10th Jubilee

RAD

INTERNATIONAL CONFERENCE ON RADIATION IN VARIOUS FIELDS OF RESEARCH

Spring Edition

June 13-17, 2022
Hunguest Hotel Sun Resort
Herceg Novi, Montenegro

BOOK OF ABSTRACTS

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Radiation sensitivity, DNA repair and death regulation of immunocompetent cells

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https://doi.org/10.21175/rad.spr.abstr.book.2022.0.1

Cells of the immune system are key mediators of inflammation. They also control cancer growth, which is harnessed for immune vaccination and immune checkpoint control in cancer therapy. We assessed the sensitivity of cells of the immune system to genotoxicants, focussing on the myeloid lineage. Previously, we showed that in monocytes DNA repair proteins of the BER pathway are downregulated, while during maturation into macrophages and DCs they become upregulated and cells aquire resistance to genotoxicants, including reactive oxygen species (ROS). Extending this work, we analysed DNA repair proteins in neutrophils and compared them with monocytes and T cells. We show that, similar to monocytes, neutrophils are deficient in BER. Monocytes, neutrophils and macrophages respond to activation by a ROS burst, which kills monocytes while macrophages are protected. We propose that the monocyte's death resulting from impaired DNA repair regulates the immune response by controlling macrophages and DCs in the ROS enriched inflammatory area. A comparative analysis of blood cell sensitivity to IR revealed that monocytes are not the most sensitive cell type in the hematopoietic system. T cells are clearly more sensitive, although they are repair competent, undergoing apoptosis following IR already in a low dose range. The mechanism of down-regulation of repair in monocytes and the high sensitivity of cells in the lymphoid lineage will be discussed.

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Role of total reflection X-ray spectrometry in nanomedicine

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https://doi.org/10.21175/rad.spr.abstr.book.2022.0.2

Analytical capabilities of total reflection X-ray spectrometry (TXRF) have been extended to medicine and biology, where accurate quantification of analytes has important implications for human health. An added layer of complexity in analyzing these samples involves the minute sample volumes often available. As such, TXRF has the potential to accurately measure the physiological interplay of trace elements in various pathologies and quantify the human exposure to environmental and/or medically introduced minor and trace elements. Both these aspects allow TXRF to make an impact in medicine and human health.

This presentation focuses on the application of TXRF for quantifying gold nanoparticles (AuNPs). They have unique characteristics compared to their bulk counterpart, making them ideal for various medical uses such as cancer therapy, biomedical imaging, photothermal therapy, and drug delivery. Given their extensive biomedical applications, it is imperative to understand both the benefits and potential side effects of AuNPs. In order for AuNPs to carry out their intended function, they must exhibit sufficient uptake in the tissue and cells of interest. In particular, the accurate assessment of AuNP delivery in tumours remains challenging, as currently used clinical approaches employ cumbersome sample preparation methods and questionable precision and accuracy.

In this presentation, we describe TXRF measurements of AuNPs, explaining the rationale behind their development, the methodology, and the health data. In addition, we provide our prediction on their potential future use.

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Determination of the inhibitor effect of boroxin on acetilholinesterase activity

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Halogenated boroxines belong to derivatives of cyclic anhydride of boronic acid. It has been suggested that halogenated boroxines can be used in the prevention and/or treatment of benign or malignant changes of the epidermis visible in the form of, nevus or skin cancer. In the development of boronic acid-based enzyme inhibitors as potential pharmaceutical drugs, dipotassium trioxohydroxytetrafluorotriborate $K_2[B_3O_3F_4OH]$ was listed as a promising new therapeutic for treatment of these diseases. The acetylcholinesterase-mediated conversion of acetylcholiniodide, in the presence and absence of boroxin $K_2[B_3O_3F_4OH]$ was studied. The kinetic processes and reactions involved in the operation of the amperometric biosensor are the reactions between the enzymes and its substrate. The results obtained indicate a competitive type of inhibition in boroxin. Using the Lineweaver-Burk equation, the values of kinetic parameters of maximum velocity and Michaelis-Menten constant were calculated which decrease with increasing concentrations of $K_2[B_3O_3F_4OH]$.

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Association of marker of inflammation, hepatic enzymes and lipid profile in non-treated T2D patients

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Type 2 *diabetes mellitus* (T2D) is characterized by hyperglycemia as well chronic low-grade inflammation and is associated with dyslipidemia and disturbed hepatic function. It is well known that liver plays an important role in maintenance of normal glucose levels during fasting as well as in the post prandial period. Although the pathogenesis is unclear but insulin resistance and chronic inflammation is thought to play an important role in triglyceride accumulation. Altered lipoprotein pattern and hepatic enzymes have been identified as independent risk factors for the development of many disease and metabolic disturbances. Aim of the present study was to assess C-reactive protein (CRP) as well the hepatic enzymes and to find its association with lipid profile in newly diagnosed T2D patients. A total number of 51 subjects were recruited in this study: a newly diagnosed diabetes (24) and healthy control (27) participants. The biochemical parameters like fasting glucose, HbA1c, CRP, lipid profile (total cholesterol, triglycerides, high density lipoprotein cholesterol), hepatic enzymes (alanine amino transferase, aspartate amino transferase, gamma-glutamyl transferase, and alkaline phosphatase) were analyzed by using standard IFCC methods. Low density lipoprotein cholesterol (LDL-C) was estimated by Freidwald's formula. All the glycemic control parameters, lipid profile parameters and hepatic enzymes were found increased in diabetes group and significantly differ from control group ($p>0.001$). A significant association between CRP with HDL levels as well as ALT and GGT activity with HDL levels was observed in control group. In non-treated diabetics a negative significant association between AST and HDL levels was found while association between lipid profile and other liver enzymes were not demonstrated. Interestingly, in diabetic patients a negative association between CRP and AP levels was observed. These findings suggest that marker of inflammation (CRP), hepatic enzymes activities and impaired lipid metabolism may play an important role in pathogenesis of T2D and related complications.

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Influence of the seasonality factor on the biochemical parameters of the blood from dogs (breeds *Beagle*, *Pomeranian*, *Jack Russell Terrier*)

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Previously, we have defined breed characteristics of the biochemical parameters of dogs' blood serum [1]. There were determined: the activity of aminotransferases EC 2.6.1.2 (ALT) & EC 2.6.1.1 (AST); lactate dehydrogenaze EC 1.1.1.27 (LDH) and of some others enzymes of homeostasis. The results of 12-month monitoring of biochemical parameters of blood serum from dogs were analyzed by methods of mathematical non-linear dynamics. Breed features of the activity of serum enzymes of homeostasis as well as the concentration of trace elements were revealed [1].

We continued biochemical monitoring of the blood of healthy dogs of different breeds, as well as animals with metabolic and cardiovascular diseases. For this, groups of animals were formed according to the principle of conditional physiological analogues. The total number of domestic dogs of various breeds and ages selected for research was 157 individuals. The analysis included the determination of the main 30 markers of the body's metabolism (enzyme activity, trace element concentrations) and the cluster, statistical and dispersion analyzes in the "*STATISTICA 6.0"* package.

The method of mathematical nonlinear dynamics made it possible to group the results according to the general direction of changes in homeostasis depending on the month of observation in dogs of different breeds. In accordance with this, we present some of the results. In the blood serum of dogs of the Beagle, Pomeranian, Jack Russell Terrier breeds, the content of *total protein* increases in March-May, with a peak value in April. This occurred with a simultaneous sharp decrease in the amount of *albumin* and a significant ($p < 0.05$) increase in the content of *globulins* against the background of a fairly stable level of protein concentration in other months of observation. The activity of *hydroxybutyrate dehydrogenase* sharply and significantly increased in April (with a strong individual scatter of data). The *glucose* content and *lipase* activity in the fifth month increased, significantly deviating from the indicators of all previous and subsequent months of observation.

The content of $\boldsymbol{K^+}$, $\boldsymbol{Na^+}$ and $\boldsymbol{Ca^{2+}}$ was stable before and after the fourth month, and since April the concentration of ions has been decreasing. A significant drop in the content of Mg^{2+} in the blood serum also falls on the month of April.

Work on creating a mathematical seasonal model for changes in homeostasis indicators has begun.

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Redox proteomic profile of tirapazamine-resistant hepatoma cell line

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The derivatives of 3-amino-1,2,4-benzotriazine-1,4-dioxide (tirapazamine, TPZ) possess potential application as radiosensitizers and in the treatment of hypoxic tumors. Their action is attributed to bioreductive activation and free radical generation. Although their aerobic cytotoxicity is lower than under hypoxia, it is important as the side-effect in the treatment of hypoxic tumours. Besides, some TPZ analogues possess anticancer activity at micromolar concentrations even under oxic conditions. In order to clarify the mechanisms of resistance of cancer cells to TPZ under oxic conditions, we obtained a TPZ-resistant subline of MH22a murine hepatoma cells (cL_{50} = 1.75 x 10^{-4} M *vs.* 3.1 x 10^{-5} M in parental cells). This subline was also resistant to H_2O_2 (cL_{50} = 1.70 x 10^{-4} M *vs.* 7.6 x 10^{-5} M) and to bioreductively activated antitumour agent 2,5-diaziridinyl-3-hydroxymethyl-6-methyl-1,4-benzoquinone (RH1, cL_{50} = 6.0 x 10^{-7}M *vs.* 1.2 x 10^{-7} M), but was equally sensitive to daunorubicin (cL_{50} = 6.0 x 10^{-6} M). The proteomic analysis of TPZ-resistant cells (total of 5818 proteins) demonstrated the upregulation of antioxidant enzymes aldehyde dehydrogenase (1.76-5.18-fold), carbonyl reductase (1.59-2.62-fold), catalase (2-fold), and glutathione reductase (1.77-fold). Glutathione-S-transferase that participates in the detoxification of xenobiotics, was also upregulated by 1.64-2.63-fold. In contrast, NADPH:cytochrome P-450 reductase and mitochondrial NADH:ubiquinone reductase which participate in the bioreductive activation of TPZ, were downregulated by 2.06 and 1.8-fold, respectively. The downregulation of glucose-6-phosphate dehydrogenase (2.5-fold) and L-lactate dehydrogenase (6.3-fold) was evidently related to the retarded growth of the resistant subline. Because the expression of DNA repair enzymes in resistant subline was practically unaltered, our data point to the membrane lipid peroxidation as to one of the main manifestations of TPZ oxic cytotoxicity.

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Evaluation of standard single-electron reduction potential of nitroaromatics by modified approach

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There is a continuous interest in quantitative characterization of electron-accepting or donating properties of nitroaromatic compounds in aqueous media because of their importance in industry, biomedicine, and environmental pollution. In particular, radiosensitizing activity and prooxidant cytotoxicity of nitroaromatics increase with an increase in their single-electron reduction potential at pH 7.0 (E^1_7). However, its estimation by means of cyclic voltammetry or pulse-radiolysis may be impossible because of insufficient compound solubility or instability of free radicals. Currently, the theoretical approach such as density functional theory has been used for this purpose. However, the data of calculations *in vacuo* may significantly deviate from the experimentally E^1_7 values, or may be confined only to a series of homologous compounds, *e.g.,* nitrobenzenes [1-3]. Thus, the new methods are proposed to overcome the above mentioned shortcomings. In this aspect, an attractive approach is the use of Born-Haber cycle protocol with the implicit solvent model involving the participation of a certain number of water molecules forming H-bonds.

In this study, the above method was tested for prediction of E^1_7 of several groups of nitroaromatic compounds. The B3LYP/ccp-VTZ approach was applied to obtain the geometric and electronic structure of molecules. The Polarizable Continuum Model (PCM) using the polarizable conductor calculation model was applied to assess the interaction of water molecules with nitroaromatics, in particular analyzing the possible clustering of water molecules. We obtained the coefficient of determination of 0.7 between the experimental and theoretical E^1_7 values of 20 nitroaromatics, including mono- and polinitrobenzenes, nitrothiophenes and nitrothiazoles. This indicates a high coincidence between experimental and theoretical results. It implies also that this approach provides a simple, fast and accurate quantitative method to predict redox potential without the requirement of large computing resources and expenses that are typically associated with molecular computation. Moreover, the use of this approach enables one to foresee the possibility of clustering of water molecules around the functional groups of electron-deficient aromatic compounds. One may suggest that this approach may be useful for the prediction and buildup of the regions of enhanced reactivity in biomimetic systems.

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Quantum mechanics-based calculations of the size- and sequence-effects on the ionization energy of stacked DNA bases

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Deoxyribonucleic acid (DNA), the carrier of human genetic information, is exposed to many influences, which can cause severe damage leading to serious detrimental effects on its functionality. In particular, the environment we live in generates both natural (i.e. UV light from the sun) and artificial ionizing radiation. The influence of ionizing radiation on DNA has been intensively investigated by different approaches from a macroscopic view to a microscopic picture of the DNA building blocks. Guanine (G) is known to have the lowest ionization energy (lower than those of single adenine (A), cytosine (C) and thymine (T) bases) among the DNA nucleobases [1-3] while the GG or GGG stacks have an even lower ionization energy [4]. These findings are supported by quantum mechanics-based calculations performed on DNA base stacks that have revealed a tendency of vertical ionization energies (vIEs) to decrease when the system size is increased [5]. However, in gas-phase simulations, no convergence of the vIEs values has yet been achieved up to the maximum size considered [6] and no studies provided a systematic study of vIEs as a function of the DNA sequence.

Our work aims at improving our understanding of the DNA photoionization by investigating the ionization energy of short single-stranded DNA sequences in gas-phase using quantum chemistry methods. The methods used must take into account as much as possible the effects of electronic correlation despite the computational constraints imposed by the large size of the DNA complexes. Therefore, we have developed a DFT-based (*Density Functional Theory*) computational method with an optimized medium size basis set. This approach allows a broad analysis of the ionization potential of DNA stacked sequences with different lengths and types of nucleobases. In particular, we achieve a systematic study of the ionization potential of all combinations of two, three and four stacked DNA bases.

Our investigation of the ionization energy is also extended to sequences containing 5-methylated cytosine (5-mC) [7]. Quantum mechanics calculations carried out on isolated methylated cytosine as well as on two- and three-base stackings containing 5-mC indicate that methylation tends to decrease the vIE of the DNA base sequence.

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The interactions between photosensitizer and cancer therapeutical targets—a computational approach

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Photodynamic therapy has the potential to be a novel and successful cancer treatment. Photodynamic therapy generates singlet oxygen due to the photoactivation of a sensitiser with a light source. While in vitro and in vivo studies are encouraging, the molecular mechanism is still unclear.

To compare our findings, we employed a similarity prediction to find the clinically used compound closest to the TPPS.

Using molecular docking simulations, we predict the binding energy of the 5,10,15,20-tetrakis (4-sulfonatophenyl) porphyrin (TPPS) photosensitizer on BCL-2, BCL-xL, BCL-W, BCLB, MCL-1, A1, Fas, NFKB, EIF2AK1, and β-catenin proteins to determine the mechanism of action of TPPS and possible protein targets.

We predicted the TPPS toxicity profile with an emphasis on hepatotoxicity and carcinogenicity. We also discuss the TPPS interactions with the Cytochrome P450 enzyme superfamily members: CYP1A2, CYP2C19, CYP2C9, CYP2D6, and CYP3A4.

Our data reveals that temoporfin is the compound that most closely resembles TPPS and that TPPS photosensitizer has similar or lower toxicity than temoporfin. TPPS also has low projected binding energies on all probable targets. But, we obtained the lowest predicted binding energies when TPPS interacts with A1 and BCLB receptors.

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Influence of UV irradiation on color strength, antimicrobial and dielectric properties of printed linen fabrics modified with ZnO and *Pinus sylvestris* L. extract

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In this paper, the experimental study of the effect of the UV irradiation on color strength, antimicrobial and dielectric properties of printed linen fabrics were investigated. The samples were screen printed using alginate paste (CHT-NV) with alcoholic extract of *Pinus sylvestris* L. plant and ZnO. All samples were exposed to 254 nm and 365 nm UV light for 24 h and after irradiation color strength, dielectric and antimicrobial properties were measured. Influence of two different UV lamps exposure was studied in detail. Color strength and color coordinates (CIE L*a*b*) were calculated using a Konica Minolta CM-2600d spectrophotometric measurements. In addition, the antimicrobial properties of the samples by agar diffusion method on *Staphylococcus aureus* and *Escherichia coli* were investigated. Dielectric spectroscopy measurements were taken on a Hameg LCR bridge in a frequency range between 20 Hz and 200 kHz. Alginate paste (CHT-NV) with *Pinus sylvestris* L. plant extract modified with ZnO results in an enhancement in color fastness and an increase in electrical conductivity. Also, it has been confirmed that the UV irradiation greatly influence on measured properties. Judging from their excellent properties, these materials can be used for clothing applications in environments in which there is a risk of transfer of microbes, or as antistatic materials.

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Application of droplet debonding testing method in dental bond strength investigations

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Introduction and Discussion. When examining the adhesive bond strength in the field of dental materials, tensile and shear tests are typically employed. According to the available data, in more than 20% of the extant studies about adhesion of dental materials shear bond strength method was used. Shear bond strength test method is highly dependent on the type of substrate being tested, the rigidity of the test material, sample preparation and storage. There is evident need for implementation of a simplified testing method that could be comparable with shear bond strength test in terms of precision and reliability. For the group of polymer materials in general, the most proposed test method is droplet debonding test. Compared to the standard shear bond test method, droplet debonding test is highly simplified, as it requires fewer specimen preparation, there is no need for human material preparation and storage, as well as eliminates the specimen cutting phase. Most importantly, the testing apparatus and procedure can be standardized, allowing the obtained results to be compared across materials or studies. In the droplet debonding test, the interfacial shear strength of different dental materials mainly resin based materials, is calculated by determining the force required to debond the droplet of investigated material from the contact area between the droplet and the fiber.

Conclusion. The droplet debonding test method is simple to use and can yield reliable information on the adhesive bond strength of different resin-based dental materials. It is worth noting that, unlike in the shear bond test method, no special sample preparation is needed prior to conducting the test, and there is no potential for damaging the specimen.

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Photopolymerization of gelatin methacryloyl hydrogels using UV-pulsed radiation and its biomedical applications

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Because of its accessibility, transdermal drug delivery is preferred over oral drug delivery for drug transport to the systemic circulation. In this regard, hydrogels are a viable option for improving drug therapeutic action while minimizing the drawbacks of traditional delivery systems, proving particularly effective in preventing drug degradation and controlling drug release. Hydrogels are three-dimensional polymeric networks that can be employed as drug delivery systems in a range of medical sectors such as cardiology, cancer, immunology, wound healing, and pain management. UV-curing technology is widely employed in a range of industries due to its benefits such as less pollution, lower energy usage, and faster curing.

The mixture of gelatin methacrylate (GelMa) and Irgacure 2959 was placed in molds and exposed to laser radiation at energies ranging from 0.25 to 1 mJ for 1, 5, 15, 30, and 60 minutes. The spot was the same size as the inner diameter of the mold. The fourth harmonic of an Nd:YAG laser was used for photo-crosslinking. The crosslink reaction was measured over time during laser exposure using laser-induced fluorescence analysis and predicted based on the optical properties of the photoinitiator. To investigate the properties of the solutions and the hydrogel, FTIR spectroscopy (structural arrangements), SEM (surface topography and composition), swelling measurements (capacity to hold the aqueous medicine), and UV-Vis absorption spectroscopy were used.

The production of the two radicals, benzoyl and hydroxyalkyl, was confirmed by UV-Vis and FTIR spectra during Irgacure 2959 laser exposure. Taking the swelling rate, the amount of chlorpromazine released, and the appearance of the hydrogel into account, the solution containing Irgacure 2959 (0.05%) and GelMa (10%) irradiated for 1 minute at 0.75 mJ produced the best hydrogel. It was also discovered that both non-irradiated CPZ-loaded hydrogel and irradiated CPZ-loaded hydrogel completely prevented bacterial colony adhesion and biofilm formation on their surface. Furthermore, the fluorescence and fluorescence kinetics profiles can be used to monitor the attachment of radicals to polymer backbones as well as the surrounding environment. This method can be used to determine the completion of the hydrogel currying process.

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Air pollution in Kosjerić and lung cancer risk

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The aim of investigation is to reduce air pollution, as potential cause of lung cancer and respiratory diseases in Kosjerić, town in Western Serbia. Kosjerić is situated in valley of the river Skrapež, surrounded by mountains over 1000 meters elevation. The mountain surrounding, high humidity and absence of winds contribute to the retention of harmful air pollutant in the city.

The air quality in Kosjerić, is classified as the 3rd category, background zone. Air in Kosjerić is excessive polluted due to high concentration of suspended particles PM 2.5 and lower, as well as, mineral dust with Cr (VI), Si, As, generated during cement production and metal industry.

The suspend and sediment particles and metals within such as As, Cd, Pb, Ni, Zn and Cr within were measured and analyzed for 5 year period. Crystalline Si dust (quartz), As, and Cr (VI) compounds have been classified as group 1 carcinogens to human health by the International Agency for Research on Cancer, where the primary target organ is the lung [1]. PM 2.5 particles are with overrange limit values during December 2019, in range from 90 till 170μg/m^3 during evening hours. In January 2020 it reached values from 150 to 200 μg/m^3 in the early morning hours. Except of lung cancer, respiratory diseases together with Covid 19 have taken 44% between all diseases during 2020.

Instrumental techniques used for air pollutant analysis were: ICP, GC-MS and statistic software. The test filters for deducting systems were analyzed by SEM and optical microscopy. Due to small size, particles of 2.5 and smaller easily inhaled and penetrate deep into the lungs, enter in bloodstream and that's way are very dangerous. The average concentrations of mineral dust have to be reduced for 30% in order to reduce high health risk.

The solution will be addressed to multistage filtration for PM particles and mineral dust.

Keywords: Air pollution, suspended particles PM 2.5, multifunctional filters, cancer lung risk

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The morphology of Harderian glands after the implantation of polycaprolactone films into the cornea

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Polycaprolactone (PCL) is a biodegradable polyester and is widely used material as medical implants. Of particular interest is the use of PCL as a corneal implant for the bullous keratopathy treatment. In addition, despite the abundance of literary sources on the use of PCL in medicine [3, 4], there is no information regarding the effect of this polymer on morphological changes in Harderian glands (HG) during implantation of the PCL films. The purpose of this research is to determine the morphological changes in the HG after the implantation of PCL films into the corneal stroma of the eye.

The feedstock for films was obtained by dissolving PCL (Netherlands) in the chloroform ($CHCl_3$). 10 pubescent male Sylvilagus bachmani rabbits weighing 2.5-3.0 kg were used. The animals were divided into 2 groups: 1st group (n = 4) – the intact (control) group; 2nd group (n = 6) – animals with an implanted PCL film with a diameter of 8.0 mm in layers of the cornea's own substance closer to the Descemet's membrane. The overall duration of the experiment comprised 30 days. Sampling (HG) was performed on day 30 after the start of the experiment for morphology studying. The counting and photographing of HG cross-sections was carried out at a magnification of 400 times using a Mikmed-6 microscope (LOMO, Russia) and an MPKS digital video camera (LOMO, Russia). The specific volumes (%) of the epithelium and stroma of the HG were calculated using Avtandilov's ocular insert. The epithelial/stromal ratio (ESR) was also calculated. The optical coherent tomography of cornea was carried out on Cirrus HD-OCT 5000 (Germany).

As a result of the research, the implantation of the PCL films into the corneal stroma of the eye is accompanied by the development of minor reactive changes in the HG, such as moderate vascular congestion, edema of the gland stroma, which cause with nonspecific reactive changes in the HG. The reactive changes in the HG (moderate vascular congestion, edema of the gland stroma) indicate an exogenous mechanism – a surgical effect on the morphological transformation of the gland.

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Kinetics of the accumulation of Ag in the internal organs and brain regions of mammals at the long-term oral exposure to Ag nanoparticles obtained by the Neutron Activation Analysis

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Ag has been used for medical purposes from the Ancient times due to its pronounced antiseptic properties. Silver nanoparticles (Ag NPs) are widely applied in food, light, cosmetic industries, medicine and pharmaceutics since the beginning of XXI century. Today it is well known that Ag NPs can demonstrate toxicity on the different cells, tissues, organs and systems of an organism. Their toxicokinetics is not sufficiently studied. Nowadays it is clear that the way of Ag NPs interaction with biological objects is significantly depends on the characteristics of the NPs such as size, shape, coating type, etc. Thus, hydrophilic stabilizing shells provide longer circulation in blood, while hydrophobic coatings provide attachment to the plasmatic membranes and accumulation in fat-rich tissues.

In this research, the kinetics of accumulation of quasi spherical Ag NPs (size 34±5 nm) with hydrophilic coating based on polyvinylpyrrolidone in the organisms of laboratory mammals at the prolonged daily oral exposure were described. The source of Ag NPs was dietary supplement Argovit-S (Novosibirsk, Russia) recommended for GUT diseases treatment. The NPs were preliminary characterized by Dynamical light scattering and Transmission electron microscopy.

Male mice C57Bl/6 since the age of 2 months were used as the mammalian model. All the animals were divided by experimental and control mice. The experimental mice received Ag NPs as the daily oral exposure with drinking water in ad libitum mode during 30, 60, 120 and 180 days. Control mice were not exposed to Ag NPs. At the end of the administration periods the animals were euthanized and their internal organs (brain, lungs, testes, liver, heart, spleen) and blood were collected. The brains were divided into the regions (hippocampus, cerebellum, cortex, and remnant). The masses of Ag in them were measured by Neutron Activation Analysis and then recalculated into concentrations.

Statistical analysis was performed using the Mann-Whitney nonparametric test. Differences were considered significant at $p \leq 0.05$. The saturation times of the curves of accumulation were established using this approach.

An extremely high accumulation of Ag in testes, significant its accumulation in the lungs and brain were detected in this research. Herewith the effect of Ag elimination from the liver at the constant maintained exposure was observed. The character of the kinetics of accumulation in the brain, hippocampus, cerebellum and remnant were mainly identical. The Ag concentrations in the cortex were lower in comparison with the other regions, while the saturation was reached earlier.

The results provide evidence about the potential risk for reproductive, respiratory and nerve systems of an organism at the long-term application of Ag NPs. Also an unforeseen influence on other systems of an organism cannot be excluded due to the concept of neurovisceral integration. More details can be found in [1].

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Biosystem complexity and unexpected outcomes of man-induced interventions on example of influenza infection

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Unexpected outcomes are often associated with attempts to interfere with complex systems. Influenza vaccination is widely perceived to be an effective public health intervention; however, sometimes it has not made any useful impact on excess winter mortality (EWM). The EWM is a measure of the net effect of all competing forces operating each winter, including non-influenza pathogens. In this study extensive data from 97 countries are used to look at the net effect of influenza vaccination rates in the elderly aged 65+ against excess winter mortality (EWM) each year over a 39-year period from the winter of 1980/81 through to 2019/20. The observed international net effect of influenza vaccination ranges from a 7.8% reduction in EWM estimated at 100% elderly vaccination for the winter of 1989/90 down to a 9.3% increase in EWM for the winter of 2018/19. Such outcomes do not contradict the known protective effect of influenza vaccination against influenza mortality – they merely indicate that multiple complex interactions lie behind the observed net effect against all-cause (including all-pathogens) winter mortality. This range from net benefit to net dis-benefit is proposed to arise from system complexity as weather, the antigenic distance between constantly emerging circulating influenza clades and the influenza vaccine makeup, vaccination timing, pathogen interference, and human immune diversity all interact to give the observed outcomes each year.

Conclusion. We propose that a narrow focus on influenza vaccine effectiveness misses the far wider complexity of winter mortality. Influenza vaccines may need to be formulated in different ways, and perhaps administered over a shorter timeframe to avoid the unanticipated outcomes seen in around half of years being evaluated in this study.

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Role of specific light spectra on the photosensitization with Zn(II)-phthalocyanine and photodynamic oxidation potential

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The well-known chemical decomposition reaction with a significant effect on the outcome after the curative treatment method photodynamic therapy (PDT) involves the photooxydation of biomolecules. PDT is based on a proper interaction between a photosensitiser (PS) and the local irradiation with specific light spectrum in an oxygen athmosphere. The main reaction product during PDT with phthalocyanine dyes is singlet oxygen which is a short-living and short-distance crossing molecule with high oxydation potential.

The present study compares two light sources for their efficacy of the photosensitized oxidation of cholesterol. The so called moleculat anchor in tumor cells cholesterol appears in highest amound than in normal cells. The specific light initiation with different spectra of irradiation namely the red-light emitting diode (LED 665-nm) and UVC lamp (χ_{max} at 253 nm) on the incubated Zn(II)-phthalocyanine (ZnPc) suggested a significant photooxidation ability of ZnPc and red spectrum at 665-nm of irradiation. The photooxidation effect of UVC light by itself was observed which by addition of ZnPc in nanomolar concentrations leads to enhancement of the impact on the reaction as seen by the amount of the hydroperoxide primary products which are produced during PDT routine.

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Heart rate variability in adolescents with irritable bowel syndrome

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Background. Dysfunction of brain-gut interaction plays an important role in the pathobiology of irritable bowel syndrome (IBS). Bidirectional communications within gut-brain axis are modulated by the autonomic nervous system. The aim of current study was to evaluate autonomic dysfunction and stress resistance in adolescents with irritable bowel syndrome by non-invasive method of heart rate variability (HRV).

Methods. We enrolled 30 adolescents aged 12-18 years with a verified diagnosis of various types of irritable bowel syndrome. Control group included 35 healthy adolescents aged 14-20 years. Time and frequency domain parameters of HRV were studied in short recordings (5 min.) in supine and standing positions. The spectral HRV analysis included assessment of total power (TP, 0.01-0.4 Hz), which reflects the total activity of regulatory components; very low frequency power (VLF, 0.01-0.04 Hz), which characterizes mainly the activity of the neurohumoral regulation component and cerebral ergotropic effects; low frequency power (LF, 0.04-0.15 Hz, predominantly sympathetic activity); high frequency power (HF, 0.15-0.4 Hz, reflects mainly vagal component of the heart rate regulation).

Results. To facilitate interpretation of the results, we divided all individuals into the subgroups of resistance based on the values of TP in the supine position (low-resistant, medium-resistant, highly resistant). Subgroup analysis demonstrated that IBS patients with the lowest and highest TP in supine position had significantly reduced LF at rest. Also we have revealed significant downregulation of the LF component in the low-resistant and high-resistant IBS subgroups especially in standing position.

Conclusions. Non-invasive HRV monitoring is a useful diagnostic biomarker of functional and metabolic reserve and thus, the stress resistance of the body. We have revealed that adolescents with IBS have decreased parameters of HRV, but it was founded mostly during orthostatic testing. Suggested division into groups of resistance according to the TP and helped us to detect significant decrease in the sympathetic activity (LF) in patients with IBS compared to healthy controls. Study of heart rate variability is a useful method to evaluate autonomic function and, thus, gut-brain interactions in subjects with IBS.

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Effect of low-molecular-weight heparin therapy on cytogenetic biomarkers values in peripheral blood lymphocytes of pregnant women with thrombophilia

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Aim. The aim of the study was to determine whether there is a difference in the values of cytogenic biomarkers (micronuclei, nucleoplasmic bridges and nuclear buds) in peripheral blood lymphocytes of pregnant women with thrombophilia in early pregnancy before low-molecular-weight heparin (LWMH) anticoagulant therapy and in childbirth after several months of this therapy.

Materials and Methods. In a population of 74 pregnant women (37 healthy women and 37 women with inherited thrombophilia), we determined the frequency of micronucleus, nucleoplasmic bridges and nuclear buds using the cytokinesis-block micronucleus assay (CBMN) at the beginning of pregnancy and in childbirth. For comparison repeated measurements (before and after therapy) in the group of pregnant women with thrombophilia were used Wilcoxon rank test (Z).

Results. By comparing repeated measurements (at the beginning of pregnancy and childbirth), it was found statistically significant difference in MN frequencies with the value Z= - 4.813, (Wilcoxon test rank, $p<0.05$), which represented a significant decrease in frequency, where for N= 37 a value of R=Z/sqrt (N)=0.80 which indicates a high magnitude of the impact. It also exists for NP values statistically significant differences before therapy and in childbirth with a value of Z= -3.460 where N=37 the obtained value R = Z/sqrt (N)=0.56.

Conclusion. In the studied population, there was a significant decrease in the frequencies of MN and NP in peripheral blood lymphocytes of pregnant women with thrombophilia after several months of use LWMH anticoagulant therapies.

Keywords: Micronucleus, nucleoplasmic bridges, nuclear buds, pregnant women, thrombophilia, LWMH

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Porphyrin-photosensitized radical reactions in solutions and cell membranes containing halomethanes

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The most widely used photodynamic therapy (PDT) photosensitizers are porphyrins owing to their ability to selectively accumulate intumors, effective absorption of light in the region of transparency of biological tissues, a high quantum yield of formation of their triplet state, and high values of the rate constant of excitation energy transfer to oxygen. At the same time, the concentration of oxygen in tumor tissues and cellsis considerably lower than in normal ones. In this context, it is of great interest to study the feasibility of creation of nonoxygenated cytotoxic radicals generator in biosystems.

The operation of such a generator can be based on the electron transfer from excited porphyrins to molecules of electron acceptors introduced into the system. In this work, we study photosensitized radical reactions in the artificial donor–acceptor systems, based on porphyrins and halomethanes.

The introduction of halogen derivatives of methane (CCl_4) into ether solutions of porphyrins and chlorophyll sharply decreases (nearly 2 orders of magnitude) their photochemical stability. The data obtained by EPR, fluorescence and transient absorption spectroscopy show that in the initial stage of the photochemical reaction there is a transfer of an electron from an excited singlet molecule of the pigments to the molecule of CCl_4. Halomethanes capture electrons from singlet excited molecules of porphyrins to form porphyrin radical cations and halomethane radical CCl_4^-anions. The radical anions dissociate yielding halomethyl radicals ($CCl_3^\cdot + Cl^-$), which have a very high reactivity (bimolecular rate constants of their reactions with biological molecules are close to diffusion controlled values).

One of the major targets of the porphyrin photosensitized cytotoxic action are cell membranes, in which sensitizers are generally localized and whose damage leads to the loss of functional activity and decay of cells. Since halogenated hydrocarbons are membranotropic compounds, this opens up an opportunity for creating a molecular photogenerator of its radicals in cell membranes. The hydrophobic zinc tetraphenylporphine (ZnTPP) and positively charged zinc 5,10,15,20-tetrakis(4*N*-methylpyrydyl)porphyrin (ZnTMPP), having relatively low oxidation potentials, were used as photosensitizers.

The carbon tetrachloride (CCl_4) and bromoform ($CHBr_3$) possessing a low reduction potential were used as acceptors. Individual erythrocyte membranes were isolated from human red blood cells. Illumination of the membrane with visible light in the presence of porphyrin leads to porphyrin photosensitized degradation of tryptophanyls. Along with this degradation, the peroxide photooxidation of lipids takes place. In the presence of CCl_4 or $CHBr_3$,the yield of the photosensitized degradation of tryptophanyls increases by a factor of approximately 2.The halomethanes enhance the photosensitized peroxide oxidation of membrane lipids as well. In the presence of CCl_4, the enhancement is by a factor of 7 for ZnTMPP and more than 2 for ZnTPP. The data obtained in this study suggest that the possibility of creation of porphyrin and halomethane based donor–acceptor systems in cell membranes of is justified. The generated halomethyl radicals exhibit a high efficiency in the destructive action on the main membrane components proteins and lipids.

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Effects of aliskiren-loaded polymeric nanoparticles on nitric oxide pathway in cardiovascular system of hypertensive rats

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Aliskiren, the most recent antihypertensive agent, has been shown to exert cardio-protective, reno-protective, and anti-atherosclerotic effects independent of its blood pressure (BP) lowering activity. However, the limiting factor for the treatment might be the relatively low bioavailability of aliskiren (2–7%). Therefore, we aimed to study the effects of aliskiren-loaded polymeric nanoparticles with gradually released aliskiren on BP and nitric oxide (NO) pathway together with structural alterations of the heart and aorta developed due to spontaneous hypertension in rats. Twelve-week-old male spontaneously hypertensive rats (SHR) were divided into the untreated group, group treated with powdered or aliskiren-loaded nanoparticles (25 mg/kg/day) and group treated with nanoparticles only for 3 weeks by gavage. BP was measured by tail-cuff plethysmography. NOS activity was determined by measuring the formation of [3H]-L-citrulline from [3H]-L-arginine, while eNOS and nNOS protein expression was analyzed by Western blot. Collagen content was measured in both heart and aorta. Vasoactivity of the mesenteric artery and wall thickness, inner diameter, and cross-sectional area (CSA) of the aorta were analyzed as well. After 3 weeks, BP was lower in both powdered and nanoparticle-loaded aliskiren groups with a more pronounced effect in the latter case. Only aliskiren-loaded nanoparticles increased the expression of nNOS along with increased NOS activity in the heart (by 30%). Moreover, aliskiren-loaded nanoparticles decreased vasoconstriction of the mesenteric artery and collagen content (by 11%), and CSA (by 25%) in the aorta compared to the powdered aliskiren group. In conclusion, aliskiren-loaded nanoparticles represent a promising drug with antihypertensive and cardioprotective effects.

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Accumulation and effect of silver nanoparticles functionalized with *Spirulina platensis* on rats

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The effect of unmodified and functionalized *Spirulina platensis* biomass silver nanoparticles on rats during prolonged oral administration was assessed. Silver nanoparticles were characterized by using transmission electron microscopy, while their uptake by the biomass was confirmed using scanning electron microscopy and energy dispersive analysis. The content of silver in the different organs of rats after a period of administration (28 days) or after an additional clearance period (28 days) was ascertained by using neutron activation analysis. In animals administrated with the unmodified nanoparticles, the highest content of silver was determined in the brain and kidneys, while in animals administrated with AgNP-Spirulina, silver was mainly accumulated in the brain and testicles. After the clearance period, silver was excreted rapidly from the spleen and kidneys; however, the excretion from the brain was very low, regardless of the type of nanoparticles. Hematological and biochemical tests were performed in order to reveal the effect of nanoparticles on rats. The difference in the content of eosinophils in the experimental and control groups was statistically significant. The hematological indices of the rats did not change significantly under the action of the silver nanoparticles except for the content of reticulocytes and eosinophils, which increased significantly. Changes in the biochemical parameters did not exceed the limits of normal values. Silver nanoparticles with the sizes of 8–20 nm can penetrate the blood–brain barrier, and their persistence after a period of clearance indicated the irreversibility of this process.

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Controllable fabrication of triangular Ag nanoparticles for biomedical applications

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The rapid nanotechnology development and permanent improvement of methods for nanomaterial synthesis leads to the expansion of their practical application in plasmonics, electronics, ecology as well as in biomedicine. Nowadays, usage of noble metal nanomaterials in biomedicine is extremely perspective, in particular in diagnosis, hyperthermia, endodontics, periodontics or therapy. Therefore, the study of optical, catalytic, fungicidal and bactericidal properties of the nanoparticles is extremely important for above-mentioned purposes.

Triangular silver nanoparticles are in a great interest for use in biomedicine due to their unique physicochemical and bactericidal properties and ability to localized surface plasmon resonance (LSPR) in the biological window, which is manifested in sharp increasing of optical absorption and scattering at a certain wavelength. Crucial for the possibility and prospects of application in biomedicine are the controlled size, shape, physicochemical and structural properties of nanoparticles.

In this work, visible range radiation was used to fabricate triangular Ag nanoparticles. The synthesis was carried out in two stages. At first, spherical Ag nanoparticles were synthesized using laser assisted (445 nm) recovery approach. Then the modification of Ag nanoparticles shape was carried out under the influence of light fluxes from LEDs with wavelengths of 525 and 623 nm during 6 days. The formation of triangular Ag nanoparticles in colloidal solution was confirmed by UV-VIS-NIR spectrophotometry and TEM techniques.

Prolonged irradiation of Ag nanoparticles with LEDs resulted in shape transformation into triangular nanoparticles. The resulted triangular nanoparticles are characterized by an average length of about 98 nm under 525 nm and close to 155 nm under 623 nm LEDs irradiation. Interestingly, irradiation of Ag nanoparticles with 525 and 623 nm LEDs resulted in the formation of intense LSPR peaks in the NIR spectral range (866 and 934 nm, respectively). Such a high efficiency of absorption radiation in the NIR region makes it possible to use Ag nanotriangles in bio-related fields.

The obtained triangular Ag nanoparticles show high ability to energy conversion and efficient heat generation under the NIR laser irradiation (880 nm). This effect was used for studying the temperature impact on antibacterial properties of Ag nanotriangles. The suitability of triangular Ag nanoparticles in dentistry for rapid disinfection of dental canals and cavities was tested. It has been shown that the synergic effect of heating and antibacterial properties of triangular Ag nanoparticles can be used favourably in modern endodontics for rapid nano-laser disinfection of the root canal system of the human tooth. It has been found that irradiation of Ag nanostructures with a concentration of 0.4 mg / ml for 3 min leads to a reduction of Staphylococcus aureus population in approximately 20%. It can be assumed that obtained effect could be significantly improved by increasing the nanoparticles concentration or by prolonging the exposure time.

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Ribarska Banja bioclimatic characteristics analysis

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Taking into consideration medical aspects of multivariate influences the climate aspects have on health and health resorts selection, it is clear that bioclimatic influences are of special importance. Ribarska Banja (altitude 540 m) is located in central Serbia, on northern slopes of Jastrebac Mountain. Its yearly average temperature is 9.8°C, according to which it can be classified among the places with a temperate continental climate. We based Ribarska Banja bioclimatic observation on determining physiological feeling according to Kruger's anthropo-climate classification. Sharl's method was used for calculation of water vapour, as well. The dominant weather type is *cold* and it lasts for five months (from November to March). All weather classes (*chilly*, *comfortable*, *hot*) are recorded. The *hot* weather class occurs in May and September, when a period of anticyclone impact is accompanied with desired bioclimatic characteristics. The *cold* weather type takes five months, including the *cold* weather class (December, February) and *very chilly* (November, January and March). The physiological feeling type *very cold* (T_{ek}<5.0 °C) is not recorded. The main characteristic of winter period is the dominant impact of middle European anticyclone that causes dry and gloomy weather. A *hot* weather type classified as *light vapour* takes place in Jun, July and August. Classes *vapour* and *heavy vapour* do not occur due to an impact of anticyclone activities and local relief characteristics of the terrain. A closed shape of the curve can be observed on the *vapour* climate-gram. The shape does not cross the boundary between the vapour and the comfort zones. Having in mind bioclimatic perspective, temperature equivalents and the vapour climate-gram, as well as physical-geographical and anthropogeographical predispositions of Ribarska Banja, one can draw a conclusion that it can be considered to be a favourable health resort.

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In vitro DPPH scavenging potential of morin-biopolymers (chitosan, lignin) complex systems

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The present study was designed to evaluate the in vitro DPPH scavenging potential of the natural polyphenol morin, the linear biopolymer chitosan and the heterobiopolymer lignin, individually and in various combinations. To evaluate the effect of the interactions between the flavonoid and both biopolymers on the antioxidant activity of the complex systems, we compared the antioxidant capacity of the individual biologically active compounds with that obtained by mixing them in two- and three-component systems. Ascorbic acid was used as a standard.

The DPPH scavenging activities of the systems: chitosan/morin (94.66%), chitosan/lignin (1:1) 96.86%) chitosan/lignin/water 1:1:1) (93.05) and chitosan/lignin/morin (98.25%) promoted synergistic effects vs. the three individual biomolecules: morin (in two-component systems – 87.35%; in three-component systems – 75.66%); chitosan (in two-component systems – 7.50%; in three-component systems – 4.70%). Antagonistic interaction was observed for the system lignin-morin only vs. pure morin.

The enriched flavonoid content in lignin probably increases the significance of the intermolecular bonds between morin functional groups and these of lignin monolignols, which results in enhancement of the radical scavenging potential of the lignin-based conjugated systems. The deviations of chitosan effect on the two-component and three-component systems antioxidant capacity could be explained by the different mechanisms of the complexation process between the polyphenol and the biopolymer in view of its reversibility/irreversibility causing either stable aggregation/precipitation or re-dissolution depending on the process conditions.

The significance of the present results is expressed in the provision of assistance for the design of drug-delivery formulations and/or functional foods based on their enhanced antioxidant activity.

Keywords: DPPH scavenging potential, flavonoid/biopolymers conjugated systems, morin, chitosan, lignin, conjugated systems

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Synthesis and antibacterial activity of thiosemicarbazide and 1,3,4-thiadiazole with 3-methoxyphenyl substituent

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Objectives. Bacterial resistance to drugs currently used in pharmacotherapy is an important and current problem of modern medicine. Sepsis, a consequence of an acute bacterial infection, is now one of the leading causes of death worldwide. The bacterial strain responsible for a large proportion of difficult-to-treat nosocomial infections is MRSA, a methicillin-resistant strain of *Staphylococcus aureus*. It is also resistant to all beta-lactam antibiotics, including penicillins, cephalosporins, monobactams and carbapenems. Despite intensive research in this area, there is still a lack of drugs that are effective against bacteria such as *Staphylococcus aureus*. To find new compounds active against drug-resistant strains of bacteria, we synthesized the series of thiosemicarbazide and 1,3,4-thiadiazole with 3-methoxyphenyl substituent.

Materials and Methods. Based on the analysis of the collected data, we designed and synthesized a group of thiosemicarbazide and thiadiazole derivatives differing in the structure of substituents at C4 and C2 positions of thiosemicarbazide and thiadiazole derivatives respectively. The antibacterial activity of the obtained compounds was then determined in biological studies with gram-positive and gram-negative bacteria strains. Moreover, using *in silico* studies we determined the interaction of the obtained compounds with the topoisomerase IV and DNA gyrase trying to explain the mechanism of the antibacterial activity of the tested compounds.

Results. Three thiosemicarbazide compounds containing in the structure the trifluoromethylphenyl group showed highest antibacterial activity against all gram-positive bacteria strains. The MIC values for those compounds were in the range of 3.9-250 μg/ml. 1,3,4-thiadiazole derivatives showed the lack of or negligible activity against all bacteria strains used in test. The tested thiosemicarbazide derivatives also showed promising activity against MRSA.

Conclusions. The antimicrobial activity of a series of newly synthesized thiosemicarbazides, demonstrated in biological tests, indicates the validity of further research involving the modification of the structure in order to find more active compounds. The results of the conducted studies suggest that thiosemicarbazide derivatives are better candidates for new antibacterial drugs than 1,3,4-thiadiazoles.

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Features of individual psychophysiological adaptation of a patient affected from extremely uneven gamma-neutron exposure

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Objective. The purpose of this work is to assess the individual psychophysiological adaptation of a patient with long-term consequences of grade III ARS, severe local radiation injuries from extremely uneven gamma-neutron irradiation, followed by amputation of both legs at the level of 1/3 of the legs, according to the characteristics of his individual mental adaptation.

Materials and Methods. The patient, born in 1939, worked as an engineer, senior researcher at the National Research Center "Kurchatov Institute" since 1963 to 2010. From 1963 to 1971 carried out experimental work on critical stands of a transport power reactor. May 26, 1971 at the age of 32 years, he underwent acute extremely uneven gamma-neutron irradiation, suffered ARS III degree with severe local radiation injuries of the lower extremities. The dose on the head is 1.3 Gy, on the chest 2.1 Gy, on the legs 16 Gy. Amputation of both legs at the level of 1/3 of the legs was carried out in 1973. For 38 years from 26.05.1971 On March 13, 2009, he underwent examination and treatment in the Clinic of the State Scientific Center of the Institute of Biophysics - Clinical Hospital No. 6. The patient since 1971 is a disabled person of the II group. He learned to walk on prostheses, drive a car and, for 39 years after the accident, continued to work at the National Research Center "Kurchatov Institute" until 2010 as a senior researcher.

