slightly influenced the survival of the *S. typhimurium* TA98 cells, whereas their survival abruptly decreased in the presence of ^{241}Am. The samples of the bottom sediments without ^{241}Am hardly influenced the "frequency of His reversions" of the indicator *S. typhimurium*. In the suspensions of the ^{241}Am-containing bottom sediments a dose-dependent effect was observed both in the "frequency of reversions" and in the quantity of the detected His revertants in the *S. typhimurium* TA98 strain.

THE CONCENTRATION RATIO OF ^{137}CS IN THE BODY OF A FISH FOUND IN THE TECHA RIVER IN COMPARISON WITH THE RESULTS OF OTHER WATER BODIES

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Quantification values of radionuclide accumulation for freshwater water bodies provides an opportunity to predict concentration levels of radionuclides in the aquatic organisms, and to estimate radiological risks and risks of receipt of the radionuclide in the human body via food chains. Accumulation of radionuclides by hydrobionts is considered to describe by an equilibrium concentration ratio (CR) of a radionuclide in an organism to the concentration in the environment. It should be noted that the CR can vary significantly depending on various environmental factors, or peculiarities of the organism.

This work presents the results of a study of the concentration ratios of ^{137}Cs for three fish species (roach, perch and pike), living in the Techa River, which was exposed to radioactive contamination in 1949-1956 due to production activity “Mayak” PA. The concentration of the isotope decreases rapidly with distance from historic place of discharges. Thus, on the river Techa, one can distinguish several areas with different concentrations of the radionuclide that allows to study the laws of its bioaccumulation in aquatic organisms in river systems. Therefore, the Techa River is a good place for research of regularities of radionuclide accumulation.

Objective: to study the concentration ratios of ^{137}Cs in populations of roach, perch and pike inhabiting in the Techa River.

Materials and methods. We studied the content of radionuclide ^{137}Cs in water of the Techa River and in the fishes species are pike, roach, perch. Samples were collected in 2011-2013 at the Techa River and on the Miass River. 403 samples of the fishes were investigated.

Results. For the fishes living in the Techa River the calculated values of the concentration ratios ^{137}Cs. It is determined that the value of CR depends on the predominant type of feeding individuals, and not depends on the location of catching, time of catching, the type of fish. Thus, all fish can be divided into conditionally herbivorous and conditionally carnivorous. CR of ^{137}Cs in the body conditionally herbivorous fish, on average, exceeds the accumulation in the body conditionally predatory fish and is 657 and 522 l/kg, respectively. The results were compared with the literature data. It is shown that the values of the relations of the concentrations obtained in this study are comparable with literature data.

It has been established that the Generalized Logistic probability density function describes well individual variability relationships of concentration and can serve as a probabilistic model of the relationship between concentrations ^{137}Cs for carnivorous and herbivorous fish found in the Techa River.

THE SUBSTANCE OF TRANSURANIC ELEMENTS IN *CORYNEPHORUS CANESCENS* AND *VACCINIUM MYRTILLUS* GROWING IN THE POLESYE STATE RADIATION ECOLOGICAL RESERVE

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The aim of the study was to investigate the content of transuranium elements in *Corynephorus canescens* and*Vaccinium myrtillus* growing in Polesye state radiation ecological reserve.

Activity Pu-238 in underground phytoweight *Corynephorus canescens* makes 621,77±93,27 Bk/kg, activity Pu-238 in soil on the given site - 87,30±13,10 Bk/kg. Substance Pu-238 in elevated phytoweight *C. canescens* it is less on two order in comparison with the content of the given isotope in underground bodies of a plant - 4,92±0,46 Bk/kg.

At *Vaccinium myrtillus* the greatest substance Pu-238 in elevated phytoweight is observed for the plants which have been selected from site M4. Activity of soil on the given site on Pu-238 makes 38,55±3,44 Bk/kg. The content in elevated *V. myrtillus* - 2,77±0,16 Bk/kg, underground - 8,78±0,49 Bk/kg.

In spite of the fact that for underground *V. myrtillus* from sites M2 and M4 insignificant distinctions in substance Pu-238 - 9,26±0,18 Bk/kg *V. myrtillus* from site M2 have been found out - in elevated phytoweight they essentially differ. Activity Pu-238 in elevated phytoweight of a bilberry on site M2 makes 0,42±0,06 Bk/kg. For soil from the given site this value is equal 71,87±10,78 Bk/kg.

For isotopes Pu-239,240 the similar situation, as well as in a case with Pu-238 is observed. The substance of isotopes Pu-239,240 in underground phytoweight *C. canescens* from site M1 makes 934,51±140,18 Bk/kg, in elevated - 2,45±0,42 Bk/kg. Activity of soil on Pu-239,240 from the given site is equal 210,24±31,54 Bk/kg.

The substance of isotopes Pu-239,240 *V. myrtillus* from site M2 naturally exceeds twice the substance of isotope Pu-238 - 0,85±0,13 Bk/kg for elevated phytoweight and 17,38±0,26 Bk/kg for underground. Activity of soil on the given site on polutoniju-239,240 makes 143,49±21,52 Bk/kg.

Elevated *V. myrtillus* from site M4 the Bk/kg, underground phytoweight - 19,99±0,86 Bk/kg has specific activity on Pu-239,240 2,26±0,15. Substance Pu-239,240 in soil of site M4 makes 86,63±7,48 Bk/kg.

The greatest activity Am-241 characterises underground phytoweight *C. canescens* from site M1 - 2051,61±10,46 Bk/kg. The elevated phytoweight of this plant differs the least activity on Am-241 among other plants and makes 4,81±0,02 Bk/kg. Substance Am-241 in soil of site M1 makes 535,25±80,29 Bk/kg.

V. myrtillus the greatest activity Am-241 is observed for site M4 having the least activity of soil on Am-241 - 259,42±54,14 Bk/kg. Substance Am-241 in underground phytoweight exceeds that value in elevated phytoweight and is equal accordingly 148,83±4,93 Bk/kg and 12,13±0,22 Bk/kg.

V. myrtillus from site M2 distinctions in substance Am-241 of elevated and underground phytoweight also are found out. Activity elevated *V. myrtillus* on the given site makes 6,32±0,19 Bk/kg. Substance Am-241 in underground *V. myrtillus* authentically above, than in elevated - 67,43±0,81 Bk/kg. Activity Am-241 from site M2 is equal in soil 501,72±75,26 Bk/kg.

THE SUBSTANCE OF TRANSURANIC ELEMENTS IN *BETULA PENDULA* GROWING IN THE POLESYE STATE RADIATION ECOLOGICAL RESERVE

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The aim of the study was to investigate the substance of transuranium elements in *Betula pendula*, growing in Polesye state radiation ecological reserve.

The highest substance of Pu-238 noted in conducting roots and is 25,10 ± 3,77 Bq/kg. Half the activity noted in the axial roots - 10,89 ± 0,21 Bq/kg. In other organs investigated *Betula pendula* content of Pu-238 in different order of magnitude lower side and less than 1 Bq/kg. Leaves activity described isotope is 0.92 ± 0.04 Bq/kg in bark - from 0.69 to 0.72 Bq/kg (depending on the distance from the ground surface) in shoots - 0.53 ± 0 08 Bq/kg. The lowest activity Pu-238 is marked in the wood from 0.16 to 0.49 Bq/kg, depending on the height from the surface. Pu-238 activity in the soil is 38,55 ± 3,44 Bq/kg.

A similar distribution of bodies there and isotope Pu-239,240. Most active was noted in conducting roots 54,50 ± 8,18 Bq/kg. Less twice the axial roots - 22,31 ± 0,33 Bq/kg. Activity detected in shoots of Pu-239,240 0,86 ± 0,13 Bq/kg. Depending on the height, observed in the bark of from 0.53 to 1.36 Bq/kg for the described isotopes. *B. pendula* leaves different activity 0,43 ± 0,03 Bq / kg. The lowest activity Pu-239,240 seen in the wood and is from 0.21 to 0.92 Bq/kg, depending on the altitude. Pu-239,240 substance in soil 86.63 ± 7.48 Bq/kg.

For Am-241 there is the same distribution of the isotope studied, as in the case of plutonium isotopes. Most active Am-241 accounted for conducting roots 762,28 ± 13,95 Bq/kg, less - at the roots of the axial 185,04 ± 4,87 Bq/kg. Is much less marked for the content of the leaves - 11,59 ± 0,85 Bq/kg. The runaways found 3,35 ± 0,08 Bq/kg. The bark and wood *B. pendula*, depending on the distance above the ground, is determined from 2.95 to 6.10 Bq/kg, and from 1.14 to 4.13 Bq/kg, respectively. Am-241 activity soil - 259,42 ± 54,14 Bq/kg.

THE SUBSTANCE OF TRANSURANIC ELEMENTS IN *PINUS SYLVESTRIS* GROWING IN THE POLESYE STATE RADIATION ECOLOGICAL RESERVE

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The aim of the study was to investigate the substance of transuranium elements in *Pinus sylvestris,* growing in Polesye state radiation ecological reserve.

For isotope Pu-238 in *Pinus sylvestris* following distribution of the substance on activities is observed. In roots - from 19,09 to 37,39 Bk/kg, in runaways and needles - from 1,02 to 26,56 Bk/kg and from 1,28 to 3,53 Bk/kg accordingly. In a bark the substance of the given isotope makes 1,90±0,29 Bk/kg, in wood - 0,88±0,13 Bk/kg. In pollen *P. sylvestris* the least activity Pu-238 - 0,54±0,08 Bk/kg is observed. Activity Pu-238 in soil makes 38,55±3,44 Bk/kg.

In roots *P. sylvestris* also the greatest substance of isotopes Pu-239,240 - from 44,13 to 77,40 Bk/kg also is marked. In a bark, to case similarly considered above, activity Pu-239,240 makes 2,74±0,41 Bk/kg that twice exceeds that in wood 1,36±0,20 Bk/kg. In runaways substance Pu-239,240 makes from 0,74 to 2,38 Bk/kg. In needles substance Pu-239,240 makes from 0,64 to 4,83 Bk/kg. Activity Pu-239,240 in pollen of a pine ordinary - 0,99±0,15 Bk/kg. Content Pu-239,240 in soil 86,63±7,48 Bk/kg.

Substance Am-241 in roots *P. sylvestris* in limits from 573,61 to 588,22 Bk/kg. On usages smaller value is marked for a bark and wood 5,10±1,11 Bk/kg and 2,26±0,56 Bk/kg accordingly. In runaways *P. sylvestris* activity Am-241 - from 1,13 to 5,37 Bk/kg. The needles substance from 0,90 to 6,67 Bk/kg Am-241. In pollen *P. sylvestris* activity of a described isotope makes 8,46±0,12 Bk/kg. Activity of soil on Am-241 - 259,42±54,14 Bk/kg.

ISOTOPES ^3H, δ^2H AND $\delta^{18}O$ IN GROUNDWATERS FROM VOJVODINA REGION

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This paper presents the results of the survey of groundwater samples from Vojvodina region, Serbia. By measuring the activity concentration of radioactive isotope tritium (half-life 12.32 years) the groundwater's age could be estimated. Tritium is directly incorporated into the water molecule (H^3HO), so it participates in the hydrological cycle and can be detected in groundwater. The presence of tritium in groundwater indicates recharge of aquifer by modern precipitation (i.e., recharge after 1952).Modern groundwater is renewable, as opposed to the older and fossil water, and in this sense it can be better utilized. On the other hand, modern groundwater is more vulnerable to contamination from the surface. It is important to know the approximate age of groundwater for better water resources planning and management.

This study included 35 groundwater samples from deep wells and natural sources and 1 surface water sample from the lake, all collected in Vojvodina region from four different hydrogeological systems. Tritium activity concentration was determined in all collected samples, as well as oxygen and hydrogen stable isotope composition (δ^2H and $\delta^{18}O$) in order to determine the age and origin of groundwater. For understanding and interpretation of the obtained results, geology and hydrogeology of researched area was taken into consideration.

The main conclusion is that the groundwaters in Vojvodina region are mostly young (not older than 10 years) and that they are mostly supplied by precipitation. There is no direct relation between groundwater age and the corresponding hydrogeological system.

RADON PROGENY FALLOUT IN TROPICAL RAINFALLS

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The laboratory of environmental radiation of ITA (São José dos Campos, 23°11′11″S, 45°52′43″W, 650 MAMSL) performs simultaneous monitoring of a natural radiation background and meteorological parameters. A time resolution of up to 1 minute allows a detailed comparison of changes in meteorological parameters with those of a concentration of ambient radon progenies in the atmosphere. Results of a study of variation of a fallout of radon progenies ^{214}Pb and ^{214}Bi concomitanting rainfalls are present. The radionuclide fallout rate is reconstructed from the observed gamma rate through a simulation of the first kind Volterra integral equation with difference kernel, determined by ratio of precipitating rates of ^{214}Pb and ^{214}Bi and their decay half times. An original straightforward step-by-step procedure was used for the numerical solution of the equation. The radionuclide concentration in the rainwater is calculated as a ratio of the reconstructed fallout to the measured rainfall. It was observed that the radionuclide fallout rate increases as the rainfall one in approximately power 0.6, i.e. the same as the mean raindrop volume. The concentration thereafter decreases as the rainfall rate in power 0.4. A numerical simulation of the process of accumulation of the radionuclides during diffusion and coalescence drop growth and aerosol scavenging during a passage from a cloud to the ground was performed. The results of the simulations agree with the experimental data.

OBSERVATION OF RADON PROGENY NEUTRONS

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The laboratory of environmental radiation of ITA (São José dos Campos, 23°11'11°S, 45°52'43°W, 650 MAMSL) performs simultaneous monitoring of a natural radiation background and meteorological parameters. Neutron flux in the energy range of 0.02 eV - 10 MeV is registered with two sets of proportional ^{3}He tubes placed into cylindrical paraffin thermalizers: one with 250 cm^2 area and the other with 70 cm^2, both detectors are located inside masonry buildings. The counter efficiency for thermal neutrons is 80%. The characteristics of the observed flux variation are quite different from those inherent to the neutrons of the cosmic ray origin. Four types of flux variations are observed: 1) seasonal with a maxima in wet seasons; 2) diurnal with maximum at about 6 h local time and an amplitude up to several dozen neutron counts; 3) abrupt transient (~1 min) increases with magnitudes up to two orders higher than the mean daily flux; 3) short (several days) quasi-periodic enhancements with amplitudes up to several times higher than the mean daily flux. A large variation of flux and its phase synchronism with that of the radon decay products means with a high probability their common origin. An apparent source of the neutrons observed is nuclear reactions of decay alpha-particles with the ground matter. In this case, the dynamics of flux variations of the first two types are controlled by those of the meteorological parameters of the region detectors are installed. The third type events correlate with lightning strokes in the vicinity (<200 m) of the detector. The more rare fourth type correlates neither with geomagnetic disturbances nor with meteorological phenomena and are probably a result of natural radon release from the Earth's crust triggered by minor seismological activity. The indoor flux is quite stable with a possible weak maximum at 16 h not exceeding 0.1.

SPATIAL DISTRIBUTION OF SOME RADIONUCLIDES IN MOSSES COLLECTED IN SERBIA

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Accumulation of elements taken from the air in measurable concentrations make mosses a superior sampling medium for heavy metals, as well for radionuclides. Moss sampling is simple procedure and very dense network of sampling sites can be established to provide excellent spatial resolution. Up to 200 moss samples were taken during autumn 2015 in Serbia. Gamma spectra of all samples were measured by large well type NaI detector. Prominent gamma lines of ^{210}Pb, ^{7}Be, ^{40}K, ^{214}Bi, etc. were detected in all spectra. Obtained data were used to get spatial distribution of several radionuclides over complete area of Serbia. Some preliminary analysis of acquired spatial distributions was done to explain some possible influence on measured distribution patterns.

MEASUREMENTS OF RADIOACTIVITY LEVELS IN THE SOIL SAMPLES FROM PRISTINA, KOSOVO AND METOHIJA, SERBIA

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Radioactivity concentrations were measured in soil samples collected from the area of Priština, the capital of Kosovo and Metohija. The specific activities of ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs in 27 samples were measured by gamma spectrometry using a HPGe semiconductor detector. The average values were 23.7, 35.1, 375.4 and 11.0 Bq kg^{-1}, respectively. These values are slightly lower than the average worldwide values of 32, 45 and 412 Bq kg^{-1}for ^{226}Ra, ^{232}Th and ^{40}K, respectively. The activity concentrations of natural radionuclides ^{226}Ra, ^{232}Th and^{40}K have shown normal distribution. The data for ^{137}Cs was consistent with a lognormal distribution. Pearson correlation coefficient between ^{226}Ra and ^{232}Th was found to be $r=0.734$ at $p \le 0.01$. Strong positive correlation is expected since they have similar lithogenic or pedogenic sources. The air-absorbed dose rates and the annual effective doses were estimated and the mean values were 47.8 nGy h^{-1} and 58.6 μSv, respectively.

THE STUDY OF THE VERTICAL MIGRATION OF ^{137}Cs IN THE CHAIN SOIL-GRASS

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The study was performed on the three locations in Bosnia and Herzegovina in order to investigate the levels of ^{137}Cs in samples of soil, grass and hay as well as to quantify the transfer factors of radio-cesium in soil-grass (hay) chain. Dried samples of soil as well as burned samples of grass and hay were measured by gamma spectrometry method with HPGe coaxial detector. The activity concentrations of ^{137}Cs in samples of soil were in range 7.32 - 828.7 Bq kg^{-1}, whilst recorded levels of ^{137}Cs in samples of grass (hay) were 0.2 – 4.8 Bq kg^{-1}. Calculated transfer factors in the chain soil-grass (hay) were in the range 0.0099 – 0.063. Obtained transfer factors indicated on the differences in bioavailability of ^{137}Cs probably caused by the differences in the chemical and physical characteristics of soil among investigated localities.

ISSUES OF SYNERGY AND ANTAGONISM OF RADIATION AND CHEMICAL FACTORS

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An important task of modern radiobiology, radioecology and general ecology is the study of the effects caused by the combination of the various stress factors impact on living organisms and the processes of restoration and adaptation to stressful influences. In polluted environments, it is important to know the features of the joint impact of various harmful factors on organisms, their interactions with each other.

The phenomenon of synergies in the interaction of different stressors in nature - it is a topical issue that attracts the attention of many biologists, radiobiology, ecologists.

To assess the effect of exposure to radiation alone, and in combination with the introduction into the medium of toxic metals salts on the state of the model plant ecosystem (aquatic plant culture), we proposed to use a sensitive indicator - radiocapacity factor. The radiocapacity of ecosystem, as mentioned above, is defined as the limit of radionuclides deposit in the ecosystem and its components, which can occur above oppression, suppression and destruction of the ecosystem biota. Radiocapacity factor is calculated as a percentage of radionuclide tracer (for example- 137Cs) in the components of ecosystem.

For example, for water culture of maize plants, when the observation time is large, it is possible to calculate and estimate a radiocapacity factor of biota and water as follows: (a12 – tracer absorption rate, a_{21} – the outflow velocity of tracer): Fb≈ a12/(a21+ a12); Fw≈ a21/(a21+ a12). The formula for radiocapacity factor comparing these equations can be obtained: a12/a21= Fb/Fw=(1- Fw)/Fw=Z (denoted by the parameter- Z).

We performed a quantitative analysis of the role of systems recovery and adaptation to the effects of the interaction of various factors, through their influence on the parameters radiocapacity water culture of maize plants. The effects are not additive (synergistic) with different modes of action of the combined stressors. In general, the -n pollutants that act on the ecosystem, the formula for estimating synergy through radiocapacity parameters is as follows:

Sn = (Z Σ • Z n -1) / (Π Zi), where Z Σ – the parameter of relationship Fb / Fw, while the action to biota of the ecosystem - n factors, Zn -1 – setting Fb / Fw for control (n -1) - degree, Π Zi - the product of parameters Fb/Fw subject to action individual factors of -n. Thus, we have a model of assessment of the combined effects of several pollutants on the ecosystem, introduced the necessary parameters to assess synergies and formulas are based on experimental data.

THE INVESTIGATION OF THE SEDIMENTATION RATE IN CUIBIDA AND ISAC LAKES FROM THE DANUBE DELTA (ROMANIA) BY USING ^{210}PB DATING METHODS

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Danube Delta is the second largest delta in Europe, having surface of 4152 km^2. Natural factors lead to its continuous change on different time-scales. Therefore the analysis of the sedimentation processes is of great importance. Moreover, the anthropogenic interventions (meander cutting on 1982), flood event and the construction of the Iron Gate hydroelectric power plant (Danube river on 1972) have the same effect. The objective of the present study is to assess the sedimentation rates and the dynamics of the sedimentation processes in the Cuibida and Isac lakes after identifying the anthropogenic influences of the Iron Gate using the^{210}Pb radiometric dating method (usable for 0-200 year old samples).

Four cores were analyzed from the Isac-lake and seven from Cuibida-lake (both lakes being situated between Sulina and Sfantu Gheorghe branches. The sediment cores were sub-sampled and physical parameters (porosity, water content) were determined. The in situ ^{210}Pb was measured through ^{226}Ra activity concentration with high resolution gamma spectrometry. The total ^{210}Pb content was measured via its alpha emitting progeny, ^{210}Po. The alpha spectrometric measurements were carried out using an PIPS detectors system. The geochronology of the sediments and their sedimentation rates were calculated using the CRS model.

The ^{226}Ra (in situ ^{210}Pb) activity concentration of the sediment cores was 14-25 Bq/kg, with an average of 19 Bq/kg (this activity concentration is typical on Danube Delta sediments), while the total ^{210}Pb activity concentration ranged from 47 to 251 Bq/kg. The mass sedimentation rate maximum was 1.48 g/cm^{2}y between 1982-1993 on the Isac-lake and 1.78 g/cm^{2}y between 2004-2008 on the Cuibida-lake. These dates is corresponding with the major floods from 1981,1993 ,2006 and the meander cutting in 1982 being visible in all sediment cores. In case of the linear sedimentation the highest value (2.24 cm/y) in Isac lake and (2.64 cm/y) was reached in 1978-1983 and 2004-2008. The sedimentation shows a decreasing tendency from 2004, while the period between 2004 and 1978 was consisting of many substantial floods proven by the average sedimentation rate of this period the average sedimentation 0.48 -0.71g/cm^{2}y, before 1980 these values were nearly two-three times lower (0.18-0.25 g/cm^{2}y). After 1972 (Iron Gates construction) the sedimentation rates was approximately two times lower (0.21 g /cm^{2}y) than in the years before (0.52 g/cm^{2}y) meaning 59% decrease which appear only one sedimentation core.

VALIDATION METHOD FOR PESTICIDE RESIDUE AFTER GAMMA IRRADIATION

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Pesticide residues include the remaining substances or mixtures, metabolites and impurities in food which are considered to be toxicological significance. The goal of this work was validation method for the determination of residue by UPLC PDA and GC MS techniques. Special scope has been chlorpyrifos from apple after oil and emulsion formulation Radar EW and Radar EC treatment. In order to fully respond to this task, it has been induced the degradation products of active component -chlorpyrifos from these formulations. The degradation products chlorpyrifos-oxon, 3,5,6-trichloro-2-pyridinol (TCP) and o,o -diethyl thiophosphate (DTPA) received after gamma radiation samples in a permanent for 66 hours with 2,5 KGray from Co-60 source. Gamma radiation is the closest degradation to natural conditions, followed degradation path, based on the chemical and microbiological processes. Four different extraction procedures have been used: liquid-liquid extraction (Dutch procedure), solid phase extraction with HLB cartridge, multiwall carbon nano tubes and Quechers extraction. The recovery for these clean up methods has been in range 75-94%. The validation parameters for UPLC PDA has been: LOD 0,06 ppm, LOQ 0,18 ppm. The linearity was confirmed by correlation coefficient, R=0.998 for UPLC. The parameter for GC MS has been on ppm level also. The correlation coefficient for GC MS is 0.999. The result on apple samples showed that for pesticide residue quantifications is more adequate GC MS technique that is characterized by highest recovery, the lowest standard deviation and better LOQ.

UNUSUAL PO-210 AND PB-210 ACTIVITY RATIOS IN THE AIR

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In fresh and clean air $^{210}Po/^{210}Pb$ activity ratio is in range from 0.01 to maximal 0.1, while for $^{210}Bi/^{210}Pb$ average activity ratio is 0.5. Both method based on activity ratios should give the same value of residence time of aerosols. In practice, especially in high urbanized regions both method give significant different value, which suggest presence of additional ^{210}Po sources than from natural ^{222}Rn decay. This phenomenon has been applied as method of ^{210}Po excess calculation.

^{210}Pb and ^{210}Bi radionuclides occur similar behavior in the air, therefore residence time method based on $^{210}Bi/^{210}Pb$ activity ratio provides a relatively correct results. Method based on $^{210}Po/^{210}Pb$ activity ratio provides overestimated values, which need correction due to specific air conditions. ^{210}Po radionuclide occurs significant different behavior than its parents, generate higher ^{210}Po activity concentration in environment. A few works confirmed extremely high excess of ^{210}Po relative to ^{210}Pb radionuclide.

Presence of excess of ^{210}Po dramatically increases the normal value of $^{210}Po/^{210}Pb$ activity ratio. $^{210}Bi/^{210}Pb$ activity ratio method is more resistant on presence anthropogenic air pollutions, and better describe natural washout processes occurred in the air. $^{210}Po/^{210}Pb > 1$ activity ratio confirm dominant contribution of ^{210}Po unsupported from ^{210}Pb.

SPATIAL AND DEPTH DISTRIBUTION OF ^{137}Cs IN SOIL AROUND "NIKOLA TESLA A" COAL FIRED POWER PLANT, SERBIA

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Soil samples collected from 30 soil profiles (0-50 cm depth) at five 10 cm layers from the surroundings of the major Serbian coal-fired power plant – "Nikola Tesla A". Samples were analyzed using standardized methods for grain size, pH, electrical conductivity, total organic carbon, carbonate content, bulk and particle density. The specific activity of ^{137}Cs was determined by means of gamma spectrometry. Pearson correlation analysis was employed to reveal relations between soil properties and specific activity of ^{137}Cs. To explore influence of sampling depth, distance and direction of sampling sites from power plant on ^{137}Cs variability ANOVA was applied.

^{137}Cs was detected in all samples, and its specific activity was found to be in the range from 0.1 to 41.1 Bq kg^{-1}. The highest mean value of ^{137}Cs specific activity was found in superficial (17.6 Bq kg^{-1}), while the lowest were measured in the deepest soil layer (6.7 Bq kg^{-1}). The measured ^{137}Cs specific activity range was similar to reported values for other locations in Serbia and Europe.

Bulk and particle density and content of organic matter exhibited the strongest influence on ^{137}Cs distribution along soil profile. Statistical analyses showed strong negative interrelation between ^{137}Cs activity concentrations and sampling depth. No relation was revealed between power plant's operation and ^{137}Cs content, although the highest activities of ^{137}Cs were found in samples taken from the power plant's closest proximity. It is ascribed to organic carbon content which is significantly higher in that part of the study area.

Corresponding external gamma-ray dose rate due to ^{137}Cs were calculated based on its specific activities in 0-10 cm soil layer. Calculated dose rate fell in the range from 0.47 nSv h^{-1} to 2.21 nSv h^{-1}, with mean 1.15 nSv h^{-1}. It can be concluded that ^{137}Cs in soil in the investigated area does not induce any significant radiation risk to the resident population, since the obtained values for external gamma dose rate were far below recommended values and represent approximately 2 % of the dose rate from gamma radiation originated from natural radionuclides (^{40}K, ^{226}Ra and ^{232}Th) contained in the same soil samples.

STUDY OF RADIOACTIVITY IN ENVIRONMENT AROUND POWER PLANTS TENT A AND KOLUBARA DUE TO COAL BURNING FOR 2015

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Coal is one of the most important sources used for electrical power generation. Coal and its by-products have significant amounts of radionuclides including uranium and thorium which are the ultimate source of the radioactive gases radon and thoron. Coal-fired power plants in Serbia are located in populated areas, hence, the environmental impact experienced by the neighboring population is significant. The radioactivity monitoring in the “Nikola Tesla”, “Kolubara”, “Morava” and “Kostolac” coal-fired power plants was performed by the Radiation and Environmental Protection Department, Vinča Institute of Nuclear Sciences in the period 2003-2015. Monitoring included the analysis of soil, water, flying ash, slag, coal and plants. Here, the results referring to the radioactivity analysis in all mentioned samples from the environment around two power plants “Nikola Tesla A” and “Kolubara” for 2015 are explained. The analysis of samples was performed by gamma spectrometry using a HPGe detector. In the investigated soil, flying ash, slag and coal samples, naturally occurring radionuclides ^{226}Ra, ^{232}Th, ^{40}K, ^{235}U, ^{238}U, as well as the man-made radionuclide ^{137}Cs were detected. The highest values of natural radionuclides were obtained in flying ash samples, which is known concentrating effect of the combustion of coal. In plant samples, beside these radionuclides, ^{210}Pb and ^{7}Be were also detected. In water samples ^{226}Ra and ^{40}K were detected, while the concentrations of ^{232}Th, ^{235}U, ^{238}U and ^{137}Cs were below the minimum detectable concentration. In water (river, drinking, drain and overflow) samples, beside the gamma spectrometry analysis, gross alpha and gross beta activity was also determined by α/β low level proportional counter Thermo Eberline FHT 770 T. The obtained values for gross alpha and beta activity in these water samples are in accordance with the current legislation in Serbia (Official Gazette 86/11), which refers only to drinking water. The results presented in this paper showed that there was no significant difference in the activity of radionuclides in all investigated samples compared to the values obtained in previous years.