Results. The averaged profile of the multilateral study of personality (MMPI) and the dynamics of indicators by years of observation (2001-2009) indicate a disharmonious combination of hypochondriacal, anxiety-depressive and demonstrative tendencies with a predominance of demonstrativeness as a way to overcome difficulties and demonstrate resistance to a serious illness. High intelligence (factor B = 10 Stan), good figurative and logical thinking (Raven test), well-mannered forms of behavior (factor N = 7 Stan), high control over the emotional sphere, restraint of emotions (G = 5 Stan), independence (factor Q2 = 8 Stan), self-sufficiency, organization, behavior taking into account the requirements of the environment (factor Q3 = 8 Stan) provided the patient with overcoming and resistance to a serious illness, contributed to good adaptation to the environment with self-confidence, high social adaptability, the ability to successfully perform professional duties, kept from the words of the patient, at the expense of work. Comparative assessment of operator performance of the patient showed a good average time of a simple sensorimotor reaction (351.2 ms) and a complex sensorimotor reaction (742.25 ms) with 2 errors, a high reaction time to a moving object (1015.5 ms), as the adequacy of the real functional reserves of the nervous system.

Conclusion. The effectiveness of psychophysiological adaptation depends not only on the dose of radiation and the severity of the disease, but, to a greater extent, on the premorbid personality traits of the victim and his social and labor attitude. Individual features of the psychophysiological adaptation of the patient and his pronounced personality traits. despite severe acute radiation sickness and local radiation injuries with amputation of both legs at the level of 1/3, late radiation ulcers on the buttocks, right thigh, radiation cataract, severe psychosomatic and general somatic pathology, largely met the requirements of the environment and determined his persistent, courageous behavior, long-term professional suitability, a full life, the ability to keep at the expense of work (47 years of work at the National Research Center "Kurchatov Institute" of which 39 years after the accident).

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Seeds primed with "Pluronic" P-85 grafted single-walled carbon nanotubes result in functional alterations in the photosynthetic apparatus of pea plants

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Single-walled carbon nanotubes (SWCNTs) are nano-objects of high research and industrial interest in the last years. Due to their small size and the capability to trespass plant tissues and cell membranes they are regarded as plausible nanocarriers of beneficial substances that might enhance plant growth in different environmental conditions. Furthermore, there are reports that SWCNTs themselves might affect and even enhance photosynthetic functionality and plant development in general.

In this report we explore the effect of seeds priming with "Pluronic" P-85 polymer grafted single walled carbon nanotubes (P85-SWCNTs) on the photosynthetic operation of pea plants with emphasis on photosystem II functionality. For this purpose, we apply PAM Imaging set-up (MAXI version; Walz, Germany) to determine specific chlorophyll fluorescence parameters of 14-day-old plants. In order to distinguish the effect of the used polymer from the one of P85-SWCNTs, we also characterize plants developed from seeds treated with corresponding solutions of "Pluronic" P-85 polymer only, as well as with "Pluronic" P-85 nanoparticles formed by stabilized micelles.

The data reveal that while "Pluronic" P-85 nanoparticles do not induce significant changes in photosystem II functionality, "Pluronic" P-85 solutions and P85-SWCNTs dispersions exert different effects that strongly depend on the applied concentration of polymeric molecules and nanotubes. The polymeric solutions at all tested concentrations (0.04 – 30 g/L) induces ca. 20% higher photosystem II quantum yield, while for P85-SWCNTs treatment (in the range 0.4 – 300 mg/L) this parameter increases linearly and proportionally to P85-SWCNT concentration; at 300 mg/L P85-SWCNTs the changes are similar to the ones observed for "Pluronic" P-85 treatment only. It appears that those effects are not due to increased number of photosystem II centers but rather to the decreased extent of non-photochemical quenching of chlorophyll *a*. The dynamic development of the latter process is observed to be slowed down upon application of "Pluronic" P-85, while the action of P85-SWCNTs has similar effect only at 300 mg/L concentration.

It should be noted that although we do not present direct evidence for the translocation of P85-SWCNTs to the chloroplasts, the fact that they exert strong effects on photosynthesis that differ from the ones of "Pluronic" P-85 only solutions and nanoparticles, strongly supports this hypothesis.

In summary, the obtained results demonstrate that seeds priming with specific concentrations of "Pluronic" P-85 solutions and P85-SWCNTs has positive effect on photosystem II quantum yield in pea plants. The data strongly suggest that seeds priming with P85-SWCNTs results in nanotubes translocation towards the photosynthetic organelles which makes them suitable objects for further development of cargo-loaded nanoparticles.

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Antimicrobial peptides: New therapy protocol that enhances the effects of radiotherapy

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Combination therapy, a treatment modality that combines two or more therapeutic agents, is a cornerstone of cancer therapy. The amalgamation of anticancer drugs and protocols enhances efficacy compared to the mono-therapy approach because it targets key pathways in a characteristically synergistic or an additive manner. This approach potentially reduces drug resistance, while simultaneously providing therapeutic anticancer benefits, such as reducing tumour growth and metastatic potential, arresting mitotically active cells, reducing cancer stem cell populations, and inducing apoptosis. Tumor spheroids strongly resemble tumor tissues, which makes them useful tools for radiation biology studies and screening of various chemotherapeutics. The goal of this study was to use tumor spheroids formed from one established human cancer cell line (HCT116- human colon carcinoma) as an *in vitro* model to determine their response to a specific antimicrobial peptide with potential anticancer properties and also to proton beam radiotherapy (PBRT) (2 and 6 Gy), single and combination of these treatments. Cytotoxic response was assessed after 24–48 h by using a senescence assay and also the cell cycle distribution. It was found that sensitivity to radiation in spheroids was significantly less than that seen in monolayer cultures. Spheroids showed different patterns of shrinkage and regrowth when exposed to our compounds or radiation: treated spheroids shed dead cells within four days of applying our antimicrobial peptide and displayed faster growth post-exposure than samples that received radiation or no treatment. Irradiated spheroids maintained a dense structure and exhibited a longer growth delay than spheroids receiving chemical treatment or combination treatment. We suggest that, unlike radiation, which kills dividing cells, chemical-induced cell death affects cells independent of their proliferation status. In conclusion, our study reveals differences in response to chemical treatment and/or radiation that were not apparent in 2D viability assays but that may significantly influence treatment efficacy.

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Characteristics of the essential oil of marigold (*Calendula officinalis*) obtained by the extraction and arrangement of its chemical composition with HPLC chromatography and its application for medical purposes

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Calendula officinalis or marigold, as it is known in our country, is a medicinal plant that has been used for centuries to treat various diseases of the human body. The plant can be used in various ways, for example in dried form to make tea, as a tincture, ointment or to make essential oil from it. Marigold oil as a bioactive substance would be categorized as a supplement in the group of solid or semi-solid foods. It can be incorporated into margarine, butter, milk or milk fat, vegetable fats and oils, such as soybean or sunflower oil, or waxes, such as beeswax. Since Omega 6 fatty acids are essential for the normal development of newlyweds, it is recommended that baby food be enriched with them. In this paper, the process of extraction of marigold essential oil was followed using the Soxhlet method with dichloromethane or methylene chloride solvent. A dry mixture of marigold leaves and flowers purchased from an herbal pharmacy was used as a material. The application of HPLC chromatography then determined the presence of saturated and unsaturated fatty acids present in the essential oil of marigold.

Keywords: Marigold, extraction, chemical composition, HPLC chromatography

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Interaction of *Priestia endophytica UKM B-5715* and plants as a base for biotechnology of plant growth stimulation

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Plants and bacteria are closely connected throughout their existence. Their interaction is based on the need to adapt to each other presence, which, in turn, leads to the formation of certain mechanisms of host-microbiome influence. Such mechanisms include both genetic (for example, genes drift) and chemical (biosynthesis of chemical compounds of directed or general action) processes. In the case of toxic compound production, the death of the susceptible organism occurs. At the same time, evolutionary processes are aimed at the formation of mechanisms favouring mutual survival. They are manifested, in particular, in the production by microorganisms of chemical substances that stimulate plant growth. The study of this effect is not only of great academic interest but also essential for developing strategies for the use of microorganisms, bacteria of the *Bacillus* genus, in particular, in the production of plant growth-promoting bioactive compounds.

The aim of the work was to study the peculiarities of the influence of *Bacillus spp* bacteria on the growth and physiological parameters of plants for the subsequent development of biotechnology of plant growth stimulation.

Culture medium (Test solution) obtained after 24 hours of cultivation of *P. endophytica UKM B-5715* and sterilized by Millipore 0.22 filter was used in the work. Seeds of *Lactuca satica* L cv Odesky kucheriavets and *Cichorium intybus* L. cv Pala rossa were sterilized with 1% Polidez solution (“Verbena”, Ukraine) and cultivated in vitro on the solidified Murashige and Skoog medium for seed germination. In 7 days, 30 µL of 5% and 20% Test solution were applied to the lower part of the seedling. After 20 days of cultivation, plant growth parameters (weight of the leaves and roots) and content of photosynthetic pigments were evaluated.

The results of the study indicated a significant stimulating effect of the used solution. This effect resided in a substantial increase in the weight of the roots and aerial parts of both lettuce and chicory plants. For example, the weight of lettuce roots (per plant) in the case of using 5% and 20% Test solution was 0.03±0.008 g and 0.02 ± 0.007 g, respectively. At the same time, the weight of the control roots was much less – 0.004 g. The stimulating effect on the growth of the aerial part of the plants was also observed. Thus, the weight of the leaves in the two experimental variants was 0.197 ± 0.029 g and 0.14±0.04, respectively. A similar effect of the Test solution was recorded when using chicory plants in the experiment. In particular, the weight of the roots was 0.054±0.01 g and 0.034±0.003 g in the experimental and control variants, respectively. The Test solution also promoted the growth of shoots, which was expressed in a significant increase in weight compared to the control (up to 2.9-fold).

Thus, a single treatment of the plants with liquid culture medium in the early stage of seedlings (cotyledon leaves) in the amount of 30 µl/plant has led to the growth stimulation of both the root system and shoots. When using this solution, an increase in root weight of 5.0-fold (lettuce) and 6.75-fold (chicory) was observed. Accordingly, an increase in shoot weight of 1.8-fold (lettuce) and 2.9-fold (chicory) was determined.

Keywords: *Priestia endophytica*, growth stimulation, plant-bacterial interaction, biostimulants

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MM-129: a derivative with a dual mechanism of action as an innovative molecule with antitumor activity against colon cancer cells

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Background and Aims. New therapeutic strategies for colorectal cancer bases on inhibiting the classic processes of oncogenesis, while restoring the efficiency of immune mechanisms. New molecules that meet the above requirements are sought after. MM-129 is a new derivative that has been tested for antitumor activity against colon cancer cells.

Methods. Mouse xenografts (Cby.Cg-Foxn1nu/cmdb, challenged with DLD-1 or HT-29) were treated with MM-129 during 2 weeks, after which its antitumor efficacy was tested. In cell culture, DLD-1 and HT-29 cell lines were exposed to MM-129, and the expression of selected proteins and genes was determined by Western Blot and RT-PCR. Additionally, occurring changes in cell cycle were investigated by the flow cytometry.

Results. In the mouse model MM-129 significantly reduces the tumor volume. MM-129 is potent to inhibit procancerous signaling pathways (PI3K, Akt, mTOR), induces cell cycle arrest in a CDK2- depended manner, and decreases expression of immune checkpoint molecule - PD-L1 on colon cancer cells.

Conclusion. MM-129 is an innovative molecule that combines the effects of a classic chemotherapeutic and immunotherapeutic agent. As an effective molecule, MM-129 may become in the future a novel option for treatment of patient with colon cancer.

Keywords: 1,2,4- triazine derivative, signaling pathways, immune check point inhibitor, colon cancer

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MM-129 as a new potential candidate against colon cancer – assessment of toxicity

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Objectives. MM-129 (pyrazolo[4,3-e]tetrazolo[1,5-b][1,2,4]triazine sulfonamide) is a chemical compound obtained by chemical synthesis which is a novel promising drug candidate against colon cancer. It has been recently shown that MM-129 effectively inhibits tumor development in both mouse and zebrafish xenografts and the mechanism of action is related to attenuation of intracellular pathways promoting tumorigenesis with a simultaneous reduction of programmed death ligand (PD-L1) expression.

Aim. The aim of the study was to evaluate the safety profile of MM-129 using the zebrafish and rodent models. Results: We observed that MM-129 at an anticancer dose of 10 μmol/kg is very well tolerated. No serious adverse events of this dose on animal welfare were observed for the time period of 14 days. It did not induce nephrotoxicity, changes in blood morphology, haemostatical and biochemistry parameters. It also displayed a favorable safety profile in zebrafish toxicity screening model. Lack of sublethal effects was noticed either detected in zebrafish embryos treated with a concentration of 10 μM.

Conclusions. Our study suggests that MM-129 has the potential as a safe and well-tolerated anticancer formulation it seems to be a promising effective and safe candidate for future treatment of patients with colon cancer.

Keywords: 1,2,4- triazine derivative, toxicity, safety profile, zebrafish, colon cancer

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Coumarin-palladium(II) complex acts as a potent and non-toxic anticancer agent against pancreatic carcinoma cells

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Pancreatic carcinoma represents one of the most lethal malignant diseases in the world although some progress has been made in treating the disease in the past decades. Current multi-agent treatment options have improved the overall survival of patients, but more effective treatment strategies are still needed. In this paper we have characterized anticancer potential of coumarin-palladium(II) complex against pancreatic carcinoma cells. Cells viability, colony formation and migratory potential of pancreatic carcinoma cells were assessed in vitro, followed by evaluation of apoptosis induction and in vivo testing on zebrafish. Presented results showed remarkable reduction in pancreatic carcinoma cells growth both in vitro and in vivo, being effective at micromolar concentrations (0.5 μM). Treatments induced apoptosis, increased BAX/BCL-2 ratio and suppressed the expression of SOX9 and SOX18, genes shown to be significantly up-regulated in pancreatic ductal adenocarcinoma. Importantly, treatments of the zebrafish-pancreatic adenocarcinoma xenografts resulted in significant reduction of tumor mass, while did not provoke any adverse toxic effects including hepatotoxicity. Presented results indicate the great potential of tested compound and the perspective of its further development towards pancreatic cancer therapy.

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Analysis of the Proline Dehydrogenase/Proline Oxidase importance in NSAIDs-induced apoptosis by using the CRISPR/Cas9 PRODH/POX-knockout MCF7 breast cancer model

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Inhibitory effect on cyclooxygenases (COX) by nonsteroidal anti-inflammatory drugs NSAIDs is considered as a preventive effect in cancer therapy according to fact of the common COX overexpression in cancers. Interestingly, some NSAIDs are also responsible for proapoptotic effect in COX2 lacking cancer cells. Here we suggest that despite COX2 inhibitory effect, NSAIDs activate PPARγ (as agonists) which leads to induction of Proline Dehydrogenase/Proline Oxidase (PRODH/POX) - dependent apoptosis. This mitochondrial enzyme converts proline to Δ1-pyrroline-5-carboxylate (P5C) during which ATP or reactive oxygen species (ROS) are generated. This suggests a distinguished role of PRODH/POX since it can promote cell proliferation or death. For the very first time, we obtained a stable MCF7 CRISPR/Cas9 PRODH/POX-knock out breast cancer cells model to verify the role of PRODH/POX in NSAIDs-induced apoptosis. We found that breast cancer cells treated with NSAIDs undergo PRODH/POX-dependent stress leading to decreased viability and activation of apoptosis. Surprisingly, clones of the MCF7 cells with knocked out PRODH/POX under the NSAIDs treatment showed lower viability and stronger apoptosis activation which underline the importance of PRODH/POX as an energy supply in the cancer development process. The observed effect was also related to the PPARγ/PPARδ interplay, oxidative stress activation, and mitochondrial/cellular proline turnover and metabolism.

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Small molecule inhibitors of KDM5 histone demethylases increase radio-sensitivity of breast cancer cells

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KDM5 enzymes are H3K4 specific histone demethylases involved in transcriptional regulation and DNA repair [1]. These proteins are over-expressed in different kinds of cancer, including breast, prostate and bladder carcinoma, with positive effects on cancer proliferation and chemo-resistance. For these reasons, these enzymes are potential therapeutic cancer targets. JARID1B/KDM5B histone demethylase's mRNA is markedly over-expressed in breast cancer tissues and cell lines and the protein has been shown to have a prominent role in cancer cell proliferation and DNA repair. On the other hand, its post-transcriptional regulation in cancer cells remains elusive. We performed a computational analysis of transcriptomic data from a set of 103 breast cancer patients which, along with JARID1B up-regulation, showed a strong down-regulation of two miRNA, mir-381 and mir-486, potentially targeting its mRNA. We showed that both miRNAs can target JARID1B 3'UTR and reduce luciferase's activity in a complementarity-driven repression assay [2]. Moreover, MCF7 breast cancer cells over-expressing JARID1B showed a strong protein reduction when transfected with mir-486. This protein's decrease is accompanied by accumulation of DNA damage, enhanced radiosensitivity and increase of BRCA1 mRNA, three features previously correlated with JARID1B silencing. These results enlighten an important role of a miRNAs' circuit in regulating JARID1B's activity and suggest new perspectives for epigenetic therapies coupled to radiation treatments. We analyzed the effects of three different inhibitors of KDM5 enzymes in MCF7 breast cancer cells over-expressing JARID1B on H3K4 demethylation levels, target gene transcription, radio-sensitivity, and damage accumulation. We showed that two compounds with completely different chemical structure can selectively inhibit KDM5 enzymes and that both compounds are capable of increasing sensitivity of breast cancer cells to ionizing radiation and H2AX phosphorylation. These findings confirm the involvement of H3K4 specific demethylases in DNA damage signaling and repair and suggest new strategies for the therapeutic use of their chemical inhibitors.

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Anticancer effect of novel imidazole berenil platinum(II) complex conjugated with G2 PAMAM-OH dendrimer in human breast cancer cells

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Chemotherapy is one of the therapeutic approaches used to treat cancer. The drug used for the systemic treatment of breast cancer, especially in its triple negative variant is cisplatin, representing the platinum complexes class. Unfortunately, this drug has many severe side effects, such as kidney, liver, heart, bone marrow, and nervous system toxicity. Moreover, the low solubility and limited bioavailability of cisplatin limit its application. An interesting group of new cisplatin derivatives are berenil platinum(II) complexes [1, 2] and their combinations with dendrimers [3]. Dendrimers appear to exhibit a multitude of properties that may have positive effects on the bioavailability of a substance while simultaneously reducing its dose and consequently the adverse effects caused by it. A very important property of these nanoparticles is their ability to overcome multidrug resistance (MDR).

Therefore, the aim of our study was to synthesize a novel imidazole berenil platinum(II) complex conjugated with and without the second-generation PAMAM dendrimer (PtMet2–PAMAM G2 and PtMet2, respectively) and evaluate the effect of these compounds on anticancer activity against MCF-7 and MDA-MB-231 human breast cancer cell lines. The cytotoxic activity of the novel complexes was examined using the MTT method of Carmichael. Cell viability studies indicated that PtMet2–PAMAM G2 exhibited higher cytotoxic activity than PtMet2 in MCF-7 and MDA-MB-231 breast cancer cells at relatively low concentrations. In relation to human normal breast epithelial cell MCF-10A the novel complexes were characterized with lower cytotoxicity than in case of examined neoplastic cells. Additionally, our experiments carried out with flow cytometry assessment of annexin V binding and propidium iodide revealed that PtMet2-PAMAM G2 inhibited the proliferation of breast cancer cells by increasing the number of apoptotic cells. Moreover, the results showed that treatment of breast cancer cells with the tested compounds activated the autophagy process, as evidenced by the formation of autophagosomes together with autolysosomes. In both the apoptosis and autophagy experiments, it is clear that the dendrimer conjugate shows a much higher potential for its induction. The dual induction of cell death through apoptosis and autophagy makes the dendrimer conjugate an ideal potential anticancer drug candidate. The high pro-apoptotic activity and the ability to activate autophagy by PtMet2–PAMAM G2 may be due to its demonstrated ability to reverse multidrug resistance and thereby increase cellular accumulation in breast cancer cells.

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Evaluation of anthropogenetic predisposition in relation to potential risk factors in COVID-19 patients

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Coronavirus disease 2019 (COVID-19), is a severe respiratory and systemic disease caused by a new form of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), which led to a global pandemic. The aim of this study was to analyze the homozygous-recessive characteristics (HRCs) in the COVID-19 patients, regarding gender, forms of the disease (milder and severe symptoms), risk factors (RF) such as hypertension, diabetes mellitus, hyperlipidemia, and smoking habits, and distributions of the ABO blood groups compared to healthy controls. The study was performed using an HRC test when we analyzed 20 HRCs in a sample of 200 individuals from April to October 2021: 100 patients (50 males and 50 females) average age 45.29±14.99, and 100 controls (50 males and 50 females) average age 46.29±15.38. The presence and absence of the disease have been confirmed with a polymerase chain reaction (PCR). Since the beginning of the pandemic, the controls had no COVID-19 symptoms, nor have they been immunized with any of the available vaccines in Serbia (Pfizer-BioNTech, Moderna, Oxford/AstraZeneca, Sputnik V, Sinopharm). Our results presented that the average value of HRC in patients was significantly higher compared to controls ($X_{hrc/20P}$=7.09±1.51, $X_{hrc/20C}$= 4.54±1.83; p<0.001). As for the form of the disease, average value of HRC in patients with severe symptoms (P_S) was significantly higher compared to patients with milder symptoms (P_M) and controls (C) ($X_{hrc/20Ps}$=7.46±1.62; $X_{hrc/20Pm}$=6.72±1.31; $X_{hrc/20C}$=4.54±1.83; p<0.001). There was a significant difference in individual variations of 20 HRC between the patients and controls (χ^2=239.05; p<0.001). In patients, four HRC were more common, and that are continuous frontal hairline, digital index, top joint of the thumb >45°, and mid-phalangeal hair absence. Variability was lower in patients compared to the control sample. Variability had the highest values in the controls while decreased in patients with milder and patients with more severe symptoms (V_C= 40.31%; V_{Pm}=19.49%; V_{Ps}=21.72%). Regarding the presence of RF, our results indicated that the average value of HRC was significantly different in patients regarding the number and presence of RFs. Patients with ≥ 2 RF had the highest values of HRC ($X_{hrc/P\geq 2}$=7.83±1.55) compared to controls ($X_{hrc/Co}$=4.70±1.98). In relation to form disease and the presence of RF, it has been observed that patients with both milder and severe symptoms with ≥ 2 RF, had increased value of HRC ($X_{hrc/Pm\geq 2}$=7.20±1.32; $X_{hrc/Ps\geq 2}$=8.29±1.60). In both, the patients and in controls, the A and O blood groups were the most represented. Binary logistic regression analysis confirmed that patients with 5 or more HRC (cut-off 5) had a 2.5 times higher risk to get sick (OR=2.520; CI =1.95-3.27; p<0.0005). The results of multiple linear regression analysis of tested variables (gender, age, smoking, ABO blood type, Rhesus (Rh) factor, and HRCs) showed that only HRCs have a significant impact on the onset of the COVID-19. Our results indicate that there is a high degree of genetic homozygosity in the group of patients in relation to healthy individuals and that it increases depending on the number of risk factors present. The HRC test could be used as a potential screening method for the assessment of predisposition to infection in humans, as well as for estimating forms of the disease.

Keywords: Blood type, COVID-19, genetic homozygosity, genetic predisposition, homozygous recessive characteristics (HRC)

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Predictive value of altered status of lipids and the markers of inflammation for cardiovascular events in COVID-19 patients

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Background. Numerous data from literature indicate that in patients with COVID-19, the development of cardiovascular complications is associated with significant and serious clinical outcomes. As the COVID-19 pandemic leaves significant medical and social consequences throughout the world, the aim of our study was to assess the lipid status and markers of inflammation in the development of cardiovascular complications in patients with COVID-19.

Methods. The retrospective research included 170 respondents. The experimental group included 105 atients with a diagnosis of COVID -19, treated in the period from January to March 2022 at the University Clinical Center Kragujevac. The control group consisted of 65 healthy subjects. In all subjects, using standard biochemical methods, serum concentrations were performed: total cholesterol (CHOL), triacylglycerol, HDL and LDL-cholesterol, C-reactive protein (CRP) and procalcitonin (PCT). Also, the LDL / HDL and CHOL / HDL indices were monitored, as well as the ratio of the absolute number of neutrophil leukocytes and lymphocytes (N/L) (in an additional assessment of the degree of inflammation). The analysis of biomarkers of heart damage included measurement of enzyme activity: creatine kinase (CK), CK-MB and lactate dehydrogenase (LDH), as well as serum concentrations of proB-natriuretic peptide (proBNP) and troponin I (hsTroponin I). The Independent samples T test was used for statistical analysis of the obtained data, to assess the significance of the difference, whereas the bivariate correlation test was used to examine the correlation between the examined variables.

Results. Statistical processing of the obtained data showed that patients with COVID-19 have (statistically) significantly higher concentrations: CHOL (6.27 ± 1.04 vs 4.82 ± 0.86 mmol/L, p <0.001), triacylglycerol (2.05 ± 0.84 vs 1.34 ± 0.54 mmol)/L, p = 0.003) and LDL (3.95 ± 1.08 vs 2.78 ± 0.55 mmol/L, p <0.001) compared to the control group of healthy subjects. Similarly, the LDL / HDL indices (3.2 ± 0.79vs 2.5 ± 1.22, p = 0.029) and CHOL/HDL (5.07 ± 1.29 vs 4.05 ± 1.54, p <0.001) were shown to be significantly higher in patients with COVID-19. The changes in lipid status were followed by similar changes in the concentration of inflammatory markers, so that the values of all analyzed markers were higher in patients with COVID -19 compared to healthy subjects: CRP (76.88 ± 75.55 vs 3.12 ± 1.79 mg/L), PCT (0.65 ± 1.62 vs 0.03 ± 0.04 ng / mL) and N/L (8.72 ± 7.24 vs 2.72 ± 1.59) (p < 0.001). When it comes to cardiac biomarkers, a statistically significant difference between the two groups of subjects was shown for LDH enzyme activity (812.93 ± 544.94 vs 289.35 ± 56.12 U/L, p(0.001), as well as the concentration: proBNP (2985.35 ± 4973.24 vs 56.16 ± 48.41 pg/mL, p = 0.001) and hsTroponin I (0.729 ± 2.902 vs 0.009 ± 0.005 ng/mL, p = 0.036). Correlation analysis showed a statistically significant association between HDL (r = -0.207, p = 0.049), LDL / HDL (r = 0.211, p = 0.050), CRP (r = 0.359, p = 0.001) and N/L r = 0.377, p <0.001) with proBNP concentration in patients with COVID -19. Also, the concentration of: total cholesterol (r = 0.224, p = 0.046), CRP (r = 0.397, p = 0.000), PCT (r = 0.372, p = 0.006) and N / L (r = 0.249, p = 0.041) statistically significantly correlates with the concentration of hsTroponin I.

Conclusion. Changes in the lipid status and the markers of inflammation may play a significant role in the prediction of possible cardiovascular events in patients with COVID-19.

Key words: COVID-19; lipid status; inflammation; cardiovascular events

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What are the most important findings regarding Sars-CoV-2 infection during the pandemic?

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The new Sars-Cov-2 virus caused a pandemic in late 2019 and has led to huge health and socio-economic problems as well as mortality around the world. At the very beginning of the pandemic, there were many misunderstandings in many aspects of the infection, especially the mechanisms of the virus's effect on the human body, all the way to diagnosis, treatment and complications. However, the application of modern techniques of molecular biology during viral testing, techniques for the production of new types of vaccines has quickly been applied in this area, but with many problems. Unprecedented debates in science have opened up, especially during the application of new types of vaccines. This paper would highlight some of the possibilities and advantages of methods used during the pandemic, which include virus isolation, identification of genes encoding viral particles, identification of new strains and the possibility of plasmid synthesis of viral proteins for testing, and application of new vaccine production techniques. In Serbia, the synthesis and production of protein S (Spike) and N (nucleocapsid) protein virus was successful with recombinant hybridization techniques that we used in in vitro tests in this study. The effects were examined on immune changes, proliferation and survival as well as on markers of perfected blood cell populations, i.e. cellular immunity using multi-color flow cytometry. These techniques during in-vitro cell cultures have shown the effects of S and N proteins as well as during vaccination on the stimulation of immune system cells. The results showed that after the vaccine was administered, the cell population of the immune system was stimulated, as assessed by the activation of markers on the cell surface. However, further research is needed to answer many other unresolved questions about the possibility of long-term effects of vaccines, re-infection and complete eradication of this disease.

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Silicon application affected cadmium translocation and plant growth in radiation derived amaranth 'Pribina' (*Amaranthus cruentus*)

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Heavy metal stress is one of the most critical abiotic factors, which directly and indirectly affects plants. Cadmium, a non-essential element, is known as a significant pollutant due to its high solubility in the water and high toxicity. It is easily transferred from soil to plant, influencing physiological and biochemical features in plants. Strategies to lower cadmium absorption and safe food production need to be developed.

Silicon is the second most abundant element found in Earth's crust and is considered as a photo-beneficial element. The application of silicon mitigates heavy metal stress by reducing the metal uptake and transport in plants. Silicon enhances metal concentration in plant roots compared to shoots.

This study considered grain amaranth variety 'Pribina' bred at the Institute of Plant Genetics and Biotechnology by radiation mutagenesis using a gamma radiation dose of 175 Gy. The aim of our work was to evaluate whether a high concentration of silicon helps with optimal plant growth and reduces cadmium uptake in 'Pribina' plants under hydroponic conditions. Our results indicated that a high silicon concentration (4 mM) combined with cadmium (80 μM) reduced root and shoot weight compared to the non-treated control. On the other hand, silicon considerably decreased cadmium concentrations in both the shoots and the roots after long-term cadmium exposure (14 days). The effect of silicon to reduce cadmium concentration in amaranth roots was also confirmed by microscopic analysis. The translocation factor for cadmium was significantly lower in amaranth plants treated with silicon and cadmium than in plants without silicon in the nutrient solution. Our results indicate a positive role of silicon in the amaranth response to stress caused by the presence of cadmium.

Keywords: Amaranth, cadmium, silicon

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Advanced chemical treatment by means of cavitation for degradation of environmental pollutants – towards importance of ultrasonic and ultraviolet radiation

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Advanced Chemical Treatment processes include Advanced Oxidation Processes (AOPs) and Advanced Reduction Processes (ARPs). In both cases, a reactive radical species (having oxidative vs reductive character) are formed to obtain effective degradation of environmental pollutants. Recently, special attention relates to processes based on cavitation phenomenon as well as UV radiation. Main applications relate to water and wastewater treatment [1-3]. Cavitation phenomenon can be generated in the liquid by formation of zones with decreased static pressure. Such conditions depending on the method of forming cavitation are named as hydrodynamic cavitation (caused by rapid change of pipeline geometry during liquid flowrate) or sonocavitation/acoustic cavitation (generated by ultrasounds). UV driven processes can be performed by relatively simple systems equipped with proper lamps or diodes.

The paper presents an overview of recent developments in the field of cavitation based AOPs and ARPs, including processes assisted by UV light for water and wastewater treatment. During the presentation significant recent developments of our research group will be highlighted in respect to effective degradation of several pollutants present in water, industrial effluents and fuels, including dyes, volatile organic compounds (VOCs), BTEXs, 1,4-dioxane, amines among others. Dedicated processes effective also in non-aqueous conditions will be presented. Detailed analysis of degradation mechanism, influence of process parameters as well as aspects of by-products formation will be discussed [4-8].

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Fig pomace biochar modified using gamma irradiation for Pb^{2+} ions adsorption from aqueous solution

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Fig (*Ficus carica L.*) is a fruit of the Moraceae family, which is mostly grown in subtropical regions, but also grows in Serbia. Fig trees are usually grown in warm and dry climates. According to the FAO world production of figs is stable, with a decade-long average of about 1.1 million tons a year. Fig pomace are formed after fermentation of this fruit which is used for the preparation of brandy. The brandy industry generates huge amounts of pomace as industrial waste, so pyrolysis as thermochemical technologies was used for organic agro-industrial waste treatment. Biochar produced by pyrolysis of fig pomace at 500 °C were characterized and investigated as adsorbents for the removal of Pb^{2+} ions from aqueous solution.

Fig pomace before and after pyrolysis was characterized using proximate, inorganic and elemental analysis, Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), X-ray diffraction (XRD), thermogravimetric analysis (TGA) and differential thermal analysis (DTA).

Biochar has a carbon matrix with a high degree of porosity and large surface area, suggesting that it can be used as a surface adsorbent and thus have a significant role in controlling environmental contaminants.

The surface modification by gamma irradiation was done to enhance the adsorption capacity of biochar. The Pb^{2+} ions contents in aqueous solution were analyzed using ICP-OES. The adsorption capacity was estimated using the Freundlich and Langmuir model.

The results of this work suggest that pyrolysis and irradiation of biomass is a promising way to produce efficient heavy metal sorbents for waste-water treatment.

Keywords: Fig pomace, biochar, gamma irradiation, Pb^{2+} ions adsorption

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Modeling of bioaerosols spreading in air indoor and outdoor

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Bioaerosol present in indoor air usually contain pathogenic microorganisms causing human and farm animal infections. They also damage materials such as wood, leather, glass, textiles, plastics, stone and building materials, but also metals and their alloys.

Bioaerosols contain viruses, bacteria particles, fungi, spores and conidia, enzymes, bacterial and fungal toxins, fragments of cell covers and allergens such as plant pollen. The air contains dust, drops of water and other liquids, fibres and various organic and inorganic pollutants as components other than biological ones. The composition of bioaerosol depends on many environmental factors and varies in time and space.

The molecules of microorganisms, such as bacteria, fungi, protozoa, but also virus particles, are very rarely found in the free state, but most often in the form of bioaerosols.

In atmospheric air and indoor air aerosol present contains particles of size below 100 μm. Bioaerosols are two- and three-phase systems, consisting of dispersing phase, which is air and a dispersed solid or liquid phase.

Air is not a suitable environment for the growth of microorganisms due to the low content of water and organic compounds. On the other hand, air is a medium through which microorganisms spread from various emitters.

Bacteria, fungi and their surviving forms particles sizes are in the order of micrometres, virus particles are usually very small - from about 20 nm to 250 nm in diameter. For example, the coronavirus SARS-CoV-2 is sphere shaped, with a diameter of approximately 130 nm. The smallest units are about 60 nm and the largest are about 140 nm.

Particles of such small size remain suspended in the air for a long time. All infectious particles smaller than 10 μm are dangerous to human health because they are able to penetrate deep into the lungs.

Bioaerosols are unstable systems, whose stability of dispersion phase depends on for example particle size, their concentration and form, surface charge, as well as their biological properties and the type of organisms suspended.

Modelling of bioaerosol spread is problematic because of obligatory taking to account of many various parameters, such as their fractional composition, spatial geometry, chemical and electrical properties and their transformations in a function of time and space, but also measurement methods and potential harmfulness.

Types of models suitable for aerosol modelling:

- research models - computational hydrodynamics, large-eddy simulation, Monte-Carlo models,
- large-scale models,
- classic mesoscale models - CAMx (Comprehensive Air Quality Model with Extensions) and WRF-Chem models,
- Operational models - SCRAM (Support Center for Regulatory Atmospheric Modeling) Models,
- Lagragian Particle Dispersion models,
- Sedimentation in a function time modelling.

In the presentation, I will focus on Monte-Carlo models.

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Could we expect a correlation between the geomagnetic field and seismicity?

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Seismomagnetism is a relatively new science with a wide field for new research. Most of the geomagnetic observatories, according to the procedures for their work, are adapted to measure geomagnetic field and its changes mostly by external influences or changes in the normal field of the Earth.

To investigate anomalies and study the changes in the magnetic field as predictors (precursors) of future earthquakes, it is necessary to observe magnetograms in long series, at least between two earthquakes of the same seismic source.

An analysis of three earthquakes from Macedonia selected according to the affiliation of a particular geotectonic unit is presented.

In this study using various examples will be shown whether the onset of electromagnetic disturbances may be the onset of seismic vibrations and whether could we expect a correlation between geomagnetic field and seismicity (be expected).

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The amaranth variety 'Zobor' (*Amaranthus hypochondriacus* × *Amaranthus hybridus*) produced by radiation mutagenesis showed activation of *Cassandra* retrotransposon under zinc stress

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Amaranth (*Amaranthus* spp.) is high biomass, multipurpose food-energy pseudocereal, perspective in a temperate climate. Here, grain amaranth variety 'Zobor' (*Amaranthus hypochondriacus* × *Amaranthus hybridus*) previously bred via radiation mutagenesis at our institute was investigated. The mutagenesis-based approach was used to improve the seed weight and seed size as important amaranth quantitative traits. In mutation breeding, especially radiation mutagenesis, chromosomal and DNA changes are induced to obtain the desired quantitative and qualitative characteristics of the target crop.

There is evidence that amaranth has the ability to tolerate and accumulate high concentrations of some heavy metals from soil. To date, little is known about the molecular mechanisms involved in the defense strategy against abiotic stress. However, there is strong link between activation of retrotransposons by stress. Hence, these elements represent important markers of plant stress.

In this study, activation of the specific *Cassandra* retrotransposon was investigated in one-week-old seedlings in the presence of zinc excess. Zinc is an essential micronutrient, but above a certain threshold, it is toxic and even lethal. Amaranth seeds were germinated on the nutrient medium, controls with a standard amount of zinc, and treatments in which multiple zinc concentrations were applied.

We have observed that higher zinc availability in the nutrient medium resulted in lower germination rates. Seedlings showed signs of elevated stress, demonstrated by morphological and physiological defects such as plant deformation and chlorosis of cotyledons. When the genomic profile of control and zinc-treated seedlings was compared, insertion polymorphism of the studied retroelement was detected. Our findings suggest that zinc above the threshold concentration triggers the defense response already in the early developmental stages of amaranth growth and *Cassandra* retrotransposon is linked to molecular pathways activated by metal stress.

Keywords: Amaranthus, zinc, toxicity, retrotransposon

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Natural radioactivity in soil samples taken in the surrounding of the Zelezara factory, Republic of North Macedonia, and the estimation of radiation exposure from soils

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Soil contamination with radionuclides is a global problem that has emerged with the development of nuclear technology in recent decades. The use of phosphate fertilizer in soil increases its radioactivity and thus contributes to the supply of radionuclides from plants growing in the soil to humans. Soil is polluted by radionuclide deposition that is initially released from the atmosphere, or on the surface of the earth by direct release of waste. The capital of the Republic of North Macedonia is Skopje, and the factory Zelezara is located in its immediate vicinity. The study is conducted in order to examine soil from two depths in the surrounding of the factory Zelezara.

The analyses were performed by means of HPGe gamma spectrometry, that is, an instrument - gamma spectrometer (Canberra Packard) with a high purity germanium detector. The obtained spectra from the measurement were analyzed by using the program GENIE 2000. During the statistical processing of the data for analysis of the samples, the mean values of the examined radionuclides were determined as follows: 30.64±1.2 Bq kg-1 for 226Ra, 36.32 ± 1.8 Bq kg-1 for 232Th, 331.65±6.2 Bq kg-1 for 40K. The mean value of the radiation risk index Heks is lower than the maximum permitted value which is <1 for Heks. The value of the radium equivalent activity Raeq is below the maximum recommended limit, i.e., 370 Bq kg-1.

In this study, it was observed that the specific activity of 40K, 226Ra and 232Th in the soil is not uniform, and it probably differs depending on the geological or typographic characteristics of the area. In addition, it also depends on the type of past agricultural activities and the various minerals present in the soil. One can notice that the average concentrations of the same isotope differ from one soil depth to another. Still, the differences are not as significant as usual, which is probably due to the similar nature of the soil. It can be concluded that although there are intensive industrial activities in this area, the natural radiation coming from the soil is normal and does not pose a significant radiological threat for the public. The natural radioactivity of the soil in this area should be periodically monitored in order to prevent the unnecessary radiation exposure of the residents who live near the factory Zelezara.

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Distribution of natural and artificial radionuclides in the attic dust and urban soil samples from a former industrial city (Salgótarján, Hungary)

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Primordial radionuclides can be found in all environmental compartments. Coal-fired power plants (CFPP) can be a source of additional contribution because coal contains trace amounts of natural radionuclides such as ^{40}K, ^{238}U, and ^{232}Th and their decay products. These radionuclides can be released as fly ash from power plants and deposited from the atmosphere into the ambient environment, enhancing the natural radioactivity background levels. The study deals with the assessment of potential exposure from ^{238}U, ^{232}Th, ^{40}K, and ^{137}C, in attic dust and urban soil, environmental samples from Salgótarján city. Radionuclide activity measurements of 19 urban soil, 36 attic dust samples, 1 brown forest soil as local background, and 1 fly-ash slag sample were carried out on an area of 98 km^2 of the city. Sampled houses were built between 1890 and 1990, considered representative of long-term accumulation(s) if there is no reconstruction. Urban soils from a playground, a kindergarten, and a park, located not farther than 500 m from the corresponding attic dust sites were collected at a depth of 0-15 cm in August 2016. In the bulk samples, the mean elemental concentrations of U (mg kg^{-1}), Th (mg kg^{-1}), K (m/m %), and Cs (mg kg^{-1}) in attic dust and urban soil were 2.4, 3.6, 0.6, 1.7 and 1.1, 4.4, 0.3,1.2, respectively, using ICP-MS at Bureau Veritas Minerals Canada Ltd. Also, activity concentrations (Bq kg^{-1}) of ^{238}U, ^{232}Th, ^{40}K, and ^{137}Cs in attic dust and urban soil samples were determined by a low background iron chamber with a well-type HPGe and with an n-type coaxial HPGe detector, respectively in the Centre for Energy Research, Hungary. The mean values of ^{238}U, ^{232}Th, ^{40}K, and ^{137}Cs (Bq kg^{-1}) activities for attic dust and urban soils are 43.3, 34.0, 534.4, 88.5, and 25.1, 32.8, 386.4, 5.2, respectively. The brown forest soil showed one of the lowest U, Th and K content and radionuclides, except for ^{137}Cs. A significant difference of U, K and Cs elemental (mg kg^{-1}) and activity concentrations (Bq kg^{-1}) was observed between attic dust and urban soil samples showing elevated radionuclide activities in attic dust samples, which preserved past records of fingerprint and components of atmospheric deposition rather than urban soil. The mean annual outdoor effective dose equivalent (E) is 0.06 mSv, which is very close to the average UNSCEAR value of 0.07 mSv. However, attic dust's means annual indoor effective dose is 0.36 mSv, confirming the technologically enhanced natural radioactivity in the attic dust samples is a consequence of the coal-fired power plant operation.

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Biosorption of europium by *Spirulina platensis* biomass

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The efficacy of europium removal using dried *Spirulina platensis* has been investigated. The effects of four variables including pH, metal concentration, time and temperature were evaluated. Maximum biosorption of europium was achieved at pH 3. Equilibrium data fitted well with the Langmuir model as well as the Freundlich model with maximum adsorption capacity of 89.5 mg/g. The pseudo first, pseudo-second-order and Elovich models were found to correlate well with the experimental data. Different thermodynamic parameters, ΔG°, ΔH° and ΔS° were evaluated and it has been found that the sorption was feasible, spontaneous and endothermic in nature. The high europium biosorption efficiency of *Spirulina platensis* may constitute an effective and eco-friendly alternative strategy to recover europium from contaminated environment.

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Advanced reduction processes (ARPs) induced by ultraviolet (UV) radiation in degradation of water pollutants

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Advanced reduction processes (ARPs) can complement advanced oxidation processes (AOPs) and other wastewater treatment methods to increase their overall degradation efficiency. The use of ARPs in the removing pollutants from industrial effluents containing a high load of toxic and difficult to biodegrade chemical compounds revealed to be effective [1,2]. Reduction of pollutants by means of hydrated electrons generated during UV-radiation through a series of contaminants transformations into non-toxic compounds has a very high potential for application in industrial wastewater treatment processes [3-4].

The paper presents basics of ARPs as well as examples of applications and comparison of the removal effectiveness with other treatment methods. Finally, the influence of environmental conditions, such as temperature and pH of the solution, on the degradation efficiency is also discussed. Application of UV radiation to generate very reactive reductive species reveals to have a high reduction potential for future developments in the field of wastewater treatment technologies.

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Assessment and differentiation of light absorbing carbon in atmospheric aerosols

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Light Absorbing Carbon (LAC) or Black carbon (BC) is one of the most important components of fine particulate matter ($PM_{2.5}$), which is formed through the incomplete combustion of fossil fuels, biofuels and biomass. Based on a number of studies, it has been shown that carbonaceous particles significantly affect air quality/environment and they are an important factor in the carbon cycle and climate change. BC, as one of the constituents of carbonaceous respirable particles, has the property of absorbing light and leads to an increase in the annual average air temperature. Therefore, its quantitative analysis and differentiation for determination of potential radiative effects is extremely important. The BC concentration is usually determined by using thermal or optical methods. In this paper, the results of the application of multi-wavelength optical technique for BC estimation which is based on measuring the intensity of absorption/transmission of light through samples of deposited aerosols on PTFE filters, are presented. Sample collection was conducted at Belgrade suburban background site, in heating and nonheating seasons, using low-volume air samplers. In order to estimate the BC concentration of different particle diameters, measurements were performed by using the MABI ANSTO instrument, with LEDs that emit light at seven different wavelengths: 405 nm, 465 nm, 525 nm, 639 nm, 870 nm, 940 nm and 1050nm. The measurement procedure is started by determination of the value of light transmission I_o through an unexposed or blank filter at different wavelengths. After sampling, the estimation of light transmission I through the exposed filters was performed. Before estimation of BC concentration, the light-absorbing coefficient (b_{abs}) at each wavelength was determined separately. More intense variations in the values of b_{abs} were observed, which most likely occur due to the change in the nature of the pollution sources at the sampling site. The accuracy of the BC concentration depends on the value of the mass absorption coefficient (ε) estimated experimentally and whose values are compared with the predefined manufacturer values. BC generated by combustion at lower temperatures is better absorbed at shorter wavelengths. On the other hand, BC generated through high-temperature processes is better absorbed in the infrared region of the electromagnetic spectrum. Therefore, the differences of BC concentrations at two boundary wavelengths: 405 nm and 1050 nm were analyzed. Finally, seasonal BC variations were observed, with increased values in the winter and autumn periods compared to the summer period.

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Removal of Cd^{2+} ions from aqueous solutions by gamma irradiation activated biochar of plum pomace

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The use of waste biomass for the production of fuels, sorbent of different pollutants or natural fillers has significant economic and environmental benefits.

Plum (Prunus domestica) is a lush fruit consisting of bones, flesh and skin. It can be consumed fresh, dried or used to make juices, jams and brandies known as plum brandy. Plum is also known as a laxative. During processing, plum pomace is formed as a by-product of plum brandy production. Plum pomace contains a large proportion of polyphenols, so it can be used to produce dietary supplements.

Therefore, in this study, the gamma irradiation activated biochar of plum pomace was examined as a low-cost biosorbent of Cd^{2+} ions from aqueous solution. It was prepared using pyrolysis process at 500 °C for a reaction time of 1 h, then was activated by gamma irradiation. The characterization of plum pomace before and after pyrolysis was done by Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), thermogravimetric analysis (TGA) and differential thermal analysis (DTA).