RADIONUCLIDE LOADING INDICES (RLI) FOR ^{7}BE AND ^{210}PB IN SERBIA IN 2015

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Within the monitoring of Serbia in 2015, ground level air samples were collected at places Palić, Vranje, Zaječar and Zlatibor and measured in the Radiation and Environmental Protection Laboratory of "Vinča" Institute. The activity of ^{7}Be and ^{210}Pb were determined by gamma spectrometry method on HPGe detectors (Canberra, relative efficienty 20 % and 50 %). The measured values were in the range of (1.5 - 9.0) mBq/m^{3} for ^{7}Be and (0.06 - 2.40) mBq/m^{3} for ^{210}Pb, with maximum values in summer-late fall for ^{7}Be and the autumn for ^{210}Pb. Minimum concentrations were in winter for ^{7}Be and winter-early spring for ^{210}Pb, which is their typical flow. Obtained Radionuclide Loading Indices (RLI) values ranged in the interval (-1.4 - 1.8) at Palić, (-1.3 - 1.2) at Vranje, (-1 - 2) at Zaječar and (-1.3 - 1.9) at Zlatibor.

Key words: ^{7}Be, ^{210}Pb, Radionuclide Loading Indices (RLI), ground level air

DIFFERENT POTENTIAL SYSTEMATIC UNCERTAINTIES INVOLVED IN ^{210}PB DATING METHOD

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The ^{210}Pb dating method is widely used for determining the ages of young sediments (0-200 y). In order to apply this method, measurements have to be made to determine the activity levels of ^{210}Pb consisting of two components: the supported ^{210}Pb (generated in situ from ^{226}Ra) and the unsupported ^{210}Pb (deposited via airborne fallout).

The aim of this study is to analyze two potential error sources associated with the ^{210}Pb measurements dating method, namely the effect of the silicates found in the sediments and the variation of the mass attenuation in concordance with the sediment depth. In order to achieve this, sediment cores were taken form lakes having different genesis. Sediments were collected from three lakes situated in the Rodnei Mountains National Park (Buhaiescu, Stiol and TaulMuced Lake), one from the Ciomadu Mountains (St. Anna Lake, being situated in a volcano crater) and one from the Danube Delta (Iacob lake, formed between the Sulina an Chilia branches).

The total ^{210}Pb content of the sediments was determined via ^{210}Po, which is the alpha particle emitting progeny of the ^{210}Pb (E_α= 5.31 MeV, $T_{1/2}$ = 138,37 ± 0,002 d). The method employs chemical separation using HNO_3, HCl, H_2O_2 and optionally HF.

^{209}Po tracer was used for determining the chemical yield and ascorbic acid was added to eliminate interferrents (Fe^{3+}). Spontaneous deposition was made onto high nickel content stainless steel discs. Measuremnts were then carried out using an alpha spectrometer containing detectors.

Results show, that if the acidic digestion is carried out without the use of HF, the ages of the sediment layers tend to appear 1-19% younger because of the silicate content. The leaching in teflon dishes can cause contaminations of up to 20-30%. The highest value measured (30%) is attributed to the Iacob Lake, explainable by the fact that the lake gathers its supply form a large catchment area.

TEN YEARS OF MONITORING ^{14}C ACTIVITY IN ATMOSPHERIC CO_2 AND BIOLOGICAL SAMPLES AROUND THE KRŠKO NUCLEAR POWER PLANT, SLOVENIA

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^{14}C activity in the atmospheric CO_2 and in biological samples in the close vicinity of the Krško Nuclear Power Plant (NPP) in Slovenia has been regularly monitored since 2006 with the aim of estimating a possible influence of the NPP on environmental ^{14}C levels and on the effective dose of local population through food chain. Atmospheric CO_2 on two locations was collected every two months, or in shorter periods during some refuelling periods. Biological samples (apples, corn, wheat, grass, vegetables) were collected twice a year (in summer and autumn) in two circles around the NPP, inner and outer, and at the control point 12 km from the plant.

Increase of ^{14}C activity in atmospheric CO_2 was observed during and immediately after the refuelling of the power plant, performed every 18 months. Good correlation between the total ^{14}C activity released in gaseous effluents and the ^{14}C activity of the atmospheric CO_2 has been observed. ^{14}C activity in plants collected close to the Krško NPP is always higher than the activities on the control point, and depends both on the distance from the exhaust of the plant ventilation system and on wind direction: it is higher on the location in the SW-NE direction that coincided with the most pronounced wind directions. Higher ^{14}C activities have been determined in plants collected in summer after the spring refuelling than in those collected during the following vegetation period after the autumn refuelling. This can be explained by the uptake of the CO_2 of higher ^{14}C activity for the process of photosynthesis after spring refuelling. To estimate the realistic effective dose due to ingestion to the population in the vicinity, a model of food consumption has been proposed. The calculated dose for the population at the NPP vicinity is not significantly different from the dose for the population at the control point.

^{226}Ra, ^{232}Th and ^{40}K in wheat samples with the estimation of the index of radiation risk in the surrounding of the city of Skopje (R. Macedonia)

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Radionuclides reach the surface of the ground in a form of solid particles or with rains in dissolved or undissolved state. The ones that come in a form of solid particles are mechanically retained on the surface, while the ones that are dissolved with the process of filtration, enter the soil. Radioactivity in the Earth's crust is transferred in small quantities in plants that grow in different soils. The intake of radionuclides in plants depends on different factors such as: the soil type, texture, the pH factor, conductivity, carbonate and sulfate contents etc.

The intake of radionuclides from the plant is affected by the distribution of the plant's root, and the distribution of the radionuclide is affected by the depth of the soil. The relative intake of radionuclides from plants from different depths also depends on the mobility and the behavior of radionuclides in the soil. However, the radioactive contamination of plant organisms is formed with a dynamic continuous action of the atmosphere, the pedosphere and the hydrosphere.

The purpose of this study was focused on determination of the concentrations of activity of ^{26}Ra, ^{232}Th and ^{40}K in wheat samples collected from locations in the surrounding of the city of Skopje by applying gamma spectrometry. In order to measure the specific activity of ^{226}Ra, ^{232}Th, ^{40}K, wheat samples were taken from different locations in the surrounding of the city of Skopje. The spectral analysis of the radionuclides of these samples was conducted by applying a spectrometer for gamma rays with high purity germanium (HPGe) detector with 30% relative efficiency and energy resolution (FWHM) of 1.8 keV for 1.33 MeV reference passage of 60Co. The software used for obtaining the data is Canberra software package Genie-2000, including search of a maximum value and modules for identification of nuclides. The system was regularly calibrated for energy and efficiency. Each sample was counted for a period of 65000s in order to obtain good statistics and the constant time was lower than 10%.

The data show that the average activity of ^{232}Th is in the range between 0.25 Bq kg-1 and 1.68 Bq kg-1. The activity of ^{226}Ra is in the range between 0.04 Bq kg-1 and 1.70 Bq kg-1.

The concentration of activity of 40K in wheat in all locations has a value higher than the value of ^{232}Th and ^{226}Ra for all samples and it is in the range between 79.58 Bq kg-1 and 124.21 Bq kg-1. A conclusion can be drawn that ^{40}K is the only radionuclide determined in a significant amount in the samples, all other determined radionuclides that occur naturally are considered to have nominal concentrations. On the basis of the data obtained by calculating the specific activities of the natural radionuclides in wheat, the index of radiation risk Heks was determined, whose value is lower than the maximally allowed value which for Heks is < 1, and this confirms the harmlessness of the radiation risk for the population.

When comparing the results to results obtained in other countries, we can conclude that the wheat samples that have been analyzed in the mentioned cities do not indicate increased radioactivity, which would jeopardize the production of food or would have a negative impact on human health. The concentrations of these radionuclides are compared with the available data from the other countries.

ENVIRONMENTAL RADIONUCLIDE DETERMINATION AND RADIOACTIVITY EVALUATION OF SEDIMENT SAMPLES COLLECTED ALONG THE BÜYÜK MENDERES RIVER, TURKEY

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Environmental radionuclides (^{238}U, ^{232}Th and ^{40}K) can be found almost in all geological structures like soils, sediments, air, plants, rivers and oceans, even in our building materials and homes. Büyük Menderes is one of the most important Basins in the Aegean Region which has the widest agricultural lands under cultivation for a long time, at least for 3000 years.

In this study, the distributions of environmental radionuclides in the sediment samples from 20 areas of the Büyük Menderes River, Western Turkey (Aegean Region), were determined using gamma-ray spectrometry with an HPGe detector. In sediment samples, the average concentrations of ^{238}U, ^{232}Th, and ^{40}K were found to be 48, 30 and 485 Bq kg^{-1} (dw), respectively. In addition, to determine the hazard from natural radioactivity, the external terrestrial gamma dose rate in air (nGy h^{-1}) and annual effective dose rate (mSv y^{-1}) were calculated and compared with internationally recommended values.

THE INFLUENCE OF GAMMA IRRADIATION ON THE PROPERTIES OF THE SURFACE OF INORGANIC SORBENTS

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In [1] variation of surface characteristics and sorption properties of microporous amorphous Zirconium Silicate (ZrSi) and mezoporous amorphous Titanium Phosphate (PhTi) under irradiation by bremsstrahlung gamma rays was investigate. The surface characteristics of the sorbents were studied by low-temperature adsorption/desorption of nitrogen. The experimental data were processed by BET, DR, and BJH methods. The results show that under exposure to Bremsstrahlung gamma rays the micropores of the sorbent under investigation are partly transformed in mesopores. The ability of zirconium silicate to absorb Sr^{2+} ions from an aqueous solution of strontium chloride is shown to increase noticeably after irradiation by 22-MeV Bremsstrahlung gamma rays. This parameter for Titanium Phosphate is decrease after irradiation.

In present research we continued to studies influence of irradiation on PhTi and ZrSi's chemical properties and surface characteristics. The samples were irradiated using a betatron (electron accelerator) with the maximal energy of the gamma-quanta 22 MeV during 40 min with and without chemical modified their surface before irradiation.

It was shown that after modify Titanium Phosphate by NH_4OH and irradiation by bremsstrahlung gamma rays its ability to adsorb of Sr^{2+} - ions increases. The IR – spectra of Titanium Phosphate has shown that NH_4^+ - ions created chemical bounds with PhTi surface. At the same time numbers of Phosphate groups (such as HPO_4^{2-}, PO_4^{3-} , $H_2PO_4^-$) leave sorbent's surface.

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THE DISTRIBUTION OF HEAVY METALS AND GAMMA-ACTIVE NUCLIDES IN NATURAL OBJECTS

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The problem of environmental pollution by various pollutants as result of human activities is very important today. Reliable information about the level of pollution of various natural systems can be obtained only by monitoring. The important role plays background monitoring of protected areas, because it allows to take into account the peculiarities of climate, morphological and geological conditions and to establish state standards of environmental objects. Technogenic impact on protected areas is relatively low, so there is a natural level of chemical elements in the environment objects. The impact of technogenesis in protected areas is relatively low, so mostly natural levels of chemical elements is observed there.

This work is aimed at study of the distribution of heavy metals and gamma-active nuclides (GAN) in soils and sediments of national natural parks Transcarpathia ("Synevyr" - mountain landscape "Uzhansky" - foothill "Zacharovany'j kraj" - lowland). Zakarpattya region borders with four EU countries and ecological state in Transcarpathia largely determine their ecological state - that is why such studies are relevant. In addition, the largest tributary of the Danube - the river Tisza begins in Transcarpathia.

Detection of heavy metals was carried out by atomic absorption spectroscopy, radionuclides – by gamma spectrometry. Some anomalies of heavy metals and gamma-active nuclides distribution in national parks were established. It was established that the ratio S ^{232}Th / S ^{238}U describes specific contribution to natural background radiation GAN various series. ^{238}U GAN series have a dominant impact in the highlands, while in lowland and foothill areas - dominated ^{232}Th GAN series, which can be used as a criterion for identification of soil. Accumulating-leveling properties of small rivers' bottom sediments at natural reserve territories concerning gamma-active nuclides were detected. It was found that towards the mountain ® foothill ® low-lying landscapes the migration of heavy metals occurs, which contributes to their higher content in low-lying areas of the region. At the same time, the migration of heavy metals in the "ground ® bottom sediments ® water of small rivers" system is negligible.

On the basis of research recommendations for setting standards of environmental objects condition were developed. Passportization of soil and mapping of protected areas studied were made.

Data mapping allows us to carry out short-term forecasts for the processes of migration and accumulation GAN and heavy metals in the environment and therefore the future status of studied and surrounding areas.

RADIOACTIVE CONTAMINATION OF UKRAINIAN WILD MUSHROOMS

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Planetary scales of nuclear accidents and their environmental consequences necessitate constant radio-ecological monitoring of the various biota objects. It is well known that some mushrooms can be hyper-accumulators of radionuclides (both natural and man-made) and heavy metals that allows to use them for bioindication. In general, the level of radionuclide accumulation in mushroom depends both on specific radio-ecological situation in the sampling site (quantitative and qualitative composition, forms of radionuclides, moisture, pH, type of soil, climatic factors, landscape peculiarities etc) and on mushroom species specificity, belonging to ecological trophic groups, depth of mycelia location in soil.

Long-term radio-ecological monitoring (from 1990) of ^{137}Cs contamination of wild Ukrainian mushrooms and soils from locations allow us to identify the trend, which is preserved in time, the growing level of radiocesium accumulation in the order from the lowest level of activity in lignotrophs, medium – in saprotrophs and maximum in mycosymbiotrophs.

Gamma-spectrometry, and radiochemical research the main doze-forming radionuclides - ^{137}Cs i ^{90}Sr in fruit bodies of macromycetes of Ukrainian Polesie (the most contaminated region of Ukraine as a result of the Chornobyl disaster in 1986) with varying degrees of contamination confirmed the previously described tendency. From the point of view of radiocaesium, the highest levels are usually observed in mycosymbiotroph species from *Cortinariaceae, Russulaceae, Paxillaceae, Boletaceae, Suillaceae, Hydnaceae* and *Bankeraceae* families. The lowest levels was found in saprotroph and lignotroph species of the *Agaricus, Macrolepiota, Lycoperdon, Calvatia, Collybia, Armillariella, Coryolus, Kuehneromyces, Pholiota, Pleurotus, Sparassis, Laetiporus, Hypholoma, Piptoporus, Picnoporus* and *Grifola spp*. which can be considered quite safe for use in food and medicinal purposes.