Analysis of morphology and functional groups presented the formation of cracks on the biochar surface, which are mainly dominated by oxygen-rich functional groups. The adsorption capacity of activated biochar was higher than inactivated biochar because its improved surface functional properties after gamma activation.

The Cd^{2+} ions contents in aqueous solution were analyzed using ICP-OES. The adsorption capacity was estimated using the Langmuir and Freundlich model. The findings of this study confirm that pyrolysis is a promising way to produce efficient environmentally friendly sorbents for wastewater treatment.

Keywords: Plum pomace, biochar, Cd^{2+} ions adsorption, gamma irradiation

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Microbiological quality of commercial fish feeds

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Feed quality is an important parameter of any aquaculture system. Among other properties, the presence of microorganisms in feed is important. The microbiological analysis of various feeds used in fish diet was performed in three trout fish ponds in the Republic of North Macedonia. The feed originated from Macedonia, Greece and Netherlands. The microbiological tests were performed during the months from April to September. The examinations included: total number of bacteria, *Escherichia coli, Salmonella*, *Staphilococcus pyogenes*, *Proteus* sp., *Streptococcus* sp., sulphite reductive clostridia, mesophilic bacteria, yeasts and moulds. The results obtained from the present investigation indicate that the feeds used in the fish diet differed in their microbiological quality. Feed from Macedonian origin and from Greece was contaminated with *Escherichia coli* and *Proteus* sp., but their number was smaller in the feed samples from Greece. This indicates that either the raw material used for feed preparation was contaminated or feed was prepared in the environment with law hygienic conditions. Therefore, the feed from Macedonia and Greece did not fulfill the feed quality criteria. Fish feed from Netherlands was the least contaminated and all the examined groups of microorganisms were in the range of the allowed amounts with very small deviations. Hence, feed manufacturing companies have to comply with the quality regulations and specifications.

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The examination of radiation-derived amaranth variety 'Pribina' (*Amaranthus cruentus* L.) as potential cadmium and lead-accumulating variety

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Heavy metal accumulation cause in plant tissue severe biochemical, physiological, and morphological abnormalities and may interfere with crop productivity. Many plant species tolerate high levels of metals without severe damage of growth and development or productivity. Thus, these plants can be used in soil decontamination. Their phytoremediation efficiency depends on the ability of plants to accumulate and translocate the metals.

Amaranthus spp. is generally considered as the accumulator of some heavy metals. On the other hand, amaranth is also one of the important pseudocereals. Thus, it is crucial to evaluate the level of translocation of contaminants to its aerial parts and seeds from the human consumption aspect.

This research was conducted to evaluate the potential of radiation-derived grain amaranth variety 'Pribina' (*Amaranthus cruentus* L.) for remediation of soils contaminated with cadmium and lead. We evaluated some growth parameters and morphology that belong to the essential criteria to assess heavy metal tolerance. Our results showed that the tested variety could tolerate cadmium and lead without any lethal effects. The accumulation of applied heavy metals increased with their increasing concentration, but the translocation to the aerial (edible) parts was low. We have classified variety 'Pribina' as cadmium and lead excluder able to grow and accumulate significant amounts of these metal ions preferentially in the roots, with limited root-to-shoot translocation. Thus, variety can be used as effective cadmium and lead phytostabilizator, to lower the soil content of these risk factors in the contaminated regions.

Keywords: Amaranthus, cadmium, lead, phytoremediation

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Ternary Ion-association complexes between the iron(III) with 4-(2-Thiazolylazo)Resorcinol and some tetrazolium cations

Galya K. Toncheva[1], Petya Racheva[2], Nikolina Milcheva[2], Vitka Divarova[2], Nicole Parapanova[1], Kiril B. Gavazov[2]

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Two liquid-liquid extraction-chromogenic systems containing Fe(III), 4-(2-thiazolylazo)resorcinol (TAR), tetrazolium salt (TZS), water and chloroform were studied. 2,3,5-Triphenyl-2H-tetrazolium chloride (TTC) and 3-(4,5-dimethyl-2-thiazol)-2,5-diphenyl-2H-tetrazolium bromide (MTT) were the examined TZSs. Optimization experiments for iron extraction were performed and the following parameters were found for each system: pH(opt), C_{TAR}(opt), C_{TZS}(opt), shaking time (opt), and l(opt). Under the optimum conditions, the molar ratio of the reacting Fe(III), TAR and TZS is 1:2:2 and the general formula of the extracted species is $(TZ^{+})_2[Fe^{II}(TAR^{2-})_2]$. Some equilibrium constants (constants of association, constants of distribution, and constants of extraction) and analytical characteristics (molar absorptivities, Sandell's sensitivities, Beer's law limits, etc.) were calculated.

Keywords: Fe(III) reduction, solvent extraction, ion-association, ternary complex

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Antioxidant potential of extracts isolated from medicinal plants

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This article summarizes the results of using cytokinesis-block micronucleus (CBMN) assay to evaluate the antioxidant potential of extracts of some plants native to our region (raspberries, blackberries, currants, blueberries, grapes, equisetum e,). The results showed that the above mentioned plants show significant radioprotective properties. For example, the antioxidant compounds from seed extract of three types of blueberries have beneficial effect on irradiated cells because they reduce the level of reactive free radicals. However, more important in blueberries is the presence of antimutagenics that promote proper repair of DNA damaged by irradiation [Gođevac, V. Tešević, V. Vajs, S. Milosavljević, M. Stanković, Blackberry Seed Extracts and Isolated Polyphenolic Compounds Showing Protective Effect on Human Lymphocytes DNA, J. Food Sci. 76(7) (2011) C1039-C1043.]. Our research has shown that two glasses of red wine per day in the diet increased the flavonoid content of 40%, which exceeds the effects of good "free radical scavengers" [M. Stanković, V. Tešević, V. Vajs, N. Todorović, S. Milosavljević, D. Gođevac, Antioxidant Properties of Grape Seed Extract on Human Lymphocyte Oxidative Defence, Planta Med. 74 (2008) 1-6.]. The antioxidant compounds of red wine have beneficial effect on irradiated cells, since they reduce the level of reactive free radicals and repair DNA damaged by radiation. The results from the analysis of the protective effects of some medicinal plants (Equisetum arvense, Seseli annuum, Rubus idaeus), showed, similar to that of red wine, that the compounds isolated from these plants show a strong antioxidant and antimutagenic effect thus reducing the level of reactive free radicals in the cell which leads to a positive physiological effect. The radioprotective effect of plants on the human body are tested on the peripheral blood lymphocytes as models, where the main criterion of efficiency is the reduction of ionizing radiation damage of the cells which are in contact with the preparation to be examined. The development of effective radioprotectors is of great importance in view of their potential application during both planned radiation exposure (radiotherapy) and unplanned radiation exposure (nuclear accidents, natural background radiation emanating from the earth or other sources).

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Preparation of molybdenum targets for high current cyclotron production of medical ^{99m}Tc radionuclides

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In this study we report a novel approach for the development of molybdenum targets to be used for high current cyclotron production of ^{99m}Tc radionuclide using the ^{100}Mo(p,2n) nuclear reaction. The challenge for the large-scale cyclotron production of ^{99m}Tc consists in the development of high-density ^{100}Mo targets that are able to support multi-hour high current cyclotron irradiation, with high density, adhesion to baseplate, and high thickness, without material losses. The choice of target preparation technique is always a compromise between fulfilling the application's particular requirements and the cost of implementation [1-3]. Therefore, a new approach to obtain a high-density molybdenum target using pressing-heating process was developed. The surface morphology, roughness, impurities and adhesion performances of the obtained molybdenum targets were established by using Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM) and Energy-Dispersive X-Ray Spectroscopy (EDX) techniques. The prepared targets were also irradiated with protons at high-current cyclotron.

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Application of copper electrodeposition processes in visualization of latent fingerprints obtained on various substrates

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Fingerprints, known for their specific topography, contain physical and biochemical information that is extremely important for personal identification and evidence. A special place in the analysis of fingerprints belongs to the research of visualization methods of invisible, so-called latent fingerprints.

The basic principle of visualization of latent fingerprints is to create a contrast between the fingerprints and the background. Then latent fingerprints become visible to the naked eye and can be further processed.

In this research, visualization was achieved by electrochemical deposition of copper coatings on conductive surfaces on which fingerprints were left. Fine-grained copper films were electrodeposited by direct current (DC) regime onto brass, stainless-steel and monocrystalline silicon substrates. The development of latent fingerprints and the quality of visualization are influenced by the initial surface roughness, microstructure, color and orientation of the substrate.

The quality of visualization was compared on untreated substrates and substrates that were mechanically and chemically treated before leaving fingerprints.

In addition to the properties of the substrate, the quality of visualization is influenced by the microstructure and properties of copper coatings. The application of electrolytes of different composition with variable deposition parameters led to significant changes in the microstructure of the coatings.

In this study, a basic sulfate electrolyte for electrochemical copper deposition and a sulfate electrolyte with additives to improve coating quality were used. It has been shown that for the visualization of latent fingerprints, it is better to use an electrolyte without additives. The use of electrolytes with additives has not been shown to be adequate for these purposes due to the effect of filling fingerprint ridges and reducing contrast.

The optimal duration of the electrodeposition process was determined experimentally depending on the type of substrate, roughness and the degree of surface treatment of the substrate and electrodeposition parameters.

The quality of the application of the electrochemical deposition of copper in order to visualize latent fingerprints was assessed visually and by applying optical microscopy for specific details.

Keywords: Latent fingerprint, forensic science, copper electrodeposition, additive chemistry

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Debris fretting testing facility at CVR

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Fuel failure caused by the cladding fretting wear is still a relevant issue, despite decades of R&D intended to improve the physical parameters of fuel. According to the Nuclear News (in cooperation with the EPRI), in the year 2010, the majority of failed fuel rods in the U.S. occurred due to the insufficient mechanical parameters of the cladding surface against cycled load. In the case of BWR units, debris fretting provably cause more than 52 % and PWR more than 24% of fuel rod failure in the review period. The present work addresses the experimental capabilities of Research Centre Řež in the frames of debris fretting wear developed and proved on Zr-1%Nb alloy tube specimens covered with protective coatings made of chromium and nitride. The experiments included debris-fretting tests in dry conditions at room temperature also wet conditions at maximum temperatures 90°C and autoclave tests in close to real PWR conditions. This thesis aims to show differences in debris wear resistance between the reference Zr-1%Nb specimens and specimens of the same alloy covered with various coatings and to prove the positive impact of coating applications on fuel cladding endurance. The conducted analysis revealed a significant advantage of cladding with a thin, wear-resistant layer against standard cladding material. The study includes also microscopic measurement of the depths of the grooves, and a detailed analysis of Scanning Electron Microscopy, Energy-Dispersive X-ray, and Focused Ion Beam. The autoclave tests are of course the most challenging also from the mechanic point of view when it is required to pass torque from the overhead motor to the shaft inside the autoclave to propel the cycling load between the debris mock-up (stainless steel wire) and the specimens. Research Centre Řež has developed a special magnetic clutch and obtained a utility model on it. Thanks to the clutch it is possible to transfer the nominal RPM from the motor, through the system of magnets and airscrews, to the rotating clamp with the wire mock-up. In this way, the specimen can undergo fretting tests.

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Mechanochemical synthesis of porous SnO_2/TiO_2-based composite ceramics: Microstructure and humidity sensing characterization

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Tin-oxide and titanium-oxide (SnO_2/TiO_2) based ceramics are modified by doping with Mo and Zn ions using a simple and economical mechanochemical procedure with low-cost starting precursors. Optimization of synthesis parameters is carried out to obtain high open porosity which provides better adsorption of water molecules when ceramics are used as sensing elements of the humidity sensors offering several advantages such as high chemical, mechanical and thermal stability. Correlations between the microstructure and electrical properties are investigated using several techniques: X-ray diffraction, scanning electron microscopy, and Raman and impedance spectroscopy. The most favorable synthesis conditions for achieving ceramics microstructure suitable for high-sensitivity and selectivity to chemisorptions, and relatively fast response and recovery time, as well as good stability and reliability, were determined.

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Cross-linked bio/inorganically modified urea-formaldehyde resins: Influence of γ-radiation on formaldehyde content

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The effect of γ–irradiation on hydrolytic stability of nano-silica, nano-titania, and wood flour (WF) modified urea-formaldehyde (UF) resins was investigated. Modified UF resin with wood flour (*Pinus silvestris L.*) as natural filler and modified UF resin with a mixture of SiO_2/WF and TiO_2/WF fillers were synthesized. A total of five samples were synthesized, with the designations UF/SiO_2, UF/TiO_2, UF/WF, UF/SiO_2/WF, and UF/TiO_2/WF, under the same conditions. The content of free formaldehyde (FA) was determined by the bisulfite method. The hydrolytic stability of modified UF resin was determined by measuring the concentration of liberated FA of modified UF resins after acid hydrolysis. The studied modified UF resins have been irradiated with 50 kGy and the effect of γ–irradiation was evaluated on the basis of the percentage liberated FA before and after γ–irradiation. The minimum percentage of free FA (0.06%) and liberated FA (0.16%) were obtained in UF/TiO2 composite before and after γ–irradiation which indicates a significant improvement in the hydrolytic stability compared to other modified UF resins.

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Lignite slag and bismuth oxide filled elastomeric hosts for radioactive waste encapsulation – radiation shielding, leaching behavior and aging

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Nuclear energy sector generates radioactive waste in various chemical and physical forms. Next to the most problematic high level radioactive waste (HLW), equal attention is paid to separation and immobilization of low (LLW) and intermediate level waste (ILW). These wastes streams are generated as a result of the pellet-cladding interactions, thermal and radiation degradation and construction materials corrosion processes occurring in reactor core and followed by releasing radioactive contaminants into primary cooling circuit. Separation of radioactive isotopes from cooling media is a main goal of the continuous water purification processes. Resulting concentrated radioactive solutions, sludges and solid wastes must be subsequently immobilized in a safe and long-term stable waste forms.

Selection of the proper waste matrix material 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 composite materials, which exhibit good mechanical behavior, very good properties of radionuclides retention and very low diffusivity within the host matrix.This work presents, discuss and summarizes leaching behavior and immobilization efficiency of Cs-137, Sr-90, Co-60 and Am-241 radionuclides in lignite slag and bismuth oxide filled elastomeric composites. Experimental procedure was based on mixing and hot pressing of the polymer and mineral fillers with radioactive tracers. For verification of immobilization efficiency of the prepared composites, and static IAEA long-term leaching test for solidified radioactive waste forms (ISO 6961:1982) was applied. Experimental results suggest good and satisfactory leaching behavior of the investigated matrices. Next to above, the host materials were investigated towards radiation shielding properties as well as modified using high radiation doses in order to verify their radiation resistance and aging rate.

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On the unified configuration-enthalpic model of radiation-induced functionality in chalcogenide glass-forming systems

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The configuration-enthalpic model grounded on mutually-interrelated configuration-coordinate and enthalpic diagrams is developed to describe the phenomenology of optical responses in chalcogenide glass-formers caused by combined effects of very long physical ageing and high-energy irradiation. The chalcogenide glasses are supposed be stabilized in the ground state and some temporary excited states, the former being presented by tightly interconnected metastable wells (i.e. rejuvenation-induced, irradiation-induced, physically-aged and deep crystalline-like ones) linked by thermally-activated over-barrier and tunneling through-barrier transitions. As an example, effect of high-energy irradiation on arsenosulphide glasses (As-S) is reflected within this model by vertical transitions of atomic sites into excited state followed by spontaneous non-radiative relaxation into irradiation-induced ground state. Approach based on interlinked thermodynamic enthalpic and configuration-coordinate diagrams allows complete parameterization of optical responses related to these states, defined in blue (bleaching) or red (darkening) shifts in the fundamental optical absorptions edge of these glasses. The phenomenological identity of radiation-optical changes obeying competitive changes from many supplemented influences is shown to be completely revealed in chalcogenide glasses of multinary Ge-AS/Sb/Bi-S/Se systems.

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High-Z TL/OSL detectors based on Mn-doped rare-earth aluminates

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Mn^{2+}-doped $YAlO_3$ (YAP) is known as a perspective high-Z material applicable for thermoluminescent (TL) or optically stimulated luminescent (OSL) dosimetry of ionizing radiation (see [1] and references therein). In particular, the green emission from Mn^{2+} ions occurring at the main TL peak at about 200 °C can be used for this purpose. This TL signal fades strongly at daylight (bleaching effect), therefore an optical stimulation by blue-green light can be used for its readout [2].

Detector materials having high effective atomic number (Z_{eff}), for which the photoelectric effect dominates especially for lower radiation energies, possess considerable energy dependence. This energy dependence can be used for characterization of spectral composition of radiation fields, which can be used in radiological emergencies and/or in high dose rate workplace fields [3].

The present study deals with further improvement of YAP:Mn-based detector (Z_{eff} ~ 31.4) in order to increase the effective atomic number of the material even more as well as to improve the TL and OSL properties of the material important for its practical application in radiation dosimetry. In particular, the (Y-Lu)AP and (Y-Gd)AP host materials doped with Mn^{2+} ions have been studied and compared with the YAP:Mn^{2+} detectors studied previously. For this purpose thermoluminescence (TL), photoluminescence (PL), radioluminescence (RL), continuous-wave OSL (CW-OSL), time-resolved pulsed OSL (TR-OSL), and dosimetric properties of the materials have been studied and compared. Observed changes in the material properties are discussed in terms of band energy structure of the host lattice and trapping/recombination levels of the studied materials.

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Radon-222 adsorption characteristics of different enhanced natural zeolites

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The radon gas (^{222}Rn) is one of the most important sources of radiation in the environment, accounting for about half of the dose received by population from natural sources. Thus, it is imperative to study and develop specific methodologies aiming at the reduction or elimination of radon from the air. In this regard, materials such as zeolites, with a well-defined three-dimensional nano- and micro-porous structure, and a great surface adsorption capacity could be suitable for radon mitigation.

The present work evaluates the adsorption efficiency of ^{222}Rn by four different types of zeolites. The experimental setup consisted of a continuous radon monitor system (RAD 7) with a drying unit, attached to a radon chamber and an adsorption tube filled with the zeolite material. The measurements started with an initial radon concentration set in the 1574±21 - 2990±18 Bq/m^3 range, and the air was recirculated in the closed system until reaching a radon activity close to zero, during which the zeolite material was replaced three times. The adsorption efficiency of the material was determined by comparing the experimental decay curve of radon in the system, determined for the same specific activity interval, with the radon adsorption curve obtained after attaching the zeolite tube.

The results indicated that the first type of zeolite (unenhanced) achieved an adsorption efficiency between 0.288%/h and 1.50 %/h, depending on the radon concentration. The second type of zeolite, which was enriched with activated charcoal, adsorbed radon at a rate between 0.20%/h and 0.66%/h. The third type of zeolite, which was enriched with silver and iodine, reduced the radon specific activity in the system by 0.36%/h and up to 0.92%/h. The removal efficiency of the material varied significantly and depended on the radon concentration. Generally, the adsorbent achieved the highest efficiency when the initial specific activity of ^{222}Rn in the system was set in the 400-800 Bq/m^3 interval. The results regarding the fourth type of material used, namely surfactant-modified zeolite, are forthcoming.

To this stage, the results indicated that zeolites can potentially be used as adsorbents to decrease radon concentrations from air, however they require a longer exposure time in order to achieve a substantial reduction of the gas compared to other materials available, such as activated charcoal.

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Graphene-based sensing for vitals monitoring

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This abstract explores the latest advancements in graphene-based sensors used in wearable devices, specifically developed for vital signs monitoring. Heart rate, respiratory rate, blood pressure, and SpO2 are the four vitals whose continuous measurements are inevitable to achieve a healthcare continuum. In the past years, we have witnessed rapid advancement in the field of wearable devices with a primary focus on human health and behavior monitoring. The usual setup is a microcontroller with various sensors attached whose signals are transmitted to a mobile device, and from there to the Cloud, where the data is preprocessed, and the results are returned to the user and displayed via the specially developed mobile application. Even though this trend lasts for years, there is still no such integrated wearable device that is able to achieve continuous monitoring of all four vital parameters. Thus, we explore the latest state-of-art material, graphene, and its power in sensing various biochemical and biophysical signals, and as such being a great candidate to solve the constraints of the existing technology. Speaking in terms of vital parameters, we will focus on the latest advancements of graphene-based sensors for each of them distinctively.

As the heart rate and respiratory rate are direct derivatives of the electrical activity of the heart (heart rate) affected by the chest movement of the person that has the sensor attached to the chest (respiratory rate), we explore the possibility of ECG signals being measured with graphene-based bioelectrical electrodes.

The common bioelectrical electrodes easily suffer from noise and high contact impedance, thus their quality is essential for accurate signal acquisition. The production is usually expensive as they must obey a high signal-to-noise ratio, accuracy, low impedance, durability, and robustness. One of the main problems is that when the person is in movement, the electrode loses contact with the skin, which results in deformation in the signal. As graphene provides excellent mechanical and electrical properties, and in addition it is the thinnest conductive medium, novel graphene-based electrodes with different composite materials have attracted the attention of wearable technology researchers. Graphene electronic tattoo (GET) are electrodes produced as “wet transfer, dry patterning”, with a thickness of 463±30 nm and more than 40% stretchability. This sensor is also suitable for measuring EMG signal, thus making it a good candidate for the respiratory rate extraction from muscle activity. However, GET electrodes are still considered high-cost for production. On the other hand, PDMS (polydimethylsiloxane) is cheaper to produce and characterize with 150% super stretchability. Another multipurpose electrode is proposed in which the problem of perspiration evaporation is solved by laser-patterned porous graphene and sugar-templated silicone elastomer sponge. This multipurpose electrode shows excellent air permeability and minimizes the inflammation risks on the skin.

Graphene-coated glass fiber pressure sensor has been tested as a part of an electronic sphygmomanometer, and its sensitivity has shown to be suitable for accurate blood pressure measurements. Another experiment is an invasive approach by implanting a wireless pressure sensor composed of a graphene sheet and a transmitter coil integrated with a polydimethylsiloxane PDMS tube.

Considering the measurements of the oxygen saturation in the blood, a graphene-based ear-conformable sensing device with embedded and distributed 3D electrodes is proposed that is able to tackle diverse physiological signals, among which is also the measurement of SpO2. Other proposed graphene-based sensors for obtaining oxygen levels are mainly in the form of implants for invasive measures. The extra thermal and bioconductive characteristics of graphene make this material yet to be explored in the upcoming years.

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Forensic application of 3D reconstruction of lumbar transverse process stress fractures – a case report

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Lumbar transverse processes fractures of vertebras can be as the result of major violent lateral left and right side bending. The aim of this report is to compare a multiplanar three-dimensional tomography reconstruction (3D-CT) with conventional radiography in lumbar transverse process stress fractures. We described a case of a 35-year-old man presented to the emergency department by pain in the lumbosacral region as a result of a beating. It was not observed traumatic changes of the lumbar spine by X-ray. CT showed fractures of the transverse processes on left 11th rib arc, L-1 vertebrae on right side and L-3 and L-4 on left side. Multiple lumbar transverse process stress of L-1, L-3 and L-4 can associated with direct lateral bending and flexion. 3D images showed number and actual sites of fractures than X-ray method. The final conclusion of forensic expertise based on the results of 3D reconstruction. The patient was subjected to blood biochemistry examinations, conventional radiography and multiplanar three-dimensional tomography CT chest with 3D reconstruction. CT scanning shows 100% accuracy in fracture detection site and number of lumbar transverse process stress fractures. In this aspect, 3D-CT has better diagnostic ability in mechanical stress case. It can be used as a powerful tool in forensic medicine practice for identifies the possible mechanism of injury.

Keywords: CT techniques, 3D reconstruction, lumbar transverse process stress, forensic medicine

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Artificial Intelligence for radiographers: A review of current applications and a survey among Dutch hospitals

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Purpose. Artificial Intelligence (AI) has changed radiology substantially in the last years, where the focus of attention has mainly been on the radiologist profession. However, the radiographer's role has been largely ignored while AI also is affecting for example workflow management, treatment planning and image reconstruction. Radiographers are not prepared for changes that will come with the introduction of AI into everyday work.

Materials and Methods. Firstly, a survey was conducted among Dutch radiographers to investigate what role AI currently plays in their everyday work and what needs with respect to education and training currently exist. Secondly, a project was developed consisting of three main steps, leading to online AI education (e-learnings) tailored to the needs of radiographers. The first two steps in this project consist of a systematic review of the scientific literature regarding AI applications that influence the radiography workflow, and focus groups with AI experts based on the outcomes of the systematic review to obtain better insight into which developments will lead to future changes for the everyday work of radiographers.

Results. The survey questionnaire was filled in by 126 radiographers from hospitals all over the Netherlands. 56% of the respondents work in Radiology, 24% in radiotherapy, and 10% in nuclear medicine. 90% is familiar with the concept of AI, and 70% encounters some form of AI in their day-to-day work. In most cases this concerns image reconstruction (40%), image recognition (35%) and image fusion (33%), but also quite often postprocessing and automatic delineation (both 29%) and dose optimization (28%). In a few instances the AI concerns patient positioning (10%), workflow management (8%) and clinical decision support (7%). Most respondents feel a need for some form of AI education (79%), preferably in the form of an e-learning (71%). The top three educational topics are the application of AI tools (93%), the basic principles of AI (79%), and the safe use of AI algorithms (70%).

In order to fulfill the need for online specific radiographer-oriented education in AI a project has been funded by the Dutch Taskforce for Applied Research (SIA) that will run until March 2023. Here, preliminary results will be presented on the first step of the project: the systematic review of the scientific literature. For the systematic review a total of 70 articles were found, ranging from review, prospective, retrospective to survey articles in search engines like PubMed, Scopus and Google Scholar. Results show a wide variety of applications of AI that (will) influence the work of radiographers, ranging from changes in everyday workflow, like patient checks, planning of examinations, acquisition of images and post-processing activities, to changes in work flexibility, like cross-modality employability or performing radiologist tasks, and training, implementing and quality control of AI systems. Knowledge of AI, the basics as well as pitfalls, challenges, ethical and legal complications is prerequisite for radiographers.

Conclusions. A survey among Dutch radiographers shows that they often encounter AI applications in their everyday work. They indicate a need for (preferably online) education to increase their knowledge about AI. A project has been funded to fulfil this wish. The first step of this project (a systematic review) has been taken and it should eventually lead to radiographer-specific e-learning in 2023.

Keywords: Artificial intelligence, radiography, education, e-learning

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Sex estimation by mastoid process size based on CT imaging

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The study aims to evaluate the sex differences in the size of the mastoid process and to develop discriminant models for sex estimation based on its measurements. The study was carried out on head CT scans of Bulgarian adults. The images were generated using a medical CT system Toshiba Aquilion 64. Based on the DICOM series, three-dimensional (3D) models of the skulls were produced by segmentation of bone tissue in the software InVesalius. The 3D coordinates of the landmarks mastoidale, asterion and porion were acquired using the software Meshlab. The landmarks were digitized bilaterally. Based on the 3D coordinates, three linear measurements, three angles and the area of the so called "mastoid triangle" were computed. The linear measurements were calculated as Euclidean distances. The angles were found using the Law of Cosines. The area was calculated using the Heron's formula. The sex differences in the mastoids measurements were tested for statistical significance by the independent t-test. The bilateral differences in the mastoid process measurements were evaluated using the paired t-test. Discriminant function analysis was applied to develop classification models for sex estimation. The results obtained in the study showed that all measurements of the mastoid process differed significantly between the male and female skulls, except for some of the mastoid triangle angles. The total mastoid triangle area was the best sex discriminator among all studied measurements.

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Machine learning classification models for sex estimation based on cranial measurements derived from computed tomography images

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The aim of this study is to evaluate the effectiveness of such Machine Learning (ML) algorithms as support vector machines (SVM) and artificial neural networks (ANN) for solving the task of sex estimation based on cranial measurements derived from computed tomography (CT) images. The study was carried out on CT images of 393 adult Bulgarians (169 males and 224 females). The images were generated using a medical CT system Toshiba Aquilion 64. Three-dimensional (3D) coordinates of 47 anatomical landmarks were acquired. The landmarks of 118 crania were digitized in the 3D reconstruction panel of VG Studio Max. The landmarks of 275 crania were picked in MeshLab, but in this case polygonal surface models of the skulls were created in advance using InVesalius. The segmentation was performed based on the predefined threshold for bone tissue in InVesalius. The 3D coordinates of the landmarks were used for calculation of cranial metric characteristics, including 64 measurements such as linear distances, angles, triangle areas and heights, as well as 22 indices. Two datasets were assembled using some of these characteristics as dataset attributes. The first dataset included 37 standard linear measurements and the second one consisted of all measurements and indexes. In order to evaluate the importance of dataset attributes two advanced attribute selection techniques (Weka BestFirst and Weka GeneticSearch) were also applied to both datasets. Classification models for sex estimation were built for all datasets by means of SVM and ANN algorithms. The classification accuracy of the models learnt was evaluated using 10×10-fold cross-validation procedure. Both ML algorithms achieved higher accuracy using the full set of attributes rather than when only some subsets of attributes were selected for constructing the datasets. Both SVM and ANN achieved the highest accuracy (over 95%) on a dataset described by the full set of 86 metric characteristics. The best result of 96.1±0.5% was provided by SVM. The results have shown that both SVM and ANN algorithms are able to learn quite accurate classification models for sex estimation based on cranial measurements derived from computed tomography images.

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Sex and bilateral differences in the position of mental foramen: A CT-study

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The mental foramen is a bilateral opening located on the anterior surface of the mandibular body. It transmits the mental nerve, artery and vein. This foramen is an important anatomical landmark for applying local anesthesia and performing surgical interventions. Its position is clinically significant for avoiding iatrogenic injury of the nerve and blood vessels. The injury of the mental nerve can cause sensory dysfunction of the lower lip and surrounding skin and mucosa. The mental foramen commonly appears as a single structure but the presence of accessory mental foramina can also be observed, which is essential in dental practice for performing medical procedures in this region. The aim of the present study is to determine the anteroposterior position of the mental foramen and the frequency of accessory mental foramina in Bulgarians based on computed tomography (CT) images. The study included 251 CT scans of Bulgarian adults (118 males and 133 females). The images were generated using a medical CT system Toshiba Aquilion 64. The position of the mental foramen was categorized in 5 groups: 1) below the 1st premolar, 2) between the 1st and 2nd premolar; 3) below the 2nd premolar; 4) between the 2nd premolar and the 1st molar; 5) below the 1st molar. The sex and bilateral differences in the position of the mental foramen were evaluated by the chi-square test. The presence of accessory mental foramina was established by visual inspection of the three-dimensional reconstructions and corresponding two-dimensional cross-sectional images. In the male and female series, the mental foramen on both sides was most frequently located below the 2nd premolar. There were no significant sex and bilateral differences in the pattern of distribution of the categories related to the mental foramen position. In most cases the right and left foramina were symmetrically located (77% in males and females). Double mental foramen was established in 2% of the sample. It was observed unilaterally in 1 female and 4 male mandibles.

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Visualization and investigation of paranasal sinuses via CT imaging

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The paranasal sinuses are a group of interconnected air-filled bony cavities adjacent to the nasal passages. There are four paired sinuses, named according to the bone in which they are located: maxillary, frontal, sphenoid and ethmoid. The function of the paranasal sinuses is not clear, although various hypotheses have been discussed. The paranasal sinuses develop through a gradual enlargement of pneumatized cells that evaginate from the nasal cavity, which occurs over the course of childhood and adolescence. The ethmoid and maxillary sinuses are present at birth but hypoplastic; the sphenoid sinus develops at around 4 years of age, while the frontal sinuses are the last to pneumatize at around 8–10 years of age.

The paranasal sinuses in adults represent a complex and highly variable by shape 3D system of interconnected air cavities, which could hardly be studied on plain 2D radiographs due to a superimposition. CT imaging allows segmentation and reconstruction of the volume of these air-filled spaces and investigation of their proper morphology. The paranasal sinuses morphology is of great importance for various surgical interventions as well as for person identification in a forensic context.

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Malignant tumours of temporomandibular joint

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Background. The anatomy of the temporomandibular joint (TMJ) includes the condyle, articular eminence, fibrous capsule, articular disc, synovial membrane, fluid, and adjacent muscles as well as ligaments.

Methods. Malignant tumours of the temporomandibular joint are extremely rare and often cause facial asymmetry deformity and occlusal disorders. The anatomical structures may be the possible explanation for the TMJ harbouring a myriad of malignant tumours.

Results. The largest percentage of tumours originates from the condylar process, and tumours originating from the rest of the TMJ structure are much fewer. Metastatic tumors in TMJ are predominantly from breast, lungs and kidneys. Among various pathological malignant tumour types, sarcoma, osteosarcoma variants, ameloblastoma, malignant odontogenic tumor, and unspecified malignant bone tumor are the most frequent. Despite other factors, malignant ameloblastoma has the highest survival rate, and unspecified malignant bone tumours show the worst prognosis.

Conclusion. Generally, signs and symptoms of tumours in TMJ region are similar to TMJ dysfunction. Therefore, the Doctor of Dental Medicine must be focused and alert, keeping in mind the occurrence of primary and metastatic tumours in the TMJ, given that early detection, early diagnosis and early treatment is fundamental. When clinical examination is suspicious, computer tomograpfy and magnetic resonance imaging are playing an irreplaceable role in the early diagnosis and differential diagnosis of these tumors.

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Multiphase computed tomography in diagnosis on the left common iliac artery and bladder ruptures: a case report

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Purpose. This report describes a mortem case of a 47-years-old woman with polytrauma after a crash incident. By abdominal scan during the initial hospitalization, have been identified ruptures of the left iliac artery and the bladder.

Methods. A multiphase whole-body CT scan was performed according to the imaging protocol. In a vena radialis was injected of 100 ml of radiocontrast lohexol (i.v.) with a mechanical bolus injector at a rate of 4.5 ml /sec. The CT scan was conducted by a taken using low-dose CT protocol with the next parameters: 3 mm beam collimation; visualization of the window W / L 400/40; 0.75 pitch; rotation speed 0.5; the magnitude of current 80-100 mAs and voltage of 80-100 kV and with the respiratory arrest for 8-10 seconds intervals.

Results. Computed tomography and angiography identified total occlusion of the left external iliac that is conically narrow by 20 mm and interrupted in its distal part of the transition by the artery superficial femoral artery. As a result of blunt trauma and regional bone fractures in the lower abdominal and groin area, are seen perivascular leakage of contrast material and the formation of a large perivasal hematoma in the vicinity, which proved peripheral vascular injuries and rupture of the external iliac artery. As a result of the polytrauma and hemorrhage, the patient developed sudden cardiac arrest and despite conducting 20 min of cardiopulmonary resuscitation (CPR), was registered exitus letalis.

Discussion. Axial and arterial phase CT images demonstrated foci of active hemorrhage in the pelvis with the arterial source of hemorrhage; the left wall bladder was not visualized.

Conclusion. The preliminary clinical examination does not allow could assessment of a risk degree in serious crash injury cases. This case illustrated an example of the multidetector CT application in the diagnosis of traumatic injuries after road accidents.

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Dose comparison of total body irradiation in different treatment planning system algorithms

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Purpose. In total body irradiations, it is not easy to have homogenous dose distribution because of inhomogeneous body shape and tissue density variations. In radiotherapy it is essential to save critical organ and to get homogeneous dose distribution in planning target volume (PTV) The purpose of this study is to compare different treatment planning system (TPS) algorithms in terms of critical organ doses, PTV coverage and dose homogeneity on Tomotherapy and VMAT technique for TBI treatments.

Materials and Methods. In this study, arms were added to the male phantom using rice to simulate the whole body geometrically. The male phantom with arms was immobilized by a vacuum bed and 3 mm CT images were received. The entire body, lungs, lens, and kidneys were contoured with a 3 mm margin and PTV was created. For TBI treatments, 7-10 Gy lung mean dose is admissible and the midpoint of lungs is seen as the reference point. Lens dose is admissible under 5 Gy for all treatments. In this study, dose constraints for organs at TPS were; mean coverage of 90% PTV is 12 Gy, maximum lens doses were 4 Gy, maximum lung doses were 8 Gy, maximum kidney doses were 7 Gy. PTVmax, lensmax, lungsmean, and kidneysmean doses were evaluated on VoLo v2.0.4, Eclipse v8.9 TPS, and Eclipse v15.6 TPS Algorithms. The homogeneity index (HI) was also taken into consideration.

Results. Results of this study showed that VoLo v2.0.4 and Eclipse v15.6 Algorithms have close critical organ doses, but Eclipse v8.9 was higher than others. Mean lung doses were 7.60/7.71 Gy (right/left) for VoLo TPS, 9.07/9.23 Gy(right/left) for Eclipse v15.6 TPS, 9.36/9.48 Gy (right/left) for Eclipse v8.9 TPS. Mean kidney doses were 6.70/6.51 Gy(right/left) for VoLo TPS, 6.46/6.43 Gy (right/left) for Eclipse 15.6 TPS, 8.19/8.21 Gy (right/left) for Eclipse v8.9 TPS. HI values were 0.16 for VoLo v2.0.4 TPS, 0.29 for Eclipse v15.6 TPS, and 0.24 for Eclipse v8.9 TPS. Maximum lens doses were 2.94/3.18 Gy (right/left) for VoLo TPS, 2.24/2.49 Gy (right/left) for Eclipse v15.6 TPS, 4.86/5.46 Gy (right/left) for Eclipse v8.9 TPS.

Conclusion. At the end of the study, it was seen that Tomotherapy VoLo v2.0.4 TPS and VMAT Eclipse v15.6 TPS algorithms had close critical organ doses, but Eclipse v8.9 resulted with higher doses on organs. HI value obtained by Tomotherapy was more desirable beside VMAT algorithms.

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Dosimetric characterization of a new waterproof silicon carbide detector

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Since the last two decades, the research in applied and biomedical physics devoted to the development of new detection systems dedicated to relative dosimetry has been very active. The effort in this field resulted in an emerging and increasing interest in Silicon Carbide (SiC) technology [1-9]. This is mainly due to the physical characteristics of SiC such as wide bandgap, ultra-low leakage current, high electron saturation velocity, almost near tissue-equivalence and high radiation resistance. Moreover, SiC based devices present dose-rate and Linear Energy Transfer independent response and linearity with energy in a wide dynamic range [10, 11]. These features make SiC also suitable for dosimetric applications with both conventional and high intensity beams. In this work, a new generation of solid-state device based on SiC technology was investigated for dosimetric applications. The detector was manufactured in the context of a collaboration between INFN (Italian Institute for Nuclear Physics) and IMM-CNR (Microelectronic and Microsystems Institute). It is a p-n junction device with a large detection area (1 cm2) and it was built by using new technological processes developed in collaboration with ST-Microelectronics (STM) in Catania. In addition, the adopted detector was embedded in epoxy resin to make it waterproof. The study aimed at evaluating the potential use of the SiC detector as a relative dosimeter, in accordance with the dosimetric protocols in force (IAEA TRS-398) [12]. The detector response was tested in water with x-ray and electron beam. The released absolute dose during each experimental session was evaluated using a standard ionization chamber.

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Implementation of a new IAEA remote and automated quality control program for radiography equipment

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Quality control (QC) guidelines published by the IAEA, American College of Radiology, European Commission, and other authorities have demonstrated that regular QC testing of radiographic facilities, involving daily or weekly tests, effectively contributes to patient radiation exposure reduction and improvement of image quality. Often lack of staff qualified to effectively perform and analyze testing results, and needed resources (phantoms, measuring equipment) leads to poor QC practice and detection in system performance deficiencies only after they become clinically significant. New IAEA publication offers a solution with simple, inexpensive test objects which, using the advantages of computer networking, can allow the collection of data in a harmonized manner. The creation of a centralized data system should ensure consistency, easier evaluation, and comparison between different systems. The aim of this study was to implement the newly proposed QC program and test the available radiographic equipment for short-term fluctuations of some critical components of the imaging chain to ensure consistent system performance, clinically adequate image quality, and increase patient safety. The measurement was performed at the University Clinical Center of Vojvodina on a “home-made” phantom.

The consistency of acquisition technical parameters and image quality indicators, metrics, and artifacts were assessed by generating images of the test phantom. Test phantom was formed by a uniform attenuator plate made of 10 cm × 10 cm, 2 mm thick square sheet of copper, and target plate consisted of a 5mm thick polymethyl methacrylate (PMMA) carrier, and 4mm thick aluminum and 2mm thick copper inserts, as proposed by the IAEA. Generated images were analyzed using the ATIA software available for download for all Member States via the IAEA Human Health Campus.

This paper presents preliminary results of the performed QC testing with the use of a “simple” phantom designed in accordance with the IAEA Human Health Series No.39 (2021).

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Investigation on the potential of improvement in the field of medical applications of ionizing radiation via the future European Metrology Network

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Due to constant development in radiodiagnostic and radiotherapy procedures with increasing complexity, a need for high-level coordination of the ionizing radiation metrology community was recognized to better respond to the needs of end users. In order to facilitate knowledge dissemination and improve communication between stakeholders involved in medical applications of ionizing radiation, a Joint Network Project was started in 2020. One of the specific objectives of Work Package 2 of the project 19NET04 MIRA, "Support for a European Metrology Network on the medical use of ionizing radiation" is to support the developing states, ensuring that the planned EMN is inclusive through improvements in the medical use of ionizing radiation [1]. Czech Republic, Romania and Serbia were defined as countries of interest to conduct the survey and collect relevant data from stakeholders in the category of medical staff and professionals, so that the potential for improvement for medical applications of ionizing radiation can be evaluated. For the purpose of data collection, an online questionnaire was prepared and distributed to the stakeholders. The questionnaire was structured in such a way to allow easier collection of information regarding availability of (1) calibration services; (2) documented technical protocols; (3) standard documentation in the establishments for different ionizing radiation applications. Implementation of a Quality assurance (QA) programme was investigated, as well as the consistency in realization of proficiency testing (PT) or audits. The stakeholders were asked if additional workshops or training programmes are needed in their area of expertise. The radiodiagnostic modalities included in the questionnaire were the general radiography, mammography, computed tomography and interventional procedures, while radiotherapy modalities included external beam radiotherapy (teletherapy) and brachytherapy. Although nuclear medicine (therapy and diagnostic) procedures were part of the questionnaire, none of the respondents have capabilities for these applications.

Based on the information collected via the online questionnaire, calibration services are available for most of the modalities, except for brachytherapy where traceability is not established. QA and PT are regularly performed in radiotherapy, while it is not the case in radiodiagnostic modalities. Improvement in knowledge transfer is needed for all of the applications investigated. Considering the acquired information, there is a clear need for EMN to support knowledge transfer, communication and technical exchange between the metrology community and the stakeholders involved in the medical applications of ionizing radiation. The forthcoming European Metrology Network will further elaborate the knowledge dissemination and stakeholder dialogue through its stakeholder panels and joint training efforts.

Keywords: European Metrology Network, ionizing radiation, radiotherapy, diagnostic radiology

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An intercomparison of multiple beam matched linear accelerators commissioned according to the accelerated go live program

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Beam matched accelerators is a modern concept in radiation therapy field applied in the clinics where more than one linear accelerator is employed for treatment. Beam matched linacs permit patients interchange without replanning and perform treatment planning quality assurance without additional labor.

Our primary goal was to analyze and compare the dosimetric parameters of 8 linear accelerators with Elekta's ultra-efficient install and commissioning program - Accelerated Go Live (AGL). AGL significantly reduces data gathering requirements by providing high quality, reliable, reference beam data, including beam profiles and percent depth doses (PDD) for all photon and electron energies. The machine's parameters were matched to the reference parameters for each of the three photon energies. The measurements were acquired with Semiflex 3D ionization chambers in the BeamScan water phantom and processed with Mephysto software. After all the measurements were completed, we compared them with AGL reference data.

The agreement was the following:

Photon beams quality varied <0.4% between reference data and measurements.

Gamma analysis demonstrated >95% agreement within 1% and 1mm for PDD, and within 2% and 2mm for beam profiles.

Output factors agreed within 0.2% on average.

Commissioning data have beam measured and analyzed with the gamma criteria required by vendor and present a good agreement. This study is similar to an internal audit and highlights the beam matching between involved linacs.

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Beam modeling of Elekta Agility MLC for Monte Carlo and Collapsed Cone Convolution computational algorithms in Monaco treatment planning system

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After the commissioning process of 8 beam matched linear accelerators, the next step is beam modeling of Monte Carlo and Collapsed Cone Convolution computational algorithms in Monaco treatment planning system.

This is done by measuring asymmetrical and irregular fields with the same number of monitor units (100 UM). These fields are predefined in the treatment plan system by the manufacturer. The maximum tolerance allowed by the manufacturer for the intercomparison of measurements with the values calculated by the system is ± 3%.

The measurements were acquired with Semiflex 3D, Farmer, PinPoint ionization chambers in the BeamScan water phantom and processed with Mephysto software.

These measurements and calculations shall be performed for each computational algorithm. In this treatment planning system 2 calculation models are used. The first one is collapsed cone convolution (CCC), used for the 3DCRT treatment technique in two variants: open fields and wedge filter fields. The second one is Monte Carlo (pMC), used for VMAT and IMRT treatment technique.

A set of eight static and intensity modulated radiation therapy fields were used to verify the Agility MLC parameters. We know from experience that with Agility it's mainly 2 parameters we need to touch are the Leaf offset and the Leaf Transmission. The measurements were performed with Octavius 4D system and PTW detector array 1500.

The beam modeling was verified using a homogeneous phantom for point dose measurements, post modelling MLC parameters and patient QA plans. All plan parameters pass the gamma criteria with an average percentage higher than 95%.

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Mutations in *ABCC9* and *LMNA* may be associated with malignant arrhythmias in a young male patient with family history of cardiomyopathy

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Introduction. A 45 year old male patient with arterial hypertension was admitted at the hospital due to experiencing chest pain and palpitations. Coronary angiogram was negative and no ectopic activities were detected with Holter monitoring. Since the patient had a brother who died from dilated cardiomyopathy at the age of 42, genetic testing was advised.

The purpose of our study was to identify possible genetic causes for the presented cardiovascular phenotype in order to prevent potential sudden cardiac death and to eventually implement early treatment.

Materials and Methods. Massively parallel whole exome sequencing was performed. The bioinformatics analysis was mainly focused on predefined virtual gene panels composed of all genes know to be associated with cardiovascular disease.

Results. Known pathogenic or likely pathogenic mutations associated with arrhythmias and other genetic cardiovascular disease were not detected. However, two relevant variants of uncertain significance (VUS) were detected, and they both meet several pathogenicity criteria (Richards et al., 2015). The first variant c.4520T>A was found in the *ABCC9* gene; pathogenic mutations in *ABCC9* may cause arrhythmias, dilated cardiomyopathy and familial atrial fibrillation. The second variant c.692A>G was found in the *LMNA* gene; pathogenic mutations in *LMNA* may cause familial dilated cardiomyopathy.

After three uneventful years and despite taking anti-arrhythmic drugs, the patient presented with non-sustained ventricular tachycardia and ventricular tachycardia storm. Cardioverter defibrillator (ICD) was implanted. Following substitution with anti-arrhythmic drugs the patient was rhythmically stable once more and ICD activation was no longer necessary. The patient was properly educated about the implication of the genetic results and for prevention and early recognition of signs and symptoms of acute cardiovascular events.

Conclusion. Comprehensive genetic testing and family screening is proving to be advantageous for risk assessment of genetic and inherited cardiovascular conditions, and it may also be a useful tool in further clinical disease management, as it can lead us to an early and definitive diagnosis.

Keywords: Genetic testing, NGS, Ventricular tachycardia, arrhythmias, implantable cardioverter – defibrillator (ICD), ABCC, LMNA

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Ways to improve the results of treatment of community-acquired pneumonia in military personnel with chronic inflammatory processes of the respiratory tract

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Respiratory tract infections caused by the virulent mycoplasma microorganism are highly resistant to antibiotics, which sometimes causes the complexity and inadequacy of antibiotic therapy for pneumonia. The aim of this study was to improve the effectiveness of treatment for exacerbation of community-acquired pneumonia in military personnel with chronic inflammatory processes in the respiratory tract.

Was carried out a retrospective analysis of archival material-case histories of 266 patients with pneumonia aged 18-26 years, who are on inpatient and outpatient treatment at the Central Military Hospital in Baku, Azerbaijan. In 22 patients who were newly admitted to the hospital, in whom no colonies of microorganisms were retrospectively detected in the sputum, blood was taken for immunological analysis. The measurement of IgM antibodies of the mycoplasma hominis class was carried out on an enzyme immunoassay apparatus, a method based on enzyme-linked immunosorbent assay.

In a retrospective analysis of case histories, 152 patients revealed concomitant respiratory diseases with acute and chronic course, the frequency of which was distributed as follows: acute sinusitis - 43 (16.2%), acute respiratory infections - 34 (12.8%), bronchitis - 16 (6.0%), tonsillitis-11 (4.1%), otitis media -2 (0.75%), chronic sinusitis -21 (7.9%), chronic bronchitis-14 (5.3%), acute respiratory infections -7 (2.63%), bronchiectomic disease - 4 (1.5%).

The material of microbiological research was registered in the medical history of 118 patients examined before the start of antibacterial therapy. According to the results of the microbiological study of induced sputum, culture growth was detected in 83 (70.3%) patients, in 35 (29.7%) cases, colonies of microorganisms were not detected.

In recent years, there has been a significant expansion of the spectrum of causative agents of acute pneumonia, which causes a significant change in the clinical course of this disease. In our observations, sputum analysis in community-acquired pneumonia also revealed only S Pneumonia, and no mycoplasma strains were detected.

As a result of the immunological studies, more than half of the patients -13 (59.1%) - showed a positive response, indicating the presence of IgM of the mycoplasma hominis class. In 3 (13.6%) patients, the level of antibodies showed a doubtful zone.

Thus, the results of the study showed that in military personnel with community-acquired pneumonia, mycoplasma hominis occupies a special place in the structure of causative factors of the exacerbation of the process, which dictates the need for this contingent to conduct, in addition to microbiological studies, also immunocomplex.

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A case report on orbital desmoid-type fibromatosis

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Purpose. Desmoid-type fibromatosis, also known as aggressive fibromatosis or desmoid tumor, is a rare type of benign tumor which develops from fibroblasts located in connective tissue, fascial and musculoaponeurotic structures of the muscles. Desmoid tumors are most commonly found in the abdomen, as well as the shoulders, arms, and thighs, but they can occur anywhere in the human body. Intraorbital lesions are extremely rare and we found only a few cases described in the literature.

Methods. On MRI scan is found a soft tissue formation (39 HE) in the right retrobulbar space that invades the neighbouring frontal and ethmoid sinuses. Histopathological analysis of the tumor formation has been performed. A Van Gieson's stain has been used to confirm the extracellular matrix of connective tissue.

Results. A 59 years old man was hospitalized with symptoms of dizziness and vomiting. Exophtalm, blepharoptosis and low vision in the right eye have been observed. After diagnosis, surgical treatment was undertaken. Horseshoe-shaped skin incision has been done in the right supraorbital area. Osteoplastic craniotomy and orbitotomy have been performed. The tumor formation has been extirpated. The postoperative period passed without complications.

Conclusion. The orbital location of desmoid-type fibromatosis is extremely rare. The management of desmoid fibromatosis is based on the function preservation and the watch-and-wait policy is currently agreed as the initial strategy. In case of symptomatic patients and/or aggressive course of the disease the surgical approach may be considered. A therapeutic alternative to systemic therapy and surgical resection could be radiotherapy.

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Efficacy of a CDK 4/6 inhibitor combined with an aromatase inhibitor as a first line treatment in the case of advanced breast cancer HR+/HER2-

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Breast cancer is a real challenge in terms of therapeutic attitude in elderly patients, who often present with multiple associated pathologies. CDK 4/6 inhibitors combined with hormonal treatment are recommended in the case of locally advanced or metastatic breast cancer, with hormone receptor positive (HR+) and human epidermal growth factor receptor 2 negative (HER2-) tumors without visceral crisis. Advanced local breast cancer comprises stage III breast tumors, which show, in the absence of metastases, any of the next signs: tumors larger than 5 cm accompanied by N1-3 regional lymphadenopathy, tumors with chest wall extension and/or skin, regardless of size or lymph node involvement or the presence of regional lymphadenopathy (infraclavicular, supraclavicular, internal mammary or clinically detectable axillary), regardless of the size of the primary tumor.

CDK4 / 6 inhibitors combined with hormone therapy as first line treatment represents an outstanding therapeutic approach in advanced or metastatic breast cancer with hormone receptor positive (HR+) and human epidermal growth factor receptor 2 negative (HER2-). Ribociclib inhibits cyclin-dependent kinase 4 and 6 which have an important role in cell proliferation resulting in blockage of the G1 phase of the cell cycle.

The case presented illustrates the evolution of an 80-year-old patient diagnosed with inoperable local advanced luminal B breast cancer, treated with Ribociclib 600 mg/day and Letrozole 2.5 mg/day. The tumor was located in the supero-external quadrant and was imprecisely delimited, with ulceration areas and also nipple and overlying skin retraction. A left axillary adenopathic block which caused the secondary functional impotence of the upper limb was detected.

Histopathology examination of the breast biopsy showed an invasive ductal carcinoma, moderately differentiated, without lymphovascular or perineural invasion. Immunohistochemistry identified a luminal B molecular subtype, with estrogen hormone receptors 70%, progesterone hormone receptors 60%, without HER2 amplification (score 1+) and with a ki67 proliferation index of 35%. The patient underwent a CT imaging evaluation to allow correct staging of the disease and to appreciate the local extension of the tumor. It was reported in the left breast a 37/26 mm tumor, imprecisely delimited, infiltrative, iodophilic, with retractile effect on the overlying skin and nipple. Also, tumor invasion of the large and small left pectoral muscles and of the left costal arches II, III and IV that presented reduction of the anterior cortex thickness, was observed. Furthermore, an axillary adenopathic block with densification of the adipose tissue in its vicinity was described, the most voluminous adenopathy being 18/12 mm. No secondary cerebral, pulmonary, hepatic or bone metastases were observed.

The patient experienced in a short period of time a favorable evolution with significant improvement of quality of life, expressed by remission of symptoms with notable dimensional reduction of both the primary tumor and the axillary lymphadenopathy. The introduction into current practice of CDK 4/6 inhibitors combined with hormone therapy, has led to an increase in the first-line therapeutic horizon for advanced or metastatic breast cancer with HR+/HER2-. As it appears from the present case, the Ribociclib-Letrozole doublet is a successful choice even for elderly patients, with multiple associated pathologies, a situation in which cytotoxic therapy would be burdened by multiple risks. Due to the favorable toxicity profile, CDK4 / 6 inhibitors should be chosen, in absence of visceral crisis, over chemotherapy in first line therapy.

Consistent with data from the literature and clinical trial data, the present case demonstrates the remarkable efficacy of this type of therapy, with an acceptable safety profile and a rapidly installed therapeutic response.

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Photodamage of DNA labeled with the halogenated thionucleoside

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Photodynamic therapy is a less invasive alternative to radiotherapy. The latter is used in over 50% of cancer patients [1]. A photosensitizer plays a similar role in photodynamic therapy as a radiosensitizer in radiotherapy [2]. Both sensitizers are chemical compounds that enhance the sensitivity of cancer cells to ionizing or visible/ultraviolet radiation. It is worth mentioning that most of the photosensitizers known so far act via singlet oxygen generation i.e., through the so-called type II mechanism of photosensitization (oxygen dependent mechanism) [2]. However, hypoxia, i.e. low oxygen concentration in cancer cells, is characteristic for solid tumors that account for over 80% of cases [3].

The modified nucleosides (MNs) sensitive to dissociative electron attachment (DEA) are the group of radiosensitizers that sensitize cancer cells to ionizing radiation. They may also demonstrate photosensitizing properties. Due to structural similarity to the native nucleosides selected MNs are incorporated into DNA strands during its biosynthesis or repair. In addition, MNs show selectivity towards cancer cells due to their uncontrolled division and rapid growth. The MNs do not reveal cytotoxic action itself but only after irradiation [4]. 5-iodo-4-thio-2'-deoxyuridine (ISdU), which due to the presence of sulfur atom exhibits absorbance within the UVA range (340 nm), reveals both radio- and photosensitizing properties proved in *in vitro* studies [5,6]. The literature reports indicate that the photoexcited 4-thio-2'-deoxynucleoside (SdU) triggers cross-links (CLs) in DNA [7]. On the other hand, the halogen atom in the uracil moiety should make the labeled DNA prone to long-distance electron transfer (ET) which results in a single-strand break (SSB) [8].

In this project, the chemical synthesis of ISdU triphosphate was carried out and then ISdU was enzymatically incorporated into a DNA fragment Next, the labeled oligonucleotide was UVA irradiated and analyzed by high-pressure liquid chromatography (HPLC) and liquid chromatography coupled to mass spectrometry (LC-MS) to identify the photoproducts. The current studies enable question about the photodamage induced in the ISdU labeled DNA to be addressed.

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Effect of altitude on solar UV irradiation in mountain locations of Bulgaria – measurements and comparisons

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The global warming and climate changes reflect on solar radiation distribution. We present new daily measurements of solar UV-A, UV-B and UV-C irradiation at locations with different altitudes in high-mountain area and mid-valley of Bulgaria: Moussala peak (2925m a.s.l.), Beli Iskar (1782m a.s.i.), Sofia city (698m a.s.l.). The present-day assumptions are based on classical UV absorption edge of the atmosphere and existing stratospheric ozone layer. However, using high-resolution UV sensor equipments anomalous behavior including dangerous sharp gradients of UV-B/UV-C is detected. The UV_irr vs. Altitude dependence is compared to satellite data obtained from SoDa database.

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Evaluation of the electromagnetic field and safety zones of existing base stations upgraded with 5G Massive MIMO antennas

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The mass penetration of 5G technology is already a fact. One of the challenges regarding the implementation of 5G networks in Bulgaria is the problem related to the assessment of electromagnetic exposure and determination of safety zones (SZ).

Bulgaria has more restrictive national legislation for the protection of public health from exposure to EMF than the Recommendation 1999/512 / EC and ICNIRP guidelines. The first stage of the implementation of 5G undergo with the upgrading the existing base stations with a new installations. This fact raised many questions about the possibility the maximal permissible values to be exceeded. The method in the national legislation for theoretical calculation of SZ around telecommunication transmitters is based on a conservative approach. It was clear that applying such method it would lead to unrealistically large SZ and will complicate the realization of planned additional 5G emitters on a particular place. The SZ assessment based on the conventional approach was also a complex task for the previous 3G and 4G technologies, but the situation seems more difficult when existing sites must be upgraded with new 5G installations, especially in the urban areas. The presence of different technologies on a certain base station requires the assessment of combined EMF exposure. The specifics of 5G New Radio (NR), characterized by intelligent technologies such as Massive MIMO (Multi-Input Multiple-Output) and beamforming, should also have to be taken into account in this evaluation process.

The paper demonstrates the theoretical calculation of SZ of an existing base station, which is planned to be upgraded with 5G smart antennas. We modified the current method for determination of the SZ boundary around telecommunication sources, which takes into account the specifics of the 5th generation technology.

The application of this method will make the safety evaluation more realistic and the upgrade of existing base stations with the 5G installations to be possible.

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Problems with general public and workers protection on using optical radiation sources for cosmetic purposes

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Numerous sources of optical radiation emitting high levels of optical radiation are used for cosmetic purposes, but data available for solving the problem with human health protection differ significantly for the different countries. The literature review performed by the International Commission on non-ionising radiation protection (ICNIRP) show that regulations comprise devices that are considered analogous to medical devices but not every type of used cosmetic devices.

For many optical sources, only technological standards exist that regulate only the product's performance. For others, the requirements are set in voluntary standards. A serious problem with the sources in cosmetics is that their application is a personal choice of the user - the exposure is voluntary. Given the growing use of optical radiation sources it is issue of great public health and social importance.

In our country, there is no policy for this type of optical radiation application except for the workers. A Directive for protection of workers with similar sources is implemented in EU countries and transposed in Bulgaria, but its application is limited especially in the field of cosmetics. Generally, the legislation does not cover applications of optical radiation not defined as medical treatment. There are no data on number and qualification of staff providing treatment. For the general public a policy for safety and health protection in this field is commonly missing.

The problems of protection are addressed for the common sources for cosmetic (solaria, IPL systems). The specific risks connected to the sources application are discussed. Following the problem analysis we propose an approach for development of specific legislation for these sources corresponding to the health risks.

The presented data of measurements performed in cosmetic studios and application of optical that show increased risk for the personnel and users as well.

The aim of the study is to propose an approach for health protection on using optical radiation sources for therapeutic and cosmetic applications on the basis of scientific literature and our own experience. It should contain as a minimum: technical requirements, use, protection, control, communicating risks, etc.

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In situ broadband measurements of non-ionizing radiation in working environment

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Non-ionizing radiation still continues to attract a lot of public attention, with tremendous increase in the usage of wireless communication devices. The achievement and development of electronics in information and communication technologies (ICT) contributed to the increase in the number of non-ionizing radiation sources. The influence of electromagnetic field on human health and biological effects is not yet fully understood, despite numerous scientific papers and studies performed, thus significant public concern is still present.

This paper presents the examination of electric field in the Laboratory for telecommunication measurements of the School of Electrical and Computer Engineering in Belgrade, Serbia. Measurements of electric field strength were performed in the vicinity of the most numerous artificial sources of electromagnetic field (power lines, mobile phones, base transceiver stations, other wireless communication and computer devises). Measured values were collected by NARDA NBM 550 broadband field meter with isotropic probe that can be used for measurements in the frequency range 3 MHz – 18 GHz.

The obtained values were analysed compared to the authorised limiting values and guidelines given by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The analysed data do not exceed exposure limits.

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Inhibition of miR-21 promotes cellular senescence in NT2-derived astrocytes

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Astrocytes are the main homeostatic cells in the central nervous system (CNS) that provide mechanical, metabolic, and trophic support to neurons. Disruption of their physiological role or acquisition of senescence-associated phenotype can contribute to the CNS dysfunction and pathology. However, molecular mechanisms underlying the complex physiology of astrocytes are explored insufficiently. Recent studies have shown that miRNAs are involved in the regulation of astrocyte function through different mechanisms. Although miR-21 has been reported as an astrocytic miRNA with an important role in astrogliosis, no link between this miRNA and cellular senescence of astrocytes has been identified. To address the role of miR-21 in astrocytes, with special focus on cellular senescence, we used NT2/A (astrocytes derived from NT2/D1 cells). Downregulation of miR-21 expression in both immature and mature NT2/A by the antisense technology induced the arrest of cell growth and premature cellular senescence, as indicated by senescence hallmarks such as increased expression of cell cycle inhibitors p21 and p53 and augmented senescence-associated β-galactosidase activity. Additionally, in silico analysis predicted many of the genes, previously shown to be upregulated in astrocytes with the irradiation-induced senescence, as miR-21 targets. Taken together, our results point to miR-21 as a potential regulator of astrocyte senescence. To the best of our knowledge, these are the first data showing the link between miR-21 and cellular senescence of astrocytes. Since senescent astrocytes are associated with different CNS pathologies, development of novel therapeutic strategies based on miRNA manipulation could prevent senescence and may improve the physiological outcome.

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Hypoxia affects the expression of SOX genes and induction of neural differentiation of human embryonal carcinoma NT2/D1 cells

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The family of *SOX* genes encodes proteins that display properties of both classical transcription factors and architectural components of chromatin. During development of nervous system, as well as adult neurogenesis, SOX transcription factors govern diverse cellular processes such as maintaining the multipotency of neural stem cells, cell proliferation, cell fate decision, migration as well as terminal differentiation of neurons. Despite their well-known function in development and brain homeostasis, the expression and role of these genes in pathology- induced neural stem cell plasticity is poorly understood. Reduction in oxygen supply or ischemia are involved in various pathological conditions, such as stroke, traumatic brain injury and cardiac arrest, which promotes neurogenesis, angiogenesis, cell proliferation and other cell mechanisms for survival under the stress. The aim of the present study was to analyze the expression of SOX genes during *in vitro* neurogenesis following chemical hypoxia.

Neuronal differentiation of human pluripotent embryonal carcinoma stem cell line NT2/D1 was used as an *in vitro* model system for studying the process of human neurogenesis. Depending on different concentration, RA directed the differentiation of NT2/D1 cells into neurons with a different phenotype. The effect of stress caused by hypoxia on the properties of pluripotent cells as well as the induction of neural differentiation was monitored *in vitro* by culturing NT2/D1 cells in the presence of cobalt chloride, a chemical inducer of hypoxia. The results of the analysis showed that the effect of hypoxia on the expression of SOX2 and OCT4 proteins involved in maintaining the pluripotency of cells depends on the duration of action of cobalt chloride. After short-term exposure of the cells, an increase in the levels of expression of SOX2 and OCT4 proteins was detected, while long-term treatment of the cells led to a decrease in the expression of these proteins. Furthermore, results showed that depending of duration of cobalt chloride treatments, the level of expression of miR-21 in undifferentiated NT2/D1 cells significantly changed. In addition, long-term pretreatment of pluripotent cells with cobalt chloride resulted in increased expression levels of SOX2, SOX3 and GAD67 proteins in neural progenitors induced for 7 days in the presence of, either low or high concentration of retinoic acid, indicating that hypoxia causes increased efficiency of NT2/D1 cell neural differentiation.

Damage of brain tissue caused by reduction of oxygen and/or blood flow to the tissue is the leading cause of death worldwide and the leading cause of disability in humans. Our results contributes to the research focused on discovering the roles of SOX TFs and their gene targets in ischemia related pathologies, making them promising biomarkers and potential targets for future diagnostic and therapeutic strategies.

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Exosomes and brain/mind machine

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Last reports suggesting that memories can be stored in the heart and recalled/retrieved from this organ opened the question on the possible role of the extracellular vesicles, exosomes, as possible partial factors in formation of personality characteristics. Nowadays, they are accepted as important lines of communication between cells which carry important information as fragments of DNA, miRNA(microRNA) and mRNA (messenger RNA). Based on such contemporary accepted findings and considering the potential functions of extracellular vesicles, we proposed recently the hypothesis of possible transfer of memory information through exosomes (Lakota et al.2021) between the heart of a donor and brain of a recipient following the heart transplantation. It supports the idea that at least a part of human memory is stored in the heart and the basic information temporally circulates in blood vessels. In such a way it could dynamically interact with all organs, mainly the heart and the brain. This concept is now open for experimental testing. Moreover, our hypothesis also opens the question of the biological basis of our memory mechanisms. Here we point to the difference between biological fundamentals of what one could call “inner” and “outer” memory. In the first case we have in mind memories stemming from our organism, maybe even from cells only. That is the memories evoked from physiological mechanisms acting inside of our body which are stored without the intentional effort. The question is whether they could be subject to exosomes transfer also. If we for the moment accept that it could be possible then the answer must be sought how? Such questions are justified because many of the internal/external signals are carriers of important psycho-social information also and, consequently, they must have biological relevance. In the second case, we take into account the memories based on the information obtained from the external environment and thus by means of focussing our consciousness. Our hypothesis opens another important question. Having in mind the fact that exosomes circulate in the body fluids and can reach any organ, brain implicitly, the most important question is if they can influence the brain/mind machinery to imprint it with novel personal attitudes. Our brain/mind machine is a parallel and distributed system, with control areas throughout (Gazzaniga 2011). And here we are again in touch with the question of the possible role of communication between cells in a given situation. Exosomes or anything else?

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Effects of cadmium on electrophysiological properties of membranes of Retzius neurons in leech *Haemopis sanguisuga*

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Introduction. Cadmium is considered one of the most toxic heavy metals which can cause cytotoxicity in multiple organs including the brain. Despite many studies over the past decades, the cellular and molecular mechanisms underlying its neurotoxicity remain unclear. The present study was designed to examine the acute effects of cadmium chloride ($CdCl_2$) on the electrical activity of Retzius neurons in leech using electrophysiological techniques.

Materials and methods. Experiments were conducted the Retzius nerve cells of isolated segmental ganglia of the adult horse leech, *Haemopis sanguisuga*. Membrane potentials were recorded in the conventional manner with glass microelectrodes filled with 3 M KCl. The outward potassium current was studied using the two-electrode voltage clamp (TEVC) method. One of the electrodes (the voltage-electrode) measures the membrane potential and connects to a feedback amplifier where this signal is compared with the desired (command) potential. The outward K^+ current was elicited by depolarization with long-lasting stimulation (300 ms) in the Tris Ringer and after exposure of the Retzius neurons to $CdCl_2$ for 10 min.

Results. $CdCl_2$, in concentrations of 10-100 μM, produced a dose- and time-dependent depolarization of Retzius neurons, paralleled by an increase in firing frequency and action potential duration. To explain the mechanism responsible for the membrane depolarization and the broadening of action potentials following the administration of cadmium, we studied the activity of outward K^+ channels. Application of 50 and 100 μM $CdCl_2$ significantly reduced the outward current response to the voltage change. Voltage clamp investigations disclosed that 50 μM $CdCl_2$ reduced the outward K^+ current by 32%. At the test potential of +15 mV, the fast and slow part of the K^+ outward current dropped by 41.43% (from 68 to 40 nA) and 25.81% (from 35 to 26 nA). In the presence of 100 μM $CdCl_2$ at the test potential of +15 mV, the fast and slow part of the K^+ outward current were reduced from 69 to 21 nA (69.57%) and from 33 to 17 nA (48.49%). All of these effects on the depolarization-induced outward current were almost reversible. However, when the 100 μM $CdCl_2$ was added in TRIS Ringer, the effects were irreversible.

Conclusion. The present results support the view that the effect of cadmium on the outward potassium channel may be a potential contributing mechanism for cadmium-induced neurotoxic damage. Potassium channels can be used as a target for the research on the cellular mechanisms of the toxic and harmful effects of cadmium. The proposed mechanism of cadmium action on the electrical properties of leech Retzius neurons might have broader significance, pertaining *not only* to *leeches, but* mammalian *neurons* as *well*.

Keywords: Neurotoxicity, cadmium, leech, Retzius cell, potassium channels

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Effects of K_{Ca} channel activator NS1619 on parameters of Ni^{2+}-induced epileptiform activity of leech Retzius neurons

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Introduction. Epilepsy is a chronic neurological disorder causing recurrent epileptic seizures. On a cellular level epileptic discharges are characterized by neuronal activity in a form of paroxysmal depolarization shifts (PDSs). The role of nonsynaptic mechanisms in cellular basis of epilepsy is shown on a number of animal models of epileptiform activity induced by blocking chemical synaptic transmission in both invertebrate and mammalian nerve cells. Calcium - activated potassium channels (K_{Ca}) play a major role in regulating the intrinsic neuronal excitability. Since K_{Ca} dysfunction or down regulation can contribute to intrinsic hyperexcitability of epileptic neurons, these ion channels are considered to be a potential target for the mechanism of action of novel antiepileptic drugs. NS1619 is an activator of K_{Ca} channels that stabilizes the resting membrane potential by increasing K^+ outward current, thereby hyperpolarizing cell membrane and reducing neuronal excitability.

Aim. This study was investigating the effects of K_{Ca} channel activator NS1619 on an *in vitro* experimental model of nonsynaptic epileptiform activity induced in Retzius nerve cells of the leech *Haemopis sanguisuga*, by blocking voltage - gated Ca^{2+} channels with Ni^{2+}.

Methods. Classical intracellular electrophysiological recording with glass capillary microelectrodes was used.

Results. Application of NS1619 (30 μM) did not show significant effects on resting membrane potential and frequency of action potentials (APs) as a parameter of spontaneous electrical activity of Retzius neurons in standard Ringer (Ri) saline. Introducing 3 mM $NiCl_2$ into the superfusing saline (Ni^{2+} Ri) induced spontaneous development of stable oscillatory activity characterized by repetitive and rhythmic generation of PDSs. Several parameters were used to describe and quantify the induced epileptiform activity: PDS frequency (1.30 ± 0.18 min^{-1}), PDS amplitude (6.71 ± 0.53 mV), PDS duration (7.76 ± 0.43 s) and the number of APs per PDS (16.25 ± 6.72, n = 4). Last series of experiments was examining the effects of NS1619 substance on Ni^{2+} - induced epileptiform bursting. Introducing NS1619 (30 μM) into the superfusing Ni^{2+} Ri saline caused a suppression of induced PDSs, as seen by a significant reduction of all of the parameters of interest, comparing to their respective controls. In NS1619 - Ni^{2+} Ri saline PDS amplitude decreased to 94.61 % (n = 4, $p > 0.05$), PDS duration dropped to 77.39 % (n = 4, $p > 0.05$) and number of APs per PDS to 67.98 % (n = 4, $p > 0.05$), while PDS frequency was highly significantly reduced to only 11.08 % of the control value (n = 4, $p < 0.01$).

Conclusion. Activating K_{Ca} channels with NS1619 (30 μM) causes modulation of Ni^{2+} - induced epileptiform activity of Retzius neurons predominantly by reducing its frequency and intensity. Thereby NS1619 can be considered to exert certain antiepileptic properties. Whether higher concentrations of this K_{Ca} channel activator would produce a stronger suppressive effect on all the other parameters of this nonsynaptic epileptiform activity on our model remains to be examined.

Keywords: Epileptiform activity, nickel, PDSs, NS1619, K_{Ca} channels, antiepileptic effect

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Study of ^{68}Ga and ^{47}Sc production for theranostics at the Bern medical cyclotron

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Theranostics is based on the use of a pair of radionuclides with identical or very similar chemical properties, allowing the use of the same radiopharmaceutical for both diagnosis and therapy. In this way it is possible to predict whether a patient will benefit from a therapeutic treatment on the basis of nuclear imaging data. Along this line, radiometals are attracting increasing interest since they can be used to label peptides and proteins and provide some of the most promising pairs.

^{68}Ga [$t_{1/2}$=67.7 min, β^+: 88.9%] is widely used in nuclear medicine for positron emission tomography (PET) and is attracting considerable interest since it can be used to label PSMA ligands, forming a theranostic pair with the therapeutic β^--emitter ^{177}Lu. Currently, ^{68}Ga is obtained via ^{68}Ge/^{68}Ga generators; however, their availability, high price and limited produced radioactivity per elution prevented the widespread use of ^{68}Ga-based radiotracers.

The matched pair ^{44}Sc/^{47}Sc satisfies the desired physical aspects for theranostic applications. ^{44}Sc [$t_{1/2}$=3.97 h, β^+: 94.3%] can be used for PET, while ^{47}Sc [$t_{1/2}$=3.35 d, β^-: 100%, E_γ =159 keV (68.3%)] is suitable for radionuclide therapy and allows single photon emission computed tomography (SPECT) during treatment. While production techniques of ^{44}Sc are at an advanced stage and the first clinical trials have been performed, the availability of ^{47}Sc is still an open issue. In contrast to the production of standard radioisotopes with liquid targets, the production of radiometals is challenging and requires the use of new irradiation instruments and methods. In particular, expensive isotope enriched materials, usually available in form of powder, have to be irradiated. For this purpose, the use of solid target stations represents a promising valuable option.

A research program aimed at studying and optimizing the production of novel radionuclides using solid targets is ongoing at the Bern University Hospital, where an 18 MeV medical cyclotron is in operation together with a Solid Target Station (STS) and a 6 m long Beam Transfer Line (BTL). Following the successful studies and developments on ^{44}Sc, ^{68}Ga production was investigated via the ^{68}Zn(p,n)^{68}Ga nuclear reaction using enriched ^{68}Zn targets and ^{47}Sc was obtained from enriched ^{50}Ti targets, via the ^{50}Ti(p,α)^{47}Sc nuclear reaction.

Despite the use of highly enriched materials, several impurities are co-produced during the irradiation. If the impurities are of the same element as the radionuclide of interest, they cannot be removed by radiochemical separation and their production must therefore be minimized. For this reason, the accurate knowledge of the induced nuclear reaction cross-sections is of paramount importance to determine the beam energy leading to the optimal production yield and radionuclidic purity.

In the case of ^{68}Ga, the main impurities to be kept under control are ^{67}Ga, obtained via the ^{68}Zn(p,2n)^{67}Ga and ^{67}Zn(p,n)^{67}Ga reactions, and ^{66}Ga, obtained via the ^{67}Zn(p,2n)^{66}Ga and ^{66}Zn(p,n)^{66}Ga reactions. All the involved production cross-sections were measured by irradiating natural Zn and enriched ^{68}Zn targets. To disentangle the contribution of the two nuclear reactions, a method based on the inversion of a linear system of equations was applied.

In the case of ^{47}Sc, the only impurity produced is ^{46}Sc, obtained from ^{49}Ti and ^{50}Ti via the reactions (p,α) and (p,αn), respectively. The latter contribution is relevant only for energies higher than 17 MeV and was isolated with the same method used for ^{68}Ga, irradiating natural Ti samples.

The results obtained were used to optimize the main parameters for the production of ^{68}Ga and ^{47}Sc. On this basis, production irradiation tests were performed using the solid target station in operation at the Bern medical cyclotron. These results confirm the excellent prospects for the production of ^{68}Ga with medical cyclotrons and contribute to pave the way for the production of ^{47}Sc with such accelerators.

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Interaction between Triton X-100 and propranolol hydrochloride in aqueous solution mixed micellar pseudo phase

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Binary mixed micelles are used in pharmaceutical formulations, especially if there are synergistic interactions between two surfactants. In this case, critical micelle concentration of the binary mixture can be lower than the critical micelle concentration of the more hydrophobic surfactant. Mixed micelles can form chiral hydrophobic domain which allows enantioselective i.e. diastereoselective binding of the active components. Triton X-100 is an aromatic non ionic surfactant while the propranolol hydrochlorid is the ionic surfactant. Thermodynamic investigations showed that critical micelle concentration of their binary mixture in ratio 1:1 has the lower critical micelle concentration than the critical micelle concentration of the propranolol hydrochloride (Triton X-100 promotes association abilities of propranolol hydrochloride toward hydrophobic molecular surfaces). Although their mixture has lower critical micelle concentration than propranolol hydrochloride, this critical micelle concentration is higher than the critical micelle concentration of the hypothetical ideal mixed micelle. In terms of thermodynamics, there is an antagonistic effect between these two sufactants toward the micellar pseudophase. Based on thermodynamical data it can be concluded that the homogene micellar psudo phase is formed. However, NMR DOSY (Diffusion Ordered Spectroscopy) experiments show that separated micellar pseudo phases are formed. The influence of Triton X-100 on the decrease of the critical micelle concentration value of propranolol hydrochloride can be explained with the rise of the concentration of aromatic rings in aqueous solution which destabilise water molecules due to hydrophobic hydratation (aromatic rings). In order to stabilise the system water molecules of the hydrophobic surface move to the bulk on the lower critical micelle concentration than the critical micelle concentration of propranolol hydrochloride (less aromatic rings in the system) at the constant temperature.

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Biological activity of new mixed ligand copper(II) complexes

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Aim. Two new cationic mononuclear Cu(II) complexes of cyclam (1,4,8,11-tetraazacyclotetradecane) and aminocarboxylate coligands glycine or alanine with general formula $[Cu(L)cyc](ClO_4)_2 \cdot nH_2O$, (**A**): L=glycine, n=1.5 and (**B**): L=alanine, n=2.5 were tested against three human cancer cell lines. Both complexes were tested for their antimicrobial activity against Gram(+), Gram(-) bacteria and the yeast.

Materials and Methods. The antimicrobial activity of the Cu(II) complexes were assayed using the broth-microdilution method against: Gram-positive bacteria *Staphylococcus aureus* and *Bacillus subtilis*, Gram-negative bacteria *Escherichia coli* and one strain of the yeast *Candida albicans*.

In vitro cytotoxicities of the free ligands (cyclam, glycine, alanine), complexes **A, B**, and cis-platin were evaluated against three cancer cell lines: human cervix adenocarcinoma (HeLa), human melanoma (FemX) and human colon carcinoma (LS174). The effect of compounds on cancer cell survival was determined by the MTS test.

Conclusion. The Cu (II)complexes have moderate bactericidal effect on Gram-(+) bacteria: *S. aureus* and *B. subtilis*. Both compounds have promoted decrease in metabolic activity of the HeLa (human adenocarcinoma), FemX (human melanoma) and LS174 (human colon carcinoma), which occurred in a dose-dependent fashion.

Keywords. Copper(II) complexes, antimicrobial and cytotoxic activity

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Cation-induced isomerization of furan molecule

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Various studies have been dedicated to understanding molecular systems' dynamics and chemical reactivity. The bond fission and new bond formation in molecular collisions have recently attracted particular attention. This is because these processes are usually preceded by extensive isomerization associated with the movement of hydrogen atoms alongside the molecule's skeleton, making it possible to induce and control chemical reactions selectively.

In the present communication, we will show results on the fragmentation of the gas-phase furan molecules in collisions with the low-energy cations that have been measured exploiting collision-induced emission spectroscopy. In particular, the formation of the OH radicals has been identified among the fragmentation products. Because they are not structural components of furan molecules, observation of their emission bands suggests the hydrogen migration prior to the cation-induced dissociation. The present results show that the cation-induced isomerization is possible in furan and depends on the particular projectile. The dissociation mechanism leading to the OH formation will also be discussed.

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Modified 2'-deoxyadenosine as a potential radiosensitizer – attempts at synthesis and stationary radiolysis

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Cancer is the second leading cause of death in developed countries after cardiovascular disease. Approximately ten million people develop cancer each year, and seven million of them die. Therefore, effective new solutions and methods are constantly being sought for treatment. Increasingly, the combined method of treatment is used, which includes a combination of standard radiotherapy with the use of compounds sensitizing tumor cells to ionizing radiation – radiosensitizers (RS). These compounds should be characterized by effective accumulation at the tumor site, high chemical purity and lack of cytotoxicity to healthy cells. Their application will increase the efficiency and safety of radiotherapy, because radiosensitizers act selectively and are activated only after the application of ionizing radiation. The main goal of using RS is to increase the mortality of cancer cells, while reducing the harmful effects of radiation on healthy tissues.

One of the promising groups of radiosensitizers are modified nucleosides, characterized by high structural similarity to nucleosides, which occurs naturally in cells. Therefore their efficient incorporation into genomic DNA is possible. Such labelled biopolymer becomes prone to damage induced by ionizing radiation that ultimately leads to its dysfunction and cancer cell death.

So far, the most well-known radiosensitizers from this group are uridine derivatives, like 5-iodo-2'-deoxyuridine and 5-bromo-2'-deoxyuridine, which are readily phosphorylated to their triphosphates and in this form are incorporated into DNA during its replication or repair. Hydrated electrons, one of the main products of water radiolysis occurring during radiation therapy, attach to the modified nucleosides incorporated into DNA leading to the formation of an unstable anion radical that readily dissociates to form a closed-shell substituent anion and a reactive nucleoside radical. In the next step, this radical detaches a hydrogen atom from the sugar residue of the deoxyribose of a neighbouring nucleoside, resulting in DNA strand breakage and subsequent apoptosis of the cancer cell if the damage is not repaired.

Currently, few examples of purine derivatives as potential radiosensitizers are described in the literature. Theoretical calculations performed in our team proved that "modified purines should also sensitize the biopolymer to electron-induced damage to much the same extent as modified pyrimidines" [1], so the synthesis and radiolytic studies on the modified purines seem to be well justified. This project presents attempts to synthesize one of the 2'-deoxyadenosine derivative. In addition, we check the susceptibility of the modified 2'deoxyadenosine to electron attachment induced decomposition triggered by stationary radiolysis of aqueous solution of the studied derivative in the presence of hydroxyl radical scavenger. The latter enables the effect of hydrated electrons to be studied exclusively. The identity of radio-products is determined with the LC-MS method.

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How do nitroimidazole type oxygen mimetics work? Computational and radiation chemistry studies

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Cancer is the leading cause of death, especially in highly developed countries [1]. One of the most frequently used methods of cancer treatment is radiotherapy. During this treatment patients are exposed to ionizing radiation (IR) which produces serious side effects [2]. Additional challenge is hypoxia of solid tumors leading to the radioresistance of cancer cells. This situation calls for the introducing to radiotherapy of the so-called radiosensitizers, i.e., substances that can sensitize tumors to IR [3]. One class of radiosensitizers are oxygen-mimetics (OM), which are represented by well-known and thoroughly studied nitroimidazoles. So far, the most effective OM seems to be nimorazole, which has been approved in Denmark and Norway as radiotherapeutic agent for head and neck cancer [4].

Despite such an extensive research the mechanism of action of nitroimidazoles remains unclear. The one of many hypotheses is based on the radical mechanism of DNA damage proposed by the O'Neill's group [5]. They assumed that OM reacts with the 5-hydroxypyrimidine radical formed in DNA during IR irradiation (via hydroxyl radical attachment to the pyrimidine nucleobases), leading to a single strand break in DNA. A different approach is presented by the Edwards group who suggested that a protonated form of OM leads to an oxidative damage to DNA by abstracting electron from the biopolymer [6].

Since understanding the mechanism of action of OM is important for the search for new, effective radiosensitizers, we decided, first, to confirm the O'Neill hypothesis through radiolytic experiments and computational studies. We did observe, the formation of stable adduct of 5-hydroxypyrimidine radical with metronidazole and as well as a favorable thermodynamics. However, a subsequent hydrogen atom transfer that is necessary for O'Neill's mechanism to be completed turned out to be highly improbable thermodynamically which questions the studied mechanistic proposal.

In the current project, we present the interdisciplinary studies attempting to identify a possible mechanism of radiosensitizing action of nitroimidazoles. The pulse and stationary radiolysis, as well as computational studies at the density functional theory (DFT) level were used to examine the physicochemical characteristics of elemental reactions for the pyrimidine-metronidazole model. We supplemented our research with computer-aided methods, in particular quantitative structure-activity relationships (QSARs) approach based on known nitroimidazoles and their radiosensitization effectiveness, given as experimentally measured C1.6 (concentration of a given radiosensitizer for which the sensitization enhancement ratio (SER) amounts to 1.6). Our preliminary computational and experimental results indicate the need to revise suggested in the literature mechanisms. Indeed, the QSAR models based on quantum chemical descriptors closely related to O'Neill and Edwards mechanisms - have both satisfactory and prognostic abilities, and favor the latter one.

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Comparison of lipid peroxidation process induced by visible light in MLV-PPIX and SUV-PPIX liposomes: TBA-MDA test

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Liposomes (as multilamellar or unilamellar phospholipidic submicroscopic vesicles) allow the incorporation of lipophilic and hydrophilic drugs and photosensitizers such as protoporphyrin IX (PPIX) in their matrix with potential for the delivery and using for therapeutic applications. It can be very important to investigate how PPIX incorporated inside the liposomes lipid bilayers influences lipid peroxidation (LP) process under visible light illumination conditions. The most prominent and currently used assay for detection and recording of LP is the spectrophotometric thiobarbituric acid-malondialdehyde test (TBA-MDA).

PPIX-loaded liposomes were prepared using dry PPIX-lipid film method to obtain MLV liposomes (multilamellar vesicles). The vesicles were downsized by extrusion through filters with 100 nm pores to obtain SUV (small unilamellar vesicles) liposomes. Lipid peroxidation was initiated by continuous illumination of PPIX-MLV and PPIX-SUV systems with visible light. The formation of the LP product malonaldehyde (MDA), was measured spectrophotometrically (TBA-MDA test). Illumination treatment of liposomes mixtures (with or without the photosensitizer PPIX) was performed in cylindrical photochemical reactor equipped with “Pure White” LED lamps with the intensity of 1800 lux.

The continual illumination of PPIX-MLV and PPIX-SUV systems resulted in lipid peroxidation process - continuous increase in absorbance band responsible for LP product. Lipid peroxidation process obeys first-order kinetics. The calculated rate constants of LP product growth are 0.0014 min^{-1} and 0.0022 min^{-1} for PPIX-MLV and PPIX-SUV illumination, respectively. Lipid peroxidation process was not observed in the samples without photosensitizer, or samples with photosensitizer kept in dark. The results showing relatively slow process of lipid peroxidation product growth in both samples, which is related with the low energy input from visible light. Lipid peroxidation is a little bit faster in SUV liposomes due to structural differences in comparison with MLV liposomes. However, it is shown that PPIX-SUV and PPIX-MLV systems are very stable against visible light, with minor differences between them and with photodynamic therapy potential.

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Novel tools to optimize timing properties of scintillation materials

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The experiments at future high-luminosity colliders (HL-LHC, FCC, etc) and medical imaging with high spatial resolution require detectors with the time resolution substantially improved towards the ambitious target of 10 ps explicitly put forward a few years ago by Crystal Clear Collaboration at CERN. The development of scintillation materials for such detectors has to be supported by novel characterization techniques with time resolution in picosecond domain. We report our current results on the adaptation of the techniques based on nonlinear optical absorption in picosecond and subpicosecond domain for studying fast processes in scintillating materials.

In the pump and probe configuration, the sample is excited by a short pump pulse and the time evolution of the spectrum of the pump-induced optical absorption is monitored by a variably delayed probe pulse of white light continuum. The technique has a high time resolution in subpicosecond domain, the capability of varying the pump photon energy for selective excitation to specific energy levels and allows for simultaneous monitoring both spectrum and kinetics of the differential optical response [1]. We also show that a multiprobe configuration enables the determination of intracenter recombination time in activator ions and other specific time characteristics of the processes in scintillators.

The applicability of these techniques was demonstrated on several self-activated and Ce-activated scintillators. Most of the results reported here are obtained on two Ce-doped single crystals prospective as fast scintillators: garnet $Gd_3Al_2Ga_3O_{12}$ (GAGG) and oxyorthosilicate $(Lu_x\text{-}Y_{1\text{-}x})_2SiO_5$ (LYSO). We show that the electrons being optically excited to the higher energy levels of Ce^{3+}, which lay in the conduction band of the host crystal have two routes for their relaxation to the radiative level $5d_1$. They relax either within the center with, according to our measurements, a characteristic time of ~500 fs or through the extended states in the conduction band, as at the excitation by ionizing radiation. A part of such electrons returns to Ce ion and results in a delay in the population of the ion. The importance of carrier trapping for the electron transfer to Ce^{3+} and the influence of aliovalent doping on this process are revealed. The obtained results demonstrate that the transient optical absorption technique is a tool convenient for studying the characteristics of the energy states important for excitation transfer and the rates of the transitions between these states and might be exploited to search for novel fast scintillators and for express routine testing of conventional scintillators.

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Diagnostic system for high power microwave pulse measurement

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Nowadays, high power microwave (HPM) pulses are used as a directed energy weapon. They are also wildly employed in different physical investigations and military projects. Since the standard pulse power meter that uses Schottky diode can handle only a small amount of power (of the order of 1 W), direct couplers or attenuators with high attenuation (60 – 90 dB) has to be used for HPM pulse measurement. On the one hand, large attenuation results in the decrease of the measurement accuracy. On the other hand, a small signal is detected, and some problems could arise to measure such a signal in the presence of the hard stray pick-up and the electromagnetic field interference, which are usual to the environment of HPM generators.

Therefore, the problem of great importance is to develop sensors, which can detect HPM pulses without using large additional attenuation and produce high output signal. To solve this problem we propose a resistive sensor (RS) the performance of which is based on the semiconductor bulk resistance change in the strong electric field. The following advantages of the RS in comparison with Schottky diode can be mentioned: (i) possibility to measure HPM power directly in the transmission line without using direct couplers or attenuators, (ii) the large output signal from the sensor is available (up to a few tens of volts), (iii) high reliability and overload resistance is characteristic to the RS, and (iv) switching off DC supply of the RS the parasitic signal induced in the measurement circuit by the external electromagnetic field can be determined. These features made the RS irreplaceable for the HPM pulse measurement at harsh conditions.

The waveguide-type RSs for the measurement of HPM pulses in different waveguide frequency bands (1-37.5 GHz) have been designed and manufactured. The have been used for the measurement of the pulses, duration of which lies in the range 0.5-300 μs. The set of the RSs with flat frequency response and improved response time for the measurement of nanosecond duration HPM pulses has also been designed and manufactured for different waveguide bands. For example X-band RS can measure 100 kW pulse power producing output signal of the order of a few tens of volts without any amplification circuit. Instead, a DC pulse supply for the RS feeding is used. Both types of sensors were tested in free space. The RS connected to a horn antenna and followed by a matched load comprises a unit for microwave pulse power density determination in free space. The tests have shown that the RS can measure pulse power density up to a few MW/m^2. The last our development was the waveguide type millimeter wave RS measuring up to 2 kW pulse power in a frequency range 78-118 GHz. We have also developed and manufactured the coaxial type RS for the measurement of pulse power up to 1 kW in a frequency range 2 – 12 GHz. The flat frequency response is characteristic of this type of sensor.

The RS could find application in HPM directed energy pulse power diagnostic and monitoring.

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Afterglow study of solid scintillators excited by gamma radiation

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The paper deals with the long-term afterglow of some types of scintillators used to detect ionizing radiation. Experiments were made in the LVR-15 research reactor building. For scintillator excitation was used horizontal channel HK1, used mainly for neutron radiography but here for excitation gamma radiation was used and neutron radiation was shielded.

The LVR-15 is a multipurpose tank-type light water moderated research reactor operated by the Research Centre Řež near Prague, Czech Republic. The reactor is operated at a maximum thermal power level of 10 MW. The reactor is equipped with nine horizontal channels and one epithermal column providing ten neutron beams for further use.

HK1 neutron beam on the output has typical gamma dose equivalent rate 200 mGy/h and neutron fluence rate 5E7 $cm^{-2} \times s^{-1}$ when neutron shielding is not applied.

After interaction of a scintillator with ionizing radiation particle, the scintillator emits main light pulse used for radiation detection. The main light pulse time is of the order of nanoseconds to microseconds and is used to detect ionizing radiation using a light detector (photomultipliers, photodiodes). The main light pulse is followed by afterglow, which is the emission of other components with a longer time. This quenching is usually undesirable from the point of view of ionizing radiation detection. Then afterglow is told to be a type of luminescence, which is well described by solid state physics. The range of afterglow times studied here was tens of seconds to days.

Six scintillator types were used for afterglow study: CaF_2(Eu), CsI(Tl), $CdWO_4$, LiI(Eu), NaI(Tl) and plastic scintillator. Scintillator samples had different dimensions and masses due to their commercial availability. For scintillator excitation, gamma radiation was used. Part of the gamma radiation comes from the reactor core and part from the prompt gamma of neutron reactions on the neutron filter (3% borated polyethylene).

Afterglow measurement procedure started with 10 min irradiation of the scintillator sample in HK1 channel beam. After the irradiation, the scintillator sample was moved to the lightproof detection unit. The sample was in optical contact with head of photomultiplier tube, and it was covered with an aluminium foil used as a light reflector. Anode PMT current measurement started about 60 s after the end of irradiation and stopped at minimum 2 hours after irradiation.

Therefore, to be able compare scintillators in terms of quenching curve, the measured time course of the current was normalized to the value of the current corresponding to the background radiation. Dose rate at the measuring point was about 1 microSv/h, measured before irradiation of the given scintillator.

As a result, CaF_2(Eu), $CdWO_4$ and plastic scintillator have relatively low long-term afterglow signal compares with other measured scintillators. The results were compared with older afterglow measurement with scintillator excitation using UV lamp.