In 2013 in mushrooms and soil samples from Drevlyansky Forestry (Zhytomyr region, Narodychi district, an average soil surface contamination with ^{137}Cs – 18.9 Ci/km^2, ^{90}Sr – 0.7 Ci/km^2), which in recent years has been derived from the Chornobyl exclusion zone, it was detected extremely high levels of ^{137}Cs activity of some mycosymbiotroph species: in *Sarcodon imbricatum* – up to 441, *Lactarius helvus* – 234, *Boletus badius* – 185,*Russula emetica* - 157, L. turpis -133, *B.bovinus* – 118, *Suillus luteus* – 61, *Leccinum scabrum* – 58, *B.edulis* – 53 kBq/kg dry mass. At the same time, the permissible limit for dry wild mushrooms in Ukraine is only 2.5 kBq/kg dm. Mushrooms mainly accumulate radiocesium than radiostrontium, an uptake of ^{90}Sr was in 10-10^4 times less than ^{137}Cs. In samples from the Kyiv region the highest ^{137}Cs activity in 2015 was detected in *L. rufus* - to 70, *B. badius* - to 55, *Paxillus involutus* - up to 30 kBq/kg dm (near city of Ivankiv).

Thus, despite the fact that since the Chernobyl catastrophe has been passed already three decades, the danger of wild edible mushrooms consumption of Ukrainian Polesie is saved.

RADIOLOGY

27

THE SIGNIFICANCE OF LUNG HRCT FOR THE EARLY DIAGNOSIS OF PNEUMOCONIOSIS

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Aim. To perform a comparison between radiological perfusion of p small round opacities (p) on conventional chest radiograph (CCR) and p' opacities on chest HRCT (HRCT) and to assess the diagnostic value of HRCT in patients suspected for nodular pneumoconiosis.

Material and Methods. 84 quartz exposed workers, endangered by pneumoconiosis and patients with reticular, and micro - nodular pneumoconiosis were studied. A comparison between mean profusion of p'- small round opacities on CHRCT with mean profusion of p - small round opacities on CCR was done. A multiple regression analysis was performed.

Results. The mean profusion of the p' - small opacities on CHRCT was more intensive in comparison to mean profusion of the p – opacities on CCR. A statistically significant correlation between p'- and p - opacities was found ($R= 0.36337$; $P < 0.001$).

Conclusion. CHRCT is more sensitive image method for detection of p small round opacities. We recommend CHRCT for early diagnosis of reticular, reticular nodular and nodular pneumoconiosis.

Key words*:* p small opacities, CCR, HRCT, nodular pneumoconiosis

CENTRAL VENOUS PORT CATHETER SYSTEM IMPLANTATION NAVIGATED BY MULTISPIRAL CHEST COMPUTER TOMOGRAPHY

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Mean safe lifetime for peripheral venous catheter is about 48 hours, for central venous catheter - 14 days. But for long term chemotherapy oncologists need to have adequate venous access for months and sometimes for years. Implantable central venous port catheter systems (CVC) provide this opportunity. Usually, CVC implantation navigated by C-arm, but last years computer tomography is the emerging option.

Objective: to evaluate safety and imaging accuracy/quality for CVC implantation assisted by X-ray C-arm or computer tomography (CT)
Materials and methods: During 2014 - 2015 for long term chemotherapy in oncology patients we have implanted 120 CVC port systems: 45 navigated by X-ray C-arm (group 1) and 75 navigated by CT (group 2). Patients' mean age was 45 years (27 - 61).
Results and discussion: Mean implantation time in group 1 was 45 minutes (30 - 60), in group 2 - 30 minutes (20 - 45). Mean radiation exposure in group 1 (cumulative dose) was 0.5 Gy, in group 2 - 15 mGy. In 3 patients from C-arm group (6.7%) technical difficulties and procedure-related complications due to vessels anatomy features has developed (1 extravasation, 1 case of atrial cave implantation, 1 case of subclavial vein perforation and lung injury with pneumothorax development). In CT-group patients no complications were detected. CT imaging in all cases helped in adequate vessels anatomy visualization and assessment, and supported catheter navigation and positioning directly above auricula atrii.
Conclusion: Computer tomography assisted catheter navigation for CVC port system implantation significantly decreasing radiation exposure and characterized by high imaging quality than standard X-ray C-arm and capable to avoid procedure-related complications.

INDICATIONS FOR MRI-GUIDED PROSTATE BIOPSY

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Introduction and Objectives: Prostate biopsy is the gold standard for cancer verification. Nowadays different biopsy technologies exist: TRUS-guided, template perinneal, in-bore MRI-guided, MR-US-fusion etc. The main objective of this study was to discuss indications for MRI guided in-bore biopsy.

Material and Methods: We have assessed 42 patients (43 – 64 years old, mean age 61 years) with high suspicion to PC based on PSA level (mean, 12.00 ng/ml) and inconclusive (n=24) or negative (n=18) TRUS and negative previous prostate biopsy in some cases (n=5). In all cases prostate MRI with 3T scanner were performed before biopsy. Patients with obvious PC on MRI graded as PIRADS 4 or 5 were referred to standard 12-core TRUS-guided biopsy. Patients with PIRADS <4 were referred to MR-guided prostate biopsy.

Results: In 21 patients with 4-5 PIRADS following TRUS-guided biopsy confirmed PC diagnosis. In other 21 patients MR-guided in-bore biopsy was performed (mean biopsy time - 30 min). Mean core number was 4. Total number of PC-positive cores – 48 (78.7%). Mean cancer tissue core volume - 40%. 6 patients had Gleason score 4+4, 2 patients 4+3, 7 patients 3+4, 6 patients 3+3.

Conclusions: Based on these results we suggest to clarify restricted patients' groups for in bore MRI-guided biopsy:

- High prostate cancer probability (PSA high level) in patients with previously negative standard biopsy,
- High PSA level with suspicious MRI signs in biopsy-naïve patients.
- The steps before the biopsy should be as follows:
- Disease history assessment;
- Primary tumor visualization (TRUS or/and prostate MRI);
- High-specific visualization (MRI with PIRADS scoring);
- Decision for biopsy and choice of method;
- MRI-guided in-bore biopsy has potential to improve cancer localization and sampling.

LOCALISATION, DIFFUSION-WEIGHT IMAGING AND APPARENT DIFFUSION COEFFICIENT IN PREOPERATIVE ASSESSMENTS OF BRAIN ABSCESSES

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Aim: To evaluate the diagnostic value of magnetic resonance imaging (MRI) and diffusion-weight imaging (DWI) in preoperative assessments of brain abscesses.

Method: This retrospective study included 25 patients, up to seven days before surgery, according to the standard protocol with the following sequence: T1WI, T2WI, FLAIR, DWI and post contrast T1WI. DWI was performed using a 1.5-T MR imaging scanner, single-shot spin-echo echo-planar pulse sequence with b=1000 s/mm. Data obtained from the DW MRI are presented by measuring the value of apparent diffusion coefficient (ADC) coefficients. ADC map was determined by utilizing DP Tools software.

Results: Most of abscesses showed on T1WI the hypointense signal (80%) and isointense signals (20%). On T2WI, most of abscesses showed hyperintense signal (88%) and isointense signal (12%). On FLAIR, the majority of abscesses showed hyperintense signal (96%) and isointense signal (4%). After contrast administration, significantly intensive sign in contrast-enhanced T1WI was observed in 92% of the tumors, while 8% showed moderate enhancement. All of 25 patients with abscesses show restricted diffusion in DWI (markedly hyperintense) with low values of mean ADC of the abscess cavity (0.000164 ±0.000019 mm2/s). Abscesses have statistically significant temporo-parietal localization 40%, compared to other localization in brain.

Conclusion: DWI with ADC is non-invasive method with high sensitivity and specificity which can be useful in providing a greater degree of confidence in morphological features of brain abscesses. DWI provides a new and potentially useful tool for neurosurgical decision-making.

APPARENT DIFFUSION COEFFICIENT (ADC) AND LOCALIZATION IN DETERMINING SUBTYPES OF MENINGIOMAS

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Aim. To verify the reliability of apparent diffusion coefficient (ADC) measurements in determining subtypes of meningiomas.

Material and Methods: Thirty patients (20 women and 10 men; average age, 53±15 years) with meningiomas were prospectively studied using Diffusion Weighted Imaging (DWI) with b values of 0 and 1000. ADC values of the neoplastic tissue were obtained as the mean of measurements from three regions of interests within the mass and compared with histologic subtypes using ANOVA test (SPSS16).

Results: The meningothelial subtype was found in 15 (50%) patients, fibroblastic in 10 (33.33%) patients and cystic in 5 (16.67%) patients. All meningiomas belonged to the WHO Grade 1 – benign meningiomas. There was no significant statistical difference between meningothelial, fibroblastic and cystic meningiomas when considering mean ADC values (0.000411+/-0.000066 mm2/s vs. 0.000750+/-0.001045 mm2/s vs. 0.000688+/-0.000063 mm2/s (p>0.05). Perifocal edema was present only with fibroblastic meningioma with mean ADC 0.000683 mm2/s. The ADC of the cystic component was statistically significantly higher in cystic meningeomas (0.001283 mm2/s) compared with fibroblastic (0.000224 mm2/s) and meningothelial meningiomas (0.000088 mm2/s) (p<0.001). The ADC of meningiomas was higher compared with contralateral healthy brain tissue (0.000642 mm2/s vs. 0.000404 mm2/s; n.s). According to the results obtained in our study, taking into account the localization of tumors, meningiomas have statistically significantly more supratentorial localization - 83.34%, compared to infratentorial localization in 16.66%.

Conclusion: ADC measurement does not seem reliable in identifying histological subtypes of Grade I meningiomas.

HOW MAY PET/CT REALLY HELP IN THE EVALUATION OF THE PRESENCE OF METASTASES: THE CASE OF LIVER METASTASES WHICH IS VISUALIZED ON THE BASIS OF CT BUT NOT ON THE BASIS OF PET/CT TECHNIQUES

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In this report, we analyzed the significance of (fluorodeoxyglucose positron emission tomography) FDG-PET/CT method in patients with primary colon tumors and metastasis in the liver and lungs, which are seen in conventional CT imaging, and histologically confirmed patients during treatment and during follow-up. Patient age 60 years was hospitalized in October 2012 because of productive cough without hemoptysis, suffocation and chest pain. Complementary immunohistochemistry was proven that it was a metastasis of the primary colorectal cancer. Magnetic resonance imaging (MRI) verified two focal changes in liver, localized subcapsular in the sixth segment, diameter and 2cm 4,4x4,3cm, and at the level of the sigmoid colon circumferential wall thickening predominantly laterally to the left, infiltration length is about 5cm. The patient is treated according to the protocol FOLFOX 4 + Bevacizumab (chemo and imunotherapy). After the fourth cycle of chemotherapy underwent CT scan of the chest and upper abdomen, which he described focal lesion in liver segment VI, 22x14mm in diameter, while the other focal lesions is not allocated. Re-evaluation of disease was done after 10 cycles of chemotherapy and biological therapy when done FDG-PET/CT. On the native CT examination focal changes in segment VI of the liver, but the PET/CT does not detect metabolically active foci. Colonoscopy showed three polyposis related to the presence of the primary tumor. It is built resection with removal of liver lobe and histology and showed the presence of the same tumor. In October 2013, there is a deterioration in the overall situation with the development of acute respiratory failure, which despite of applied measures of treatment leads to a lethal outcome in November 2013. The question is whether we should do surgical resection of any change detected imaging methods available and if they are at the PET/CT does not appear as metabolically active. Certainly the definitive nature of the change prove histopathological examination in accordance with the findings to plan appropriate treatment modality. In addition, future research should be directed towards examining the importance of imaging methods in the evaluation of therapeutic response after the administration of the new drug target.

CT FOR THE MONITORING OF OSTEOARTHRITIS: A RARE LOCALIZATION OF THE SHOULDER OF A BOY AGED 12 YEARS

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Acute osteomyelitis represents pyogenic infection of bone and bone marrow. On this occasion will be present a boy of 12 years with disease confirmed as osteoarthritis of the right shoulder joint. On administration was febrile, with pain in his right shoulder which occurred in the morning of the day after the one-hour workout. The pain increases when the movement and spread along the front of the upper arm, with a high temperature to 39,0°C. The laboratory and biochemistry finding: Leukocyte 10.9 x 10^{9}/L, Hb 122g / l; Fibrinogen 34.7, CRP: 56.8, ASTORIA: negative, RF: negative; ALT 53U/L, AST: 56U/L, RC: 56U/L. The changes were not observed in the conventional radiograph. CT right was done on the right limb using light sped 16 slice and by the native and contrasting series. On axial and reconstructive sections through the investigated region, on the eve of the fluid collection intra articular density rarely liquids (20 HU) are seen, with a thickened capsule and joint soft tissue swelling around the joint. On the bone structures are not observed the CT morphological changes. After the deterioration of the situation, elevated CRP levels, despite the antibiotic treatment, the operation is done. By surgery purulent content was removed, and after prolong antibiotic therapy, rehabilitation and leads to improvement in the overall situation. After 2 months on the control images, ultrasound shows that there are no changes, as well as normal CT while MRI showed minimal fibrosis tissue is not the place of surgery. This work shows the importance of achieving a timely diagnosis with the help of modern methods that include CT scan in order to initiate appropriate treatment and prevent the consequences of disease, which include deformities and morbidity. In this case, it was enough to confirm the diagnosis by means of CT, although it is sometimes necessary and magnetic resonance imaging.

ULTRASOUND TO MONITOR THE SIZE OF THE GALLBLADDER DURING MEALS

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Ultrasound is one of the non-invasive, inexpensive and widely available methods in medicine. Ultrasonic testing in gastroenterology is widely used because it is quickly and easily possible to test the size of gallbladder, its position, presence of anomalies, amenities that include the presence of polyps, sludge or biliary stones. In this paper we investigate the size of the gallbladder before and after meals with ultrasound in 15 patients with fatty liver. The size of the gallbladder measured including its width, length and thickness of the wall in patients with fatty liver at Cabinet for ultrasonography of the Clinic for Gastroenterology and Hepatology, Clinical Center of Serbia, Belgrade. Volume gallbladder is calculated according to the formula $V = 0.524 \times W \times T \times L$, where W (width) maximum width, T (thickness) is the thickness and the maximum length L. To test was used with Toshiba using convex probe PVT 375BT 3.5 MHz. The work is particularly focused on the functional test of time in which they are the most significant changes in the size of the gall bladder after 1h, 1,5 h, 2h and 3 h after the meal. As stimulation of the gallbladder, used the drinking of coffee, which is a good secretagogue. The results showed that over time there is to decrease the size of the gall bladder to response to stimulation, and that in the period after 1.5h to 2h been a statistically significant contractions (Mann-Whitey U test), while at time of 3 hours, no significant difference from compared to the value of a meal. This finding is likely due to the fact that after 3 h leads to relaxation of muscles and the gall bladder in the back of the previously state. This work has shown that with the help of ultrasound can be simply and easily track and compare the size of the gallbladder to confirm the functional state.