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Innovative dosimeters with ultra-fast scintillators and optical fibers for FLASH radiotherapy

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FLASH radiotherapy is a very promising technique in cancer care. Recent scientific findings demonstrated a significant reduction in the normal tissue toxicity ("FLASH effect") when ultra-high dose rates (> 40 Gy/s) are delivered in very short times (< 1s). The clinical translation of the FLASH therapy implies several challenges including the development of new instrumentation for the beam monitoring and dosimetry. Indeed, ionization chambers used in conventional radiotherapy exhibit a reduced ion collection efficiency with increasing dose per pulse, whereas radiochromic films are dose rate independent but they do not provide real time response with standard reading techniques.

A research project aimed at the development of new dosimeters for FLASH radiotherapy based on ultra-fast scintillators and optical fibers recently started at the 18 MeV medical cyclotron laboratory at the Bern University Hospital (Inselspital). In particular, we developed a first dosimeter prototype consisting of a thin (0.5x0.5x0.2 mm^3) plastic scintillator coupled to a 600 μm core multimode optical fiber. The optical fiber transmits the scintillation light pulses to a silicon photomultiplier (SiPM) placed in a dark-box. The light pulses from the SiPM are digitized by means of a high bandwidth (1 GHz) and sampling rate (4 GS/s) digitizer connected to a computer for data analysis. These plastic scintillators are characterized by fast time response (2.4 ns decay time) and low cost; moreover, they can be easily manufactured in different shape and size. On the other hand, the optical fibers transmit optical signals over long distances with very low attenuation (<100 dB/km in the wavelength range 320-900 nm). As a result, only the part of the optical fiber with the scintillator is exposed to the radiation, whereas the SiPM and the digitizer are outside the irradiation area. In addition to plastic scintillators, we aim to use thin cylinders (1 mm diameter, 0.5 mm length) of yttrium-doped barium fluoride (BaF_2:Y) in combination with optical fibers. BaF_2:Y scintillators are characterized by an ultra-fast (0.8 ns) scintillation light emission peaked at 220 nm.

Beam tests of these dosimeter prototypes are performed at the 18 MeV medical cyclotron in operation at the Bern University Hospital (Inselspital). The cyclotron features a 6 m long Beam Transfer Line (BTL) equipped with an X-Y steerer, two quadrupole magnets, two beam viewers, and a two-dimensional beam profiler (named UniBEaM) based on cerium-doped optical fibers passing through beam. The quasi-continuous cyclotron beam (42 MHz RF) is extracted in air through a 50 mm stainless steel window and delivered to the tip of the optical fiber with the scintillator. The radiation dose in the position of the scintillator is assessed with radiochromic films. Typical values of the dose rate in the position of the scintillator are 60 Gy/s. Stable proton beams from a few pA to tens of mA with variable current density per unit of surface can be obtained, allowing to study the response of the dosimeter in a wide dose rate range.

In our project, we aim to 1) define the observable to put in relation with the dose, 2) establish the calibration of the dosimeter at fixed dose rate, and 3) study the dosimeter response as a function of the dose rate. Preliminary results on the development of this new class of dosimeters for FLASH therapy will be presented.

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Development of composite scintillators and thermoluminescent detectors based on the epitaxial structures of garnet compounds for radiation monitoring and medical applications

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This work presents the review of last results in the development of multilayered composite scintillators and thermoluminescent detectors based on the single crystalline films (SCF) and single crystals (SC) of garnet compounds using the liquid-phase epitaxy (LPE) growth method for application in the environment radiation monitoring and medical microimaging technique.

The first approach of our research is connected with the creation of *multilayer composite scintillators* of phoswich-type *(phosphor sandwich)* based on SCFs and SCs of garnet compounds for simultaneous registration of different types of ionizing radiations (particles and quanta) in mixed ionization fluxes [1]. Such composite scintillators present the *two or three-layer epitaxial structures containing* SCF scintillators grown 'step-by-step' using LPE method onto substrates from SC scintillators. Films and crystal parts of composite scintillators were fabricated from 'best as possible' effective scintillation materials on the basis of Ce^{3+}, Pr^{3+} and Sc^{3+} doped $Lu_3Al_5O_{12}$ garnets (case of homoepitaxial growth) and the Ce^{3+} doped $R_3B_5O_{12}$ (R=Lu, Gd, Tb; B=Al, Ga) mixed garnets (case of heteroepitaxial growth) with various scintillation decay kinetics due to the different type of dopants [1-3] and various garnet content [1].

The report presents the results on fabrication of different types of the composite scintillators based on the crystals and films of mentioned garnet compounds by LPE method and the results of investigation of their luminescent and scintillation properties. The testing of these composite scintillators for simultaneous registration of α- and β- particles and γ-quanta was performed and the obtained results were analysed for the optimization of their scintillation figure-of merit.

Prototypes of TL composite materials based on epitaxial structures of garnet compounds comprising crystals and SCFs of YAG:Ce and LuAG:Ce garnets were developed also using the LPE method. It has been shown that such composites can be used for detection of α- and β-particles using the differences between TL glow curves recorded from the SCFs and substrates. Furthermore, the YAG:Ce and LuAG:Ce crystals as well as the composites on their base can be applied also as TL detectors for the investigation of the uniformity of ionizing radiation dose with different energies for clinical radiotherapy applications.

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Compensation of the temperature effect of the dark current in photodiodes dosimeters

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Introduction. Ionization chambers are the most commonly used device for radiotherapy treatment control, presenting some limitations compared to semiconductor-based systems, such as comparatively high cost, larger size and high voltage requirement for biasing. As an alternative or complement, some current-mode semiconductor devices have been studied for the same purpose, such as photodiodes and phototransistors [1,2]. The induced photocurrent current can be related with the radiation dose rate, and the absorbed dose is proportional to the integration of the current over the exposure time. Due to the exponential temperature dependence of the photodiode dark current, base line will be strongly affected in dosimetry. Consequently, a thermal compensation during dose reading should be required for an accurate dose measurement by photodiodes as affordable skin dosimeter. Our proposal consists in periodically measuring the forward voltage (V_γ) as a method of temperature estimation of the device. This value is employed for the thermal correction of the reverse dark current (I_S) which is the baseline of the radiation-induced photocurrent and the main contributor to its thermal drift.

Experimental setup. Six samples of the commercially available Si PIN photodiode BPW34S, divided in two groups of three devices, were used for the thermal modelling of forward biased DUT at constant current, and for the validation of the proposed model, respectively. Moreover, thermal dependence of the dark current under reverse biasing was measured in five samples. For temperature-controlled tests, samples were introduced in a climate chamber VCL4006. In a second step, the dosimetric characterization of the photodiodes was performed. Eight samples of the BPW34S were irradiated with a linear accelerator (LINAC) Siemens Artiste placed at the "Hospital Universitario Clínico San Cecilio" (Granada, Spain). The photon beam was produced with an electric potential of 6 MV. DUTs were located in the radiation isocentre (at 100 cm), and were irradiated with a field of 10x10 cm^2. The irradiation cycle of 90 minutes of duration is composed by a six-step decreasing average dose rate staircase from 4.87 to 0.81 cGy/s, a six-step increasing average dose rate staircase from 0.81 to 4.87 cGy/s, and a last step of 0.81 cGy/s. Between each step, a period without irradiation of 2 minutes was applied.

System design. To measure the internal temperature of the photodiode, a sink current source with a LM334 (Texas Instruments, Dallas, TX, USA) has been added to the reader unit. The working principle for thermal compensation is as follows: after dose measurement, the photodiode used as sensor is disconnected from both bias voltage source and current to voltage converter and connected between ground and sink current source. Then, the forward biased photodiode has a direct voltage drop proportional to temperature, typical of p-n junctions.

Results and conclusions. Excellent linear and exponential fittings with the temperature have been obtained for V_γ and I_S respectively, that provided accurate device temperature estimation and I_S thermal drift correction of 0.3°C. Once our compensation method is applied, resulting in a maximum relative error of 0.4%, thus a significant reduction of the baseline thermal drift is achieved. Therefore, the algorithm presented in this work is suitable for model and reduce the thermal dependence in measured induced photocurrent of photodiodes.

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A new dosimeter based on real-time spectroscopy of radiochromic films

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This work concerns the development of a new dosimeter based on the real-time reading of radiochromic films with a spectroscopic method. The measurement of the real-time dose is a crucial aspect when the relation between the radiation dose and its effects on the materials is needed. For example, the monitoring of electronic components for radiation hardness assurance tests requires the measurement of the dose in relation to a specific damage, such as Single Event Effects (SSE). In such cases, the correlation between the damage of the device and the imparted dose must be as punctual as possible.

In this work, we present a compact and versatile dosimeter which allows to measure the real-time dose on devices in a wide dynamic dose range. The dosimeter is based on RadioChromic Films (RCF) and on an opto-electronic instrumentation which allows to read the light spectrum of the RCFs. One optical fiber drives the light from the source to the RCF, while a second optical fiber collects the reflected light spectrum. The dosimeter is shaped as a trapezoid where the two fibers are fixed to the two oblique sides, pointing to a common vertex in the center of the major base where a RCF is placed. A cylindrical hole connects the minor and the major base, allowing the radiation to reach the RCF. As the radiation passes through, the darkening of the RCF is detected as an intensity decrease of the reflected light spectrum. This results in an absorbance increase (with respect to the reference spectrum not exposed to radiation). In this work, we show that is it possible to relate the absorbance of the reflected spectrum to the accumulated dose on the RCF during the irradiation.

The dosimeter presented in this work has been characterized with three types of RCFs for three different orders of magnitude of dose: EBT3 Gafchromic film (~Gy), HDV-2 Gafchromic film (~kGy) and Risø B3 (~MGy). The new dosimeter was used to monitor three radiation fields: 1) a 90Sr/90Y source, 2) a 19.9 MeV proton beam and a 3) 1 MeV electron beam. We show that it is possible to perform a calibration as a function of the absorbance at a fixed wavelength. Moreover, we show that the analysis of the spectrum at different wavelengths allows to perform a calibration for different dose ranges and thus, to extend the nominal dynamic range of the RCF used. In particular, for the EBT3 Gafchromic films the extend dose range is 1.4 Gy – 210 Gy (nominal 0.1 – 20 Gy), for HDV-2 Gafchromic film 0.13 – 26.1 kGy (nominal 0.01 – 1 kGy) and for B3 Risø film 1 kGy – 800 kGy (nominal 0.5 – 200 kGy). The dosimeter was also tested for the monitoring of the performance of an electronical device (2N3055 transistor) irradiated with a 19.9 MeV proton beam. As result, we determined the relation between the dose imparted to the transistor and its radiation-induced damage, this latter quantitatively evaluated in terms of gain decrease.

In conclusion, the dosimeter presented in this work is addressed to radiation hardness assurance tests, however further developments can be foreseen in the dosimetry monitoring for radiotherapy applications.

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A Metal Oxide Semiconductor ionizing radiation detector architecture with increased voltage sensitivity

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A Metal Oxide Semiconductor (MOS) ionizing radiation detector architecture which senses trapped charge in the dielectric due to incident ionizing radiation is presented. The detector architecture increases output voltage signal as a function of trapped charge in the sensing dielectric in comparison with state of the art MOSFET (RADFET) technology.

Numerical simulations were employed to help develop the device concept. It is shown that an improved voltage sensitivity is possible due to a reduction in the sensing capacitance which, unlike RADFET technology, is decoupled from the dielectric capacitance.

An initial prototype of the detector has been fabricated in the silicon fabrication facility of Tyndall National Institute and irradiation experiments have been performed which confirm the improved voltage sensitivity versus commercial RADFET detectors. It is envisaged that further sensitivity increases may be possible by integrating dielectrics other than silicon dioxide.

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Quantitative mapping of ^{226}Ra ultra-trace content by spectroscopic autoradiography using a gaseous detector

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Spectroscopic autoradiography is a method of interest for geological sample analysis. Indeed, researchers may face different issues such as radioelement identification and quantification in the field of environmental studies. Imaging radioelements using gaseous ionization detectors find their place in geosciences for environmental monitoring aftermath uranium mining activities, for example.

In ^{238}U series, the spatial distribution of each decay product (such as ^{226}Ra) in mine tailings is fundamental for relating radionuclides concentration to the mineralogy, in order to predict the long-term reactivity of tailings, that are commonly stored at surface on mine site. However, the location and identification of the minerals bearing radioactive elements at the thin-section scale remains a major challenge as the detection limit of the usual elementary microprobe techniques is far higher than the concentration of most of the natural radioactive decay products.

The present study aims to use spectroscopic autoradiography analysis method for measuring the initial energy of alpha particles (8 radionuclides of the ^{238}U decay chain are alpha emitters) with a parallel ionization multiplier gaseous detector. The analysis method has been developed thanks to Geant4 modelling of the detector. The analysis of the tracks of alpha particles recorded in the gas detector allows the simultaneous measurement of the initial positions of emission of each particle and the reconstruction of their initial energies by a selection based on the linear energy distribution. The characteristics of this measurement are an energy spectrum resolution of 17.2% (FWHM) at 4647 keV and a spatial resolution of at least 50 µm. The raw efficiency of energy spectrum reconstruction is low (4.4%) compared to the efficiency of a simple alpha autoradiograph (50-80%). However, this spectroscopic autoradiography method was successfully used to discriminate ^{226}Ra dispersed with other radioactive elements of the ^{238}U decay chain. This selection of the ^{226}Ra is possible by applying a threshold on the alpha particle energy measurement. The mapping of ^{226}Ra was performed on thin-section slides of tailings and radiolabeled sediments.

The concentration of radium is low (ppt) but can be quantified using a standard for calibration of radioactivity emission. One major input of the method is that the mapping of ^{226}Ra concentration can be performed in the presence of other alpha emitters of the ^{238}U series.

This novel measurement approach can be coupled with scanning electron microscope characterizations to identify ^{226}Ra bearing minerals. The direct application of this dual modality (energy-position) of analysis will be the subject of other developments such as the measurement of the radioactive equilibrium state of heterogeneous geological structures.

Keywords: Alpha spectroscopy, mining activities, uranium decay products, real-time autoradiography

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Multi-sensor MOSFET dosimeter for radiation measurements in Precursor CubeSat

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Introduction. The Precursor CubeSat is a private project that is aimed to develop cube-sat to test some novel technologies and to estimate the radiation dose during the life of the satellite measurements is very advisable. The Multi-Sensor MOSFET is an excellent and efficient solution for future dosimeters in space. This allows the use of commercial components which have a well known behaviour in a radioactive environment. In 1970 the RADFET was invented by Andrew Holmes-Siedle [1] and in 2010 Tyndall National Institute (Ireland) started with the manufacturing and commercialization of the RADFET [2]. Nowadays more dosimeters for small satellites can be found on the space market but these are still having high prices for small satellite missions (CubeSats). The tendency will be the use of commercial transistors as radiation sensors in small satellites. This paper is a good example for this tendency and is based on mature technology.

Therefore, an electronic circuitry has been designed to provide analog outputs of four different radiation sensors. Some special considerations should be taking into consideration, as well as high thermal stress in each orbit and high vibration stress during the satellite launching. To face these challenges, we have designed, fabricated and tested a compact PCB with different MOSFET-based radiation detectors.

System design. As radiation sensors, four commercial MOSFETs were selected: Two CD4007 manufactured by Texas Instruments and couple of 3N163, one of them manufactured by Vishay and by Motorola. To minimize thermal dependence, the transistors have been biased at constant current using the I_{ZTC} (Zero Temperature Coefficient). The source voltage was buffered and divided to increase the dose range. During irradiation periods, a JFET short-circuit all the terminals of the MOSFETs and no external voltage is applied (unbiased mode); and, during the readout process the JFET is cut-off and then, each sample is biased at I_{ZTC}. The source voltage is buffered and divided and connected to the ADC of an external microcontroller.

Results and discussion: A thermal characterization was carried out from -20 to 60°C. The devices were placed into a climate chamber and the source voltage was monitored, obtaining an average thermal drift of (120±50) µV/°C for the CD4007 devices, (350 ± 30) µV/°C for Motorola-3N163 and (120 ± 60) µV/°C for Vishay-3N163. Two identical prototypes were manufactured: one thermal and radiation endurance test, and the final one to be sent to the mission, that was pre-irradiated and thermal characterized too. The total dose provided to the test prototype for endurance, was 85 Gy; and 6 Gy for the final prototype. The setup for irradiation used a LINAC (Artiste, Siemens) with field of 10x10 cm^2 a phonon beam of nominal energy of 6 MV and a build-up layer of 1.5 cm over the PCB. Sensitivity of (16.9 ± 1.7) mV/Gy was found for Vishay-3N163, (16.0 ± 1.6) mV/Gy for Motorola-3N163 and (4.1 ± 1.9) mV/Gy for the CD4007. Therefore, if the maximum ADC input voltage is set at 2.5V, (gamma rays of 6MV) a maximum dose upto 250 Gy for 3N163 and 500 Gy for the CD4007 was achieved.

The final tested prototype was send to Germany in March 2022 to be mounted over the mother board of the satellite.

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Commercial MOSFET characterization for proton dosimetry

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Introduction. In recent years, proton beams have started to be more widely used in proton therapy treatments. Therefore, the interest in proton dosimetry has significantly increased. MOSFET transistor-based dosimeters present some features such as small size, low power consumption and immediate readout [1] that are very suitable for quality control of clinical beams and even for in-vivo dosimetry. In the present work, a set of three samples of a commercial MOSFET have been characterized under a proton beam of 5.6 MeV.

Methods and materials. Radiation source: This test campaign has been performed at the CNA (National Accelerators Centre), in Sevilla (Spain). In particular, the tests were carried out with a 5.6 MeV proton beam from the 3MV-Tandem accelerator. Three irradiation sessions were programmed with an average dose rate of 25.7 cGy(Si)/s to provide a total dose of 28.9 Gy(Si) per sample. Reader unit: The reader unit developed in our research group has been used to continuously monitor (every 5 seconds) the threshold voltage during radiation exposure. To achieve the thermal compensation, the parasitic diode (from drain to source) is activated with a reverse drain current, as it was described by Carvajal et al. [2]. The sensor module is composed of the DUT (3N163 from Vishay, USA) and two JFETs to connect or open the source-gate and source-drain terminals. During the measurements, the MOSFETs were in three different states:

• Sensing state: The source and drain of the MOSFET are grounded, and 10 V is applied to the gate terminal (2 s).

• Read-out state: The gate and the source are short-circuited and MOSFET is biased at IZTC drain current (Zero Thermal Coefficient), 230 μA in our case (2 s).

• Temperature measurement state: A reverse drain current of -600 μA activated the parasitic diode and the forward voltage is measured (1 s).

Finally, when the measurement process is completed, all terminals are shortcicuited.

Experimental setup: Three samples of the 3N163 transistor from Vishay (USA), packaged in TO-72 metal case, were decapsulated to be used as a low-energy proton detector. Due to the low power penetration of low-energy protons, the silicon die had to be directly exposed to the proton beam. The reader unit was placed close to the DUT, but out of the irradiation chamber. And it was connected to the computer using a USB port. The sample was connected to a 5-vias standard IDC wire to control the JFETs, to bias during the sensing state and to measure the source voltage.

Results. The accumulated source voltage shift with dose presents high linearity with dose, $R^2 > 0.99$ for all studied samples. The average sensitivity of the set of three samples, obtained as the slope of the source voltage shift with dose per sample, was (23 ± 2) mV/Gy.

Conclusions and current task: The 3N163 transistor from Vishay presents a promising response as a dosimeter for proton beams. A completed characterization with other bias voltage will be carried out to study the sensitivity, the sensitivity decay, and the fading among others parameter.

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Stacked floating gate MOSFET as a passive dosimeter

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Introduction. The approach to increase the sensitivity of semiconductor radiation dosimeter with a stacked design was presented for the thick oxide pMOS transistors, also known as RadFETs (A. Kelleher et al., IEEE transactions on nuclear science 42, 1995). The sensitivity is increasing with the number of RadFETs in stacked structure, but there were limitations because of the diode reverse breakdown voltage during readout current (B. O'Connell et al., In Proceedings of the Third European Conference on Radiation and its Effects on Components and Systems, 1995). Further improvement of the stacked RadFETs device enables detecting a minimum absorbed dose of less than 50 μGy for a 20 V power supply (B. O'Connell et al., Fifth European Conference on Radiation and Its Effects on Components and Systems, 1999). Floating gate MOSFET is a modified structure of MOSFET with another polysilicon gate surrounded by oxide. The advantages of the floating gate MOSFET as a radiation dosimeter are that it does not require thick oxide fabrication and the highest sensitivity is for the zero-bias at the control gate during irradiation (S. Ilić et al., Sensors 20 (11), 2020).

Experimental setup. Commercial floating gate MOSFETs designed by Advanced Linear Devices Inc. were used in this paper. Four transistors were connected in the stacked structure (drain and control gate are shorted and connected to the source of the next stacked transistor), and their threshold voltage drift values were measured before and after each irradiation portion with the same conditions. The experiment was performed at the Institute of Nuclear Sciences "Vinča", Belgrade, Serbia. Radiation source Co-60 was used for irradiation of the components, with the following portions of the absorbed dose (Si): 10 μGy, 10 μGy, 10 μGy, 20 μGy, 50 μGy, 400 μGy, 500 μGy, 4 mGy, 45 mGy, 50 mGy, respectively (absorbed dose was 100 mGy in total). All measurements were performed in a test fixture with triax cables by Keithley 2636A Source Measure Unit. During irradiation, all stacked transistors were zero-biased.

Results. Observing the threshold voltage drift of the four stacked floating gate MOS transistors, we noticed that the stack of two transistors has the most stable reading values over time (smallest drift). Considering this, we analyzed only two stacked floating gate MOS transistors as a passive dosimeter for the low doses. The results show that it is possible to detect the first portion of 10 μGy at which the sensitivity of the two stacked transistors is 23 μV/μGy. For the next same portion, the sensitivity is 17 μV/μGy, while for the third, the value is 7 μV/μGy. However, for the next 20 μGy, there is a tiny shift, and the sensitivity is only 1 μV/μGy. Decreased sensitivity with absorbed dose is a feature of the floating gate MOSFET that has been observed before for much higher doses (S. Ilić et al., Sensors 20 (11), 2020). There is a large overlap in the threshold voltage drift values for the next four radiation portions. However, for the last two largest portions, 45 and 50 mGy, there is a significant threshold voltage shift with no overlapping, and thus it is possible to determine the sensitivity of 0.0226 and 0.0214 μV/μGy, respectively.

Conclusions. Using a floating gate MOSFET as a low-dose passive dosimeter is possible, but recharging the floating gate and reusing this device for higher total ionizing doses should be investigated.

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Behaviour of pMOS dosimeters during and after X-rays

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Since it is important to control and reduce the absorbed radiation dose to a minimum, the detection of ionizing radiation is of great interest. The main component that could be used for this detection is a p-channel metal oxide semiconductor (MOS) transistor, so-called pMOS dosimeter. The fundamental idea of using a pMOS dosimeter is to transform the induced threshold voltage shift - ΔV_T, into the absorbed radiation dose - D. Compared to other dosimetry systems, the advantage of the pMOS dosimeter includes the possibility to read the dosimetry information immediately and without causing damage, the ability to store the absorbed dose, broad dose range, extremely low power consumption, interoperability with microprocessors, and inexpensive pricing. Also, it is also possible to reduce the geometry of sensors so that they can fit into other devices. Among pMOS dosimeters, the radiation sensitive field effect transistors (RADFET) are very useful for absorbed dose measurement due to unique performances. However, they are more expensive because of additional manufacturing processes. This indicates the need to test other MOS transistors as well, such as commercial transistors in addition to RADFETs.

This paper investigates the behaviour of three different types of pMOS transistors as X-ray dosimeters during and after the irradiation. The first type of used components was RADFET transistor manufactured at the Tyndall National Institute Cork, Ireland, available under the code STD 9707. These components have the aluminum gate and gate oxide thickness (d_{ox}) around 400 nm and the threshold voltage (V_{To}) measured prior to the experiments was about -7.2 V. The second type of examined components was pMOS transistors MGD 1A, manufactured at the Electronic Industry Niš, with three different gate oxide thicknesses, 314, 727 and 1226 nm. The third investigated group of components was commercial p-channel power vertical double diffused metal-oxide-semiconductor field-effect transistors (commercial p-channel VDMOSFETs), IRF 9520 type of two manufacturers. These components have the d_{ox} approximately 100 nm. The performed experiment consisted of irradiation at room temperature with X-rays up to total dose value of 160 Gy, at the Vinča Institute of Nuclear Science, Belgrade, Serbia. During the irradiation, the gate, source and drain were grounded. After irradiation, the spontaneous annealing, representing the room-temperature annealing without a gate voltage, was monitored for about 3 months.

A significant increase of the threshold voltage shift during the irradiation was observed, in all groups of components. This increase was the most pronounced for MGD components, and the slightest at commercial IRF, for which d_{ox} was the smallest. Slight changes, which were more pronounced in the first period of annealing were observed in all components. Regarding the STD components, the most pronounced increase of ΔV_T was observed for components with metal lids. During the irradiation of MGD components, the largest changes of ΔV_T were noted for components with d_{ox} of 727 and 1226 nm, which contain an additional CVD process during the oxide growth. Observed changes in the threshold voltages are caused by the formed gate oxide traps (N_{ot}) and interface traps (N_{it}). The influence of the gate oxide traps is more pronounced over the interface traps because the examined components have thick oxides. Also, the greatest change in the gate oxide traps was observed in MGD components with additional CVD process during the oxide growth. Since the changes of N_{ot} and N_{it} affect ΔV_T, their variations also lead to a change in the dosimeter important parameter such as fading, which refers to the irradiated dosimeter's threshold voltage recovery during annealing. It was observed that the fading is increasing with time for all components, and it was positive for most of the components except for MGD 1A3 and for IRF 9520.

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Impacts of ionization radiation on the cuticular hydrocarbon profile and mating success of male house crickets (*Acheta domesticus*)

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Ionizing radiation can cause severe negative outcomes to organismal life history, being shown to affect aspects of survivorship, fertility, and growth. In insects especially, due to "pest-control" programs, much research has been conducted on radiation induced male sterilization. However, although much is known on ionizing radiation impacts on reproduction and sterilization much less is understood on how radiation impacts the subtle traits associated with sexual signaling. In the House Cricket (*Acheta domesticus)* cuticular hydrocarbon signaling, along with acoustic signaling are the main avenues in which males attract and court potential mates. These cuticular hydrocarbon profiles are sex and species specific and have been shown to be vital to successful reproduction in this species. Here, we investigate how various doses of ionizing radiation (0-27.8Gy) impact the cuticular hydrocarbon profiles of male *Acheta* and its subsequent impact on mating success. Using gas-liquid chromatography we identified 26 significant hydrocarbons within the male profile. Radiation generally increased hydrocarbon intensity across all compounds p <.0001. In irradiated groups two of the larger peaks (22 & 23) increased significantly across dose (4.6-27.8Gy). These two peaks were identified to likely be alkenes which have been shown in other studies to be male specific in *Acheta*. Mating success was also significantly reduced in 27.8 Gy (p <.0001), 23.2 Gy (0.0001), and 16.2 Gy (0.0060) groups compared to non-irradiated controls. As chemical signalling in this species is sex and species specific it is plausible that radiation induced alterations to cuticular hydrocarbon profile is contributing to the observed reduced mating success in exposed males when compared to controls. However, further research should be conducted to analyze other sexual signals i.e., acoustic signals, as crickets have several signaling modalities that are required for successful reproduction and may therefore also be contributing to reduced mating success.

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Nature and structure of the radiation-induced paramagnetic centres in borate glasses

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The un-doped lithium tetraborate ($Li_2B_4O_7$) and other borates single crystals are characterized by very high radiation stability to influence of different kinds of ionizing radiation. Particularly, only fast and thermal neutrons of high fluence (more than 10^{15} cm^{-2}) leads to generation of stable paramagnetic centres in the lattice of $Li_2B_4O_7$ single crystals [1,2]. In this presentation is considered the results of detailed studies of nature and structure of the radiation-induced paramagnetic centres in some borate glasses with chemical compositions similar to corresponding single crystals.

The X-band electron paramagnetic resonance (EPR) spectra of borate glasses with chemical compositions of LiB_3O_5, SrB_4O_7, CaB_4O_7, $Li_2B_4O_7$, $KLiB_4O_7$, SrB_6O_{10}, and $LiCsB_6O_{10}$, irradiated at room temperature by high doses of γ - rays (10^7 Gy) and X - rays ($1 - 2 \cdot 10^4$ R) were registered and interpreted. The un-doped borate glasses of high chemical purity and optical quality were obtained from corresponding polycrystalline compounds by fast cooling of their melts according to technological conditions, described in [3]. The EPR spectroscopy of the γ - and X - irradiated borate glasses shows presence radiation-induced paramagnetic centres stable at room temperature practically in all investigated glasses. Detailed analysis of the observed EPR spectra shows that the registered spectra belong to radiation-induced paramagnetic centres that can be described in the framework of model of the O^- hole centres, located in different network sites of the studied glasses. The 4-component EPR spectrum of the O^- centres are related to superhyperfine (SHF) structure, caused by interaction of the unpaired electron spin with one nearest nucleus of the ^{11}B magnetic isotope (nuclear spin $I = 3/2$, natural abundance – 80.1 %). In the irradiated borate glasses also were observed weak EPR signal with the 7-component SHF structure that belongs to the O^- centres, localized near one nucleus of the ^{10}B isotopes (nuclear spin $I = 3$, natural abundance – 19.9 %). Unstructured anisotropic EPR signal, observed in the irradiated borate glasses, is ascribed to the O^- hole centres, located in the glass network near non-magnetic isotopes. Observed in the irradiated borate glasses unstructured anisotropic EPR signal was ascribed to the O^- hole centres, located in the glass network near non-magnetic isotopes. EPR spectra of anisotropic O^- hole centres without SHF structure were observed previously by us in the neutron-irradiated $Li_2B_4O_7$ single crystals [1,2] as well as in the γ - and X - irradiated glasses of the $CaO\text{-}Ga_2O_3\text{-}GeO_2$ system [4].

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On the role of intrinsic free volume in radiation-induced effects in chalcogenide vitreous semiconductors

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Phenomenological description of radiation-induced effects in chalcogenide vitreous semiconductors (ChVS) is critically reconsidered with respect to intrinsic free volume determining compactness of glass-forming network. Destruction of covalent chemical bonds in ChVS under high-energy irradiation (with 1.25 MeV energy, ^{60}Co source) is accompanied by structural relaxation towards novel metastable state, this phenomenon being known as radiation-induced physical ageing. Within such relaxation occurring via direct interaction of bond-constituting atoms and nearest surrounding neighbors, the pairs of over- and under-coordinated atoms possessing an excess of positive and negative electrical charge appear. Hence, the final optical response in the metastability of ChVS is revealed as combining irradiation-excitation and physical-ageing effects. In this work, we'll analyze the role of structural compactness in the efficiency of relaxation pathways in ChVS of multicomponent Ge-As/Sb/Bi-S/Se glass-forming systems possessing different intrinsic free volumes.

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Stability investigation of gamma-ray irradiated antibiotics

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Together with human spaceflight progresses beyond low-Earth orbit, various problems arise, including the requirement for a safe and effective pharmacy for long-duration spaceflight. Pharmaceutical radiosterilization procedures on Earth typically employ doses of 25–50 kGy, which are significantly higher than the dosages predicted for a single Mars mission (0.5 Gy), for example. Radiosterilization dosages delivered in a matter of minutes or hours far exceed the dose rates expected in interplanetary space, where such doses would be accumulated over 2–3 years according to current estimates. It has been stated that if a drug is stable at greater dose rates (such as those provided via radiosterilization procedures), it should also be stable at lower dose rates (such as those delivered in space) [1], [2].

The aim of this work was to determine the stability of three antibiotics (Rifampicin, Nalidixic acid, and Spectinomycin) subsequent their gamma irradiation exposure by using UV-VIS and FTIR spectroscopy methods.

Different radiation doses (up to 204 kGy) from encapsulated ^{60}Co source have been applied to the crystalline solid samples of antibiotics. The control samples have been either stored in laboratory (at room temperature and protected from environment light), at the irradiation facility in the same conditions and in the fridge (4-8°C and protected from environment light).

The spectral properties of both control and gamma irradiated antibiotics were measured using an UV-VIS-NIR spectrophotometer (Lambda 950, Perkin Elmer, USA) and a FTIR spectrophotometer (Nicolet IS50, Thermo Scientific, USA).

The extent of the radio-induced degradation was limited for Rifampicin and Nalidixic acid, according to their UV-VIS spectra evolution. On the contrary, Spectinomycin exhibits the strongest molecular modifications noticed either for control kept in dark at room temperature or for gamma irradiated samples.

Vibrational changes occurred for the three antibiotics on which irradiation doses of 6 kGy and 24 kGy have been applied. Also, many of these modifications are registered for the control samples kept in dark, at room temperature at irradiation facility.

In a molecular irradiated solid, the radiosensitivity is expressed by the formation of radicals, so one of the possible next steps consists on side-products identification.

Keywords: UV-VIS absorption spectra, FTIR spectroscopy, gamma irradiation, Rifampicin, Nalidixic acid, Spectinomycin

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Assessment of pigment content on wild growing plants in Moussala Peak

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Rila Mountain is the highest mountain on the Balkan Peninsula whose peak Moussala is 2925 m a. s. l. high. Its climate conditions depend on the geographic location, peculiarities of relief and atmospheric circulation, and a specific microclimate is formed. In alpine regions conditions become extremely variable with the increase of the altitude. Plants which are growing in alpine conditions are exposed to combined impact of environmental factors such as altitude, prolonged UV irradiation, low temperature and etc.

The aim of this study is to compare and assess whether pigment content of wild growing species changes in two following years. As plant material were used following species: *Saxifraga cymosa* Waldst & Kit (*Saxifragaceae*), *Anthemis carpatica* Waldst. & Kit. ex Willd. (*Asteraceae*), *Geum repens* (Rosaceae), *Doronicum columnae* Ten.(Asteraceae), *Achillea clusiana* L. (*Asteraceae*), *Allium sibiricum* L. *(*Liliaceae*)* and *Festuca valida* L. (*Poaceae*). Plants were collected from Moussala Peak in July-August, in two successive growing seasons of 2020 and 2021. Photosynthetic pigment content was applied as endpoint.

It was obtained that genotype response varies depending on the environmental conditions of the studied year. Our data showed that the levels of total chlorophylls, chl. *a*, chl. *b* and total carotenoids for most of the studied alpine plants measured for 2021 were higher in comparison with those measured 2020. Lower levels of total chlorophylls, chl. *a*, chl. *b* and total carotenoids were detected for *D. columnae* and *A. sibiricum* during 2021 than those levels measured for 2020. No change in chlorophyll *a*/*b* ratio was obtained for all studied plants growing at this altitude. On the other hand chlorophyll a/b ratio detected for 2021 was lower than that for 2020.

Our preliminary data indicate a change in pigment content depending on the different environmental conditions in the respective years and alpine plants examined. Probably studied alpine genotypes have different adaptive strategies to overcome environmental stress at this altitude. Based on the knowledge of the high mountain conditions prevailing at the Moussala peak and the impact of these extreme environmental factors on the pigment content of plants, further studies are needed to understand the mechanisms of interaction of factors and plant response in the long-term aspect of time.

Keywords: Photosynthetic pigments, altitude, UV radiation, alpine species

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Pilot study of radiofrequency radiation impacted bystander effect on dermal fibroblast cells *in vitro*

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The International Agency for Research on Cancer classifies radiofrequency (RF) radiation as "possible carcinogenic to humans" (Group 2B) since 2011 [1]. In the last decade the exposure to RF radiation emitted by wireless devices has increased in the human environment, whereupon has raised concerns about its health effects. With the development of new generations' wireless technologies (3G, 4G, WiFi, 5G) the used frequency band increases, the penetration depth into human tissue decreases. This means that most of the RF power is absorbed in the skin of the body [2].

Radiation-induced bystander effect (RIBE) is a well-known phenomenon, defined as a variety of stress induced response in non-irradiated cells resembling that observed in directly irradiated cells. Molecular signals secreted by irradiated cells can be carried far apart, possibly affecting distant targets [3].

We would like to investigate whether radiofrequency radiation (RF) has any effect on RIBE. Here we present a pilot study about RF radiation impacted bystander effect on the human skin. *In vitro* experiments were performed on normal human dermal fibroblasts, when these cells were exposed to 1950 MHz RF and different doses of ionizing radiation. Bystander effects observations were achieved by media transfer. Genetic toxicity, such as oxidative stress will be assessed by FPG-modified Comet Assay and genetic aberration by Cytokinesis-block Micronucleus Assay. This is an ongoing study, the final results will be presented at the meeting.

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Examination of UV-induced pan-nuclear H2AX phosphorylation on human skin *in vitro*

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Ultraviolet (UV) radiation is divided in the literature into 3 ranges, UVA (320-400 nm), UVB (280-320 nm) and UVC (100-280 nm). The UVC range is completely filtered by the ozone layer, therefore it can only be found at artificial sources. Certain ranges of UV radiation have been used for a long time to treat various types of skin diseases. Treatments of psoriasis, vitiligo and atopic dermatitis are used for both UVB and UVA radiations. The low dose UVA radiation is used for treatment of morphea [2]. The UVC radiation has been successfully used to cure non-healing wounds, infected with multi-resistant bacteria [1]. In addition, UVC radiation is a well-known disinfection agent in industry and healthcare. Several areas, UV radiation is increasingly being used, which is known to be carcinogenic. The UV radiation has been classified as Group 1. carcinogen by the WHO's cancer agency, IARC (International Agency for Research on Cancer). It would be important to know the molecular biological processes that occur in different skin cells when exposed to UV radiation. The γH2AX assay is a method that is able to detect DNA double-strand breaks with immunofluorescent procedure. After ionizing radiation, the Ser-139 of H2AX histone is phosphorylated – then called γH2AX –, which is labelled with an anti-γH2AX fluorescent antibody to mark the double-stranded DNA damage as a focus. UV radiation causes a completely different phenomenon, known as pan-nuclear phosphorylation, which is still poorly understood. The aim of this study is to construct an adjustable wavelength UV irradiation system (254 nm, 305-311 nm, 350-368 nm) in which cells can be irradiated in sterile circumstances with determined doses and wavelength of UV radiation, in order to better understand the phenomenon of pan-nuclear phosphorylation on human keratinocyte and fibroblast cells *in vitro*.

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Simulation of single event transient effects in CMOS circuits using open access tools and device models

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Single Event Transients (SETs) are voltage glitches induced in electronic circuits as a result of the passage of high energy particles (e.g. heavy ions) through the sensitive transistors. If propagated to the sequential elements, the SETs may result in soft errors, leading to data corruption or even system failure. With the scaling of transistor size and supply voltage, and increase of operating frequency, the SET effects are becoming more critical. Besides the space applications, the SETs have become an important reliability concern also for terrestrial safety-critical applications such as automotive electronics. Therefore, it is important to address the SET effects in the design of reliable integrated circuits.

A typical approach for analysis of SET effects is based on computer-aided simulations. One of the most common techniques is the SPICE-based current injection. This approach allows to study the sensitivity of individual transistors and logic gates in the circuit. Based on the obtained information, appropriate SET mitigation solutions can be applied to improve the system robustness. In most cases, the SET simulations are done with commercial tools and proprietary device models, which may be a limiting factor for widespread adoption of SET analysis methodologies for educational purposed. For this reason, in this work we demonstrate how open access simulation tool LTSpice and open source Predictive Technology Model (PTM) library could be applied for the analysis of SET effects in scaled CMOS technologies.

As a case study, a CMOS inverter was analyzed. For simulation of SETs, a bias-dependent current source was connected to the output of inverter. The threshold Linear Energy Transfer (LET_{TH}) and SET pulse width have been analyzed for six process nodes: 130 nm, 90nm, 65nm, 45nm, 32nm, 22nm. The influence of supply voltage and temperature on the SET sensitivity of inverter has been investigated.

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Study of Total Ionizing Dose and Single Event Upset effects on a commercial 65nm-SRAM using gamma and neutron radiation

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Introduction. Several articles have proposed Static Random Access Memories (SRAM) as excellent candidates for radiation detectors thanks to their sensitivity to Single Event Upsets (SEU) [1], and some of them have been characterized by different radiation sources [2], [3].

However, some 65nm-SRAMs have shown Total Ionizing Dose – Single Event Upset (TID-SEU) synergistic effects from 3 kGy [4] and 10 kGy [5] doses, increasing their initial sensitivity to SEU. This change could dramatically affect the performance of SRAM-based detectors.

Our purpose is to evaluate the possible impact of TID on SEU response based on the value of the cross-section under different accumulated doses.

Methods and Materials. Radiation source: The tests were performed at the European Organization for Nuclear Research (CERN) with two different radioactive sources: a Cobalt-60 (Co-60) from the CC60 facility and Americium-Beryllium (Am-Be) from CalLab facility, to provide gamma radiation and neutron radiation respectively.

Test samples. The Device Under Test (DUT) was a 65nm SRAM from Cypress, with 16 MB density and part number CY62167GE30-45ZXI-ND.

Experimental setup and method. Two samples were used for the tests. Both of them were exposed to neutron radiation in order to obtain the initial value of the SEU cross-section. Then, one memory was submitted to gamma radiation up to achieve a final accumulated dose of 5.9 kGy(Si) and again was exposed to neutron radiation to check any change of SEU cross-section. And the other memory was also submitted to gamma radiation but with four intermediate steps, obtaining the SEU cross sections at these doses, up to a final dose of 3.9 kGy(Si).

Results. From the results, it is evident that the memories were still functional at the end of the tests. The standby and supply currents slightly increased during the tests due to TID effects, but they remain within the limits specified by the manufacturer. And the SEU cross-section does not show any significant change with respect to the accumulated dose.

Conclusions and current task. The gamma radiation test with Co-60 reveals that 65nm SRAM from Cypress is resistant to a TID of 5.9 kGy(Si). Moreover, the TID effects do not have any impact on the sensitivity to SEU, which represents an advantage as a radiation detector.

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Characterization of irradiated and NBT stressed p-channel power VDMOSFETs

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Negative bias temperature instability (NBTI) is one of the important reliability issues for metal-oxide-semiconductor field effect transistors (MOSFETs). It is identified mostly in p-channel MOSFETs operated at elevated temperatures (100-250°C) under negative gate oxide fields in the range 2-6 MV/cm. NBTI manifests through deviation of many parameters, where threshold voltage shift (ΔV_T) is the most critical one, since it directly impacts the device lifetime. Our earlier papers [1 - 3] were dealing with power vertical double diffused MOS (VDMOS) transistors This type of transistor is an attractive device for application in high-frequency switching power supplies due to its superior switching characteristics. Still, power VDMOS transistors showed as very sensitive to ionizing irradiation. Therefore, in order to assess the overall reliability of these devices, it is needed to perform the characterization of irradiated and NBT stressed p-channel power VDMOSFETs.

Devices subjected to characterization were commercial p-channel power VDMOS transistors IRF9520 encapsulated in TO-220 plastic cases. In order to perform characterization and investigate the impact of the irradiation on these devices, a series of the experiments have been carried out.

Experiments were divided into three phases. First phase was irradiation of samples with different doses. The samples were irradiated at the Metrological Laboratory at the Institute for Nuclear Sciences, Vinča, Serbia. Second phase was NBT stressing in duration of 168 h under temperature of 175°C and negative bias gate voltage of -45 V. Third phase was thermal annealing, where temperature was again 175°C, but no voltage was applied.

For characterization of samples, it is needed to measure transfer I_D-V_D characteristics of the samples through the experiment phases in the precisely defined time intervals. Transfer characteristic was measured under room temperature using SMU Keysight B2901A, controlled by PC via USB.

Based on experimental results, values of threshold voltage shift for different sets of samples were determined. Analysis of these results and the impact of irradiation are reported.

Keywords: NBTI, VDMOSFET, characterization, irradiation

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GSM 900 MHz radiofrequency electromagnetic field effects on the resting Human EEG: study of the beta, theta, and delta bands

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Introduction. Electromagnetic field environment has increased people's exposure to radio frequency electromagnetic fields (RF-EMF). This exposure has raised questions about the potential effects of RF-EMF on brain activity. In our previous studies we have reported that exposure to GSM signal of mobile phone (MP) has an impact on the amplitude of spectral power of alpha band of the waking electroencephalography (EEG) (Wallace et al., 2021a, Wallace et al, 2021b, Ghosn et al; 2015). Alpha band was the most studied parameter amongst others in relation to the effect of RF-EMF on EEG. This biological modification on the alpha band amplitude is the more observed effect in the literature while other frequencies of the waking EEG were rarely reported (Wallace and Selmaoui, 2019). The objective of this paper is to explore the effects of mobile radio frequency of 900 MHz GSM signal on the beta, theta and delta bands of waking EEG in healthy volunteers at rest.

Materials and Methods. Participants. Twenty-one healthy volunteers were included in the experiment (10 females and 11 males; mean age ± SD: 25.1 ± 3.6 years). All volunteers underwent a clinical interview to assess inclusion criteria to exclude any history of health. All women participated to the experimental sessions during the follicular phase of their menstrual cycle. A written informed consent was obtained from participants before the investigation. All procedures were approved by the French Ethics Committee CPP Ouest VI and were in accordance with the Declaration of Helsinki.

Radiofrequency electromagnetic field exposure setup and dosimetry. The RF-EMF exposure system was constituted by two identical commercial dual-bands GSM MPs (Nokia 6650), which differ only for the RF-EMF emission, in order to realize a double-blind design. The sham or the real exposure was carried out using a 'load' or a 'dummy load' of the MP, respectively. The maximum SAR of the real MP averaged on 10 g tissue, 1 g tissue, and the peak value were measured at 0.49 W/kg, 0.70 W/kg, and 0.93 W/kg, respectively.

Experimental protocol. Subjects underwent two experimental sessions at weekly interval at the same time of the day, with a crossover, randomized, double-blind and counterbalanced experimental design. Experimental sessions started with 12 minutes of baseline EEG recordings combined with magnetoencephalography (MEG) in a specific MEG room (from Run 1 to Run 2), followed by 12 minutes of baseline EEG recording in another room (from Run 3 to Run 4). During both baseline phases, there was no RF-EMF exposure. Then, the EEG recordings continued in the same room for 25 minutes and 30 seconds of exposure phase with sham or real RF-EMF exposure (from Run 5 to Run 8). EEG recordings combined with MEG during baseline and postexposure phases will not be analyzed and not reported in the current paper.

Statistical analysis. First, a three-way repeated measures ANOVA was applied to power spectral density values of each band to determine the effect of period (two levels: baseline, exposure), eyes condition (two levels: EO, EC) and exposure condition (two levels: Sham exposure, real exposure). Second, to further characterize RF-EMF exposure effects, we carried out a one-way repeated measures ANOVA on baseline-corrected exposure powers computed for each electrode for the two exposure conditions.

Results. Preliminary results showed that the three-way repeated measures ANOVA did not disclose any statistically significant effect of RF-EMF on the spectral power of beta and delta frequency bands. Only the theta band showed a statistically significant effect of period factor.

The results of the one-way repeated measures ANOVA showed that there was no statistically significant difference between exposure conditions for the beta and the delta bands. Only the theta band showed a statistically significant difference between powers computed for the sham and real exposures.

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Long lasting luminescence decay and spectral properties of irradiated feldspar samples

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Feldspars are common minerals constituting more than 50% of the earth's crust components. Due to good radioluminescence properties the minerals are widely used for dating of quaternary sediments by optically stimulated luminescence (OSL), infrared stimulated luminescence (IRSL) and thermoluminescence (TL) methods.

Unfortunately, feldspars are very complex materials. Localized energy levels of traps and recombination centers are distributed randomly. So, the energy levels have continuous distribution resulting in broad TL peaks and long OSL decay tails.

Selected feldspar minerals were irradiated using $^{90}Sr/^{90}Y$ beta sources with different dose rates with doses up to 1 kGy. OSL, IRSL and TL properties were measured. For most feldspars the IR stimulation is more efficient than the stimulation in the visible. Spectral measurements were performed to show the emission properties of the minerals. The data were analyzed using advanced theoretical models taking into account continuous distribution of energy levels.

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Measurement of radiofrequency (RF) exposure around a 5G base station

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The fifth generation (5G) mobile system, similarly to previous mobile phone telecommunication technologies (2G, 3G, 4G, Wi-Fi), uses electromagnetic waves. The 5G service to be introduced will partly use the same radio frequency (RF) bands as the previous technologies, while new frequency bands have also been designated on the basis of international conventions. In Europe, including Hungary, the 5G service was already launched in the 3.6 GHz frequency band. With the use of beamforming and MIMO (Multiple Input Multiple Output) technology in 5G technology and optimised service, the ambient RF exposure, will change, the peak exposure could be increased, but the expected average ambient electromagnetic exposure will remain below the exposure limit.

The aim of this study was to evaluate the "bystander" RF exposure of a 5G base station used beamforming antenna in the 3.5 GHz band. For this purpose RF measurement devices were fixed at 134 m distance in front of a building deployed a 5G base station while a test mobile phone which generated standard data traffic was moved step by step away from the measurement point. The electric field strength was measured with three devices: (i) RF spectrum analyser (Narda SRM-3006, Narda-STS, Germany); (ii) broadband RF field monitor (Narda NBM-550); (iii) band selective RF exposimeter (ExpoM-RF, Fields at Work GmbH, Switzerland). All RF measurement devices were set in data logging mode. Two minutes of mobile data was generated by the test phone every five metres moving away from the measurement devices. The results show that at the fixed point the electric field strength of the 5G band (3.4-3.8 GHz) is decreasing with the distance the mobile phone generates the traffic. The field level decreased around 50% while the test mobile distance reached 25 meters. The background of this phenomenon is the "beamforming" technology of 5G systems, which means that the RF beam of base the station antenna focuses and follows the active mobile device.

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Citizen monitoring of ambient dose rate: metrological challenges

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For some years Citizen Science (CS) has become a topic in scientific discussion. This regards also monitoring ambient dose rate (ADR). The reason is increased interest after the Chernobyl and Fukushima accidents, the easy accessibility of measurement technology and altogether the interest of parts of the public in science. Benefits of CS are its contribution to scientific education, its democratic character and from a scientific perspective, the possibility to generate enormous amounts of data which institutional monitoring is hardly able to do.

An ADR monitoring project is *Safecast* (www.safecast.org), initiated in Japan after the Fukushima accident 2011. It soon spread world wide and through millions of measurements performed by volunteers, an ADR map has been compiled which covers parts of the world (https://map.safecast.org/). The measurements are performed with a standard instrument called *bGeigie Nano*, essentially a GM counter coupled with GPS, which logs data to a file that can be mapped by GIS software or sent to *Safecast* to be published. Several thousand such devices are said to be circulating globally. Similar, though smaller-scale projects exist.

An essential problem with CS in general, but with radiation monitoring in particular is quality assurance (QA). In metrology, this has two aspects:

1. Classical metrological QA (not confined to CS), concerned with characterization of an instrument, its calibration and measurement statistics;

2. Citizens are usually not trained metrologists, therefore handling of the instruments can be subject to errors, leading to in increased uncertainty of results. This concerns mainly measurement geometry. This QA aspect is important to ensure reproducibility and interpretability of results.

In this contribution, we shall shortly introduce *Safecast* and discuss the two QA aspects, showing a number of examples of possible errors and experiments which have been performed to estimate their impact on the uncertainty budget. Although the experiments have been performed with *bGeigie Nano* devices, the results can be generalized.

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Results of IMS participation in international intercomparisons for whole body dosemeters – 10 years of study

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The regular participation of an accredited individual monitoring service (IMS) in the international and/or interlaboratory intercomparisons (IC) is required according to ISO/IEC 17025:2017 standard, General requirements for the competence of testing and calibration laboratories. By taking the part in an IC, IMS shows competence, reliability, and has an opportunity to learn further and improve its measurement method. The European Dosimetry Group (EURADOS) Working Group 2 (WG2) has acknowledged the value of the regular IC and also found that data and results from it are fundamental for the harmonization of the measurement process [1]. Thus, EURADOS started a self-sustained program of IC for IMS for external radiation on a biannual basis. The results of an accredited IMS at the Department of Radiation and Environmental Protection, "VINČA" Institute of Nuclear Sciences, Belgrade, Serbia (IMS VINS) in the EURADOS IC for the period 2010-2020 (excluding 2014) are presented.

IMS VINS use thermoluminescent whole body dosemeters based on two TLD-100™ (Thermo Scientific™ Harshaw™, USA) detectors. The readouts are done on the Harshaw TLD™ Model 6600 Plus Automated Reader (Thermo Fisher Scientific, USA). The whole glow curve is used for dose estimation (all of 200 channels). The calibration of the dosimetric system is done twice a year in S-Cs (previously in S-Co) field at the secondary standard dosimetry laboratory (SSDL VINS), according to ISO 4037-3:2019.

The IC had 40 different reference values of personal dose equivalent, $H_p(10)$ in noted period ranging from 0.431 mSv to 501 mSv. There were 20, 16, 22, 22, 20 dosemeters irradiated in year 2010, 2012, 2016, 2018, 2020, respectively. The radiations were done in 12 different fields: N-60, S-Co, S-Cs, N-40, N-150, S-Cs+Sr-90, S-Cs+N-40, W-110, S-Cs+W-250, W-60, S-Cs+W-80, and S-Cs+N-150. The relative response (R) range is from 0.23 to 2.26. Quantile values for R are: 0.23, 0.79, 0.90, 1.1, and 2.26, respectively for (0%, 25 %, 50 %, 75 % and 100 % of points). Mean and standard deviation of R are 0.97 and 0.30, respectively.

The performance limits are established according to ISO 14146 trumpet-curve [1]. Due to trumpet-curve there were 6 outliers (2 in 2010, 4 in 2016). All of the outliers were for reference dose around 1 mSv and lower. One outlier from 2010 was irradiated in N-40 field and 30° of incident angle. The other outlier was irradiated in the S-Cs field, without any rotation, and thus should have had a satisfying response. The possible explanation is an insensitive TL detector. The outliers in 2016 were all for N-40 quality and ±60° angle. Thus, considering the low number of outliers (only one true outlier) and expected dosemeters faulty response for given irradiation parameters, we conclude that the IMS VINS dosimetry system had satisfactory behavior during IC from 2010-2020.

Keywords: Whole body dosemeter, $H_p(10)$, intercomparison, IMS, external radiation dosimetry

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Study on the efficiency of p-type HPGe detector using PHITS MC for samples with volumetric geometry

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HPGe detectors are widely used in gamma spectrometry for identification and quantification of samples due to their high energy resolution. The most important and basic parameter to be determined by the analyzer in gamma spectrometric calculations is the full energy peak efficiency (FEPE) value of the detector. FEPE is thus a complex function characterized by the detector (its dimensions and composition) and the measurement conditions (composition and geometry of the source). FEPE can be determined in two ways, either experimentally or by the Monte Carlo (MC) method. In this study, FEPE values for IAEA-RGU-1, IAEA-RGTh-1 and IAEA-RGK-1 volumetric samples prepared in 6×5 cylindrical containers were determined by both experimental and MC methods. PHITS MC program is used for MC calculations. In the PHITS MC simulation code; all geometric parameters of the detector such as dimensions of the crystal, end cap window thickness, the structure of the detector holder, dead layer thickness, etc. given by the manufacturer are defined and the HPGe detector is modeled. Modeling the germanium crystal, which is the region where the energy accumulation will be calculated, is one of the critical steps in simulation. Therefore, modeling this region as rounded or sharp is important as it will change the active crystal volume and solid angle. The sharp edge of the front face of the crystal reduces the detector performance and causes weak field regions. This problem is avoided by rounding the crystal front face in a process known as bulletization. In this study, the effect of rounded or sharp modeling of the crystal face geometry, which is one of the geometric parameters of the detector, on the detector efficiency value was investigated. In this aim, the differences between the simulated efficiency values obtained from the volumetric sources counted on the detector endcap and the experimental values were investigated. The relative differences from the experimental efficiency were found to be 2.7% in the sharp edge geometry and 0.8% in the rounded edge at 46.5 keV, where the effect is expected to be most dominant. Thus, in the counts made directly on the detector endcap in volumetric geometry, it was seen that the difference in the geometry of the front edge of the crystal was not as much as the point source geometry counted at a certain distance from the detector. This difference, which is caused by the solid angle between the source and the detector, shows that we should model the crystal as rounded in the volumetric source geometry. In this study, volumetric geometry, which is the most used geometry in routine gamma spectrometry, was modeled for the first time with PHITS MC. MC simulated results compatible with the experimental values were obtained. Therefore, this study has shown that PHITS MC can also be used successfully in volumetric source geometry.

Keywords: HPGe, rounded edge, sharp edge, PHITS, detector modeling

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Increasing uniformity of dose distribution throughout spherical objects during radiation treatment

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Providing dose distribution uniformity of irradiated objects is a topical task these days. The problem is especially acute when it comes to the foodstuff categories for which narrow ranges of treatment doses are prescribed, making it necessary to provide uniformity of radiation treatment higher than 0.8.

Currently, electron accelerators are increasingly used as radiation sources in industrial radiation treatment centers. Dose distribution uniformity might be increased by varying the energy of electrons. However, this method cannot be used with accelerators operating in a single energy mode. If irradiating scheme implies several iterations, repeated sessions of irradiation increase radiation treatment time and cost. It is also possible to place aluminum plates between electron beam and an object to blur the initial beam spectrum, which leads to an increase in irradiation uniformity.

The purpose of this study is to evaluate the effect of using 3 to 5 mm thick aluminium plates to increase the absorbed dose distribution uniformity over the volume of a spherical object during radiation treatment with 5 to 10 MeV electron beams.

The absorbed dose distribution uniformity criterion was K = Dmin / Dmax, where Dmin, Dmax are the minimum and maximum absorbed doses in the phantom volume respectively. Calculations were carried out by computer simulation using Geant4 toolkit developed by CERN.

The simulation of water sphere (with the diameter of 4.6 cm and density of 1.0 g / cm^3) irradiation with 1 MeV by accelerated electrons with energy of 5 — 10 MeV was carried out. We also simulated 18 irradiation configurations, where 3, 4 and 5 mm thick aluminium plates were integrated into irradiation scheme.

It was found that irradiation by electrons with energies of 9 and 10 MeV ensures radiation treatment uniformity at least of 0.56. At the same time irradiation by electrons with energies below 9 MeV ensures the uniformity from 0.34 to 0.44. Additional placement of aluminium plates during irradiation by electrons with energies 6 to 8 MeV causes radiation treatment uniformity to increase up to 0.72.

During radiation treatment by accelerated electrons for a given shape and linear sizes of an object, it is possible to find the initial energy of electrons and the thickness of the aluminum plate, at which the absorbed dose distribution uniformity over the object volume will be the maximum possible for a given irradiation scheme.

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First experimental test of D-T neutron generator and related Monte-Carlo simulations

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D-T Neutron generator Model GENIE16 is based on DT neutron emission, providing neutrons with energy of 14 MeV and has power of 10 W. The GENIE16 can be operated either in continuous or in pulsed mode. Maximum average neutron yield is from $1*10^7$ to $2*10^8$ n/s/4pi sr and maximum peak neutron yield (during pulse) within the range $2*10^8$ to $1*10^{10}$ n/s/4pi sr. Based on these specifications, the estimated neutron fluxes at radius of 50m, 70m and 100 m from the D-T neutron generator have been calculated, along with corresponding equivalent doses due to ionizing radiation associated with neutrons (taking into account fluence per unit dose equivalent). These calculations were applied for determining the safe distance of remote D-T neutron generator operation, at an open field. Furthermore, at the site, portable neutron monitor was used as well, to track the current exposure. First experimental test of this generator comprised the activation of several targets by neutrons: 3 copper coins (with m≈1.5 g, radius of 30 mm and 0.2 mm thickness) and indium object (with m≈8.5 g, 40 mm x 39 mm and 1 mm thickness). After neutron activation, these objects were analyzed by gamma spectroscopy at the laboratory, using HPGe detectors.

Monte-Carlo simulations, using GEANT 4 simulation toolkit, have been developed to assess the neutron fluxes and further analyze interactions of emitted 14 MeV neutrons with the mentioned targets.

The results of experimental measurements using D-T Neutron generator Model GENIE16 and developed GEANT4 simulations will be presented and compared in this work.

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Measurements of radioactivity in cereals using gamma-ray spectrometry

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In the modern age, the agricultural sector is using manure and chemicals to increase the efficiency and yield of the crops, thus introducing new elements inside the plants, and favoring the absorption in the plant of other elements existing in the soil. Considering that almost 80% of the agricultural products of Romania are cereals, measurements of the amount of radioisotopes in grains is very important to assure the radiation protection of the population according to the national and international regulations [1, 2].

In the laboratory two methods of measurement have used: gross alpha-beta measurements using an ORTEC PROTEAN MPC-2000-DP system and gamma spectrometry using an ORTEC HPGe detector. The gross alpha-beta measurements are performed using a 2 inch dual scintillator, being able to measure both alpha and beta radiation together or separated, in order to get more exact results.

A number of nine samples of cereals (corn and wheat) were measured and analyzed, the laboratory recording a higher demand in the last part of the year 2021 and the beginning of 2022. The samples were fine grounded and the integral powder was used for measurement. For the gross alpha-beta measurements, the mass of the sample was usually ~2 g, while for gamma, the mass of the sample was larger, ~100-130 g. In both cases, the measurements were performed for an acquisition time between 60 000 s and 300 000 s, in order to obtain a lower minimum detectable activity.

The results showed that the gross alpha activity was between 0.030 ± 0.003 Bq/kg and 4.19 ± 0.4 Bq/kg, with an average of 2.21 ± 0.24 Bq/kg, for both corn and wheat, and for gross beta activity these were between 4.27 ± 0.45 Bq/kg and 18.70 ± 1.7 Bq/kg, with an average of 8.20 ± 0.90 Bq/kg. Since the gamma spectrum has the possibility to discriminate the radionuclides, we took in consideration three categories: natural radionuclides (^{238}U, ^{232}Th, ^{226}Ra, ^{40}K), ^{134}Cs and ^{137}Cs. Although the acquisition time was a lot longer than that of alpha-beta measurements, both ^{134}Cs and ^{137}Cs were below the minimum detectable activity (MDA) for both the corn and the wheat. The natural radionuclides activity concentrations showed varied results between 71.00 ± 6.5 Bq/kg and 274.5 ± 18.5 Bq/kg, with an average of 146.44 ± 10.2 Bq/kg.

The analyses results of cereals under investigation in this paper showed that in all cases the activity concentrations of the radionuclides measured were below the IAEA guideline levels, where the maximum value is 1000 Bq/kg, also true for gross alpha and beta activities. Therefore, the cereals measured are in concordance with the regulatory laws, and they are safe for use for human consumption.

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Natural radioactivity measurements of various ground water samples

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Water is one of the most abundant substances on earth, playing an important role in the development of daily activities. For its safe consumption, its quality must be in accordance with the rules and regulations applicable at European and national level (Directive 98/83/EC, Directive 2013/51/EURATOM, Romanian law 301 of November 27/2015), regarding its radioactivity, together with other concentration of elements/chemicals that may be found in it.

The SALMROM laboratory, notified by Romanian National Commission for Nuclear Activities Control (CNCAN), performs water analysis on samples coming from various sources (ground, tap, well, surface water) using the gross alpha-beta system MPC-2000-Ortec-Protean, and gamma using a HPGe Ortec detector, to determine their radioactivity content. The laboratory has implemented standard and routine methods to achieve good analytical results (ISO 9696, ISO 9697, ISO 10704 and ISO 17025). The water samples are slowly evaporated and the dry residue is used for the measurements. In both types of measurements an acquisition time between 60 000 s and 300 000 s is used in order to achieve a low minimum detectable activity.

The results obtained from the gross alpha-beta measurements showed values between 0.002 ± 0.001 and 0.045 ± 0.002 Bq/l, with an average of 0.015 ± 0.003 Bq/l for alpha, respectively 0.05 ± 0.01 and 0.15 ± 0.02 Bq/l, with an average of 0.10 ± 0.03 Bq/l for beta. These values are within the European quality standards, below 0.1 Bq/L for gross alpha activity and 1 Bq/L for gross beta activity. For gamma radiation measurements the obtained spectra were analysed with GammaVision software and the resulted activity concentrations for ^{238}U, ^{40}K, ^{226}Ra, ^{232}Th were used to calculate ingestion doses associated with these natural radionuclides, considering the annual consumption rate of 150 L/yr for infants, 350 L/yr for children and 500L/yr for adults. Natural radioactivity is present in water through the existing radioactivity of rocks, existing in the earth crust from its formation. Thus, the dose values obtained for ingestion of water were between 11.0-27.0 μSv/year, with an average of 18.5 μSv/year. In all cases the values were well below the reference level of the committed effective dose (100 μSv/yr) recommended by the international regulations.

The surveillance of the ground, tap, well water shows a radiological perspective on dose ingested due to various radionuclides contained in water. The radiological water surveillance assessment is not a new subject, however, this has to be done continuously. The obtained data provide basic information for consumers and competent authorities, making them aware of the actual problem of the variation of the chemical composition and of the radiation. In addition, information can give a perspective on the variation composition of the soil through which water infiltrates.

References

[1] Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption

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[3] ROMANIAN LAW no. 301 of November 27, 2015 on establishing the requirements for the protection of the health of the population regarding radioactive substances in drinking water

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International standardization of basic industrial radiotracer and radiation applications

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The International Atomic Energy Agency (IAEA) in cooperation with the International Society for Tracer and Radiation Applications (ISTRA) promotes the international standardization of basic industrial radiotracer and radiation applications. On behalf of IAEA and ISTRA experts from many countries employed in leading research centers and renowned industrial companies analyze existing international standards regarding the necessity of their update or amendment as well as the need for new standards in this field.

In June 2020, a new international standard on “Non-destructive testing - Gamma ray scanning method on process columns” was published as ISO 23159. About three years ago, the experts detected the need to standardize this method meanwhile widely used in petrochemical and chemical process plants as a possibility to check the interior and to locate the cause of malfunction in tray and packed bed columns to avoid basic errors at the application of this method.

In the field of flow rate measurements of fluids in conduits using radioactive tracers several international standards are known:

- Measurement of water flow in closed conduits (ISO 2975)
- Measurement of gas flow in conduits (ISO 4053)
- Measurement of liquid flow in open channels (ISO 9555).

All three standards describe more or less the same measuring methods. Therefore, there is no reason to maintain three independent standards on similar subjects. To bundle the existing diversity experts proposed a new international standard on “Measurement of Fluid Flow Rate in Closed Conduits – Radioactive Tracer Methods”. A committee draft (CD stage) is currently being processed. As soon as finalized, this standard will be published as ISO 24460.

Furthermore, two other international standards using radioactive tracer methods are under development just now. One of them will deal with leak testing in pressured vessels and underground pipelines, another one will be on determination of concentration or density of suspended and deposited sediment in water bodies by radiometric methods. For both, the working drafts (WD stage) are currently in progress. The first one is being edited in ISO Technical Committee 135, Sub Committee 6, Working Group 1 (ISO TC 135/SC 6/WG 1), the second one in ISO TC 113/SC 6/WG 5.

ISO standards are part of accreditation of radiotracer and radiation applications groups, facilitating the promotion and implementation of these competitive technologies in national, regional and international scale.

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Non-radiochemical technique to determine the activity of long-lived nickel radionuclides in nuclear reactor construction materials

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Structural materials and the inner layers of concrete are activated during the nuclear reactor's operation under the influence of neutron irradiation. In addition, deposition of radioactive products of corrosion and fission products on the surface of the technological equipment and enclosing building structures is possible. The total amount of waste of various materials during decommissioning of any reactor can reach hundreds of tons. Therefore, it is necessary to characterize the state of the equipment and structures of the reactor at the beginning of decommissioning.

This work aims to determine the activity of long-lived nickel isotopes in structural materials of nuclear power plants. Nickel is widely used in stainless steel and alloys of structural materials for nuclear power plants. Alarge amount of nickel-59 and nickel-63 are produced during a reactor operation. The half-life of nickel-59 is 76,000 years, nickel-63 is 100 years. Nickel-63 is a pure beta emitter, while nickel-59 decays by electron capture, emitting characteristic X-rays of low energy. It makes characterization and determination of their activity in nuclear power plant structural materials difficult by traditional methods of applied gamma spectrometry.

We propose to determine the activity of the accumulated nickel radioisotopes in the structural materials of nuclear power plants using photoactivation method and the cobalt-60 activity with the half-life of 5.27 years. Natural cobalt consists mainly of one stable nuclide ^{59}Co. It is inseparably linked with nickel, as it is an admixture of nickel ores. According to state standards, the cobalt impurity should not exceed 0.5% for steels used in structural materials of nuclear power plants. However, cobalt-60 has been produced due to the extensive capture cross-section of thermal neutrons from ^{59}Co in the (n, γ)-reaction during reactor. And its activity is reliably identified by the 1333 keV gamma line in all irradiated structural materials.

Photoactivation analysis could assess the ratio of the number of nuclei in the initial structural material. Whereas the activity of cobalt-60 makes it possible to evaluate the activation of nickel due to (n, γ) reactions. We propose to use the products of (γ, n) reactions on the stable nickel and cobalt isotopes, such as nickel-57 (with a half-life 35 hours) and cobalt-58 (with a half-life 70 days).

The method's calculated error is about 5-10%. Its sensitivity is 1 Bq/g.

The photoactivation technique for determining the activity of long-lived nickel isotopes can significantly simplify their identifying, monitoring, and certifying in reactor structural materials and various types of radioactive waste. The proposed method is more efficient than traditional radiochemical methods for the large volume of radioactive waste generated at nuclear power plants.

Up to 100 samples of structural materials or radioactive waste can be irradiated at the same time by an electron accelerator. Therefore the proposed approach reduces the cost of work compared with traditional methods.

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Comparison of the dose recovery test results for selected materials with potential application in emergency dosimetry

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The use of ionizing radiation in various fields of medicine, science and industry, as well as the danger of using nuclear weapons, carry the risk of undesirable nuclear or radiological events. In the case of occupational exposure, the level of danger is constantly monitored. For the general population, who is not professionally exposed to radiation and usually does not have access to dosimeters, non-standard methods are needed for the risk assessment. Therefore, there is a need to search for cheap and commonly widespread materials which can act as passive radiation detectors in places where standard radiation meters are not available. The passive emergency detectors can be materials that show luminescent properties - phosphors. In order to obtain information about dose absorbed by such emergency detector, the sensitive luminescence method as Optically Stimulated Luminescence (OSL) can by applied. Among the materials studied by many researchers for the purposes of emergency dosimetry are: quartz, building materials, ceramics, mobile phone elements, glass displays or protective glasses, credit card chips, money, dental materials, table salt, medicines, resistors, tooth enamel, watch glass, and many others. To be used in emergency dosimetry, the material must meet certain properties, the main one is that the signal from the sample must be sensitive enough to measure a dose of about 1-2 Gy within several days of the exposure.

The aim of this study is to investigate the potential of selected materials for accidental dosimetry and comparison of dose recovery test results using various commonplace phosphors. Protective glasses for mobile phones, dietary supplements with potassium chloride and table salt were selected for the study. The protective glass for the camera lenses were round shape tempered glass (9 H) for iPhone 12 (Camera Film) and for Samsung Galaxy A32 (Camera Screen Protector) with a thickness of 0.3 mm and a diameter of 9.5 and 8 mm, respectively. Dietary supplements under study were in the form of tablets (Potas Apteo) or granules (Potazek). The tablets were cut into smaller pieces, so that each type of sample has a repeatable sample size and weight (405 ± 28 mg). The granules were measured in a specific amount (30 granules, 40 ± 3 mg) and glued to the tape that facilitated the measurements (the tape did not give an OSL signal). Table salt (O'Sole, sea salt) in the form of a crystalline powder was divided into samples of similar weight (10 mg) using a measuring cup. The samples were irradiated using 90-Sr/90-Y beta source.

The dose recovery test was performed for doses 0.61 Gy, 1.84 Gy and 3.07 Gy represented three levels of risk in emergency dosimetry (radiation dose triage levels): <1 Gy low, 1–2 Gy medium, and >2 Gy high. In the event of an unexpected radiation event, it is not possible to measure the OSL signal immediately. Therefore, in this experiment after irradiation the samples were stored one day and seven days in a light-tight package until the OSL readout. The OSL measurements were performed using a Helios OSL reader (manufactured by Zero-Rad) with green light stimulation (LEDs with peak at 520–532 nm, Schott optical filters GG495 and OG515). Detection of the luminescence was made by H7360 photomultiplier (Hamamatsu) with Schott UG11 filters in the range 300–380 nm. The measurements were carried out in a continuous wave OSL (CW-OSL) mode collecting OSL decay in time of 60 s. Depending on the type of material, the unknown dose was determined on the basis of an appropriate calibration curve using an corresponding fading correction factor for the measured OSL signal. The dose recovery test for all materials tested showed promising results. All recovered doses were well-classified under the triage category. Noticeably table salt and dietary supplements are sufficient to determine the dose for a period of at least one week, which proves the high potential of these materials for use in emergency dosimetry.

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Simultaneous determination of ^{226}Ra and ^{210}Pb in sediment and peat bog samples by Liquid Scintillation Counting technique for geochronological uses

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The most extensively used approach for determining recent (100–150 years) chronologies and sediment accumulation rates in aquatic environments is by ^{210}Pb dating, which has been successfully utilized to recreate a variety of environmental processes linked to global change. In order to successfully apply the ^{210}Pb dating model, it is required to first determine the specific activities of ^{226}Ra and ^{210}Pb in the samples, as ^{226}Ra is responsible for generating the in-situ fraction of ^{210}Pb in the sediment.

The measurement of the two radionuclides can be performed using various techniques, the most commonly applied being gamma spectrometry, due to its simplicity. However, this method presents major disadvantages regarding ^{210}Pb measurements, due to its low energy and gamma yield, resulting in the absorption of radiation within the sample. Although the literature presents several models to aid and correct this attenuation, the small yield of disintegration necessitates a larger sample mass, to ensure that the detection limit is exceeded. If a good resolution is considered (0.5-1 cm), the sediment mass resulted after undergoing drying and homogenization, will not surpass, in some situations, the value of a few grams, due to the limited cross section of the core. For this reason, the sediment mass may be insufficient or barely sufficient to perform gamma spectrometry measurements with a well-type detector geometry, especially if a multi-proxy analysis is considered. Due to technical reasons and sediment texture, wider sediment core samples cannot be considered, so alternative methods that are suitable for reduced sample sizes needs to be approached.

The current paper presents a new method for the simultaneous determination of ^{226}Ra and ^{210}Pb, which is also suitable for low mass samples, thus enabling higher resolution chronologies. The sample preparation technique consists of mineralization (acid leaching of the samples), followed by filtration of the resulted solution and the addition of a known amount of a stable element (Ba and Pb), used to determine the chemical recovery efficiency. ^{226}Ra and ^{210}Pb are then precipitated in the form of insoluble sulphates, which are washed and redissolved with a EDTA-alkaline solution. Then, a pH-dependent sequential precipitation of ^{226}Ra and ^{210}Pb is performed. The resulted precipitate is recovered by centrifugation in an alcohol solution, then further dissolved with NaOH and mixed with scintillation cocktail. The chemical recovery of the proposed method ranges from 73 to 95%, with a detection limit of 20 mBq for ^{210}Pb and 30 mBq for ^{226}Ra, measured immediately after sample preparation.

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Fast determination of radium isotopes (^{224}Ra, ^{226}Ra, ^{228}Ra) from water samples by combined nuclear spectrometric techniques

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Radium isotopes (^{224}Ra, ^{226}Ra, ^{228}Ra) are entering groundwater as a consequence of the radioactive decay undergone by ^{238}U and ^{232}Th present in the surrounding geological environment. By resembling the chemical behaviour of calcium, radium may be easily deposited in the bones of living organisms, and for this reason it is considered a carcinogen. Numerous international and national guides and regulations are imposing limits on radium isotopes concentrations in drinking water. Therefore, in consideration of its importance both in the field of environmental radioactivity and public health, it is compulsory to develop fast and accessible laboratory techniques for the determination of radium isotopes present in water samples.

The present work suggests a new, time-efficient methodology for assessing radium isotopes levels present in water, by coupling the LSC (Liquid Scintillation Counting) technique with beta counting and alpha spectrometry. The sample preparation procedure consisted of co-precipitating the radium isotopes in the form of Ba(Ra)SO_4, in the presence of a Ba_2^+ carrier, to assess the chemical yield. The resulted precipitate was then filtered and measured by alpha spectrometry for ^{224}Ra and ^{226}Ra determinations. In the case of ^{228}Ra, a beta counting system equipped with a plastic scintillator detector was utilized. For low activity concentrations (poor counting statistic), the filter was dissolved and analysed by LSC. The detection limits achieved for a sample volume of 1 L, are 3 mBq for ^{226}Ra, 5 mBq for ^{224}Ra, respectively 10 mBq for ^{228}Ra.

The developed methodology was applied for 23 natural spring water samples from Harghita county, Romania, and the resulting specific activities ranged from 35±3 to 694±30 mBq/l for ^{226}Ra; from 7±1 to 50±3 mBq/l for ^{224}Ra; and from 30±4 to 800±47 mBq/l for ^{228}Ra.

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A new approach for the determination of gross α/β activity in water samples by integrating Liquid Scintillation Counting with beta spectrometry

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Radionuclides are naturally present in water as a consequence of the processes of dissolution, leaching and desorption of the traversed rocks. With the aim of ensuring public health safety, a considerable number of international guidelines and regulations were issued, concerning the level of radioactivity in water destined to human consumption. The first insight regarding the level of radioactive contamination presented by a water sample is given by assessing the gross α/β activity. Subsequently, if this parameter is above the permitted level, detailed measurements on specific isotopes are required. Therefore, the gross α/β determination is the first and most important analysis used to obtain preliminary radiological data in the assessment of drinking-water safety for the public health. For this reason, methodological developments and advances are required to enable researchers to perform these measurements with ease.

The present work introduces a time-efficient and reliable method for the determination of gross α/β activities in water samples, developed to compensate for the deficiencies presented by Liquid Scintillation Counters (LSC) systems that are unable to perform α/β – discrimination. The proposed method involves the quantitative determination of the total activity of the sample by Liquid Scintillation Counting, while performing the gross β activity measurements using a beta spectrometer detector system. Thereafter, the gross α activity values can be achieved by subtracting β values from the total activity.

The sample preparation procedure consists in evaporating the sample to dryness then dissolving part of the residue, and mixing the resulting solution with scintillation cocktail. The remaining fraction of the residue was evenly distributed on an aluminum disc, and measured using a beta spectrometer system shielded by a lead cover. The resulted detection limits, achieved using the proposed method, are 50 mBq/L for gross α activities, 30 mBq/L for low energy β emitters activity, respectively 80 mBq/L for high energy β activity. Considering the detection limits of the method, which are in accordance to those specified in international regulations, the technique is suitable and can be successfully used for the assessment of gross α/β activities in water samples.

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Measurement and analysis of radiation induced optically stimulated luminescence (OSL) decay

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Optically stimulated luminescence (OSL) is a measurement technique used in dosimetry of ionizing radiation and luminescence dating of archaeological and geological samples. The samples are typically highly defective dielectric crystals or polycrystals. The mechanism of the energy storage (during irradiation) and subsequent recombination (during light stimulation) leading to luminescence is quite complex. Many materials (detectors) show significant changes of the OSL signal with respect to the storage time. Typically the signal is decreasing with within a few weeks or several months. Measuring such characteristics is a challenge.

This paper presents some OSL fading properties measured in various samples. Possible mechanisms of fading are discussed. Examples are shown explaining why the fading is usually non-exponential. New ideas are presented for a less time consuming OSL measurement that allows determination of fading properties in a long time scale.

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Predicting a sudden failure of the conversion disk in a medical accelerator based on data from dosimetric measurements

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In a classic medical accelerator, the therapeutic beam of radiation is obtained from a stream of high-energy electrons that rapidly brake on the element called “conversion target”. Intensive use of the device in a clinical work may lead to the systematic degradation of the disc and, as a consequence, to a point break in its continuity. Probably the damage has small lateral dimensions at first, hence its influence on the quality of the therapeutic beam is not immediately noticeable. The therapeutic beam is aberrated only in the brief moments when the narrow electron beam passes centrally through the damaged sector of the target. Damage to the target leads to temporary changes in the spectrum of the beam, which, however, are not registered by the measurement systems. The cause of this condition is due to the fact that the accelerators work in a pulsed system. In order to be independent of this limitation, the reading from radiation detectors (ionization chambers) is averaged over a time. Such a procedure simply leads to the loss of information on short-term changes in the quality of radiation.

Routine procedures recommended by international scientific societies are insensitive to slow changes in dosimetric parameters of the therapeutic beam. Usually the dose distribution along beam axis is verified as beam-quality indicator. This curve is always standardized, due to the pulsating nature of the accelerator’s operation, therefore it does not show momentary fluctuations. On the other hand, possible electron contamination occurs at shallow depths (up to 2 cm), and these are rarely the subject of detailed analysis due to the significant influence of measurement inaccuracies.

After the failure of an accelerator (Clinac 2300CD) that took place in our facility, we carried out a retrospective analysis of all the measurement data we had for this device. We focused on the 6MV beam data collected during the year preceding the accident. We are able to show that the existing procedures are not able to sufficiently detect short-term changes in the spectrum indicating target degradation. However, extending the routine procedures to measure additional parameters will provide the necessary information. Our assumptions were confirmed by an experiment during which the quality of the beam was deliberately changed in a manner similar to the failure that took place.

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Possible health risks from exposure to microwaves from base stations

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Base stations emit microwaves (MW) at intensities that are significantly lower those of mobile phones. However, contrary to mobile phone exposure, people are continuously and involuntary exposed to MW base stations being at their work places or homes in proximity of these stations.

Current safety standards adopted by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in 2022 are based on the assumption that energy delivered by MW to the exposed tissues is safe if it does not induce heating. Therefore, exposures from base stations are assumed to be safe according to the ICNIRP safety limits. However, the ICNIRP safety standards do not take into account non-thermal MW effects and prolonged exposures as from base stations, and in evident contradiction with the classification of MW as possible carcinogen, group 2B, by the International Agency on Research in Cancer (IARC).

Multiple studies show that effects of MW depend not only on delivered energy but also on other exposure parameters such as carrier frequency, modulation, polarization, and duration of exposure. The data about the non-thermal effects of MW at super low intensities and significant role of duration of exposure in these effects along with the data showing that adverse MW effects depend on carrier frequency and type of the signal suggest that MW from base-stations/masts can also produce adverse effects at prolonged durations of exposure. Of most importance for possible health effects from base stations is the overwhelming evidence that duration of exposure may be an even more potent contributing factor to the MW radiation bioeffects than the delivered energy levels. In particular, MW at intensities comparable with those from base stations and prolonged exposure were shown to inhibit DNA repair.

The number of studies evaluating detrimental health effects from the base stations/masts is still limited. However, a worrying incidence of symptoms such as headaches, concentration problems, fatigue, nausea, memory problems, irritability, lack of appetite, insomnia, depressions, cerebral symptoms, joint illnesses, infections, skin changes, heart and circulation disorders, and disorders of the optical and acoustic sensory systems and the gastro-intestinal tract has been reported. Other studies indicate that MW exposure from base stations affects psychobiological stress markers, causes oxidative stress and clinically important neurotransmitters and increase mortality rates of residents inside a radius of 500 m from base stations. Recent studies reported increased prevalence of adverse neurobehavioral symptoms or cancer in populations living at distances < 500 meters from base stations. These results indicate that neoplasmas of different types including leukemia is under concern with whole body exposure from base stations. At our department, evaluation of genomic instability in peripheral blood lymphocytes (PBL) of persons exposed to MW from base stations has been performed. Several biological endpoints were analyzed in the participant's peripheral blood lymphocytes, namely: DNA damage by FPG comet assay and alkaline comet assay; oxidative stress by TBARS – lipid peroxidation assay; micronuclei by cytokinesis-block micronucleus assay; DNA double-strand breaks by gH2AX/53BP1 DNA repair foci and immunofluorescent assay; chromosomal aberrations (dicentrics, rings, acentrics, gaps, chromatid fragments, total aberrations); MLL-AF4, MLL-AF9 and MLL-PTD preleukemic fusion genes (PFG), and total MLL gene rearrangement by RT-qPCR and FISH, respectively. The data, which revealed genomic instability in persons chronically exposed to MW from base stations, will be reported. Precautions are recommended to reduce exposure to radiation from base stations.

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Targeting sonic hedgehog pathway in combination with proton radiation or gamma irradiation decreases viability of glioma cell lines

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Proton therapy is used to treat many types of cancer. Due to proton properties, the tumors that are difficult to reach for surgical procedures could be irradiated by a proton beam. The use of proton therapy for cancer treatment is becoming more widespread due to the advantages of protons compared to gamma-rays. Cancer patients may benefit from these advantages, as the surrounding healthy tissues receive a lower dose. Increased biological effectiveness of protons can control radioresistant cancer cells better. High-grade gliomas are invasive, rapidly progressive brain tumors that poorly respond to standard therapies. Malignant transformation is associated with loss of cell differentiation. Activation of mechanisms maintaining stem cell state is a possible cause of this process. Accumulating evidence indicates that the Sonic Hedgehog signaling pathway is one of these mechanisms. It is linked to the development and progression of glioma cancer cells, as well as resistance to gamma irradiation and the migratory capacity of cancer cells.

Therefore, there is an increasing interest in targeting Sonic Hedgehog pathway in combination with radiotherapy. Several studies have already investigated this treatment strategy associated with conventional radiotherapy. However, the combination of Hedgehog inhibitors with particle therapy hasn't been explored sufficiently. The aim of our study was investigating the potential of Hedgehog inhibitor, GANT61, as an effective modulator of radiosensitivity of gliomas, and comparison potential differences between proton irradiation and gamma irradiation.

Cancer cells were pre-incubated with inhibitor and irradiated with increasing doses 0.5-6 Gray at the proton Bragg peak at the synchrocyclotron SC-1000 (energy: 200 MeV) of the NRC KI PNPI. Cell lines were also irradiated with graded doses 2-6 Gray using lift-up type ^{60}Co γ-ray source "Researcher". In other group of experiments malignant cells were firstly irradiated with the same increasing doses at the proton Bragg peak and gamma rays. Then the inhibitor was added to show its additive radiation effect. The radiation sensitivity was determined by MTS-test and clonogenic assays using the crystal violet for staining.

Sonic Hedgehog targeting had weak radiosensitive effect with any radiation type used. The observed additive effect could be explained by biological influence of GANT61 to cell cycle. In conclusion, combining Sonic Hedgehog inhibition with radiation decreased gliomas viability more effectively compared with radiation treatment alone.

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Method of setting optimal operating voltage for radiation detectors containing thin plastic scintillators

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In this paper we discuss the method of setting the optimal working voltage on the photomultipliers of detectors containing thin plastic scintillation materials. These plastic scintillators may additionally include a zinc sulfide ZnS(Ag) layer for the separation of alpha and beta particles.

The ionizing radiation on the thin plastic scintillators is not fully absorbed and therefore it is not possible to determine the position of the Compton edge. This is very important for energy calibration. We have proposed a simple method for this purpose and carried out all tests with newly developed smart frisking probe. The results are presented.

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Effect of electron irradiation on the characteristics of green LED quantum well structures

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The large number of studies devoted to the study of III-V nitrides and published in the last two decades is mainly due to their unique physical properties and applications in optoelectronic technology. Compared with arsenides or phosphides of this group, the sensitivity to dislocation density in nitrides is almost an order of magnitude lower; at $\rho_d=2\cdot10^{10}cm^{-2}$ light-emitting diodes (LEDs) are practically insensitive to their influence. The high binding energy of atoms in these crystals ensures the thermal stability of the parameters of devices made on their basis and increased radiation resistance; the threshold displacement energy is $E_d=440keV$ and somewhat less than in diamond. Nitrides and their solid solutions are direct-gap; the bandgap, and then the wavelength of LED radiation, can be controlled by changing the concentrations of *In* and *Ga* and additionally varying the width of the quantum wells.

Modern *InGaN/GaN* LEDs can achieve an efficiency of $\eta=80\%$ and can cover the entire range of the visible spectrum.

Considering the possibility of their use under conditions of hard penetrable radiation, it should be noted that it is necessary to study in detail the effect of fast particle fluxes on the electrophysical characteristics of these modern highly efficient luminescence sources since the development of ideas about the mechanisms of radiation-degradation changes in such rather inhomogeneous objects is still far from complete.

In this paper, we present the results of studying the effects of electron irradiation with $E=2MeV$ ($F=3\cdot10^{14}cm^{-2} \div 5.3\cdot10^{14}\ cm^{-2}$; $T_{irrad}=300K$) on two groups of green *InGaN/GaN* LEDs with $\lambda_{max}=525nm$ and $\lambda_{max}=505nm$.

Within the indicated doses, a drop in the radiation intensity was detected, amounting to ≅ 2.5.

Both original and irradiated diodes are characterized by a nonmonotonic dependence of the luminescence intensity on temperature, which is obviously due to the nature of the distribution of energy levels in quantum wells.

The unequal *In* concentration in the samples with $\lambda_{max}=525nm$ and $\lambda_{max}=505nm$ does not lead to a difference in the degradation rates of both lines, which indicates the absence of a tendency to form nonradiative indium complexes with radiation defects.

It was also found that with increasing current, the maximum of the spectral curves of LEDs from $\lambda_{max}=505nm$ shifts to the short-wavelength side ($\Delta\lambda=8nm$) is a "blue shift", usually explained by the filling of the upper levels of quantum wells by electrons with an increase in the injection level.

The temperature shift observed by us is most likely also associated with the filling of the upper levels of the E_c-band, but in this case, due to the thermal ionization of impurity levels, the detected thermal shift is just the result of the recombination of electrons of the filled upper layers of the E_c-band with holes of the E_v-band.

The main feature of the current-voltage characteristics of the *InGaN/GaN* LEDs is the formation at T=90K of regions of negative differential resistance due to the existence of positive feedback. Its nature will be discussed in a future extended publication.

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ThreSpect – a computer program for the threshold energy determination

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Electromagnetic radiation and charged particles found in space or applied in medicine and engineering affect matter at the macroscopic and microscopic scale. The most severe modifications are produced at the molecular level, where radiation often triggers compounds' excitation, ionization, and fragmentation. These processes produce electrons, chemically active cations, excited molecules, and highly reactive free radicals. Each molecule has well-defined bond energies, so a precisely defined energy value specifies when a given product should appear. This minimal energy is usually associated with a particular interaction mechanism.

Therefore, to know how physicochemical reactions proceed at the molecular level, it is necessary to determine the threshold energies (appearance energies, E_A) of respective fragments as accurately as possible. It can be performed experimentally by measuring particular product cross-section changes as a function of incident electron/ion/photon energy. Then, the usual way of determining E_A is to fit an appropriate theoretical threshold law to these results. Two methods have been used routinely to determine the E_A. The first one is a cross-curve approximation. In this approach, experimental results are interpolated to two crossed curves, one fitted to the background points and one to the points at a rising slope using the least-squares method. Then, the energy value is determined at the point of intersection of these lines [1]. This method is vague because it does not consider the energetic blurring of the radiation beam. Furthermore, the calculated threshold energy value is usually higher than the real one. The second method considers the beam's blurring by convolution of the Wannier threshold law and Gaussian function, representing the energy blurring distribution implemented in the standard data analysis and graphing software [2, 3]. This approach is also susceptible to malfunction because determining the curve fit is the researchers' subjective eyeball assessment.

A theoretical E_A closest to the actual value can only be obtained by programming these mathematical functions and performing a fully automatic fitting process utilizing iterative non-linear optimization algorithms. However, to the best of our knowledge, there is currently no commercial or free software on the market dedicated to determining the threshold energies. Therefore, this communication will present a proprietary computer program, "ThreSpect," addressing this gap. Our approach involves programming the convolution of Gaussian and Wannier functions and employing the Trust-Region-Reflective Least Squares algorithm [4] to solve the curve-fitting problem. The program's interface, functionality, and examples of determining the threshold energy of some compounds known from the scientific literature will be presented.

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Determination of radionuclide activity concentration in red mud

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Natural radionuclides are present in many industrial raw materials, products, and waste. All industrial products containing radionuclides require significant attention of researchers due to the harmful effects of long-lived radioactive elements. The basic raw materials for the production of alumina and related products are bauxites. Depending on the location of the mine, the concentration of natural radionuclides in bauxite is different. The main residue in Bayer's alumina production process is red mud. The aim of this paper is to determine activity concentration of natural radionuclides in red mud. Samples collected in Alumina Ltd. Company "Alumina" are located in the Industrial zone of Zvornik, Republic of Srpska, Bosnia and Herzegovina. The main activity of the Company is the production of alumina, hydrate, zeolite, and water glass. The samples were analyzed using a gamma spectrometer with a hyper pure germanium detector. In the red mud radionuclide activity concentration (*208Tl*, *210Pb, 212Bi, 212Pb, 214Bi, 214Pb, 234Th*) was determined. The obtained results were compared with those obtained in previous research from Brazil, China, and Australia. It gives the possibility of research composition and properties of red mud as well as its potential uses as construction material, catalyst, and adsorbent.

Keywords: Natural radionuclides, activity concentration, red mud, gamma spectroscopy

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ISO 4037:2019 validation of radiation qualities using the half-value layer at the national secondary standard dosimetry laboratory of Morocco

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Background/Purpose. The radiation qualities of the narrow-spectrum X-ray series in the range from 30 to 300 kV designed for calibration of radiation protection and dosimeter irradiation instruments have been established, characterized and validated experimentally in accordance with the recommendations of ISO4037-1:2019 in the automated X-ray calibration facility of the Service of Calibration and Metrology of Ionizing Radiation of a national Secondary Standard Dosimetry Laboratory (SSDL) in Morocco.

Materials & Methods. The measurements were carried out with a machine model X80-320 of X-ray irradiator represented by HOPEWELL DESIGNS, INC and that represents a complete system for the irradiation of the badges of dosimetry of the personnel and the instruments of detection of the radiations with X-rays, it possesses ceramic tube and an anode target in tungsten with an angle of 20°, a focal field of 5,5 mm and an inherent filtration of 3 mm of beryllium. The high voltage that may be applied to this X-ray tube varies from 15 to 320 KVp, a current of 0.5 mA to 13 mA and a minimum power of 1500W to 4200W. The charge generated by the X-ray photons was measured using a PS (50) ionization chamber connected to a PTW Unidos electrometer.

Without any additional filtration and at 60 kV the inherent filtration was measured using the ionization chamber Ps(50) placed at 1m from the tube center. Aluminum filters with different thicknesses were added in the beam in order to calculate the HVL taking the 1st value in absence of filter as reference, based on the ISO 4037(1), the inherent filtration was calculated using an extrapolation with second order polynomial.

Out of the fact that the total filtration = inherent filtration + additional filtration and after determining the inherent filtration, the additional filtration was deduced.