CASES OF ABSCESSES OF THE STERNOCLEIDOMASTOID MUSCLE

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The abscess of the sternocleidomastoid muscle is rare as localization. We present 3 cases of patients with sternocleidomastoid muscle abscesses. The etiology of the abscesses in all three cases is connected with regional non specific inflamation diseases. In the first case we have a patient with foliculitis of the neck, in case 2 - a patient with granuloma of the 7th tooth, and in case 3 - a patient with purulent tonsilitis and enlarged lymph nodes. We consider the rare localization of the abscess in this area due to the specific structure of the muscle.

RADIOTHERAPY 28

THE PENUMBRA OF IRRADIATIONS IN LINEAR ACCELERATORS, ITS USE IN RADIOTHERAPY OF CANCER DISEASES, NEGATIVE EFFECTS, AND THE POSSIBILITIES OF REDUCING THEM

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The aim of this study is to highlight the understanding of radiation, changes in the radiation of the same type but with different energy, the causes of these changes, the damages caused by their presence in the primary beam, or the reduction of the effectiveness of radiation, compared with the same radiation beam, in which the presence of penumbra is higher. Penumbra is the region near the edge of the field margin where the dose falls rapidly. The dose falls off around the geometric beam edge is sigmoid in shape and extends under the collimator jaws into the penumbral tail region, where there is a small component of the dose due to the transmission through the collimator jaws (transmission penumbra), a component attributed to the finite source size (geometric penumbra) and a significant component due to the in-patient X ray scatter (scatter penumbra). The total penumbra is referred to as the physical penumbra and it is the sum of the three individual penumbras: transmission, geometric and scatter. Without pretending that we can eliminate the negative effects caused by the presence of Penumbra in the primary beam, we note that: a part of the quantitative reduction of the radiation dose already performed through the use of high energy of linear accelerators and further reduction of the energy difference between the primary radiation with average beam energy can significantly improve the quality of the beam, including radiation.

* 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

NATIONWIDE AUDIT OF SMALL FIELD OUTPUT CALCULATIONS IN POLAND

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Purpose: Modern radiotherapy routinely involves the use of small radiation fields, either for the delivery of stereotactic treatments, or as components of intensity-modulated radiation therapy (IMRT). The purpose of the small field dose rate dependence audit is to check dosimetric data in the treatment planning system (TPS), as used for patient Intensity Modulated Radiation Therapy (IMRT) treatments, related to a radiotherapy treatment unit equipped with an MLC.

Material and Methods: The methodology worked out in the framework of the IAEA Coordinated Research Project E2.40.18 was used. The audit participants were asked to calculate the number of MUs for 5 MLC-shaped field sizes (10×10 cm², 6×6 cm², 4×4 cm², 3×3 cm² and 2×2 cm²) to deliver 10 Gy on axis at 10 cm depth, 100 cm SSD in water, using their treatment planning system. These calculations had to be repeated for each photon beam energy used for IMRT treatments. Eventually, they had to calculate the dose rate (Gy/MU) for each of the five MLC defined field sizes and normalize each value to the 10×10 cm² value. These results were compared with the benchmark data from the publication: "The Radiological Physics Center's standard dataset for small field size output factors" (Followill et al., Journal of Applied Clinical Medical Physics, 2012). Since this dataset did not provide data for certain beam qualities the interpolation/extrapolation was performed fitting the second degree polynomials to the RPC measured values.

Results: The audit was performed in 32 (out of 35) Polish radiotherapy centres for different linacs, TPS, MLC types and beam energies. The beam qualities ranged from 4 MV to 20 MV. In total, 81 beams were checked (Varian 41, Elekta 24, Siemens 16). When compared to the treatment planning system-calculated mean output factors, the RPC's mean measured values agreed for all field sizes and energies within 1% difference for Elekta machines. For Varian machines the difference exceeded 1% for 3×3 cm² and 2×2 cm² fields for 6 MV beams (1.6% and 2.3%). For Siemens machines the differences exceeded 1% for 2×2 cm² fields for both beam qualities 6 MV and 15 MV (1.6% and 1.7%).

Conclusions: The RPC's measured values provide a consistent dataset for small field output factors that can be used as a redundant QA check of a treatment planning system dosimetry data for small-field treatments. The RPC's measured values have a small uncertainty (standard deviation < 2%), while the values calculated from the various planning systems and their beam models had a greater uncertainty, especially for the smallest field sizes. Such QA dataset against which the institution can compare its measured or calculated values is helpful to ensure accurate IMRT dose delivery by identifying discrepancies prior to any patients being treated. Any discrepancies noted between the standard dataset and calculated values should be investigated with careful measurements and with attention to the specific beam model.

A PHANTOM FOR BRACHYTHERAPY TREATMENT PLANNING SYSTEM VERIFICATION WITH THE ARCCHECK® DEVICE

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Purpose: Brachytherapy HDR treatments are performed according to the plans calculated with the computerized treatment planning systems. The source positions and dwell times are established to produce required dose distributions. However, in general, the treatment plans are not verified. A phantom for such dose distribution verification is proposed to be used with the ArcCHECK system.

Material and methods: The ArcCHECK detector array and the SNC Patient software were designed by Sun Nuclear to verify dose distributions in the IMRT and VMAT external beam therapy. It is a cylindrical tissue-equivalent phantom, containing 3D detector array, consisting of 1386 SunPoint diodes. The detectors are located helically along the cylinder with the external diameter of 21 cm. We believe that the ArcCHECKphantom could also be used to verify the brachytherapy dose calculations. For this purpose a special additional part of PMMA, a Brachyplug, was designed and manufactured.

The Brachyplug is a special cylinder installed inside the ArcCHECK in which it is possible to place dosimetric films or ionization chambers. The phantom has a number of through holes, where the HDR catheters can be placed into which the Ir-192 stepping source may enter.

A special brachytherapy plan was created using the Ocentra MasterPlan planning system with 4 source positions in order to create evenly distributed dose over the detectors of the ArcCHECK array. In order to check the amount of dose which could be absorbed by the electronics of the ArcCHECK system the doses at the relevant distance were measured with the PTW dosimeter and a Farmer type 30013 ionization chamber placed in PTW RW3 plate phantom under the Brachyplug. The measurements were carried out with and without a shield, a 8 cm thick Wood alloy plug, designed in order to protect the electronic control unit of theArcCHECK from irradiation. After that the dose distribution for the planned source positions was measured with ArcCHECK device with 8 cm thick Wood alloy plug and Brachyplug placed inside the ArcCHECKcylinder.

Results: Measurements of irradiation according to the prepared plan indicate that when the ArcCHECKdetectors obtain the dose of 1 Gy the total dose which could reach the ArcCHECK electronics is 12.7 cGy. Such dose is acceptable and similar to the dose in a case of teletherapy. The ArcCHECK allowed for detecting and displaing in the SNC Patient software the HDR brachytherapy irradiation distributions.

Conclusions: The ArcCHECK device may be potentially used for pretreatment verification of dose distributions in brachytherapy. This would require the development of proper energy calibration procedure for the ArcCHECK detectors and the SNC Patient software update. The Brachyplug phantom will be used for further research on verification of clinical treatment plans in brachytherapy.

INFLUENCE OF DIFFERENT RADIOTHERAPY PARAMETERS ON OVERALL DISEASE / SPECIFIC SURVIVAL IN PATIENTS WITH LOW-GRADE GLIOMAS

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Objectives: Development of new alternative radiotherapy regimens in the treatment of supratentorial infiltrative low-grade WHO Grade II gliomas (LGG).

Materials and methods: A retrospective study was performed from 2003 to 2014 and 52 patients with LGG participated in it. Following histological variants of LGG were verified: diffuse astrocytoma – 35 (67%), oligoastrocytoma - 7 (14%), oligodendroglioma - 10 (19%). Women – 23 (44%), men - 29 (56%). Mean age – 39.50 years, median age – 37.32 years (standard deviation +/- 12.09). Mean Karnofsky Performance Status (KPS) – 76.92% (standard deviation +/- 12.29). 12 patients (23%) had gross total resection (GTR), 19 (37%) - subtotal resection (STR), 21 (40%) - stereotaxic biopsy (STB). All patients had radiotherapy, different dose per fraction regimes were used: 1.8 and 2 Gy per fraction (standard fractionation), 3 Gy per fraction (hypofractionation), 2 – 3 Gy per fraction (dynamic fractionation). Total dose was from 45 Gy to 64 Gy, and only in one patient total dose was 36 Gy, 19 patients (37%) also had chemotherapy. Equivalent dose was calculated using TDF (time-dose-fractionation) model, standard 2 Gy fractionation, once a day, 5 days a week.

Results: In our study, we analyzed overall disease – specific survival using Kaplan – Meir model and Log Rank (Mantel - Cox) statistic criteria. All patients were divided into two groups: patients who had total dose < 60 Gy, and total dose ≥ 60 Gy. 5 – year overall survival (OS) in patients with total dose < 60 Gy was 68% (19/28), in patients with total dose ≥ 60 Gy – 83% (20/24), however overall survival median (95% Cl) was 3,33 years (2,38- 4,54) in first group and 5,13 years (3,24-6,39) in second group. No statistically significant difference was found (p=0,230). Different fractionation subgroups had the following 5 – year overall survival rate: 1.8 Gy and 2 Gy – 96% (27 / 28), 2 Gy to 3 Gy – 60% (10/15), and in 3 Gy subgroup none of the patients reached 5-year survival mark (0/9). Median OS (95% Cl) was 4,89 years (3,88-6,45), 3,98 years (1,96-4,95) and 1,64 years (1,00-2,42) respectively. Difference was statistically significant (p=0,000). We also divided all the patients into two subgroups according to number of radiotherapy fractions. Patients with less than 27 fractions (<27) had 54% (13/24) 5 - year OS and median OS (95% Cl) – 2,56 years (1,77 – 4.17). Patients with ≥ 27 fractions had 93%(26/28) 5-year OS, median OS (95% Cl) – 4.84 (3,43 – 6,31). Difference was statistically significant (p=0,001).

Conclusion: No statistically significant difference was found depending on the total dose. Better OS rate was found in standard fractionation subgroup and in patients who had ≥ 27 treatment fractions.

Key words: low-grade cerebral gliomas (LGG) (grade II), radiobiology parameters of radiotherapy, the cumulative overall survival

AN INVESTIGATION OF DOSIMETRIC CHARACTERISTICS OF COMPOSITE SHIELDS FOR ELECTRON THERAPY: A MONTE CARLO STUDY

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Introduction: The goal of radiation therapy is to provide a homogenous dose to tumor and spare critical structures. When electron beams are used to treat superficial lesions, an oral or eye shield may be used to limit the dose to the healthy tissues. The following criteria is used to design such shields: a transmitted dose of less than 5%, proper thickness for minimum patient discomfort and minimal backscatter electron and bremsstrahlung production in order to prevent dose enhancement at the tissue- shield interface. In order to satisfy the above criteria, electron composite shields are made from a combination of materials of different atomic numbers (Z). In this study, we investigated dosimetric characteristics of composite shields made of a combination of high and low Z materials. Monte Carlo simulations were used to determine the optimize characteristics of a composite shield for applications in electron beam treatment.

Materials and Methods: Monte-Carlo models of 6, 8 and 10 MeV electron beams were developed using BEAMnrc code and were validated against experimental measurements. Using the developed models the followings were calculated under every shielding material combination: transmission percentages (TP), depth dose distributions (PDD), beam profiles and electron backscattered factors; defined as the ratio of dose at the tissue-shield interface to the dose without shield. All of the simulations and measurements were done in an acrylic phantom. A NACP Parallel palate chamber was used for measurements (ScanditronixWellhofer AB, Sweden). Shielding materials include: high Z- lead, tungsten, cerrobend and titanium and low Z- aluminum, nylon paraffin and polystyrene.

Results and Discussions: Using the same thickness of all materials, TP values for all energies were between 1.45% (tungsten, 6MeV) and 4.75% (cerrobend, 10MeV). PDD curves calculated under the shields showed the highest falloff gradient for tungsten and the lowest for titanium. Electron backscatter factor was highest for 6MeV for all shield materials, lowest for titanium in 6MeV and for tungsten in 8 and 10 MeV. Change in backscattered factor in all energies was studied by applying thicknesses of 0.5 to 2 mm of aluminum, nylon, paraffin and polystyrene to the shields. Results of this research can be used for custom designing composite electron shields for individual patients in our radiotherapy division.

EARLY RESULTS OF HYPOFRACTIONATION COMBINED WITH WHOLE PELVIC IRRADIATION FOR HIGH-RISK PROSTATE CANCER

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Objective: This study reports the early results and acute toxicity from treating patients with high-risk prostate cancer with combined conventional whole pelvic and hypofractionated prostate radiotherapy using the Simultaneous Integrated Boost technique.

Materials and Methods: The study included 20 patients with high-risk prostate cancer (stage T3 or Gleason 8-10 or PSA> 20 ng/ml). All patients received neo-adjuvant and concurrent androgen deprivation using LHRH agonists. In order to improve accuracy of radiation prostate radiopaque markers were implanted by TRUS guidance. All patients underwent CT, MRI, delineation of prostate, seminal vesicles, pelvic lymph nodes and critical structures. Planning target volume for prostate and seminal vesicles was generated by adding a 5 mm margin around gross tumor volume except posteriorly, where the margin was 3 mm. PTV for pelvic lymph nodes was 10 mm. The dose prescription to lymph nodes was 50 Gy in 25 fractions at 2 Gy per fraction. Simultaneously, prostate and seminal vesicles were given 68 Gy at 2.72 Gy per fraction (25 fractions), that is equivalent to 82 Gy (α/β=1,5) in conventional fractionation. Irradiation was performed at TrueBeam STx with RapidArc technique. Patient position verification consisted of two steps. The 1st step was CT, using ConeBeamCT, to verify bladder filling, location and filling of rectum, location of prostate. The 2nd step was to verify position of prostate by radiopaque markers, using ExacTrac system. Also, this system was used to assess and correct intra-fractional prostate motion. Side effects were assessed and recorded based on NCI CTCAE v.3.0. Patients were followed clinically 1 month after the RT, and then every 3 months.

Results: Median follow-up was 10 months (2 to 30). Most of rectal and bladder toxicities were recorded on the 4th and 5th week of treatment. The bladder toxicity manifested as frequent urination and burning sensation during urination. 8 patients (40%) had grade 1 GU toxicity, grade 2 was seen in 4 (20%) patients. 8 patients recorded no acute urinary toxicity. There was no grade 3 or 4 GU toxicity. None of the patients showed grade 2, 3 or 4 GI toxicity, while 3 (15%) patients experienced grade 1 GI side effects. Among 17 patients who were followed for more than 6 months after RT, no any further rectal or bladder toxicity was recorded. None of patients discovered signs of recurrence during the follow-up period.

Conclusion: Daily performed ConeBeamCT allows to verify bladder filling, rectal filling and rectal location while radiopaque markers provide the precise prostate position verification which in turn significantly reduces frequency and severity of side effects. Combination of conventional whole pelvic and hypofractionated prostate radiotherapy using Simultaneous Integrated Boost technique can significantly reduce duration of radiation therapy course. Patients are being observed for assessment of late toxicity and disease-free survival

CONVERAY®: A DEVICE FOR CONVERGENT BEAM RADIOTHERAPY

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This work investigates the feasibility along with main characteristics of a novel teletherapy device of radiation therapy based on a convergent X-ray beam capable of concentrating dose distribution around the target volume.

Converay® is designed to adapt to the head of conventional linear accelerators. Electrons produced by the linac impact upon various points of the anode cap, aimed at the focal point generating Bremsstrahlung directed forward. After passing the system of movable collimators, Converay® emits many beams from the output that make a virtually definitive convergent beam.

Monte Carlo simulations are performed using the realistic conditions. The simulations are performed for thin cap target of different radii. Dose distribution is calculated in a cubic water-equivalent phantom. All the interaction mechanisms of the Bremsstrahlung radiation with the phantom are taken into consideration for different energies and in correspondence to different physical/geometrical configurations of the Converay® dedvice.

The results achieved for the the first phase (convergent X-ray beam production) by means of Monte Carlo simulations show that the Bremsstrahlung generated on the thin cap is mainly directed towards the focus point. The obtained results for the dosimetry performance demonstrate that in-depth dose peaks are generated at the focus point or isocenter. These results are consistent with those obtained with Monte Carlo codes. The peak-focus is independent of the energy of the photon beam, though its intensity is not.

DOSE DISTRIBUTION IN ARCCHECK UNDER THE INFLUENCE OF POSITIONING ERRORS

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Aim: Using 3D CT-scan simulation in radiotherapy planning systems gives a better precision in the targeted structures and also a better protection of the organs at risk. Reproducing the patient's exact position every session of treatment as during scanning is still a problem in modern radiotherapy. The purpose of this paperwork is to analyses the influence of possible positioning errors in dose distribution during a Rapid Arc technique treatment.

Materials and methods*:* The experimental setup consist of: CT simulator "Siemens", Rapid Arc treatment plans using treatment plan system "Eclipse 13", Unique machine from Varian and the checkup device Sun Nuclear ArcCheck using the software "SNC patient 6.6".

Three different simulated Rapid Arc treatment plans were converted in the ArcCheck phantom device. For the first measurements the ArcCheck was aligned correct in order to verify the treatment plans and the next step was to move the ArcCheck up to 1 cm (independent moves on the three axis) and determine the dose distribution errors according to gamma errors criteria. Same measurements were done with a correct alignment on the three axis but with the rotation positioning errors up to 5^0.

Results: For positioning errors up to 0.2 cm on the three axis and 1^0 rotation positioning errors, less than 5 % of the measured points didn't pass the gamma criteria (3% or 3 mm). For positioning errors up to 1 cm on the three axis and up to 5^0 in rotation, errors which may be frequent in each treatment session, less than 50% of the measured points passed the same gamma criteria.

Conclusions: Having a better precision in the targeted structures with the new treatment planning techniques doesn't necessary means that we always have a better treatment. In order to obtain a real correspondence between the theoretical simulated plans and the real dose distribution during treatment, quality assurance as immobilization devices, portal imaging and dosimetry check-up systems are needed.

THE DOSE KERNELS FOR PENCIL BEAM AND DIFFERENTIAL PENCIL BEAM OF PHOTONS WITH THE SPECTRUM OF THE TREATMENT MACHINE WITH ^{60}CO SOURCE AND THEIR ANALYTICAL APPROXIMATIONS

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Article includes results of dose kernel Monte-Carlo calculations in EGSnrs program in terms of point spread function (differential pencil beam kernel) and pencil beam kernel in water medium for photons spectrum of ROKUS Co-60 treatment machine. Photons spectrum of ROKUS machine also was calculated with Monte-Carlo simulation. Calculated data were approximated along radial dimension separately for primary and scattered dose kernel terms with sums of exponential functions divided by radius for pencil beam and by square radius for differential pencil beam. This approximation makes possible direct implementation of Collapsed cones convolution method and Pencil beam method. Original algorithms were developed for verification of approximation formulas. Mean accuracy turned out to be better 5 %. Verification algorithms can be useful for independent checking calculations in radiation therapy.

IMPACT OF CALIBRATION CURVE PRECISION ON RESULTS OF IMRT VERIFICATION WITH EBT_3 FILMS

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This study aims to establish proper methodology for IMRT treatment plan verification using EBT3 film dosimetry. This preliminary part focuses on proper calibration curve fitting and its impact on results of gamma analysis.

First, scanner and film properties were tested, in order to estimate their important characteristics. The films in use were Gafchromic EBT3 together with EPSON Perfection V700 Photo scanner.

Three sets of calibration points were obtained for EBT3 film. Irradiation was carried out on a Siemens Artiste linear accelerator in the Thomayer Hospital in Prague, using the photon energy 18X. Film pieces of approximately 6 x 6 cm were irradiated with 16 doses ranging from 0 to 12 Gy in an RW3 slab phantom in reference conditions. Three sets of films of the same calibration doses were irradiated in three subsequent weeks and scanned in two different ways, changing the scanned region of interest. The mean value of each scanned piece of film was taken as one calibration point.

Different calibration curves were obtained in MATLAB, Excel and FilmQA Pro. Both polynomial fits with a fourth degree polynomial and rational functions as proposed in FilmQA Pro were assessed. Different approaches to curve fitting were examined: use of all measured points; omission of devious points from the calibration curve; average values of all sets of calibration points. The single channel approach was used in all cases, using the red channel.

Then films were irradiated with an IMRT plan for prostate and lymph nodes. The plan contained 5 fields with 18X photon beams and each field was tested separately with the gantry position at 0°. Moreover, two sets of irradiated films were evaluated, so as to minimize influence of film handling errors. Films were placed into the coronal isocentric plane of an RW3 slab phantom. They were scanned using the same protocol as for the calibration films, fitted with the different calibration curves in MATLAB and evaluated in OmniPro IMRT software using gamma analysis with 4 %/3 mm criteria.

Different gamma pass rates for the very same fields could be seen when different calibration scenarios were applied. These differences in gamma pass rates were not negligible, even when the estimated precision of calibration curves was similar. Best results were obtained with a MATLAB curve when all the three sets of calibration points were averaged out. This reduces the impact of film and scanner inhomogeneity and other deviations that can occur during film handling.

Careful investigation into the calibration curve assessment should be carried out when implementing film dosimetry for IMRT or VMAT verification into the clinic to achieve best results. Otherwise, results of plan verification can be dependent on calibration curve and can fail tolerance limits, even if the predicted and measured dose distributions agree reasonably well if measured properly.

RADON AND THORON

29

THE ITALIAN THORON REFERENCE MEASUREMENT SYSTEM

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Thoron (Rn-220) is a radioactive noble gas generated by the alpha decay of radium-224, a naturally occurring radioactive element belonging to thorium-232 decay chain.

Scientific literature, confirmed by direct experience of the authors, indicates that Thoron can be a real danger to human health.

For this reason, the INMRI ENEA (Italian National Institute for Metrology of Ionizing Radiation) his developing a reference measurement system for thoron gas, in collaboration with other European partners, in the frame of the MetroNORM project (Metrology of Naturally Occurring Radioactive Materials).

In particular, INMRI has realized two Thoron sources based on natural thorium in equilibrium with hits progeny and built two Thoron chambers where stable activity concentration of thoron are achieved. It was made a long series of measures with two monitor based on electrostatic collection cell: “RAMONA” made by the University of Naples and the commercial monitor RAD7 Durridge. These monuitors may distinguish Rn-220 from Rn-222. The third monitor in use is Tesys MR1 based on a scintillation cell (Lucas Cell).

Monitor calibrations for Rn-222 measures are based on "standard atmosphere" having known concentrations of radon. This approach is particularly difficult in case of thoron, due to hits very short half-life, therefore it is necessary to develop an absolute method for Rn-220 measurement. Sensibility (or calibration factor) of the monitor must be computed using Monte Carlo code, starting from hits technical characteristics and the physical process involved in the measure.

The Lucas scintillation cell (LSC) is a simple, classic detector where the alpha particles emitted by radon/thoron and their progeny interact with the ZnS(Ag) scintillator producing photon that are counted by a photo-multiplier. It is relatively easy to realize a suitable Monte Carlo model to calculate the detection efficiency of a Lucass cell. For this reason it was chose as reference monitor for thoron measure. Thus, in our thoron standard, MR1 is used to measure the actual Rn-220 activity, while RAD7 and Ramona monitors are used to check the presence of Rn-222.

In the present work we show alpha spectra of ^{220}Rn daughters collected in field in old roman houses. We describe laboratory Rn-220 measure realized with Ramona and RAD7 monitors, their features and limits in thoron measure.

The procedure adopted for continuous Rn-220 measure with Lucas cell is described. This procedure allows the determination of counting rate due only to Rn-220 and Po-216 and to give a measure of thoron activity concentration with about 5% uncertainty. Several measure are performed with different flow rate for sampling, they give all the same result within 2.5%.

RADON EXHALATION OF THE URANIUM TAILINGS DUMP DIGMAI, TAJIKISTAN

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The uranium tailings dump Digmai in Northern Tajikistan is situated near Khujand, the second largest Tajik city. Since 1963 uranium ore processing residues in slurry form were pumped into a tailings pond until the uranium production in Tajikistan was stopped in the 1990s. Until 2000 the surface of the tailings completely dried up and in the central and southern part of the dump deep desiccation cracks occurred. The surface area of the dump is almost 1 km^2 and the total quantity of uranium tailings is estimated at about 20 million tons. Because the dump is uncovered radon resulting from the high radium content of the tailings can be easily emitted into the atmosphere.

In a joint project of the Research Centre Jülich (Forschungszentrum Jülich GmbH, FZJ) and the Khujand State University (KSU) a radioecological survey of the Digmai uranium tailings dump was carried out in the period from 2012 to 2014. In order to investigate the seasonal variation of the radon emission automatic long-term measurements of the radon exhalation rate were performed at one location using a new device developed at Forschungszentrum Jülich. Area-wide measurements in 90 places showed the local variation of the exhalation rate all over the dump surface. In addition to exhalation measurements on the horizontal tailings surface measurements were also performed on the vertical walls of the desiccation cracks, where the radon exhalation rate was found to be significantly higher.

Besides the radon measurements area-wide dose rate measurements were carried out on the surface of the tailings and in some tailings samples the Ra-226 activity concentration was measured by means of gamma-ray spectrometry.

In the paper a description of the measuring equipment and an overview of the measured results will be presented, as well as an estimation of the total annual radon exhalation of the uranium tailings dump Digmai.

PROTOTYPE OF RADON CONCENTRATION STANDARD WITH CLOSED SYSTEM

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The present paper describes a prototype calibration standard system for radon concentration to use in establishing the traceability of radon concentration measurements in dwelling. Radon gas was generated with radium-226 solid source in certified volume as a closed system (50.4 l). The activity of radon which released in a closed system was determined from the difference between the absolute activity of the standard radium solid source and the residual radon decay products (^{214}Bi or ^{214}Pb). A high-purity germanium (HPGe) detector, which calibrated using gamma reference standard sources, was used for activity measurements of radon decay products (^{214}Bi or ^{214}Pb). The emanation factor of the ^{226}Ra source was controlled online by HPGe detector. Under equilibrium conditions the activity of the radon released from the radium source 4 kBq was found to be 1390±13 Bq and the activity transferred into the closed system produces radon activity concentration 30.1±0.3 kBq/m^3. The total systematic error was found ~ 4% with random error around 0.5%.The developed system with a low level of uncertainty can be recommended as a national or regional prototype standard of radon activity concentration to calibrate different working radon measurements devices.

ASSESSMENT OF INDOOR RADON LEVELS IN PORTUGUESE THERMAL SPAS

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Radon is a naturally occurring radioactive gas produced by the decay of radium-226 which is present in uranium ores, phosphate rocks, shales, igneous and metamorphic rocks such as granite, gneiss and schist. It is recognized as the most significant natural source of human exposure being appointed by the World Health Organization as the second leading cause of lung cancer after tobacco smoke. Therefore, the assessment of indoor radon levels is important from the point of view of radiological protection and public health.

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 spas thermal waters contributing in this way to the indoor radon. In particular, radon levels can be extremely high if these establishments are located in radon-prone areas.

Th main purpose of this work was to assess the concentration of indoor radon both within occupational and residential environments by considering different workplaces at Portuguese thermal spas and workers' dwellings located in areas identified with a potentially high level of indoor radon.

Measurements of indoor radon have been achieved using CR-39 detectors, placed both at the workplaces and at workers' dwellings, exposed for an average period of 45 days, in different seasons of the year. The indoor radon concentration in the selected thermal spas, ranged between 43 and 4335 Bq/m^{3,} with a geometric mean of 440 Bq/m^3 and an arithmetic mean of 687 Bq/m^3 while within workers dwellings radon levels ranged between 68 and 4051 Bq/m^3, with a geometric mean of 432 Bq/m^3 and an arithmetic mean of 805 Bq/m^3.

The results showed that the EU reference level of 300 Bq/m^3 (Directive 2013/59/EURATOM) was exceeded in several cases, being sometimes much higher at residential environments than at workplaces. The results also showed some variations related with the occupation of the space and ventilation as well as the influence from geological settings. According to the obtained results and the reference levels from the European Directive 2013/59/EURATOM, some recommendations are proposed in order to optimize the workers' exposure as well as some mitigation measures to decrease radon levels within workers' dwellings.