The half-value layers of the beam qualities from 60KVp to 320KVp were determined in the same way as the HVL of the inherent filtration but this time in the presence of the additional filtration.

Results. The deviation of the first half-value layer (1st HVL) and the second HVL (2nd HVL) between the experimental results and the values given in ISO 4037-1:2019 were all within 10% similarly, the homogeneity coefficients h were for most of the code beams between 0.88 and 1.0 according to ISO 4037:2019 except for N-30 and N-40 with homogeneity coefficients of 78% and 84% respectively. In addition, the Monte Carlo code Gamos/Geant4 was used to simulate the spectra of these radiation qualities, which showed good agreement with the spectra given in ISO 4037-1.

Conclusion. The study and characterization of the reference radiations of the narrow spectrum series at the National Laboratory of Secondary Standard Dosimetry of Morocco revealed a good compliance with the recommendations of ISO 4037 which reflects that they can be used for the calibration of protective radiation instruments.

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The effect of X-ray irradiation on charge trapping processes in zinc and molybdenum containing oxides

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Due to excellent physical properties such as wide direct bandgap of 3.37 eV and large exciton binding energy (60 meV at 300 K) zinc oxide (ZnO) attracts attention for decades. It is cheap and can be easily grown in the variety of forms from bulk single crystals to nanoparticles [1-4]. Nowadays the most demanded are ZnO micro- and nanostructures. These find application in many fields e.g., as energy convertors, i.e., solar cells. Furthermore, ZnO-based nanostructures are used in optoelectronics, photonics, gas and bio sensors, photocatalysis and scintillators. Significant drawback of the material is its ageing. The existence of defects, for example, charge traps, affects optical properties [1-4]. As a rule, the traps are inactive until the exposure of the sample to the light, X-ray or any other kind of irradiation. The situation can be, at least, partly, fixed by moderating the conditions of growth. Furthermore, injection of dopants can also have positive effect on the suppression of defects as well as post-growth treatment [1-4]. In the recent years, molybdenum was considered as a dopant with the potential to serve as a donor contributing to the increase of the conductivity of ZnO. Molybdenum is the transition metal which charge states can be easily changed ($Mo^{3+,4+,5+,6+}$) so it can contribute with few electrons. The serious obstacle tailored with the Mo doping of the ZnO nanostructures grown by hydrothermal method is the fact that Zn along with Mo in oxide form creates some tiny amount of complex zinc molybdates even at small Mo doping levels (below 1%) [1,4]. The zinc molybdates dominate over ZnO material phase at high doping levels (above 5%) [5]. On the other hand, the complex molybdates can serve as coatings for ZnO nanoparticles (grown separately and then additionally covered with the layer of molybdates) thus protecting them from ageing as it was demonstrated for the metal Zn [6]. Besides, the zinc molybdates as a shell could improve energy delivering to the ZnO particle as a core. This process can be affected by the charge trapping in the shell. Therefore, in the present study we address the important task of the X-ray induced defects creation processes in the ZnO:Mo(10 and 30%) samples in comparison with the MoO_3 microrods to determine the role of molybdenum. The molybdenum charge state was Mo^{6+} before X-ray irradiation in all the materials. X-ray irradiation resulted in creation of molybdenum- and oxygen-based charge trapping centers, i.e., Mo^{5+} and O^- or O_2^-.

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Computer simulation of PFN detector

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PFN emission of ^{235}U(n,f) reaction are under investigation in JINR for last 20 year. The recent achievements in experimental apparatus simulation are the subject of this presentation. The object of simulation is prompt fission neutron (PFN) detector used for resonance neutron induced fission of U-235. The neutron source was IREN facility and double ionization chamber (DIC) with Frisch grids was used for fission fragment spectroscopy. The PFN detector was multi detector system consisted of 32 BC501 scintillation liquid filled modules from the Sionix (Netherlands) company. Detectors were located on the sphere surface with 50 cm radius. Double Frisch gridded ionization chamber, used as fission spectrometer at the same time generated trigger signal for PFN registration apparatus. For each fission event the following simulated information was recorded: correlated fission fragments time mark, emission angle in respect to the selected coordinate frames along with the pulse heights and shapes of neutron detector signals. Multiple neutron scattering and the cross-talks were taken into account in order to evaluate contribution of those effects in the final results.

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PFN multiplicity variations measurement at IREN

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Investigations of prompt fission neutron emission are of importance in understanding the fission process in general and the sharing of excitation energy among the fission fragments in particular. Experimental activities at JINR on prompt fission neutron (PFN) emission are underway for more than 20 years. Main focus lied on investigations of prompt neutron emission from the reactions ^{252}Cf (sf) and ^{235}U(n,f) in the region of the resolved resonances. For the last reaction strong fluctuations of fission fragment mass and the mean total kinetic energy distributions have been observed as a function of incident neutron energy [1, 2]. In addition fluctuations of prompt neutron multiplicities were also observed in [3]. The goal of the present study is to verify the current knowledge of prompt neutron multiplicity fluctuations and to study correlations with fission fragment properties. Recent measurement of PFN multiplicity in resonance neutron induced fission of ^{235}U(n,f) reaction [4] reveal surprising result, stimulated us to investigate the PFN multiplicity at IREN with new high efficiency experimental setup.

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Development and investigation of EMR shielding textile materials for protection of dismounted soldier against battlefield radar

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Electrically conductive woven or knitted fabrics with particular electromagnetic radiation (EMR) shielding properties may act as a shield against the penetration of electromagnetic waves with frequencies identified as a potential hazard to human health. Such materials can also be applicable in the development of radar-absorbing materials (RAM). Electrically conductive fabrics used in stealth technology can help to disguise a vehicle or soldier from radar detection.

In this study the results of development and investigation on textile-based radar absorbing materials for protection against battlefield radar are presented. This research has been carried out within the Project ACAMSII, “Adaptive camouflage for the soldier”, which has received funding from the European Union’s Preparatory Action for Defence Research (PADR) programme under grant agreement No 800871. During this project (2018-2022) a future soldier system is being developed and implemented that provides adaptive camouflage against all relevant sensor threats, ranging from visible to thermal and radar. Scientists from Sweden, Germany, Portugal, France, Lithuania and the Netherlands cooperate in the project.

To develop the fabrics with microwave shielding and absorbing properties samples of woven and knitted fabrics were coated with compositions containing inherently conducting polymers (ICPs), carbon-based formulations or their mixtures. For coating conventional textile coating technologies - screen printing and knife-over-roll, were applied, as our aim was to develop the fabrics coated with conductive layer only on the back side of camouflage pattern printed fabric, that it could be integrated in the military camouflage clothing system.

In the radar threat evaluation, as a part of ACAMSII project, it was pointed up that a major threat to dismounted soldiers are battlefield radars commonly operating within X and Ku-bands. Consequently, the investigation of reflection and transmission properties of developed textile fabrics was performed in a frequency range of 6–18 GHz, which cover the defined frequencies relevant to the application. It was found that shielding effectiveness (SE) as well as absorption properties depend not only on the amount and type of conductive paste topped on the fabric, but also resides in the construction parameters of fabrics and their finishing before coating. By controlling coating deposit on the fabric, it is possible to tune the electrical properties to a certain extent and hereby influence the reflection and transmission parameters of the coated textile material.

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Radiation safety studies of wooden burning materials

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The Chernobyl nuclear power plant accident resulted in radioactive pollution of forest ecosystems in Latvia and its neighbour countries with artificial radionuclides ^{137}Cs and ^{90}Sr [1]. With the growing transition to renewable energy resources - one of which is burning of wood, wooden chips and pellets for heating, it is important to know the concentration of artificial radionuclides in used wooden fuel materials and disposed combustion ashes, as well as their compliance with EU and national radiation safety regulations.

In order to obtain data about concentration of ^{90}Sr in the conifer tree needles, and in the bark of various trees in dependence from trunk height above the ground, the ^{90}Sr radioactive decay product isotope ^{90}Y was extracted from samples via radiochemical methods. Comparison of ^{90}Sr concentrations in the bark of pines, firs and birches at different heights shows that the highest ^{90}Sr concentration is in the bark of firs, and the lowest – in the bark of birches. The ^{90}Sr concentration maximum for all trees was observed at ~3/4 height of the corresponding tree trunk.

Concentration of ^{137}Cs in the needles of firs, pine wood, woodchips, their combustion ashes, as well as in electrostatic air filters capturing combustion fumes was measured with the gamma-spectrometry method. Analysis included also the moisture and ash coefficients of corresponding wooden fuels.

Uncertainty of obtained results comes mostly from sampling due to uneven distribution of radioactivity in woodchip loads. Moreover, radioactivity of ashes depends not just on the level of radioactive contamination of the fuel, but also on its technological characteristics (moisture, material content, mechanical properties, etc.) as well as on the type of furnace and combustion process.

The allowed ^{137}Cs contamination level for timber imported into Latvia to use as biomass fuel is 10 Bq/kg for dry material and 1000 Bk/kg for its ashes [2]. For disposal of ashes one should take into account the impact due to increased concentration of natural ^{40}K radioactivity as well. Measurement results have shown that the concentration of artificial radioisotope ^{137}Cs in the Latvian origin wood burning materials and their ashes is below the level provisioned in regulations. However, the ^{137}Cs activity of most samples of imported (from Belarus) woodchips and their ashes was ~2.5 times higher than allowed. It means that regular radiation control should be recommended in facilities using larger amounts of wooden fuels, especially imported from countries with high radioactive contamination risk territories.

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Determination of gamma active radionuclides for the purpose of ConvEx-3 emergency response exercise

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Public Company Nuclear Facilities of Serbia, Belgrade, Serbia

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In 2021, Public Company "Nuclear Facilities of Serbia" (PC NFS) participated in the activities of the International Atomic Energy Agency (IAEA) within ConvEx-3 emergency response exercise. ConvEx-3 refers to exercises designed to evaluate international emergency response actions and capabilities for a nuclear or radiological emergency within a certain time, regardless of its cause. According to nuclear accident scenario, a laboratory had to show preparedness and competence to give a quick response to the accident, i.e. conduct fast gamma spectrometric analysis of the given sample and report results through official channels by a short deadline. This paper presents the results obtained by analysing gamma spectrum of water sample taken from the primary circuit of an operational Pressurized Water Reactor as well as challenges the PC NFS laboratory faced during this exercise. Results were also evaluated and compared to the "reference values" determined from original analysis of this spectrum at IAEA's Terrestrial Environment Laboratory in Seibersdorf. The outcome is that the results achieved by the laboratory are satisfying, considering the complexity of the spectrum and short deadline. Some of the analytical challenges, such as interferences from different radionuclides, mother/daughter decay and identification of small peaks among much larger peaks, can be used as valuable experience for further quality improvement of laboratory analytical capabilities.

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Occupational radiation exposure in diagnostic radiology in general hospitals in Serbia

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In radiological diagnostics, radiation exposure represents a major hazard for staff, as for the patient himself, who represents a secondary radiation source during the diagnostic procedure. For this reason, monitoring the exposure of staff involved in radiodiagnostic procedures is very important. This paper presents the study of the levels of X-ray exposure of the staff at the radiological diagnostics centers at the General Hospital in Šabac (Center A) and General Hospital in Loznica (Center B) in Western Serbian region. About 320,000 potential patients gravitate toward these two centers. Exposure monitoring at both centers was performed using thermoluminescent personal dosimeters (TLD) in the period 2011 – 2015. The staffs whose exposure was monitored were radiologists and technicians (10 radiologists and 27 technicians in Center A and 6 radiologists and 18 technicians in Center B). Typical staff residence time in a controlled radiation zone is 6 h per day or 966 h per year at both Centers. In the analyzed period, centers A and B performed 17676 and 15023 mammographic procedures, 97868 and 73500 radiographic, 17252 and 14183 teleradiographic, 1042 and 725 urographic procedures, respectively. In Center A, computerized tomography (CT) procedures were performed with 23440 procedures in the analyzed period. Based on the obtained TLD values, average dose were evaluated per X-ray procedure for staff. The obtained values for the staff were compared and analyzed among the centers. The annual doses obtained from TLD values for all employees at both centers are less than the recommended 20 mSv annually and 100 mSv for the analyzed period of 5 years.

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Broadband absorbers of electromagnetic radiation

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Minimization of the influence of electromagnetic field on humans is of great importance since electromagnetic radiation (EMR) harms living species by affecting bioprocesses at the cell level and injures nervous, immune and other systems. On the other hand, action of EMR on electronic devices results in emerging of spurious signals that may cause malfunctioning of the equipment and lead to partial or even total loss of information. An important problem is protection of electronic communication channels against unauthorized access by acquiring of accompanying electromagnetic radiation [1]. To mitigate the EMR influence and to protect electronic equipment and humans' vital space protective coatings that absorb (reflect and/or scatter) microwaves are greatly desired.

In the present work, we report on fabrication and studies of hybrid polymer-magnetite composite based on the epoxy resin filled with magnetite Fe_3O_4 particles and conductive conjugated polymer polyaniline (PANI) doped with carbon nanotube (CNT) or *p*-toluene sulfonic acid (TSA). The composite is capable to absorb electromagnetic radiation in the broad spectral range including microwaves and near-infrared. Dispersed magnetite Fe_3O_4 in a form of spherical particles with the diameter 1...2 μm provides effective scattering of IR radiation substantially reducing reflected IR signal.

It was found that composite containing magnetic micro- and nanoparticles and particles of polyaniline doped with CNT exhibits strong microwave absorption. Studies of microwave absorption of the composite were performed with HP 8722C spectrum analyser. The specimen of 0.2 mm thickness was placed across the waveguide normal to the direction of propagation of electromagnetic radiation. The composite exhibit high attenuation of EMR in K band (18–26.5 GHz) and Ka band (26.5–40 GHz) on the level of –25 dB with a peak value of –47 dB at 23 GHz that makes the material perspective for electromagnetic radiation shielding and for antiradar purposes. Shielding properties of similar composite materials based on epoxy resins with graphene nanoplates as filler in the microwave frequency range exhibit only 10 dB at 27 GHz [2].

In the wavelengths range from 1000 nm to 2000 nm spectral distribution of the absorption coefficient (A, cm^{-1}) for all composites being studied exhibit absorption bands at the spectral interval 1380–1420 nm, 1670–1680 nm and 1900–1950 nm. The highest value of A at 1680 nm is observed for composites containing 5% of nano-dispersed magnetite and 5% PANI-TSA (A = 57.2 cm^{-1}). For composite without filler, absorption coefficient amounts only 3.5 cm^{-1} and 14.8 cm^{-1} for composites containing only PANI. It was found, that the coating made of composite with highest absorption also possesses the best mechanical properties, in particular, high microhardness. At the same time, prepared composition provides not only high microhardness and IR-absorption but effective water protection and excellent anticorrosive properties when used as the coating on the surface of steel [3]. This makes the proposed composite perspective for EMR shielding, for anti-radar purposes reducing the intensity of microwave radiation scattered by a target and at the same time act as protective coatings on the surface of metals.

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Radiobiological assays to predict normal tissue toxicity after radiotherapy: expectations, strategies, fails and perspectives

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Normal tissue radiobiology is becoming critically important to radiation oncology in the era of higher energy therapeutic radiation beams. Despite accurate treatment planning with tumor contouring, a significant proportion of patients still cannot fully tolerate standard radiotherapy (RT) doses and experience noticeable side effects in their irradiated normal tissues. The risk of normal tissue toxicity (NTT) manifestation increases with the prolongation of patients' survival. An obvious way to improve patients' life quality is to individualize RT schemes according to the risk of side effects. It is widely accepted that the most promising strategy is to predict such a risk using either patients' personal constitutional genetic traits or their functional cellular responses to *ex vivo* irradiation. To date a lot of efforts and resources have been expended on research in both directions, but rather moderate success has been achieved, and no universal predictive biomarker for NTT has been developed and fully validated yet.

The aim of this study was to make an overview of various suggested tests to predict adverse effects in normal tissues or critical organs after radiotherapy. For that the analysis of publications found by the search in PubMed and cross-references was performed; summarized data were presented in reviews [1-3].

The use of single nucleotide polymorphism analysis in "intuitively" chosen candidate genes appeared to be not very successful for NTT prediction. The search for radiosensitive haplotypes by Genome Wide Association Studies and measurements of constitutive expression of genes, identified by GWAS, is much more promising but very expensive technology. Meanwhile, functional tests based on ex vivo irradiation of patients' cells and focused on cell survival or DNA repair, or molecular machinery and transcriptomics underlying these processes, have proven their effectiveness, and some have successfully passed multicenter clinical trials. The radiobiological toolbox of methods, which showed an acceptable value for NTT prediction, currently includes radiation-induced apoptosis assay, chromosome aberration analysis, the estimation of pATM nucleoshuttling and γ-H2AX foci dynamics and the measurement of transcription products of certain sets of genes. A combination of several predictive assays into multiparametric platform would probably be especially beneficial. However, a thorough pharmacoeconomic analysis is still needed to assess the cost-efficacy ratio of introducing these techniques into the practice of radiation oncology.

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Study of radiosensitivity of probiotic microorganisms

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Probiotic (*pro-for and bio-life*) are living organisms with beneficial effects on human health. Some of them find application in treatment of diseases, including radiotherapy of cancer. Ground-based research has shown that probiotics have the potential to prevent adverse changes in the microbiome of people with prolonged exposure to ionizing radiation. The irradiation leads microbial inactivation through different direct or indirect effects. The susceptibility of microbes to irradiation, however, differs greatly.

In present work, we assessed the radiosensitivity of widely accepted as probiotic lactic acid bacteria (LAB) and yeast. We joint our effort to analyze genetic, biochemical, metabolic, radiobiological and radioprotective characteristics of different probiotic cultures. With this aim two *Saccharomyces* yeast, isolated from commercial products *Enterol* (France) and *Cosm-o-tentic* (Belgium) and original dairy lactobacilli (combined as probiotic multibacterial formula) were pre-selected.

A high resistance to X-rays exposure of exponential and lyophilized LAB cultures were shown. The growth parameters and biofilm formation capacity of irradiated LABs were assessed. Moreover, no difference in viability after exposure was detected when the strains were submerged in a laboratory model of undesirable environment.

An analysis of the sensitivity of yeast probiotics to hard X-rays (150 kV, 5 mA, doses up to 100 Gy) and high-energy proton irradiation (150 MeV, 0.54 keV/mkm, doses up to 20 Gy) has been carried out, too. The mutability of the strains was assessed by the frequency of antibiotic resistance mutation induction. The probiotic strains differed from each other and had lower frequency of gene mutations then laboratory strains of *Saccharomyces cerevisiae*. In the future, we are going to analyze the radio-protective properties of probiotics.

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Removal of U(VI) by selected type of cyanobacteria from the territory of Bosnia and Herzegovina

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Cyanobacteria have great biotechnological potential since they are present in nature in large quantities, their growth rate is 5-10 times higher than the growth rate of higher plants, biomass is homogeneous and doesn't contain lignocellulose. They can be collected during all seasons, and no pesticide residues are present in the biomass. For the growth of cyanobacteria are essential water, sunlight, CO_2, nutrients such as nitrogen and phosphorus. Cyanobacteria contain numerous functional groups, such as carboxyl, phosphorus, hydroxyl and amine, which in the role of ligand can bind metal ions and form surface metal-ligand complexes. Taking into account all these advantages the main aim of this research was to investigate cyanobacteria (*Anagnostidinema amphibium*) for the biosorption of U(VI) from the aqueous solution. The optimal process parameters for U(VI) removal by *Anagnostidinema amphibium* was found to be: T=20 °C, $m_{biosorbent}$=50 mg, t=40 min, pH= 9-11, V= 50 mL) with the biosorption capacity of 324.94 mg/g. FTIR analysis showed that the main functional groups on the surface of cyanobacteria responsible for U(VI) binding are CONH, COOH and PO alkyl group. EDXRF analysis showed that the main constituents are iron and calcium. According to the obtained results for desorption study cyanobacteria could be used in 4 cycles of sorption/desorption with a uranium recovery of more than 80%. Thermodynamics data showed that biosorption process is spontaneous and exothermic in nature. The best agreement was found with Temkin's adsorption isotherm model, and for the kinetics best agreement was found with pseudo-second-order model. The proposed biosorbent represents environmentally and economically acceptable sorbent for possible application at higher scales.

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Study of the kinetics of extraction of HLW components (Cs^{+}, Sr^{2+}, Eu^{3+}) from model solutions using microsensor methods of analysis

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The problem of selecting effective and selective extractants for the needs of the radiochemical industry is still relevant, however, methods for testing the extraction ability of new synthesized compounds are currently limited: verification using classical approaches to liquid extraction requires a significant consumption of reagents, time and is rather complicated experimentally, and the main methods simulations of the extraction behavior of new compounds have a satisfactory predictive ability only in relation to homologues within the same class of compounds.

We have developed a design and created prototypes of microcells for express screening of new extraction systems with IR control of the composition of the organic phase based on an attenuated total internal reflection (ATR) attachment for a single-beam Fourier IR spectrometer.

In the developed cell, a series of two-component extraction systems were studied using crown ethers and phosphine oxides (DTBDCG18C6, DB21C7, triamylphosphine oxide, carbamoylphosphine oxide) as extractants with respect to strontium, cesium, and europium (Cs^{+}, Sr^{2+}, Eu^{3+}).

An important part of the performed studies of extraction systems was the study of the kinetic characteristics of the process. They are essential to understanding the suitability of extraction systems in industry, as too slow an extraction can render the entire separation process inefficient. On the other hand, in some systems, the separation of the mixture into components is carried out precisely on the basis of the rates of mass transfer of various components through the phase boundary.

IR spectra were recorded on an IR Affinity-1 instrument using an attenuated total internal reflection attachment with a diamond working surface. The microcell was positioned on a diamond single crystal and fixed with a clamping device. The measurements were carried out at 25°C. An organic phase containing an extractant was introduced into the microcell with a chromatographic syringe (50 µl), after which the spectrum was recorded. Then, an equivalent volume of the aqueous phase containing the extractable metal nitrate was added on top of the organic phase. At the moment of adding the aqueous phase, the recording of a series of spectra began. Changes in the composition of the extractant when it was saturated with a metal cation were recorded by changing the bands in selected parts of the absorption spectrum. The method developed by us makes it possible to carry out kinetic studies of extraction processes using minimal volumes of contacting phases.

For the studied extraction systems based on the considered crown ethers and phosphine oxides, the possibility of calculating the distribution ratios of elements depending on their initial concentration in the aqueous phase from the intensity and position of the vibration bands of the IR spectra is shown. During testing, the optimal parameters for recording spectra were determined. By analyzing the characteristic bands from the resulting array of spectra, the rate constants for the extraction of metals with crown ethers and other polyfunctional extractants were calculated using a microcell with spectrometric control. The obtained experimental data are compared with the data obtained in the Lewis cell.

The developed technique will allow us to carry out an express assessment of the efficiency of the extraction properties of new promising extractants and systems based on them.

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Quality control for measurements of tritium in water samples by liquid scintillation counter

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Key purpose of this paper was to present quality assurance for low level tritium measurements in water samples using standard test method for Tritium in drinking water, ASTM D4107-20 and to clarify quality control procedures within validation. Determination of tritium concentration in water samples was conducted using liquid scintillation counter Quantulus 1220. The most important sources of uncertainty were discussed. Four different internal quality control methods have been presented and explained in detail. Validation of the measuring method included evaluation of accuracy (trueness and precision), detection limit, and the calculation of combined uncertainty. Based on the results of the measurement, it is concluded that all values are within the limits of the criteria for validation of the method, which means that the results obtained are reliable.

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Stress memory in *Plantago major* from the zone of radioactive contamination (East Ural Radioactive Trace, Russia)

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Kyshtym disaster resulted in the formation of the East Ural Radioactive Trace (EURT) in 1957. Plant populations in this territory are exposed to Ionizing radiation (IR) more than 60 generations. IR can induce the formation of reactive oxygen species and modify antioxidant enzymes activity in plants. Numerous studies have revealed that the consequences of stress are observed not only in plants growing under adverse conditions, but also in their offspring after the removal of stress. The aim of the investigation was to study the persistence of changes in lipid peroxidation and antioxidant capacity in several generations of greater plantain (*Plantago major* L.) after the cessation of IR impact.

Seed mixture of F1 generation was collected from *P. major* natural populations growing for a long time in the East Ural Radioactive Trace (doze rates for parental plants 73.1-157.1 μGy/h) and background areas (doze rates 0.1086 μGy/h). Seeds of F2 generation were obtained from F1 generation plants grown on experimental plots with "clean" agricultural background; F3 generation was grown from F2 generation in the same experimental plots. Seeds were cleaned and stored in the refrigerator at -4 °C. Seeds of all generations were cultivated simultaneously using roll culture; 21-day seedlings without roots were used for the spectrophotometric analysis of malondialdehyde content, superoxide dismutase activity and low molecular weight antioxidants content.

Malondialdehyde (MDA) content, which indicates the intensity of lipid peroxidation, was increased in the EURT samples of F1 generation in comparison to reference ones (U-test, $p=0.004$). The increased content of MDA persisted in F2 and F3 generations after the cessation of exposure to radiation in the sample that had the greatest exposure to the ancestors ($p=0.004$). The activity of superoxide dismutase (antioxidant enzyme) was higher in seed progeny samples, collected in EURT ($p=0.045$) and in subsequent F2 generation ($p=0.004$). The activity of superoxide dismutase in EURT seedlings of F3 generation did not differ from the reference, hence the differences leveled out. The total content of low molecular weight antioxidants was increased only in EURT sample of F1 generation with dose rate of parental plants 73.1 μGy/h, but the differences with reference did not remain in F2 and F3 generations.

Therefore, with the example of *P. major*, current study showed that the features of oxidative stress in plant populations affected by low-dose irradiation could persist in the subsequent generations after the cessation of radiation exposure.

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Gamma spectrometry control of fish and fish food during 2016-2021

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In the current conditions of economic and social development, the danger of radioactive contamination on a large scale has increased significantly due to more frequent accidents at nuclear power plants, which increases the degree of threat to biotechnical production and radiation risk to the population. It is known that the main route of intake of radioactive substances in humans and animals, in the case of radioactive contamination of a territory, is intake through food (it accounts for over 70% of the total intake of radionuclides). It is also known that the basis of any protection, including radiation, is prevention, i.e. cutting the chain of contamination before the contaminant reaches the human or animal body. As the food chain is the main route of intake of radionuclides in the body, it is clear that the protection of that chain can most successfully protect a person. For over 35 years, LABRAH-Laboratory for Radiation Hygiene, as an accredited laboratory, has been performing continuous radiation-hygienic supervision, import-export, over products of animal origin, animal feed, feed additives and other products. This paper presents the results of gamma spectrometric control of fish samples, fish products and fish food in the period from 2015 to 2021. The aim of this paper is to point out the current radiation situation in the field of radiation hygiene control and the manner of implementation of procedures and measures for protection against radioactive contamination of produced radionuclides in regular conditions, as a basis for human and animal health. Based on the results obtained in the period from 2016 to 2021, the activity of ^{137}Cs in fish, fish products and fish food was below the prescribed limits. During this period, there was no additional radioactive pollution of the environment, we mean the nuclear accident in Fukushima, and also that the activities of this radionuclide in our diet are at a very low level.

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Physico-chemical characterization and tritium activity determination in spring waters

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The quality of drinking water should be monitored and analyzed with the aim of determination of water pollution and to minimize health hazards. From a radiological point of view, drinking water may contain natural and artificial radionuclides. One of the radionuclides that can occur in drinking water is tritium.

Tritium, as the only radioactive isotope of hydrogen, occurs naturally as a cosmogenic radioisotope in the stratosphere but also has an anthropogenic origin.

This study presents the results of some physico-chemical analysis and tritium activity determination carried out for natural water sources in the vicinity of Smederevska Palanka. Water samples from eleven natural water sources were analysed: (source “Veliki Sipovac” (Azanja), source “Pinosava” (Kusadak), source “Vrelo” (Glibovac), source “Vidovača” (Vodice), source “Mineral water” (Vodice), source “Mineral water” (Cerovac), source “Sveta Trojica” (Cerovac), source “Šiljakovac” (Ratari), source “Klis” (Golobok), source “Palanački Kiseljak” (Smederevska Palanka), source “Sveta Petka” (Smederevska Palanka)), in order to determine possible contamination, because the local population is supplied with drinking water from these springs.

Physico-chemical characterization was performed measuring pH, total dissolved solids (TDS) and conductivity. The pH values were measured using InoLab pH meter WTW with glass electrode SenTix 81. The conductivity of the samples was measured using Conductometer InoLab WTW Cond7110 at 20°C. TDS measurement was based on the weight of the solid residue remained after evaporation of 40 ml of sample and subsequent drying at 105°C.

For tritium activity determination samples were distilled and electrolytically enriched using direct current source SORENSEN DCR60-B30. After electrolytic enrichment samples were measured by Ultra Low Level Liquid Scintillation Spectrometer Quantulus 1220.

Conductivity and pH were measured before and after distillation of water samples. Some of investigated waters are naturally acidic and measured values for pH and conductivity show different results for samples before and after distillation. TDS has a higher value for natural mineral waters.

In accordance with the legislation in the Republic of Serbia elevated tritium levels in water samples may indicate the presence of other artificial radionuclides. If tritium concentration exceeds allowed value, additional analysis is required. In that case it is necessary to perform gamma spectrometric analysis of the content of artificial radionuclides or analysis of ^{90}Sr. The permissible value of tritium in drinking water is 100 Bq/l. All analyzed waters in this study meet the legal regulations and from the radiation point of view can be used for drinking. The annual effective dose was calculated based on the tritium concentration in the investigated samples for different age groups. The obtained results are in accordance with legislation.

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Radiological status of mineral, spring and table waters from different regions in Bulgaria

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Radiological analysis of mineral waters sampled from springs in the region of Sofia and Velingrad spa resort, and of bottled mineral, spring and table waters from other regions in Bulgaria was carried out as part of the overall monitoring of drinking waters in the country.

Natural uranium content in studied waters varied from 0.003±0.001 to 0.023±0.005 mg/l, gross alpha activity – from ≤0.01 to 0.50±0.05 Bq/l and beta activity – from ≤ 0.02 to 0.30±0.06 Bq/l. The concentration of the indicators in all studied waters met the requirements, provided for in the Regulation for mineral, spring and bottled waters in Bulgaria (U ≤ 0.06 mg/l; gross alpha activity ≤ 0.5 Bq/l; gross beta activity ≤ 1 Bq/l).

However, alpha activity higher than more restrictive control level of 0.1 Bq/l, specified in the Regulation for drinking waters, was determined in the mineral water from Ovcha Kupel in Sofia (0.34 Bq/l) and in the bottled mineral water from Devin in the Rhodopes (0.5 Bq/l). Both water samples were further tested for polonium-210 content.

The specific activity of radon-222 measured in the mineral waters sampled from the springs was under the reference levels specified for drinking waters.

In result of the analyses carried out it was concluded the studied waters were not hazardous for human consumption in terms of radiology.

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Effect of climate on the ^{222}Rn activity concentration in spring water in a rare earth element and uranium mining areas in North Vietnam

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The inhalation and ingestion of ^{222}Rn and its daughter elements contribute a large portion of the annual effective dose received by the public. High background radiation areas, such as the vicinity of rare-earth-element and uranium mines, have an increased probability of risk, however, only limited information is available on North Vietnam. As part of an ongoing effort to assess the radiological impact of the local rare earth element and uranium mining activity and assure public safety, the ^{222}Rn activity concentration in spring water was determined by RAD-7 at seven locations, with average activity concentrations ranging from 1270±60 in Binh Duong to 66400±2630 Bq m^{-3} in Muong Hum. These spring waters are being used as sources of drinking water by local residents, thus their possible contamination can have high local significance. The highest activity concentration values were recorded near REE mines, while the lowest value was measured in the vicinity of a uranium mine, which could be explained by the differences in cultivation methods and the presence of weathered ore on the surface. The observed ^{222}Rn activity concentration was higher in the dry season at every location, which could be attributed to ^{222}Rn leaching into spring waters from the nearby mines and weathering ore on the surface, while lower values were observed in the rainy season due to the dilution of ^{222}Rn activity by the increased precipitation. Activity concentrations observed in the dry and the wet season had a strong positive relationship. The ^{222}Rn activity concentrations and the estimated annual effective doses were within the permissible limits according to international recommendations.

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Measurement of natural and artificial radioactivity in sediment samples along the coastline of Ghana

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Radionuclides are present in the environment as they exist in geological formations such as sediment, rock, soil, sand, air and water. Their concentrations in these elements are determined by the geological conditions and geological formations of the area. Beach sediments are key environmental media for evaluating the health risks associated with gamma radiation exposure [1]. The aim of this survey was to determine the radioactivity concentration of ^{226}Ra, ^{232}Th and ^{40}K and ^{137}Cs in sediment along the coast of Ghana. A total of 19 locations were sampled from the geological latitude between 5°0'44.64"N 2°42'44.38"W and 6°6'21.88"N 1°11'4.02"E for the study. Samples were taken using a plastic core tube of diameter 7 cm from a depth of 25- 50 cm above the ground and 100- 150 m away from the seawater [1]. The samples were air-dried for 1 week, oven-dried at 105°C for 24 hours, homogenized, transferred into Marinelli beakers and allowed for secular equilibrium to be established between the parent and daughter radionuclides for 4 weeks. Then they were measured with gamma spectrometry at a count time of 80000 seconds. The generated spectra were analyzed with the ORTEC GMX40-76 software at the respective energy levels. The measured activity concentrations of ^{226}Ra ranged between 15.24 ± 10.63 and 133.27 ± 6.85 Bq/kg with a mean of 42.82 ± 12.51 Bq/kg, 8.67 ± 1.34 and 75.72 ± 0.34 Bq/kg for ^{232}Th with a mean of 22.10 ± 1.23 Bq/kg, 208.94 ± 75.24 and 1265.59 ± 68.72 Bq/kg for ^{40}K having a mean of 391.48 ± 74.44 Bq/kg and 1.23 ± 0.55 and 109.75 ± 0.33 Bq/kg for ^{137}Cs with 8.42 ± 0.51 Bq/kg as its mean. The high ^{137}Cs activity concentration (109.75 ± 0.33 Bq/kg) measured at one of the locations ascertains that the global atmospheric fallout of ^{137}Cs has impacted the coast of Ghana. All the measured radionuclides had average concentrations below the world averages [2] except for ^{226}Ra. Again, it was observed that some sampled locations had activity concentrations of some radionuclides higher than the world recommended action limits.

The radiological risks associated with the sampled sediments were evaluated with indices such as Ra_{eq}, H_{ex}, H_{in}, D, I_{γ}, AED and AGDE. The average concentrations of these radiological variables were 104.57 Bq/kg, 0.28, 0.40, 50.09 nGy/h, 0.38, 61.43 µSv/y and 347.64 µSv/y, respectively. Apart from AGDE, the evaluated radiological risks were below the world limit values [2,3]. This indicates that radiation dose rates from beach sediments may pose a health risk to humans, especially at locations with recorded high AGDE values. Nonetheless, the low Ra_{eq}, H_{ex} and H_{in} values mean beach sediments along Ghana's coast may be used as building materials for construction.

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Assessment of farm animal breeding possibility on the Semipalatinsk test site

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Semipalatinsk Test Site (STS) operated in Eastern Kazakhstan during 1949 – 1989 and its territory has local areas with high concentrations of radionuclides in the environment. After the test site was shut down, people in the neighbouring locations started quite active unauthorized commercial activities at the site: more than a hundred farms are currently running year-round uncontrolled breeding there. Grazing pasture sheep and horse breeding at vast steppe territories are typical there.

The major part of STS (18 thous. km^2) territory considered as "background" ones in terms of radiology [1]. The formal transfer of these "clean" lands for commercial utilization is currently in progress. For that, a reliable radiological contamination forecast for livestock products from animals bred at STS is needed for assessment of the dose loads on consumers of these products. Knowledge about the ^{137}Cs and ^{90}Sr radionuclides transition to livestock products is quite extensive. Still, a prevailing portion of this knowledge has been obtained in laboratory experiments or at the territories contaminated due to radiological accidents [2], which are different from STS conditions in terms of radiological contamination, natural and climatic conditions. Few works are devoted to the transition of transuranium radionuclides, such as Pu and Am, to livestock products and the gaps in data are common [3]. One should also note that the main studies of such transitions and, particularly, of the transfer coefficients are performed for the chain "forage – livestock product" based on the common assumption that the radionuclides are mainly delivered to animal bodies with forage. However, the major contribution to livestock products contamination at the sites of surface nuclear explosions comes from contaminated soil– more than 90% of ^{137}Cs and ^{90}Sr content in mutton is due to the radionuclides intake with soil.

Since 2007 at the Institute of Radiation Safety and Ecology researched transfer parameters of radionuclide (^{3}H, ^{137}Cs, ^{90}Sr, ^{241}Am, $^{239+240}$Pu) into livestock on SST condition. To the assessment of the possibility to use for breeding animals, the STS territory was used transfer parameters of radionuclide into farm animals' product, which obtained on the STS condition. The results of the assessment show that animal products (milk, meat) will meet the hygienic standards for radiation safety. First, the contaminated area is very small comparing with animals pasture territory. The second reason is the relatively low migration bioavailability of radionuclides in the system "soil-forage-farm animals' product" on the STS.

The exception is the district Shagan river and water sources of "Degelen" site (underground test site). When animals grazing at these sites high concentration of ^{3}H can be pass into products. In general, it can be argued that more than 95% of the STS territory can be used for farm animal breeding.

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Assessment of radioactive contamination with the ^{90}Sr isotope of feed used in feeding of various animal species

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Introduction. Strontium-90 is one of the most dangerous radionuclides, which can penetrate and contaminate the natural environment as a result of various radiation events. The result of contamination, among others, of fields and pastures is the entry of this radionuclide into fodder. Therefore, in addition to food testing, it becomes reasonable to assess the contamination of feed used in the nutrition of various animal species.

Aim. The aim of the study was to determine and evaluate the presence of Sr-90 in samples of feed for pets and farm animals.

Materials and Methods. In order to assess the contamination of feeds in the widest possible range of their availability on the market, various types of feed for both pets and farm animals were tested. Among the tested samples of pet food there were, among others, rodent food, dog food, cat food). The tested samples of feed for farm animals included various types of cereals as well as compound feed. After grinding and appropriate homogenization, the samples were incinerated and then analyzed using liquid scintillation spectrometry method using the liquid scintillation counter Quantulus 1220 ™.

Results and discussion. The tested feed samples showed very low activity of ^{90}Sr (<0.06 Bq / kg), not exceeding the MDA value (minimum detectable activity). In the case of several samples, the presence of interferents was found, which made it difficult to correctly determine the activity of ^{90}Sr. The conducted research allowed us to draw attention to another analytical problem. Due to the presence of contaminants in some feed samples, this matrix can present a serious challenge in analytical determination of Sr-90 activity. Appropriate methods of sample purification, however, allow to effectively eliminate the problem of interferents, the presence of which translates into overstating and ultimately distorting the result of measuring ^{90}Sr activity. Therefore, it is important to have an appropriate test procedure in place to effectively remove contaminants. Reliable results obtained in this way make it possible to properly assess the contamination of various elements of the environment.

Conclusions. After the assessment of contamination of feed with the radioactive isotope Sr-90, the feed should be considered as safe for animals. The demonstrated activity of the tested samples was very low, which means that the feeds do not pose a threat.

Keywords: ^{90}Sr, contamination, animal feed

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Radiocaesium in plant feed for animals: 2017-2021 results

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Introduction. Radioactive contamination food of animal origin is one of the major problems in the radiological protection of consumers, especially after the accident at the Chernobyl nuclear power plant. Contamination with radioactive substances of livestock and domestic animal feed is an equally important problem. Assessment of radioactive contamination of feed is carried out on the basis of measurements of caesium radioisotope concentrations.

Aim. The aim of this study was to evaluate the radioactive caesium contamination of feed of plant origin sent to PIWet-PIB as part of the 2017-2021 research.

Materials and Methods. A total of 89 feed samples were tested. These were mainly feeds of plant origin for livestock (compound feeds, cow feeds, malt, barley, hay and wheat) and for domestic animals (hamster, guinea pig, rabbit, parrot, chinchilla, dog food). The feeds were homogenized, then samples weighing approximately 300 g were placed in Marinelli-type containers and measured using scintillation (NaI/Tl) and germanium (HPGe) detectors.

Results and Discussion. The Cs-137 activity concentrations varied widely (from MDA values to more than 50 Bq/kg). Most often, they ranged up to several Bq / kg (0.35-5.76). The highest concentrations of Cs-137 were 54.0 +/- 25.0 Bq/kg and 26.1 +/- 2.98 Bq/kg, in rodent feed and hay samples, respectively.

Conclusions. The fact that there are higher concentrations of Cs-137 in feed of plant origin is connected with the ability of plants to accumulate artificial radionuclides present in the environment (soil, air, water) from nuclear explosions and radiation accidents. From the radiological protection point of view, the consumption of feeds of plant origin for livestock and for domestic animals does not pose a risk.

Keywords: ^{137}Cs, contamination, plant feed for animals

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Lung cancer screening program using low dose computed tomography in Serbia

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Introduction. Lung cancer (LC) is one of the leading causes of mortality worldwide. Incidence and mortality of LC in Serbia are among the highest in Europe. Diagnosing the disease in early stages significantly increases survival rate. Therefore, early diagnosis is very important, and it is best achievable by screening. Importance of LC screening is highlighted during past decade in order to improve early diagnosis and treatment. The first pilot LC screening program in Serbia for started in October 2020 organized and granted by Provincial Secretariat for Health Care of Autonomous Province of Vojvodina. Purpose of this study is to display the results of the first low-dose lung cancer screening.

Aims and Objectives. To present the 1-year results of Pilot lung cancer screening program.

Methods and Materials. Persons aged 50-74 years, with a smoking history of 30 pack-years or more and/or 20 pack-years with additional risks (COPD, LC hereditary history or exposure to environmental carcinogens) either active or quit smoking within the previous 10 years undergone low-dose CT evaluation. The screening was performed on a 64 slice CT scanner GE Light speed and Philips Ingenuity using low-dose protocol (Techical standars Eurpean Society of Thoracic Imaging). Total number of nodes and morphology of each node (localization, site, consistency, diameter, volume, calcifications, margins and other) were analyzed, with the aid of CAD (computer aided detection) Lung nodule assessment software package. Radiological assessment and further evaluation was done per LUNG RADS version 1.1 (American College of Radiology).

Results. From a planed 2.000 participants, 50.7% (1015/2000) respond to screening during the 1 year. Most of the participants were females 59,5% (604/1015). 73.1% (742/1015) of included were 55-69 years of age. 1.3% (11/851) of active smokers accepted the smoking cessation treatment in the Counseling center, and 1.1% (9/851) stop smoking. Invasive diagnostics were performed in 3.44% (35/1015) of cases, among 57.1% (20/35) was malignant and 42.8% (15/35) was benign. Among primary lung cancers, 81.3% (13/16) were NCSLC (adenocarcinoma 50.0% (8/16), squamous 25.0% (4/16), non-differentiate 6.3% (1/16)), and 18.7%(3/16) were SCLC. 56.2% (9/16) of lung cancers were in the first or in the second stage of disease. Malignant etiology of primary lung carcinoma was often present in group of males vs. females (2.67% vs 1.32%, p=0.02).

Conclusion. Decreased irradiation dose, together with higher accuracy (CAD software package) compared to chest X-rays, makes LDCT excellent screening tool, which allows early detection of lung cancer, and therefore improves survival rate. Responds rate for pilot LC screening in Serbia is still low and need to be increased, in particular among males, singles and unemployed. This pilot program shows the need for widening in all regions. Better health education, innovative approaches and more recognizable campaign needs to be established in order to decrease smoking prevalence.

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Rare case of sequestrated thoracic disc

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Sequestered disc is common entity of the lumbar spine, which is easier to be diagnosed than the sequestration of thoracic spine is an extremely rare case and can mimics spinal lesions like tumor, abcess, disc space infection or another space-occupying lesions. Our case is about 60 years old patient, male, who was admitted to the Neurosurgery Clinic due to severe paraparesis of the lower extremities with preserved sensitivity. MRI was very effective for the diagnosis of this rare pathological condition. Peripheral rim enhancement around the nonenhancing disc fragment is typical appearance on contrast MRI for disc fragment. On the other hand, we don't always use contrast for diagnosis of the sequestrated lumbar disc. Using the DWI sequence, we showed that there is no restriction of diffusion, which once again confirmed that it is not about an inflammation, not a tumor lesion. So, MRI as a diagnostic procedure offers opportunities to eliminate dilemmas regarding diagnosis in one fell swoop, which is necessary for the timely resolution of the patient's condition.

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Absces periapicalis

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Objective. To present a rare complication of orthodontic infection that extends into the orbit. There is an increasing rate of patients for hospitalization due to acute dental infections [1,2].

Case Description. A 62-year-old patient was admitted to UC KCS as an emergency due to periorbital swelling and pain in the region of the left facial mass, as a result of dentogenic infection, upper jaw on the right side, fossa canina abscess and suspected phlegmon. About a month ago, the appearance of discomfort in the region 13th at the top right, which was devitalized 5 years ago. The dentist decides on the treatment of the patient for the remediation of the infection and the preparation for the placement of ceramics in the upper jaw. Devitalization and drainage were done through the 14th on the right, and after a week, the same thing was repeated with the 12th, which was devitalized and filled with cement, while the 14th was not filled. After some 15 days, the drains are filled with cement and 14th and 12th without giving any therapy. After 24 hours, pulsating pain begins with mild tightening of the facial skin, followed by rapid and progressive deterioration of the clinical picture with body temperature 38.9 0C, swelling of the face, peribulbar tissue with incomplete closure of the right eye, and the initial feeling of limited jaw opening. CT of the facial mass was performed, which shows swelling and fogging of soft tissues in the region of the fossa canine right, maxillary parasagitasal right cavum with purulent content, cement filling of tooth canals 14 th and 12 th, and gas. Surgical MF treatment in the form of an incision in the right upper fornix is indicated. Abundant sanguinolent content with gas admixture was obtained. Bone curettage was also performed with rinsing with physiological solution and hydrogen peroxide until fresh blood appeared. Taken material for sowing the substrate. The dominant pathogens of the dentooral system are bacteria of the genus Streptococcus, which can be divided into 4 groups according to biochemical and physiological differences, but also according to genetic affiliation. These are: mutans species (S. mutans), which bind to caries and dental plaque, then mitis species (S. sanguis), which are present in dental plaque, salivarus species (S. salivarius), mostly associated with mucous tissues oral cavities and species of anginosus (S. intermedius), detected mainly in gingival cavities.

Presentation of the patient 24 hours after the onset of pain and swelling; Presentation of the patient before the start of MF treatment:

Therapy is diverse, disease modifiers, including transient or permanent host-related factors, can also affect the development and severity of acute abscesses [3]. Drug therapy for the next 48 hours:

Immediately after the MF intervention:

- Controloc I amp
- Lemod solu 120 mg (with dose reduction in subsequent administrations to 100, 80 and 40)
- Zodol amp I
- Longacef 2gr
- Amikacin 1 gr
- Paracetamol 1 gr
- Orvagil 400mg 3x1 per 24 hours

Drug therapy after the first in the next 48 hours:

- Longacef 2gr
- Amikacin 1 gr
- Lemod sol 100 mg (reduction 80 to 40)
- Orvagil 400mg 3x1 per 24 hours

Then another week:

- Panklav 500 + 125 mg x 3
- Orvagil 400 mg x 3

Conclusion. A case of periapical infection of the maxillary right molar resulting in orbital abscess is presented. Identification of the odontogenic source of infection, introduction of drainage, removal of damaged teeth and appropriate antimicrobial therapy are mandatory in the prevention of vision loss and cerebral extensions. Ways of spreading the infection, aspects of treatment and complications are considered.