FIRST NATIONAL INDOOR RADON SURVEY IN SERBIA

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The accession of Serbia to the EU needs to harmonize regulative in the field of radiation protection and this will be one of the tasks we have to perform, and the radon is an important part of that process. In that sense, Serbia has started work on the national radon action plan (RAP) in 2014. The responsibility for the establishment and implementation of RAP is on national regulatory body in the field of radiation protection: Serbian Radiation Protection and Nuclear Safety Agency (SRPNA). SRPNA formed a “radon working group” that will manage RAP in Serbia. Radon working group consist of the representatives from the Institutes and Universities with the experience in the radon field, mainly through the research activities. The main task in 2015 is to perform the first national indoor radon survey in Serbia. The project is supported by the IAEA through the technical cooperation, the national project: SRB9003 - Enhancing the Regulatory Infrastructure and Legislative System: expert mission on “National Radon Trial Survey and Raising Awareness of Key Stakeholders” held in SRPNA, Belgrade, 2-4 February 2015 and leasing of track-etched indoor radon detectors. The distribution of detectors across the Serbian territory is the responsibility of SRPNA. In this work, the sampling design of the first national indoor radon survey is described in detail. The distribution of the detectors started in October 2015, and exposure time is six months. The first preliminary results from national indoor radon survey are expected in the first half of 2016.

EXPERIENCE IN MAPPING GEOGENIC RADON POTENTIAL IN RUSSIA

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We have selected a categorial GRP (geogenic radon potential) indicator as an end-state variable of our work. This indicator is generally similar to the categorical RI radon index used in the European countries. However, as input parameters, values of radon flow density (RFD) for the soil surface and radium specific activity in soils forming the territory of the city to a depth of 20 meters are used to assess GRP. Assessment of the geogenic radon potential level (category) of the specific territory depending on its determining parameters (low, medium, high), is based on the following:

high GRP: RFD > 150 mBq/m^{2}s, OR radium specific activity in the soil > 100 Bq/kg;

medium GRP: RFD < 150 mBq/m^{2}s, AND radium specific activity in the soil 40 - 100 Bq/kg;

low GRP: RFD < 150 mBq/m^{2}s, AND radium specific activity in the soil < 40 Bq/kg;

As a basis for the GRP mapping, the cadastral division of Moscow is accepted. Such approach is suitable for designing and building companies, which are are the main commercial consumers of information on geogenic radon potential of the Russian areas. The GRP map for Moscow territory is based on statistical results of engineering studies of more than 1000 plots. According to the received data, 51 cadastral quarters have been identified, where GRP assessment was high. Within 172 cadastral quarters, GRP was medium. The rest part of the city (1354 cadastral quarters) is specified by low GRP.

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ASSESSMENT OF POTENTIAL RADON HAZARD OF BUILDING SITES IN RUSSIA

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According to the Russian regulatory practice, an assessment of radon hazardous sites is based on measurement of radon flow density from the soil surface before the beginning of building activities. The majority of the European countries use an assessment of the various integrated indicators characterizing radon-induced hazard of the site, based on measurements of radon activity concentration in the subsoil air at a depth of 0.5-1.0 m and permeability of soil. However, both approaches have significant disadvantages connected mainly with large temporal variations of measured parameters (both of radon flow density and radon activity concentration in the soil air). Moreover, the radon concentration changes significantly due to the depth variation of the soil permeability and radium concentration in soil. Therefore, the radon concentration parameters being measured both on the ground surface and at depth of 1.0 m from the ground level, specify, strictly speaking, only the very near surface soil layer, of not more than 1.5-2.0 meter depth.

The paper proposes and justifies a comprehensive approach based on direct measurement of the radon concentration (such as radon flow density from the surface) and the calculated assessment of average annual separation of radon from soil lying in the area to a depth of laying the foundation base of the building. We developed an empirical equation to facilitate calculations on the basis of radium specific activity in soil, emanation coefficient, soil density and other properties of soil. At that, direct measurement of radon concentration help to identify radon anomalies at the site, because of the presence of geodynamic zones and faults on the site, while the calculation of radon flow from soil of the building base takes into account the presence of rocks characterized by elevated radium exhalation in near-surface part of the geological section. Research was supported by the Russian Foundation for Basic Research (RFBR).

RADON ACTIVITY CONCENTRATIONS IN UNDERGROUND WORKPLACES OTHER THAN MINES IN KOSOVO

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Radon (^{222}Rn) activity concentrations were measured in different locations of underground workplaces other than mines as hospitals, universities, schools and other public institutions in Kosovo. The aim of this study was to know about the indoor radon levels in these areas that were expected to be with high radon risk. The main method for this study was by exposing solid state nuclear track detectors (CR-39) in the winter season for three months. In these workplaces the radon activity concentrations ranged from 24 to 360 Bq m^{-3} and 0.36 to 6.41 mSv y^{-1} for annual effective doses calculated. According to Europian Legislation for Radiation Protection the limit from 300 Bq m^{-3} for workplaces was exceeded only in one place. The investigation should be extented in more underground and also groundfloor workplaces.

Key words: Radon, underground workplaces, concentration, dose, track detectors

* 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

SEASONAL AND SPATIAL VARIATION OF RADON AND THORON IN ANGOLAN ADOBE HOUSES

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Indoor radon and thoron is widely studied nowadays in all over the world. In adobe houses, indoor radon and thoron can potentially get accumulated from the walls of the building beside the soil and rocks below. This kind of building construction is widely used in Angola mostly in rural areas. However, no studies have been carried out regarding radon and thoron. This work aims to constraint the levels of radon and thoron activity concentrations in Angolan adobe houses at three regions with highly different geological background.

The three areas studied are Cabinda, Huambo and Menongue at the North, Central and South parts of the country, respectively. The indoor radon and thoron measurements were performed by Raduet passive detector pairs (Radosys Ltd.) and took altogether for a one year period in 2014 and 2015 divided into two seasons. These were the rainy season from November to May and the dry season from April to October. Fifteen houses per area, 45 in total were monitored.

The radon and thoron **average** (range) activity concentrations in Bq/m^3 are found to be the following:

· In Cabinda (North Angola)
o for radon **22** (12-39) in the rainy season and **20** (12-35) in the dry season;
o for thoron **169** (22-323) in the rainy season and **148** (22-284) in the dry season.
· In Huambo (Central Angola)
o for radon **106** (40-160) in the rainy season and **91** (42-152) in the dry season;
o for thoron **272** (28-560) in the rainy season and **250** (105-499) in the dry season.
· In Menongue (South Angola)
o for radon **48** (31-94) in the rainy season and **53** (31-53) in the dry season;
o for thoron **116** (27-569) for rainy season and **101** (47-237) for dry season.

The data of both radon isotopes show the highest indoor activity concentrations in Huambo with slightly higher values in the rainy season than in the dry. Here, the average radon activity concentration is higher than the worldwide value of 40 Bq/m^3 [1]. In the case of this study area it has to be also considered that the WHO recommends to keep radon values primary below 100 Bq/m^3 [2]. The thoron activity concentration average was measured significantly higher than that of the radon at the measurement location (about 10 cm from the adobe walls). These points out that inhalation doses from this isotope cannot be completely ignored even though there is no recommended limit value available in the literature.

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DETERMINATION OF RADON CONCENTRATIONS AND DIFFUSION COEFFICIENTS IN SOILS OF THE KÜÇÜK MENDERES BASIN

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Soil type and geology have the greatest effect on radon levels and is typically the largest source of radon. Because radon is a gas, it has much greater mobility than uranium and radium, which are fixed in the solid matter in rocks and soils. Radon can more easily leave the rocks and soils by escaping into fractures and openings in rocks and into the pore spaces between grains of soil. In this study, the radon exhalation in the soil gas was analyzed around geothermal fields of the Izmir-Bayındır region. In the field, six stations in three great soil groups were constituted and radon measurements were periodically taken for one year. The soil gas radon measurements were carried out by using LR-115 Type II nuclear track detectors.

As a result of the study, it was seen that the soil gas radon concentrations changed between 0.17 and 15.18 kBq m^{-3}. The radon diffusion coefficients were measured by using the obtained radon values. It was observed that diffusion coefficients change between 0.04 and 6.79×10^{-6} $m^2 s^{-1}$.

Key words*:* Radon, diffusion, earthquake, exhalation, Bayındır

DETERMINATION OF INDOOR RADON CONCENTRATION IN MANISA-SOMA MINE

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In this study, the radon concentration measurement underground coal mine that run by private company in the city Manisa-Soma was carried out. We detected 14 workstation and we placed to the different points of coal mine LR-115 track detectors. These detectors were kept at these points for 60 days. Collected detectors were carried out to Ege University Institute of Nuclear Sciences and proceed for experimental processes and lastly radon concentrations were obtained as Bq/m^3. We obtained minimum value 321.2 Bq/m^3 and minimum value 32.5 Bq/m^3. The measured values of radon concentrations are under the action levels 500-1500 Bq/m^3 recommended by International Commission of Radiation Protection (ICRP) for underground coal mines.

IN-FIELD INTERCOMPARISON INDOOR RADON MEASUREMENTS IN RADON-PRONE AREAS OF NISKA BANJA, SERBIA

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In the latest recommendations of the International Atomic Energy Agency (the new Basic Safety Standards) and the EU Directives (issued in January 2014), relating to the field of radiation protection, radon issues got much more importance since the World Health Organization has identified radon as the second cause of lung cancer. Application of the new European Directive will require competent measurement services in all member states. The indoor radon measurements have several standard procedures world-wide [1]. Intercomparison exercises are a very important tool for laboratories involved in radon measurements in order to detect potential problems and perform quality control procedures for monitoring the validity of measurements undertaken as well as to provide calibrations for instruments using international standards. Usually, radon intercomparisons are performed in radon chambers and in controlled conditions. Also, there is need to perform intercomparison radon measurements reproducing "in-field" conditions, likewise normal ordinary measurements conditions. In this work we present the results of the simultaneous in-field indoor radon measurements both by active method, i.e., short-term measurment and by passive screening method using charcoal canister, in the well-known radon-prone areas in Niška Banja, Serbia [2].

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PSA DISCRIMINATOR INFLUENCE ON ^{222}RN EFFICIENCY DETECTION IN WATERS BY LIQUID SCINTILLATION COUNTING

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A procedure for the ^{222}Rn determination in aqueous samples using liquid scintillation counting (LSC) was evaluated and optimized. Method applied assumed preparation of homogenous samples that contain 10 ml of sample mixed with 10 ml of liquid scintillation cocktail OptiPhase HiSafe 3. Measurements were performed by ultra-low background spectrometer Quantulus 1220™ equipped with PSA (Pulse Shape Analysis) circuit which discriminates alpha/beta spectra.

This paper presents improvement of calibration procedure described in EPA Method 913.0. i.e. investigation of ^{222}Rn efficiency detection dependence on PSA discriminator level variation and activity concentration of ^{226}Ra referential standard used. Quench effects on generated spectra and radon efficiency detection determination were also investigated with quench calibration curve obtained. Radon determination in waters based on modified procedure according to the activity of ^{226}Ra standard used, dependent on PSA setup, was evaluated with prepared ^{226}Ra solution samples and drinking water samples with assessment of measurement uncertainty variation included.

Key words: PSA discriminator, radon measurements, liquid scintillation counting (LSC), calibration factor

ESTIMATION OF THE EFFECTIVE DOSE FROM NATURAL SOURCES IN THE VICINITY OF MOCHOVCE NUCLEAR POWER PLANT, SLOVAKIA

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Under normal circumstances, natural radiation is the most important source of radiation exposure to the population. External sources of radiation consist of gamma radiation of rocks (mostly ^{40}K, ^{238}U and ^{232}Th), cosmic radiation and to a smaller extent, of gamma radiation of atmospheric radionuclides. The main sources of internal exposure are ^{222}Rn and its decay products (due to inhalation). Another radionuclides responsible for internal exposure are ^{40}K (ingestion), ^{220}Rn with its decay products (exposure mechanism is similar to ^{222}Rn) and ^{210}Pb (ingestion and inhalation).

In our contribution, a method for determining the effective dose to the population from natural sources of ionizing radiation in the vicinity of Mochovce nuclear power plant will be presented. All major contributions to the effective dose were taken into account, including the contributions from gamma radiation of soil and rocks, cosmic radiation, and indoor and outdoor radon and thoron. On the basis of recent indoor radon measurements in four Slovak cities and publicly available data about radon concentration in the soil air, a roughly linear relationship was found between these variables. Consequently, the annual effective dose from indoor radon and thoron was conservatively estimated. For the area of interest, map of conservatively estimated potential effective doses was created.

INDOOR RADON AND THORON CONCENTRATIONS IN SOME MUNICIPALITIES IN SOUTHERN PART OF SERBIA

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Study presents the results of indoor radon and thoron activity concentrations of residential houses in some municipalities at southern part of Serbia: Brus, Blace and Kursumlija. Measurements were carried out using passive discriminative radon-thoron detectors known as UFO detectors in 16 dwellings during winter season. The time interval of exposure was 90 days. The mean vales of measured radon and thoron concentrations were 97.9 Bq m^{-3} and 89.9 Bq m^{-3} , respectively. Bearing in mind the extremely carcinogenic effect of these radionuclides in human body we determined effective equivalent doses of inhaled radon and thoron-thoron progenies annually, with means values of 3.04 mSv y^{-1} and 0.89 mSv y^{-1} , respectively. There is no statistically significant indoor radon and thoron concentration with period of construction.

The results of this study represent the firs step of investigation radon and thoron levels in this municipalities in this part of Serbia.

Key words: Radon, thoron, UFO detector, period of construction, annual effective equivalent doses

THE STUDY OF RADON, THORON, ATTACHED/UNATTACHED PROGENY, UNATTACHED FRACTIONS, EQUILIBRIUM FACTORS AND THE RADIATION DOSES IN THE INDOOR ENVIRONMENT OF GARHWAL HIMALAYA

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The annual exposure to indoor radon, thoron and their progeny imparts a major contribution to inhalation dose received by the public. In this study, we report the time integrated passive measurements of indoor radon, thoron and their attached and unattached progeny concentrations that were carried out in Garhwal Himalaya with the aim of investigating whether the exposure to these nuclei involves significant health risk to the dwellers of the investigated region. The experimentally determined values of radon, thoron and their progeny concentrations were used to estimate the total annual inhalation dose, annual effective doses and equilibrium factors. The attached and unattached progeny fractions are found positively correlated, although only weakly, with Pearson correlations R^2 = 0.28 and 0.31, for radon and thoron, respectively (significant with $p < 0.01$ in both cases). The estimated values of equilibrium factors for radon and its progeny and for thoron and its progeny were found to be 0.42 and 0.07, respectively. The estimated value of total annual inhalation dose due to the exposure of radon, thoron and progeny was found to vary from 0.8 mSv/y to 4.6 mSv/y with an average of 1.8 ± 0.7 mSv/y. The estimated values of annual effective doses from the exposure to radon and its progeny and from the exposure to thoron and its progeny were found to vary from 0.5 mSv/h to 3.1 mSv/h with an average of 1.2 ± 0.5 mSv/y and from 0.2 mSv/h to 1.3 mSv/h with an average of 0.5 ± 0.3 mSv/y, respectively. The estimated values of radiation doses have shown no significant health risk due to exposure of radon, thoron and progeny in the study area. Moreover, the contribution of indoor thoron and its progeny to the total inhalation dose ranges between 13%- 52% with the mean value of 30%. Thus, thoron cannot be neglected when assessing radiation doses. The detailed description of measurement techniques and results obtained is given in the paper.