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Determination of photon radiation spectrum by application of standard unfolding technique

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Introduction. For the successful application of radiation therapy, it is necessary to know well the characteristics of the radiation used. The problem we encounter is the distribution of the dose in an irradiated inhomogeneous medium of a given volume consisting of different tissues with different attenuating properties. Therefore, it is necessary to know the value of the mass energy absorption coefficient as well as the spectrum of the incident beam of the therapeutic accelerator for each point of the irradiated volume in order to be able to calculate the distribution of the received dose in the irradiated part of the body. For this reason, in this paper we have tried to determine the photon radiation spectrum of a medical linear accelerator using a measurement technique based on the unfolding method.

Materials and Methods. The radiation spectrum of the Vrian DHX therapeutic linear accelerator was analyzed by the attenuation method. The accelerator is multi-energy, but in this paper is analyzed only the spectrum of photon radiation of 6 MeV energy. The radiation dose was measured after attenuation of the beam in the materials used, water, aluminum, lead, iron and copper. Determination of the photon radiation spectrum is performed using these measured data, known values of attenuation coefficients for given materials and using standard unfolding techniques, already well developed in the field of neutron activation measurements.

Results. The results obtained in this paper show that the applied technique can provide reliable information on the photon spectrum characteristics of medical linear accelerators. The performed analysis shows that the calculated radiation doses using the photon spectrum obtained by the unfolding method agree better with the measured values than in the case of using the standard Schiff spectrum.

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Dosimetric comparison of deep inspiration breath-hold of left-sided breast irradiation with wedges and forward-planned IMRT

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Background/Aim. This study evaluated the dose distribution of two different types of radiotherapy: forward-planned intensity-modulated radiotherapy (IMRT) in comparison with standard wedged tangential-beam three-dimensional conformal radiotherapy (3DCRT) of the left breast in deep inspiration breath-hold (DIBH) and free breathing (FB). Aim of this retrospective study was to compare dosimetric effects of the DIBH on the heart, left anterior descending artery (LAD), ipsilateral lung (IL) and target coverage compared to free breathing (FB) technique.

Methods. For 48 female patients, who underwent left-sided breast cancer conserving surgery, forward IMRT and 3DCRT plans with wedges were planned on DBIH and FB computerized tomography (CT) series. Plans consisted of two opposed tangential segmented beams and, if necessary, one direct beam with small dose contribution. Heart, IL, LAD, and PTV were delineated on both CT series.

Results. Dosimetric comparison between forward IMRT FB and DIBH plans for median of mean dose to the heart was 4.05Gy (IQR=2.52) vs. 2.17Gy (IQR=1.89), and for plans with wedges median of mean dose to the heart for FB was 3.76Gy (IQR=2.52) vs. 2.07Gy (IQR=1.33) for DIBH. Median of the mean dose for FB forward IMRT for LAD was 23.17Gy (IQR=16.81) vs. 7.86Gy (IQR=8.27) for DIBH. Median of the mean dose for FB plans with wedges for LAD was 24.64Gy (IQR=16.39) vs. 6.19Gy (IQR=14.62) for DIBH. Median of the percentage of the volume receiving 20Gy for the IL was 15.21% (IQR=6.58) vs. 13.44% (IQR=19.09) for FB and DIBH for forward IMRT, respectively. For plans with wedges results were 17.38% (IQR=7.00) vs. 14.43% (IQR=4.95) for FB and DIBH, respectively. Median of PTV coverage with 95% of prescribed dose was 97.06% (IQR=1.69) vs. 96.96% (IQR=1.69) for FB and DIBH for forward IMRT, respectively. For plans with wedges median PTV coverage were 92.48 (IQR=2.94) vs. 89.37% (IQR=5.19) for FB and DIBH, respectively.

Conclusion. DIBH technique planned with forward IMRT showed better results to surrounding organs at risk (OAR), particularly to the heart and LAD. Target coverage was better for forward IMRT plans than plans with wedges.

Keywords: Breast cancer radiotherapy, deep inspiration breath hold, heart, respiratory gating, IMRT, wedge

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Proof-of-concept PRAGUE (Proton range measurement using silicon carbide) detection system: Monte Carlo simulation and first experimental results

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Particle therapy is a viable alternative to conventional radiotherapy for treating deep-seated tumors on account of reduced radiation loading on the patient arising from more targeted dose deposition by charged particles along their tracks. In order to exploit proton therapy to the fullest, a robust quality assurance (QA) protocol and tools for reducing range uncertainties are essential. To address the latter issue, the PRAGUE (Proton range measurement using silicon carbide) detection system was proposed by the medical physics group of INFN-LNS, aimed at developing a real-time solid-state detector in "stack" configuration to measure depth-dose distribution (DDD) curves with μm-spatial resolution and perform routine proton therapy QA for both conventional and ultra-high dose-rate beams. Additionally, the Monte Carlo TOPAS software (a Geant4 wrapper dedicated to medical physics applications) was used to analyze and predict the proton DDD. Results have been experimentally benchmarked through measurements performed at the Trento Proton Therapy Center. A positive match between simulated and measured data provides proof-of-concept support to the application of the proposed detection system to conventional proton therapy, paving the way for PRAGUE to potentially become a standard in dosimetry for clinical treatment.

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Battery-less NFC tag for radiation dose measurement with MOSFET dosimeters

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This work describes the development of a passive NFC tag designed as an ultra-portable and compact readout system to quantitatively measure the irradiation dose absorbed by a MOSFET dosimeter. The tag is supplemented by a smartphone running a custom-developed application based on ISO15693 Near Field Communication (NFC) protocol, a subset within the family of Radio Frequency Identification (RFID) technology.. As a passive tag, the energy harvested by the designed tag antenna can supply the RFID/NFC tags (without battery). In this case, the device used to power up the tag and readout the dosimetric parameter is an NFC-enabled smartphone.

The tag consists of:
- Antenna
- NFC IC: M24LR64E by STMicroelectronics (Switzerland).
- Ultra-low power microcontroller unit (MCU): PIC16LF1703 from Microchip (USA) to acquire the samples from the dosimetric sensor and send it to the M24LR64E IC.
- 2.5 V LDO regulator: MCP1824T-2502E from Microchip to regulate the voltage provided by the M24LR64E and get a static analog-to-digital converter (ADC) input range.
- Charge pump ADM660 from Texas Instruments IC to double the voltage provided by the linear regulator.
- Current source to bias the MOSFET dosimeter, based on LM334 (Texas Instruments, USA).
- Analog conditioning stage to adjust the signal level to the input range of the MCU ADC.

The NFC-enabled smartphone provides an electromagnetic field that is harvested by the tag antenna for powering. In this case, the harvested power is rectified but not regulated by the chosen NFC chip. This voltage is then regulated by the Low Dropout (LDO) regulator and then a charge pump IC doubles it to bias the MOSFET-based dosimeter through a current source. The MOSFET dosimeter is integrated in the tag and its source is connected to the conditioning circuit to acquire the signal by the microcontroller ADC. A linear accelerator (LINAC) model Siemens Artiste (Siemens AG, Germany) with a field of 20x20 cm^2 has been employed to irradiate a single tag integrating one DMOS transistor model ZVP3306A (Zetex diodes, USA) with electrons of 6 MV. A two-cm thick layer of solid water was placed above the DUT to reach electronic equilibrium conditions, and five irradiation sessions of 3Gy were conducted with a dose-rate of 5 cGy/s. As usual, the increase in the threshold voltage (V_T) was measured as the dosimetric parameter in this type of MOSFET-based dosimeters.[C1]. The slope of the linear fit of the accumulated dose and the source voltage accumulated shift was used to calculate the global sensitivity of the system (15 Gy). In this case and unlike in the previous works, both DMOS and NFC reader tag were irradiated. The value obtained with the conventional reader [2] was (3.7 ± 0.3) mV/Gy, which is in line with the results registered by our designed NFC reader, (3.72 ± 0.05) mV/Gy. Conducted tests show that the reader tag electronics supports the radiation doses, working well after 15 Gy. Finally, the total cost of the system is less than 25 euros.

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Dosimetric comparison of dose calculation accuracy based on standard and extended CT conversion curve for metallic ports in temporary tissue expanders

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Aim. Temporary tissue expanders (TTEs) with a metallic port are currently a wildly used option for mastectomy patients. The magnetic properties of the port allow it to be localised by an external magnet, making it possible to fill the expander with saline injections. However, artefacts in CT and treatment planning systems (TPS) calculation inaccuracy for high-density materials are likely to contribute to discrepancies in dose distribution. This study aims to analyse the influence of two conversion curves (CC), the standard one and extended to the high densities, on TPS calculations in the presence of metallic ports. Next, compare these calculations with radiochromic film measurements.

Materials and Methods. Two TTEs with integrated ports (Nagor/Mentor) and one with a distal port (Mentor) were tested. During CT collection and measurements, ports were placed horizontally on a 15 cm water-equivalent base (slabs). CT was reconstructed using metal artefact reduction algorithms and an extended HU scale. Calculations for a single beam were done in the Eclipse TPS (v 15.6, Varian Medical Systems) for 6MV, 6MVFFF, 15MV beams and two versions of CCs. were used. The AAA calculation algorithm (electron density CC - ED). For 6MVFFF beam, additional calculations using the Acuros XB algorithm (dose-to-medium option, mass density CC - MD) were added. The maximum values of standard range CC were 6 000 HU for the ED and 2 832 HU for the MD. Extended CC (E_ED and E_MD) were lengthened to high Z materials (up to 10 000 HU). Measurements were done on TrueBeam (AAA) and EDGE (AXB) machines. A fixed number of monitor units was set during the calculations and measurements (525 MU for 6MV and 6MVFFF beams and 900 MU for 15MV beam). Pieces of Gafchromic EBT3 films were placed under slabs of appropriate thickness. For 6MV and 6MVFFF beams, measurements were taken at depths of 1, 2, 5, 10, 14, 20 and 50 mm below the ports. For 15MV beams, the depths were 1, 2, 5, 14, 25, 30 and 50 mm. Depths for both energies were chosen to fit the dose distribution in a build-up region and a maximum dose location. For two CCs ranges, doses calculated in TPS relative to the measured ones were compared.

Results. Better agreement between measured and calculated doses was obtained for both extended CCs. Extended CCs had a more significant influence on improving AAA dose calculation accuracy than for the AXB algorithm. For integrated ports 98% and 80% of measurement points were improved, respectively. Greater improvement in results was noted at shallow depths (1-5 mm). However, the differences between system calculations and measurements for these points were still greater than for deeper located points. For AAA algorithm, depths to 5 mm and integrated ports, the average improvement was: 6.1 percentage points (pp) and 10.3pp for 6MV, 6.7pp and 10.9pp for 6MVFFF, and 3.0pp and 5.8pp for 15MV beams for Nagor and Mentor, respectively. For measurements at depths deeper than 5mm, it was respectively 3.5pp and 6.7pp, 3.9pp and 7.5pp, 2.8pp and 4.4pp for 6MV, 6MVFFF and 15MV beams. For the distal port, the maximum difference was 0.3pp. No such significant depth-dependent differences were observed for the AXB. The agreement was improved on average by 0.8pp (Nagor) and 0.5pp (Mentor) for the integrated ports and 0.7pp for the distal port. Overall for the distal port, better results were achieved for 52% (AAA) and 71% (AXB) of all measurement points. For all other points, the difference between calculations using E_MD and MD CCs was not observed or did not exceed the value of 1cGy. The maximum difference for the distal port was 0.3pp (AAA) and 1.8pp (AXB), favouring the extended CC.

Conclusions. TPS calculations based on the extended CCs show higher agreement with doses measured under metallic ports of TTEs. It is more pronounced for integrated ports than for distal ones. Clinical implementation of extended CCs seems necessary when patients with implanted metal components are irradiated.

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PIN photodiodes as high dose dosimeters for proton beams

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Introduction. High irradiation dose can be provide to sterilize medical products, to induces modifications in plastic materials, or as a pasteurization process, among others applications. Photodiodes may be a suitable candidate for use as ionizing radiation detectors due to low size, immediate readout, etc [1]. In the current work a commercial photodiode is characterized as high dose radiation sensor for proton beams of 5.6 MeV and a total dose higher than 5kGy.

Methods and Materials. Radiation source. Irradiation tests have been conducted at the CNA (National Accelerators Centre), in Sevilla (Spain). In particular, the tests were carried out with a 5.6 MeV proton beam from the 3MV-Tandem accelerator. Five irradiation sessions were programmed with an average dose rate of 3.48 Gy/s to provide an accumulate total dose of 5.24 kGy (Si) per sample. Reader unit. The reader unit developed in our research group was used to monitor the photo current induced by proton beam [2]. Sensors were reverse biased at 10 V, and the device´s induced current has been converted to voltage with a transimpedance amplifier based on the operational amplifier TL072 (Texas Instruments, Dallas, TX USA) with a feedback resistor of 4.7 MΩ, achieving a theoretical current resolution of 80 pA. However, the circuital electronic noise avoided achieving this theoretical value.[JFS1] A resolution above 200 pA was reached, which is enough for our application. Experimental setup. Three samples of the PIN photodiode BPW24R from Vishay (USA), cased into a TO-18 encapsulation hermetically sealed with a glass lens to allow light reaches the sensitive area (0.78 mm^2), were modified to be use as radiation detector of protons of 5.6 MeV. Due to the low power penetration of this beam, the top of the housing had to be removed with a circular saw, so the protons impact directly on the silicon die. The reader unit was placed into the irradiation room but out of the small bunker with the DUT in vacuum conditions. The sample was connected to a 2-vias standard IDC wire to the reader, which was connected to a PC via USB.

Results. The sensitivity has been considered as the slope of the linear fit of accumulate dark current shift as dose function. The natural logarithm of accumulated dark current shift shows high linearity with accumulated dose, R^2 > 0.99 for all studied samples. The average sensitivity of the set of three samples was (758 ± 30)[JFS2] fA/Gy. Due to the high dose, an important sensitivity degradation with dose also was found.

Conclusions and Current Task. The BPW24R from Vishay shows a promising behavior as dosimeter for proton beams to high dose range. An exhaustive characterization with a wider set of DUTs is going to be carried out to study the sensitivity decay, among other parameters. Although this PIN photodiode model had a reproducible response under proton beams, other models will be tested to compare sensitivities and degradations.

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Definition and sensitivity analysis of a CFD model for the study of radon immission in buildings

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Within the framework of a research project funded by the Spanish Nuclear Safety Council, two different models will be developed to allow the study of radon immission and accumulation in buildings located in different regions of potential risk. The final use will be aimed at the prediction of radon entry rates according with different levels of available information about buildings and environmental parameters. In addition, they should be able to predict the reductions achieved by implementing different types of mitigation solutions. One of them will be developed using the finite element analysis software COMSOL MULTIPHYSICS.

This paper presents the first phase of the project, describing the fundamentals of the model and a sensitivity study on some of the parameters it incorporates: radon levels in the ground and soil permeability; envelope conditions in terms of porosities, permeabilities, diffusion coefficients, discontinuities; environmental parameters such as pressure conditions, indoor and outdoor temperature, winds, moisture content of the ground. The results and the analysis of their feasibility of application will be compared later with the second model developed with the STELLA software. In a second phase, both models will be compared and calibrated using the monitored data from two real buildings located in areas with high radon exhalation potential.

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Statistical coherence of ambient conditions affecting indoor radon concentration

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The continuous real-time measurements of indoor radon concentrations were carried out over two weeks in order to examine daily and seasonal variations and possible dependence of radon entry on ambient conditions. The advantage of active radon monitors used for this study is the fact that they are equipped with sensors for constant monitoring of ambient parameters such as temperature, pressure and relative humidity. To find a potential correlation between indoor radon concentration and three independent variables (i.e., temperature, pressure, and humidity) a Pearson's correlation was run. Moderate positive, but statistically significant correlations are found between: radon concentration and temperature, $r = 0.532$, $p<0.01$; radon concentration and pressure, $r = 0.304$, $p<0.01$ and, radon concentration and humidity, $r = 0.497$, $p<0.01$. To predict the value of indoor radon from temperature, pressure, and humidity a multiple regression analysis was run. There was linearity as assessed by partial regression plots and a plot of standardized residuals against predicted values. The multiple regression model statistically significantly predicted radon concentration, $F(3.329)=46.275$, $p<0.01$, explained 30 % of the variability of radon concentration. Temperature and humidity added statistically significantly to the prediction, $p<0.05$.

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Comparison of alpha spectrometry methods for radon determination in water

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Radon (^{222}Rn) has been recognized as the second cause of lung cancer in the world, due to the ability of its progenies to remain in the lungs, where they emit alpha particles damaging lung tissue and increasing chances of developing lung cancer over the course of a person lifetime. Radon can be found in soils, building materials, as well as in water. As a noble gas, radon is chemically inert, and diffuses easily, which is causing a problem in the precise determination of its activity concentration in samples. In this paper, the activity concentration of radon in water samples (from public fountains) is determined using two alpha spectrometry methods–one with active radon monitor device RAD7 and the other with liquid scintillation counter Quantulus. The comparison and discussion of the obtained results were made, while the advantages and disadvantages of both methods were discussed. Furthermore, the radon health risk assessment for all samples was estimated.

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Feasibility of *in situ* radon monitoring using common GM counters

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Radon gas is the main natural factor for spreading out radioactivity in the environment. Its monitoring on a large scale is of scientific interest in two different fields: assessment of the human health radiation risk, and/or investigation of some natural phenomena related to radon exhalation and its propagation in the Earth's crust and atmosphere.

Most of the detectors used for radon measurements rely on registering the alpha-rays coming from the ^{222}Rn decay itself and those from its daughters ^{218}Po and ^{214}Po, as well. Although alpha-detectors have very low background and good efficiency, they are relatively expensive and are not well suited for field work due to their sensitivity to the ambient air humidity.

In this work, an alternative possibility for *in situ* systematic measurements (monitoring) of radon concentration is investigated. It is suggested to use simple and wide spread detectors - Geiger-Mueller counters which are sensitive to beta/gamma radiation of ^{222}Rn daughters ^{214}Pb and ^{214}Bi. Long term measurements of the radiation background in uninhabited dwelling rooms were performed using simultaneously a classical radon alpha-particles detector (based on an ion chamber) and a beta/gamma detector (GM counter); the basic meteorological parameters at the site were also monitored. A very high correlation between the response of both detectors was found ($r^2>0.9$) which indicates that the radon monitoring can be successfully performed by means of cheap and moisture resistant GM counters. The drawbacks and the limitations of this method are also discussed.

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Determination of indoor radon concentration and radon concentration in soil: Regional Interlaboratory Comparison – RADON2021

Igor Čeliković[1], Gordana Pantelić[1], Miloš Živanović[1], Jelena Krneta Nikolić[1], Ranko Zekić[2], Nikola Svrkota[2], Sofija Forkapić[3], Branko Predojević[4], Bojan Pavičar[4], Vesna Arsić[5], Ivana Vukanac[1]

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In accordance with ISO/IC 17025:2017 testing laboratory shall have a procedure for monitoring the validity of results that includes regular participation in interlaboratory comparisons. Interlaboratory comparison RADON2021 was organized in the frame of the bilateral project between Serbia and Montenegro: "Measurement of the radon equilibrium factor in typical residential buildings in Serbia and Montenegro and harmonization of radon measurement techniques" in order to assess congruence of different measurement techniques, and then harmonize methods in case of inconsistencies. Harmonization is of particular importance to neighboring countries, in order to avoid inconsistencies in the classification of radon risk zones along border areas. Thus, six regional laboratories took part in the intercomparison – three from Belgrade and one from Novi Sad, Serbia; one from Podgorica, Montenegro; one from Banja Luka, Bosnia and Herzegovina. All laboratories participated in the indoor radon measurements, while 4 laboratories measured radon in the soil also.

The measurement methods and detectors used by the laboratories were:

- for air - EPA 402-R-92-004 – Indoor Radon and Radon Decay Product Measurement Devices Protocols, ch. 3.1. with RAD 7, RTM1688-2 and RadonEye; EPA 520/5-87-005 – 1987 EERF Standard Operating Procedures for Rn-222 Measurement Using Charcoal Canisters, ch. 3.4 using adsorption on charcoal canisters; ISO 11665- 4: Measurement of radioactivity in the environment – Air Radon 222: Part 4: Integrated measurement method for determining average activity concentration using passive sampling and delayed analysis with Electretes, and
- for soil gas - ISO 11665-11:2016 Measurement of radioactivity in the environment — Air: radon-222 — Part 11: Test method for soil gas with sampling at depth by using active devices RTM1688-2 and RAD 7.

The measurements were performed in real conditions where the radon concentration varied following a typical daily variation. Indoor radon concentrations were measured at four locations, while radon measurements in soil were performed at one location, all at the Vinča Institute site in the period from October 1 to October 8, 2021. The exposure period was consistent with a typical soil and indoor radon measurement protocols. The radon concentration in the soil was measured at depths of 20 cm and 80 cm.

The robust mean and robust standard deviation were calculated as the mean of all measured radon concentrations (excluding outliers) and their standard deviation. Reference values of indoor radon covered the wide range of concentrations: (65 ± 9) Bq m^{-3}, (519 ± 80) Bq m^{-3}, (900 ± 160) Bq m^{-3}, (1980 ± 160) Bq m^{-3}, while in the soil reference values were (13350 ± 780) Bq m^{-3} and (26100 ± 2400) Bq m^{-3} at 20 cm and 80 cm depth, respectively.

In order to assess whether there is a statistically significant difference between individual measurement results and the reference value, the Z - test was used as a criterion for success. If, for the calculated z value, $|z| < 2$ the result is satisfactory, if $2 < |z| < 3$ the result is questionable, while for $|z| > 3$ result is not acceptable.

All results of indoor radon measurements were satisfactory, except in the case of one measurement (for the lowest reference value) with electret, that was at the detection limit. Three laboratories had satisfactory results of radon concentration measurements in the soil, while the results of one laboratory were systematically lower, with $z < -3$, which indicated the need for additional analysis of the causes of systematic error and the possible need to change measurement protocols and/or re-calibration of used device.

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Radon levels and dose assessment in Modrič Cave (Croatia)

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Modrič Cave is located at only 29 m above sea level near Starigrad-Paklenica at the Adriatic coast and in close vicinity to the highway. Its total length of about 800 meters in two channels provides a special experience of the underground world in completely intact nature. Although the interior of the cave is passable because both channels are of sufficient height and width for passage, it is not possible to explore it without adequate equipment and expert guidance. Since March 2020, eighteen-month monitoring of natural radioactivity originating from radon and its short-lived progeny has been performed, to estimate the dose received by both cave visitors and the tourist guide(s).

Integrated radon measurements were performed by LR115 type II nuclear track etched detectors. Continuous measurements were made using TSR3 detectors and the AlphaGUARD measuring device equipped with the TN-WL-02 module for measurement of equivalent equilibrium concentration of radon progeny. Track etched detectors and TSR3 were exposed for 3 months periods during climatological seasons, while AlphaGUARD and TN-WL-02 measuring devices were exposed for two days at each season which enabled the determination of equilibrium factor between equivalent equilibrium concentration of radon progeny and activity concentration of radon.

The average radon concentrations with its standard deviations in the Modrič Cave in the climatological seasons were: $c_{Spring\text{-}20}$ = 3.6 ± 1.5 kBq m^{-3}, $c_{Summer\text{-}20}$ = 5.2 ± 2.7 kBq m^{-3}, $c_{Autumn\text{-}20}$ = 2.9 ± 1.6 kBq m^{-3}, $c_{Winter\text{-}20/21}$ = 0.88 ± 0.96 kBq m^{-3}, $c_{Spring\text{-}21}$ = 2.0 ± 1.3 kBq m^{-3} and $c_{Summer\text{-}21}$ = 6.6 ± 3.6 kBq m^{-3}. The measured maximum values of radon concentrations in the summer period rank the Modrič Cave among karst caves with above-average radon concentrations. Radon concentrations in each climatological period had statistically significantly different values in the right and left (tourist) channels, which was confirmed by the corresponding t-tests. No daily variations of radon and its short-lived progeny because of human activity during or after sightseeing were observed. The correlation between radon and partial pressure of carbon dioxide, which is an important factor in the variety of geochemical processes that occur in caves, is analyzed and discussed.

The mean equilibrium factors at the beginning (F_B) and at the end (F_E) of the touristic season of 2020 were also determined and the following values were obtained: F_B = 0.432 ± 0.068 and F_E = 0.430 ± 0.087.

The maximum effective radon dose received by visitors during the two-hour cave tour was 38.7 ± 7.3 μSv, on August 19th, 2001, calculated by using the epidemiological model (ICRP-65) or 161 ± 30 μSv using the biokinetic model (ICRP-137). According to this biokinetic model, the tourist guide received an effective dose of 1045 ± 252 mSv in 2020 and 1410 ± 452 mSv in 2021 for a little bit more than twenty guidance's in each year due to pandemic restrictions. A comparison of the received dose values with the recommendations of the ICRP and the EU on the maximum annual exposure limit for radon and its short-lived progeny for employees of 50 mSv in one year or 20 mSv averaged over 5 years show that guide in the Modrič Cave in 2020 and 2021 received 19- and 14-times lower doses, respectively than the average reference dose of 20 mSv for the workplaces. Nevertheless, in regular tourist seasons with daily guided cave tours during summertime, the guides would receive a higher dose than the reference level and thus should be monitored.

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Radon in a high karst area of Montenegro

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The largest part of Montenegrin territory has limestone bedrock. National average annual ^{222}Rn activity concentrations in ground-floor dwellings are AM_d = 131 Bq/m^3 and GM_d = 71.5 Bq/m^3, while in ground-floor rooms of schools they are about twice higher: AM_s = 275 Bq/m^3, GM_s = 174 Bq/m^3. The highest values are in dwellings in the Niksic municipality ($AM_{d,N}$ = 261 Bq/m^3, $GM_{d,N}$ = 138 Bq/m^3), and the second-highest in Montenegrin schools in the same municipality ($AM_{s,N}$ = 599 Bq/m^3, $GM_{s,N}$ = 414 Bq/m^3).

In the western, rural part of the Niksic municipality, which is a typical high karst region, within national radon surveys in 2016 and 2018, radon was measured in ground-floor rooms of 9 houses and 16 schools, at 25 locations which belong to an area of 800 km^2. The average annual radon concentrations ($C_{Rn,ind}$) were found to be very high: range (219 – 2494) Bq/m^3, AM = 977 Bq/m^3. In order to investigate correlations of these indoor radon concentrations with properties of underlying soils, by the end of August 2021, at the same 25 locations, in the immediate vicinity of those 9 houses and 16 schools, the following soil parameters were measured *in situ* or later in a laboratory: humidity (H), electrical conductivity (EC), pH, activity concentrations of ^{226}Ra, ^{238}U, ^{235}U, ^{232}Th and ^{40}K, radon concentration at the location ($C_{Rn,loc}$), permeability (k_{loc}), and gamma dose rate (D) in the air 1 m above the soil. The geogenic radon potential of the location (GRP_{loc}) is calculated from $C_{Rn,loc}$ and k_{loc} values. Observations of geomorphological and pedological characteristics and construction characteristics of buildings are made on site.

Quantities which characterize radon in soils of the investigated area are found to have high values: $C_{Rn,loc}$ – range (8.9 – 390) kBq/m^3, AM = 115 kBq/m^3; k_{loc} – range (3.9 – 180) · 10^{-13} m^2, AM = 153 · 10^{-13} m^2; GRP_{loc} – range 11 – 419, AM = 129. Also, concentrations of ^{226}Ra, as ^{222}Rn parent, are found to be elevated (range (48 – 326) Bq/kg, AM = 167 Bq/kg), probably because of traces of bauxite presence at some of the investigated locations.

Spearman correlation reveals strong relationship between $C_{Rn,loc}$ and GRP_{loc} (r_s = 0.906, p < 0.001), moderate between $C_{Rn,loc}$ and D (r_s = 0.517, p = 0.008), $C_{Rn,loc}$ and ^{226}Ra (r_s = 0.521, p = 0.008), k_{loc} and EC (r_s = 0.614, p = 0.001), and weak relationship between $C_{Rn,loc}$ and ^{238}U (r_s = 0.400, p = 0.048), $C_{Rn,loc}$ and ^{235}U (r_s = 0.465, p = 0.019), $C_{Rn,loc}$ and EC (r_s = -0.442, p = 0.027), GRP_{loc} and ^{226}Ra (r_s = 0.475, p = 0.016), k_{loc} and pH (r_s = -0.458, p = 0.021). Relationship between D and ^{226}Ra is strong (r_s = 0.719, p < 0.001), D and ^{235}U (r_s = 0.615, p = 0.001) moderate, while it is weak between D and ^{238}U (r_s = 0.426, p = 0.034) and D and EC (r_s = -0.438, p = 0.029). Spearman correlation does not reveal statistically significant relationship between $C_{Rn,ind}$ and measured variables which characterize soils at investigated sites.

By applying the t-test and Mann-Whitney test statistically significant differences (at the significance level of 95%) between values of $C_{Rn,ind}$ are not found for different categories of underlying lithology (limestone, dolomite), soil (calcomelanosol, rendzina), type of building (house, school), period of construction (before 1980, 1980-1990), the material of outer walls (stone, concrete), type of window frames (wood, PVC/Al). Furthermore, the ANOVA procedure and Kruskal-Wallis test do not confirm statistically significant differences in $C_{Rn,ind}$ for the three categories of foundation slabs.

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Correlation between radon in water, radon in soil gas and indoor radon based on the extensive measurements in Croatia

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Radon is known as the main source of radiation for the general public. Radon is a part of the uranium (^{238}U) decay chain and is formed by radioactive decay of its parent radium nucleus (^{226}Ra) inside various geological structures (both rock and soil minerals) in which radium is naturally present in various concentrations. Radon enters water most often by dissolving in groundwater that surrounds geological structures. And to a much lesser extent, radon can enter the water by dissolving from the air. Clean and safe tap water for human consumption is one of the important goals of the EU according to the Horizon Europe – the next EU research and innovation programme 2021 – 2027.

Results of extensive measurements of radon in water samples collected from private wells, natural springs and public water supply in Croatia are presented, and annual effective doses are estimated. Since 2011 water samples were gathered during targeted indoor radon surveys (schools, kindergartens and homes) in 10 counties (out of 21) in Croatia. Radon activity concentrations in water were determined by two different methods: by using the emanometry method (AlphaGUARD instrument with additional AquaKIT module) and the liquid scintillation method (LSC TriCarb). A total of almost 1000 water samples gathered in the field gave the arithmetic mean of 5 Bq/l (with the measured minimum value below the detection limit - around 1 Bq/l; on the other hand, the maximum measured value was 154 Bq/l). These concentrations result in average ingestion doses of around 30 μSv for adults and 50 μSv for children.

Correlation between radon concentration in water samples, indoor radon concentrations (measured by SSNTDs in a yearlong measurement) and calculated geogenic radon potential (based on the radon in soil gas measured by radon detector RM-2 and soil permeability measured by Radon-JOK instrument) in selected counties are examined. All of these measurements were performed in the investigated dwellings or in their immediate vicinity. The results of these correlations can serve as a starting point for more detailed investigations in defining radon priority areas in Croatia, in the future.

By doing a statistical analysis of the data gathered in each county the Spearman correlation coefficients (nonparametric version of the Pearson correlation coefficient) are calculated in order to measure the degree of association between two variables based on their ranks. We wanted to analyze correlations between these measured variables: indoor radon, radon in soil gas, geogenic radon potential (GRP), and radon in water. In all of the cases a positive correlation is found with strong (r_s = 0.6 - 0.8) or moderate (r_s = 0.4 - 0.6) relationship between measured variables.

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Indoor radon concentration measurements and the radiological risk assessment within Accra dwellings, Ghana

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The daughter isotopes of radon can adhere to dust particles and enter the respiratory system as radon freely circulates in the air. These progenies are also known to accumulate in buildings leading to increased risks of lung cancer when found in high concentrations as stated by the WHO [1, 2]. For this survey, the objective was to measure the indoor radon concentrations in residences within Accra, Ghana, and to evaluate the associated risks as a result of the inhalation of radon. A total number of 95 dwellings were selected for this purpose and the measurement was for a period of 90 days. The NRBP radon dosimeter with CR-39 detectors was used for the measurements. The exposed detectors were then chemically etched in 6.0 M NaOH solution at 90 °C for 9 hours. The next step was to clean the detectors with distilled water and alcohol. The densities of the radon tracks were counted using a high-resolution image scanner and analysis software [3].

The measured indoor radon concentrations were tested for normality using the Kolmogorov-Smirnov normal test and the normalizing Q-Q plots. Both tests showed the data was not normally distributed which could be as a result of different soil compositions and building materials used and the level of ventilations within the dwellings. However, a log-normal distribution of the data showed normally distributed data with a significant value of 0.077. The calculated indoor radon concentrations for the surveyed dwellings ranged from 36.07 to 91.96 Bqm^{-3} with an annual mean of 50.81 Bqm^{-3}. Thus, all the measured indoor radon concentrations were below the WHO limit of 100 Bqm^{-3}. The geometric mean and geometric standard deviation was also found to be 49.90 Bqm^{-3} and 1.19, respectively.

The average annual indoor radon level of 50.81 Bqm^{-3} corresponded to an annual effective dose of 1.28 $mSvyr^{-1}$ which is below the ICRP limit of 3.0 $mSvyr^{-1}$ [4]. The effect of inhalation of indoor radon on lung cancer was projected by determining the ELCR and LCC for the surveyed area. The mean ELCR was calculated to be 4.93 whereas the LCC was 23.05. From the LCC it was estimated that approximately 5% of lung cancer deaths would be recorded annually due to indoor radon concentrations. Lung cancer risk has been known to be proportional to indoor radon exposure by the increment of 16% per 100 Bqm^{-3} of indoor radon levels and therefore depicting a linear relationship between the two factors [1-3].

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CFD based simulation of RRI thoron calibration chamber and its validation with measurement results

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It is well known that inhalation of radon, thoron and their decay products contribute the largest fraction (52%) of radiation dose to humans, received from natural background radiation [1]. Most of the past studies have been focused on radon, neglecting ^{220}Rn contribution due to its shorter half-life [2]. The release of ^{220}Rn is an issue of concern from the radiological point of view for occupational environments pertaining to the thorium fuel cycle. Studies for understanding its release and developing systems to control it are crucial for exposure control research. The ^{220}Rn distribution and its state of mixing inside the calibration chamber are simulated using ANSYS&FLUENT 2020 R1 software based on Computational Fluid dynamics (CFD). There exist studies wherein CFD has been used to study ^{220}Rn distribution in rooms and dwellings [3-4]. This work attempts to employ CFD technique to assess the ^{220}Rn distribution in confined volumes in the presence of a forced flow.

Simulations have been carried out with ^{220}Rn source in a cylindrical chamber of 0.2 m^3 volume. The study aims to obtain transmission factor of ^{220}Rn (i.e. C_{out}/C_{in}) for different configurations of inlet-outlet positions and flow rates in Thoron calibration chamber existed in Institute of Radiochemistry and Radioecology, university of Pannonia.

As a results, thoron concentration was tending towards uniformly distributed at higher flow regime due to the well-mixing of the gas inside the chamber. Then, predictions made by CFD simulation were compared with experimentally measured transmission factors, and the results show that the flow and the position of the inlet and outlet play an imperative role in the transportation, mixing and subsequent mitigation of thoron gas inside the chamber. Moreover, it is highlighted the well agreement of CFD based predictions with experimental and analytical model results due to the corresponding appreciable relative deviation (around maximum of 9%). Our results clearly demonstrate the applicability of RRI thoron calibration chamber for calibration of monitor instruments.

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CFD simulation of indoor radon distribution in a naturally ventilated laboratory room in Hungary

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Recently, Computational fluid dynamics (CFD) is receiving wider attention as it is cost-effective and less time consuming than passive methods for measuring indoor radon and thoron, which require very long time to get a time-averaged reliable result. CFD is an analytical tool that was already shown to be useful for predicting indoor radon and thoron concentration [1-3]. CFD involves the solution of a set of non-linear partial differential equations using numerical methods. CFD analysis tools solve the system of mass, energy, and momentum conservation equations known as the Navier-Stokes equations to determine the air velocity, temperature, and contaminant concentration at each of these nodes in space and time. Therefore, I have simulated the distribution of indoor radon levels in a naturally ventilated laboratory room in Hungary by using the widely used and commercially available CFD package ANSYS FLUENT 2020 R1. A three-dimensional room with size 3.0×2.8×4.0 m^3 was considered to study the indoor distribution of radon. The room included one window (1.2 m×0.8 m) in the middle of the right wall, which opens to the outer environment, and a door (2.2 m×1.0 m) on the left side of the front wall. The complete volume was meshed in the ANSYS mesher using 1,267,543 unstructured hexahedral cells with a minimum volume of 2.3×10^{-9} m^3. Hexahedral cells were chosen because the specified volume can be modelled with high accuracy.

The average radon concentration from the CFD simulation was found to be between 70.21 and 66.25 Bq m^{-3} under closed and open-door conditions, respectively, at the desired ventilation rate of 1 ACH (Air Changes per Hour). Moreover, the highest concentrations of radon were measured close to the floor and the lowest values were recorded near to the inlet, resulting in the airflow velocity profile. The simulation results were in good agreement with the maxima of 19% and 7% compared to analytical calculations at different indoor air velocities in the open- and closed-door scenarios, respectively. The results from analytical solution and numerical simulations showed that air change rate, indoor temperature and moisture had significant effects on indoor radon concentration. Increasing air change rate reduces radon level and for a specific air change rate. It is concluded that CFD analysis is a powerful tool to visualize indoor radon distribution.

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Monitoring of equine infectious anemia in some areas of Albania – Preliminary results

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Equine infectious anaemia is considered as an important disease, OIE list, which causes severe economic damage, hinders the trading and the movement of equines. The disease is caused by a lentivirus of the Retroviridae family and transmitted by insects especially Tabanus and Stomoxys calcitrans. This disease is represented by a persistent viral infection characterized by intermittent fever, anemia, edema, fatigue and in some cases it can cause the death of the affected animals.

In this preliminary study, 112 healthy equines were tested for the disease using agar gel immune diffusion and fluorescence polarization assay methods. Samples for each animal were analysed simultaneously at the laboratory of infectious diseases at the Faculty of Veterinary Medicine in Tirana and at the reference laboratory of the Faculty of Veterinary Medicine in Zagreb. Many areas of Albania were considered in this study including districts of Tirana, Elbasan, Durres, Peqin, Mat, Librazhd, Berat, Kolonje, Pogradec and Devoll. Serological results according to both methods (FPA and AGID) were negative for all samples. Laboratory results of the infectious and reference diseases were identical.

Keywords: Equine infectious anaemia, Fluorescence Polarisation Assays, Agar Gel Immunodiffusion

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In vitro evaluation of genotoxic activity of methanolic extracts of *Onobrichys viccifolia* plant

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Onobrichys viccifolia is one of the most widely employed legume forages worldwide, which due to its antioxidant and antimicrobial activities use in folk medicine in the treatment of bleeding, cuts and wounds in humans. This study aimed to investigate the genotoxic effect of methanolic extracts obtained from the root and inflorescence of this plant and determine effect of quality of the soil in relation to the quantity of heavy metals on which the plant grew (uncontaminated locality at Gornji Milanovac and tailing site at Žitkovac near Kosovska Mitrovica). In this study after collecting (June 2020), identifying (identified and deposited at the Herbarium of the Department of Biology and Ecology, Faculty of Science, University of Kragujevac, Serbia) *O. viccifolia* plants washed and dried in the shade. Then methanolic extracts of root and inflorescence of these plants were prepared in a Soxhlet extractor. The genotoxic activity of these extracts was investigated *in vitro* on human peripheral blood lymphocytes using the single-cell gel electrophoresis (SCGE) or comet assay. The effects of four different concentrations (125, 250, 500 and 1000 μg/ml) for all extracts were tested. In addition, the heavy metals in the soil were analyzed by atomic absorption spectrophotometry (Perkin Elmer 3300). Methanolic extracts obtained from root and inflorescence of *O. viccifolia* from uncontaminated locality were significantly genotoxic in all tested concentrations and dose dependently increased the level of DNA damage, expressed as genetic damage index (GDI) (Pearson: $r = 0.831$, $p = 0.001$ for root, $r = 0.953$, $p < 0.0005$ for inflorescence). Average GDIs ranged from 1.16 ± 0.09 to 1.78 ± 0.17 for root extract, 0.97 ± 0.02 to 2.04 ± 0.24 for inflorescence extract in treatments with their different concentrations and was 0.32 ± 0.08 for negative controls (untreated cells). Methanolic extracts of root and inflorescence of *O. viccifolia* from tailing site were significantly genotoxic in all tested concentrations (average GDI values: from 1.64 ± 0.20 to 2.63 ± 0.19 for root extract, from 1.43 ± 0.07 to 2.69 ± 0.13 for inflorescence extract and 0.32 ± 0.08 for negative control cells). There was significantly positive correlation between tested concentrations of extracts and GDI values (Pearson: $r = 0.928$, $p < 0.0005$ for root; $r = 0.965$, $p < 0.0005$ for inflorescence). The heavy metal analysis showed that soils from both localities contained a higher quantity of Fe, Ca, Mg and Mn compared to other identified metals such as Ni, Zn, Cr, Pb and Cu, with the proviso that these quantities were many times greater in tailing than in environmental uncontaminated soil. Based on the results methanolic extracts of root and inflorescence of *Onobrichys viccifolia* originating from environmental uncontaminated soil and tailing site had genotoxic effect in all tested concentrations, but both extracts of plants from the tailing site (of root and of inflorescence) showed a greater genotoxic effect than the extracts of the plants from environmental uncontaminated soil. For safety reasons this plant should not be used in folk medicine until more extensive genotoxicity studies and *in vivo* studies.

Keywords: *Onobrichys viccifolia,* single-cell gel electrophoresis, human lymphocytes, genotoxic activity, heavy metals

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Developing and manufacturing physics laboratory equipment (apparatures) using standard materials and 3D technologies

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Apparatus for performing experimental exercises in general physics courses must be simple and robust, but at the same time they must provide a clear insight into the physical phenomenon through observation, measurement and data processing. Although manufacturers of teaching laboratory equipment offer a large number of devices, the search for the appropriate equipment sometimes fails or the price is too high. On the other hand, the availability of service use of CNC machines and the relatively low price of 3D printers provide the possibility to make some appliances yourself. In combination with an appropriate computer program or existing laboratory electronics, complete exercises can be realized that students can use. In this paper, we have developed an apparatus for observing the Doppler effect with a rotating source and an apparatus for observing classical magnetic resonance. We also made a Newton-type telescope. The Doppler Effect is observed using a computer program that performs spectral analysis of the sound wave emitted from a rotating source in real time. Magnetic resonance is observed on a compass needle that is at the same time in a constant homogeneous magnetic field (mT range) and a much weaker variable field that is realized by a function generator. Newton's telescope is equipped with equatorial mechanics with a GO-TO system that allows live observation of some deep sky objects using an analog security camera and a 7 "LCD screen. For the production of equipment, we used standard materials and CNC machine processing services from local companies, and we printed some parts on a 3D printer in our laboratory.

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Decontamination of working area after radiological incident in ex-industrial complex radiography unit

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Sealed radioactive sources (SRS) are widely used for many purposes in the industry due to their physical properties. Improper management of such sources can cause damage and result in unwanted contamination and exposure. SRS- Cesium 137 was used for radiography measurements and after the closing of this complex, documentation was lost or unreliable. This caused the leftover of one sealed source of Cesium 137 in this unit. Part of an industrial complex was sold to a private investor and during construction works sealed source was broken and contamination was spread all over the unit. The maximum dose rate was in a place where lead shielding and source were left after the incident and it was 5.8 mSv/h. Public Company Nuclear Facilities of Serbia was chosen to carry out the sanitation process, to the levels after which regulatory surveillance was not required. The process of sanitation was divided into four stages, and after every stage dosimetry measurement and gamma spectrometry were performed. During the process dosimetry, surface contamination and specific activities of Cesium-137 were monitored. Circumstances required the usage of high lever protective equipment for respiratory and physical protection of workers. Due to the porous structure of concrete dry decontamination methods were used (vacuum cleaning with HEPA filter, grinding, etc.), while wet methods were used during the decontamination of metal surfaces. During the process, 18 ISO barrels (208l) with radioactive waste were generated, which complies with the general radioactive waste management policy that implies minimal waste generation. Even though all this protective equipment was used, whole-body counter and gamma spectrometry measurements of body fluids of all workers before and after the process were performed, and all these measurements confirmed the absence of the internal contamination of all workers.

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Astroparticle experiments to improve the biological risk assessment of the exposure to ionizing radiation in exploratory space missions: A research topic initiative

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The actual and next decade will be characterized by an exponential increase in the exploration of the Beyond Low Earth Orbit space (BLEO). Moreover, the firsts tentative to create structures that will enable a permanent human presence in the BLEO are forecast. In this context, a detailed space radiation field characterization will be crucial to optimize radioprotection strategies (e.g., spaceship and lunar space stations shielding, Moon / Mars village design), to assess the risk of the health hazard related to human space exploration and to reduce the damages potentially induced to astronauts from galactic cosmic radiation. On the other side, since the beginning of the century, many astroparticle experiments aimed at investigating the unknown universe components (i.e., dark matter, antimatter, dark energy) have collected enormous amounts of data regarding the cosmic rays (CR) components of the radiation in space.

Such experiments essentially are actual cosmic ray observatories. The collected data (cosmic ray events) cover a significant period and permit to have integrated information of CR fluxes and their variations on time daily. Further, the energy range is exciting since the detectors operate using instruments that allow measuring CR in a very high energy range, usually starting from the MeV scale up to the TeV, not usually covered by other space radiometric instruments. Last is the possibility of acquiring knowledge in the full range of the CR components and their radiation quality.

The collected data contains valuable information that can enhance the space radiation field characterization and, consequently, improve the radiobiology issues concerning one of the most relevant topics of space radiobiology represented by the dose-effect models.

In this talk, the status of the art in this research topic will be presented as well a related research topic initiative titled “Astroparticle Experiments to Improve the Biological Risk Assessment of Exposure to Ionizing Radiation in the Exploratory Space Missions”. We launched in December 2021 on three different Frontiers Journal (Astronomy and Space Science/Astrobiology, Public Health/Radiation and Health, Physics/Detectors and Imaging).

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Strengthening interface between safety and security in Public Company "Nuclear Facilities of Serbia"

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Public Company Nuclear Facilities of Serbia (hereinafter PC NFS) is the only nuclear operator in Serbia. It was founded in 2009 under the Law on Ionizing Radiation together with the Serbian Regulatory Body. Since its establishment, PC NFS has continued all nuclear activities previously managed by Vinca Institute of Nuclear Sciences; Two research reactors (RA-final shut down and RB- zero-power critical assembly, operational but currently not-licensed), RWM facilities- old Hangars H0, H1 and H2 with legacy waste, new hangar H3 (for the storage of intermediate and low-level radioactive waste) together with the secure storage for the high activity sealed radioactive sources, waste processing facility and closed uranium mine Kalna are the part of the Company.

Nuclear safety is defined by the International Atomic Energy Agency (IAEA) as "The achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards". The IAEA defines *nuclear security* as "The prevention and detection of and response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive substances or their associated facilities". Although nuclear safety and security have a different focus, they overlap with each other. For example, radiation monitoring can be used to fulfill goals of nuclear safety and security. This paper will present equipment and procedures that can be used from the aspect of nuclear security and also be part of nuclear safety.