EXPOSURE TO RADON AND NANO AEROSOL IN DWELLING OF HIGH RADON LEVEL

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In two living rooms in a rural dwelling of high radon levels in the Karstic Region of Slovenia, radon was monitored all the year round (using Radon Scout devices, Sarad, Germany). While in one room in the ground floor without basement two inhabitants spend the majority of their daily time indoors, the other one in the first floor was mostly closed, and entered only occasionally. In the former, yearly average radon activity concentration was 7.2 kBq m^{-3} and in the latter, 1.3 kBq m^{-3}, in both with lowest values in summertime and highest, in wintertime. Correlations of radon level with outside air pressure and temperature were determined and are discussed. Based on radon concentrations, monthly, quarterly, semi-yearly and yearly effective doses of inhabitants were calculated for their entire time indoors, and for the time they actually spent in the room. The yearly values for the first case was 128 mSv and for the second, 120 mSv.

In addition, morning inhabitants' activities in the ground room were several times surveyed by measuring activity concentrations of the attached and unattached radon progeny (using EQF3020-2 device, Sarad, Germany), and number concentration and size distribution of the 5–1100 nm particles (using SMPS+C system, Grimm, Germany). Boiling coffee and preparing meals were strong indoor particle sources, augmenting their concentration from the background level of 3−4 thousand particles per cm^3 up to about 100,000 cm^{-3}. For each source, particle generation and loss rates were determined and are commented on. Because these activities were short, the influence of nano particles generated on the hourly run of the fraction of unattached radon progeny has not been manifested, and thus not affecting the dose conversion factor.

CONTROL OF PUBLIC EXPOSURE TO RADON IN REPUBLIC OF MOLDOVA

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With the publication of the fifth edition of the International Basic Safety Standards, of the WHO's Handbook on Indoor Radon and new ICRP statement on Radon, there is increased interest from the public health and radiation protection authorities on controlling exposure due to Radon and its progeny.

The IAEA Safety Standards GSR Part 3 "Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards" sets out requirements on governments for control of existing exposure situations, which includes exposure due to 222Rn.

In the radiation protection of the population exposure to natural sources an important role is to establish reference levels for indoor exposure to gamma radiation emitted by building materials, including for Radon. The new concept of Directive 2013/59/Euratom, based on the provisions of Recommendation 90/143/Euratom, reviews the exposure situations indoors as a mandatory requirement of the basic safety rules with sufficient flexibility regarding their implementation.

In the "Fundamental Norms on Radiological Protection Requirements and Hygienic Rules" in the Republic of Moldova stated that the average concentration of 222Rn in the air spaces designed, constructed or rebuilt with permanent habitation of humans, should not exceed 100 Bq/m3, and already constructed buildings – 150 Bq/m3.

Beside the fact that Radon contributes in a very high percentage of the human body irradiation his target is very precise – the lungs, particularly bronchial epithelium. There is an increased risk of lung cancer in proportion to exposure to Radon concentrations. Currently in the world are carried out epidemiological studies which try to estimate this risk factor. A considerable number of studies prove that the Radon is the leading cause of death from lung cancer in mine workers.

The Radon concentrations and its progeny in indoor air in different location in rural and urban areas of main zones of Republic of Moldova and also the correlation analysis between Radon concentrations and the incidence of lung cancer have been carry out in this investigation. The measurements of Radon were performed with the portable Detector RTM1688-2 (SARAD company production).

Data from the Cancer Institute Register about the cancers morbidity have been statistically analyzed. It was demonstrated that the concentrations of indoor Radon ranges between 96-622 Bq/m3 and in majority cases exceed exposure limits of 100-150 Bq/m3 recommended by authorities. It was found that the numerical value of the correlation coefficient between cases of lung cancer and indoor Radon concentrations was r=0.571. This indicates about a middle positive correlation between these two indices.

MAPPING RADON RISK ON TERRITORY OF REPUBLIC OF BELARUS

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The problem of natural radioactive gas radon, is an important problem of biology, ecology, and radiation medicine directly related to the population in many regions of the world. According to the report of UNSCEAR (1990), radon and its daughter products of decay is determined approximately 2/3 of the annual individual effective dose received by the population from terrestrial sources of radiation, and about half the dose from all sources of radiation. The most important factor is the dose-response effects of radon contained in indoor air, and the effects of α-radiation on cells highly sensitive respiratory system and increases the risk of lung cancer (WHO, 2005). In ICRP Publication №115 noted that public exposure due to radon may account for up to 20% of the total number of lung cancer. In line with international practice risk assessment and radiation protection from radon mapping taken hold territory. For the mapping of radon risk using the results of studies conducted Joint Institute for Power and Nuclear Research (Minsk) for 2005-2014. They were examined 6 regions and Minsk. The uniformity of the initial placement of dosimeters meets European requirements: Box 10 by 10 km (Friedmann H., 2005). The number of measurements on areas: Brest – 178 measurements in 71 locality (L), Vitebsk – 372 in 90 L, Gomel – 960 in 48 L, Grodno – 900 in 101 L, Mogilev – 585 in 89 L, Minsk – 201 in 54 L, city Minsk – 398 Total: 3594 measurements in 454 L. Map shows 5 gradations of volume activity of radon: 0-40 Bq/m^3, 40-70 Bq/m^3, 70-100 Bq/m^3, 100-200 Bq/m^3, 200-400 Bq/m^3. There is substantial heterogeneity in the distribution of radon in the territory of Belarus. In the southern and central regions (Brest, Gomel, southern districts of Minsk and Mogilev regions) have relatively low levels of radon in the room – up to 70 Bq/m^3. In the northwest of Vitebsk, Mogilev and north west of the Grodno area averages 2-3 times higher. Use the map defined “radon spot” of the critical level of radon danger – radon concentration of 200-400 Bq/m^3 (Grodno, Shklov, Gorki, Rosson, Miory, Sharkovshchina, Glubokoye, Dokshitsy districts). It should be noted that the analysis of the radiological situation should include a contribution from natural radionuclides from Chernobyl contamination. This will allow to fully appreciate the existing radiation risks of possible radiation effects and, taking into account the low efficiency of countermeasures after the Chernobyl accident, to raise the level of radiation safety through antiradon events or changes in the approach to rationing of radiation.

DOSE ASSESSMENT OF INHALATION EXPOSURE TO INDOOR RADON IN SUDAN USING SSNTDs

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Study of indoor radon has been carried out in a number of 207 measurements of Singa town in Sinnar State in Sudan, using CR-39 solid state nuclear track detectors (SSNTDs). The measurements of radon have become a global phenomenon due to its health hazard effects on population. Lung cancer risk depends upon the concentration of radon and their decay products in air above recommendation level. In the present study the value of concentration of radon ranges from (21 ± 4) Bq.m-3 to (86 ± 11) Bq.m-3 with an average value of (51 ± 8) B.qm-3. The recorded values of indoor radon concentration in our study are much lower than the radon action level 200-600 Bq.m-3 as recommended by ICRP-1993, slightly higher than the average world-wide value (population weighted) since the average radon of 40 Bq.m-3 has been reported by UNSCEAR . The effective dose rate ranges from (0.53 ± 0.11) mSv.y-1 to (2.16 ± 0.28) mSv.y-1 with an average value of (1.29 ± 0.19) mSv.y-1, which is slightly larger than the "normal" back ground level of 1.1 mSv.y-1; as quoted by UNSCEAR-2000, but way below even the lower limit of the recommended action level (3-10 mSv.y-1) as reported by the ICRP-1993. The lung cancer risk due to inhalation exposure of radon was found to range between (1.018 to 1.078) with an average of 1.046, which is consistent with other findings. KEYWORDS: Indoor Radon, Annual Effective Dose, CR- 39, Lung cancer risk.

RADON ACTIVITY CONCENTRATION IN DRINKING WATER IN TUZLA CITY, BOSNIA AND HERZEGOVINA

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Radon is a colorless, odorless, radioactive gas. It forms naturally from the decay of radioactive elements, such as uranium, which are found in different amounts in soil and rock throughout the world. Radon gas in the soil and rock can move into the air and into underground water and surface water. In this paper are presented the results of measurements of radon activity concentration in drinking waters from drilled wells in Tuzla City, Bosnia and Herzegovina. The obtained results of radon activity concentration in drinking water samples ranged from 182 $mBqL^{-1}$ to 2368 $mBqL^{-1}$ which does not exceed the value of 11.1 BqL^{-1} recommended by Environmental Protection Agency for drinking water. The measurements of radon activity concentration were done with AlphaGUARD and AquaKIT equipment (Genitron instruments).

THE ESTIMATION OF ANNUAL EFFECTIVE DOSE FROM INDOOR RADON AND RADON CONCENTRATION MEASUREMENTS IN THE GEOLOGICAL INSTITUTE OFFICE BUILDING, BUCHAREST, ROMANIA

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Since most of our time is spent indoors at workplace and radon together with its short-lived decay products (^{218}Po, ^{214}Po) in the buildings is the major source of public exposure to natural radioactivity, the measurement and evaluation of radon concentrations in buildings are important. This paper presents the measured indoor radon concentration and the annual effective doses from indoor radon received by researchers in the Geological Institute of Romania office building (GIR).

The radon concentrations were measured continuously during seven days in four rooms from each level of the office building. The GIR office building has thirteen floors, ground floor and two lower ground floors.

The Pylon AB-5 alpha monitor with Continuous Passive Radon Detector was used for measurements. The system was set to operate in *continuous mode* with the calibration factors of 0.060 ± 3.58% cpm/Bq/m^3 (1.664±4%). The specific activity of radon was measured at a height of 1.5 cm above ground level and radon exhalation rate was continuously measured for 168 hours with a counting time of 60 minutes /interval in each room. A statistical analysis was performed using the SPSS 17.0 software.

The concentration of ^{222}Rn in the offices ranged between 19.2 and 121.7 Bq/m^3. The highest concentrations of radon were found in the second lower ground floor of the building, where are stored the geological materials (rock, soil, fossil) and there is no mechanical ventilation, this is located under soil level. The frequency distribution of the radon concentrations measured and the Kolmagorov – Smirnov test (Sig. 0.14) (Sig. > 0.05) show an approximately normal distribution. This distribution depends mainly on the entry or production rate from various sources, the ventilation source, on the nature of building materials, soil type and geological background.

The indoor radon concentrations recorded are comparable to values reported for similar locations in other parts of the world; the mean of indoor of radon activity is lower than the range of 200 - 600 Bq/m^3 as recommended by the ICRP.

The annual effective dose received by the occupants of the working rooms for the using the assumed recommended value of 2000 hours per year at work and an equilibrium factor of 0.4 was found to vary from 0.10 to 0.72 Sv/y, which are below the rang of the action level (3 - 10 mSv/y) recommended by ICRP. The risk of exposure to indoor radon in the office building is very low and the occupants of these offices are therefore, relatively safe.

INTERCOMPARISON OF SELECTED MONITORS FOR Rn-222 ACTIVITY DETERMINATION IN THE AIR

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A comparative study of three types of active and one passive detectors for measurement of 222Rn concentration at the same conditions in a radon chamber was carried out. In intercomparison study SARAD EQF 3020, SARAD EQF 3220, RAD 7 and PicoRad detectors have been applied. Five days experiment was performed inside a 2 m3 radon chamber with a radon concentration of about 260 kBq/m3. A set of detectors were exposed at natural climatic conditions and with dynamically change aerosols concentration, by spread of oil aerosols at various injection time. Major task of used set of detectors was to222Rn activity concentration measurement, but several additional parameters: such F-factor, Thoron concentration, relative humidity and temperature of the air, pressure and other has been controlled. The aim of this study was to compare three active and one passive radon detectors in presence of aerosol in the air in radon chamber.

Radon activity concentration has been measured by SARAD EQF 3020, EQF 3220 (both SARAD GmbH Company, Dresden) and RAD7 (Durridge Company Inc., USA) detectors, at 2 hours measurement time, during 5 days sampling time. At first two days 222Rn activity concentration has been stabilized and non of the aerosols injection has been done. Starting from third day aerosols injection has been made twice per day, in the morning and in the evening. F-factor, thoron concentration, temperature, relative humidity and pressure parameters were analyzed automatically.

OTHER TOPICS 30

THERMAL CONDUCTIVITY OF REFRACTORY BRICK MATERIALS USING TRANSIENT HOT WIRE METHOD OF COMPARISON

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Thermal conductivity of refractory bricks made from the materials; Mfensi, Adankwame and Fomena clays, and their respective grogs and kaolin in their dry and damp states at atmospheric pressure have been measured at different porosity percentages. This was done, considering the effects of firing shrinkage and weight loss at **1200°C** and porosity for each material. The thermal conductivity values were determined by an unsteady state method, the transient hot wire method of comparison, which is based on the model of heating a cylinder of a perfect conductor surrounded by an infinite amount of a reference material whose thermal conductivity is being measured. A thin nickel wire, **50mm** long, is placed between the sample and soda lime glass of known conductivity. The heat generated by the current, **I**, and voltage, **V**, is recorded by the thermocouple as temperature and plotted as a function of time and used in evaluating the thermal conductivity. The percentage shrinkage for the samples are: **12.2%** for Adankwame, **9.2%** for Mfensi and **10.5%** for Fomena clays. Percentage porosities of the bricks ranged from; **34.27** to **45.60 %** for **Nfensi**, **31.18** to **32.50 % for Adankwame** and **Fomena** had **45.95** to **48.15 %.**The effective thermal conductivity values registered in the damp state are**1.181W/m°C**, **1.089W/m°C** and **0.852W/°C** for Adankwame, Nfensi and Fomena respectively. Lower values were registered for the effective thermal conductivity for the dry state. Thus; **1.026 W/ m°C**, **0.843 W/ m°C** and **0.761 W/ m°C** for **Adankwame**, **Nfensi** and **Fomena** bricks respectively. The thermal conductivity values of the refractory bricks increased with increasing temperature and decreasing percentage porosity. The rate of increase of these thermal conductivity values was higher at low temperatures and lower at higher temperatures. Designers use these results to calculate heat losses in refractory material applications.

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