BOOK OF ABSTRACTS

INTERNATIONAL CONFERENCE ON RADIATION APPLICATIONS

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Radioactivity in the oil exploration sector

Sheldon Landsberger

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One of the very first papers describing radioactivity in oil extraction appeared in 1906 just a scant eight years after its discovery by Henri Bequerel in Paris 1896. The world currently consumes about100 million barrels of oil daily and is produced in countries throughout the globe through onshore drilling which refers to drilling deep holes under the earth's surface and offshore drilling which relates to drilling underneath the seabed. It was only in the late 1970's and early 1980's where a significant amount of research was done in characterizing the radioactivity in extraction processes which included, scale, produced water, sludge, etc. What is more surprising than the unexpected amounts of radioactivity in the oil extraction sector is the orders of magnitude differences of radiation from different onshore fields. Thus, handling of these radioactive by products including transportation, clean-up procedures, and burial requires stringent training and monitoring procedures. A detailed overview of radioactivity measurements and radiation protection guidelines for the oil exploration sector of the waste products will be presented.

Abscopal effects of radiation and nanoparticle hyperthermia with immune checkpoint inhibitor therapies

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Enhancing immune responses in metastatic cancers remains a challenge. We present results obtained from studies in immune competent mice that aimed to determine whether magnetic iron oxide nanoparticle (MION) hyperthermia (HT) can enhance abscopal effects with radiotherapy (RT) and immune checkpoint inhibitors (IT) in models of disseminated disease. Models described include metastatic breast (4T1 in BALB/c mice), prostate (Myc-CaP in FVB/N mice), and colorectal (CT26 in FVB/N mice) cancers. Methods involved focal treatment of primary tumor with a combination of single-fraction MION HT +/- fractionated RT (e.g. 3 x 8 Gy) +/- systemic IT with anti-PD-1 and anti-CTLA-4 antibodies (both 4 x 10 mg/kg, weekly i.p.). Endpoints included measures of primary tumor growth, disease burden (growth of distant or metastatic tumors), survival, and immunologic correlates from tumor tissues using histopathology, cytokine array, or flow cytometry analysis. Results generally demonstrated that compared to untreated controls, all treatment groups demonstrated a decreased primary tumour volume; however, when compared against surgical resection, only combination therapies that included RT provided the best local and distant tumor control. These cohorts showed more infiltration of CD3+ T-lymphocytes into the primary tumour. Combinations that proved most effective for primary tumours generated modest reductions in numbers of lung metastases in the 4T1 model. We conclude from these studies that single-fraction MION HT added to RT+IT improved local tumour control and recruitment of CD3+ T-lymphocytes, with a modest effect to reduce lung metastases.

Current challenges in radiation protection in medicine

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Medical use of ionizing radiation has been a major contributor to the population dose from man-made sources of radiation for many years. Current issues in radiation protection of patients include not only the rapidly increasing collective dose to the population, but also that a substantial percentage of diagnostic imaging examinations are unnecessary, and the cumulative dose to individuals from medical exposure is growing. Therefore, a number of new challenges have emerged in recent years with regard to a various issues related to use of ionizing radiation in medicine. Inevitably, major issues of protection pertain to high dose procedures, as interventional procedures, computed tomography and hybrid imaging and sensitive population groups as children and females of reproductive capacity. The challenges have been brought to different professionals groups and stakeholders as dosimetrists, radiation biologists, patients, referring physicians, radiologists, radiographers, medical physicists and manufacturers. This talk explores these issues with special emphasis on the appropriateness of medical exposures, dose tracking and optimization of practice, impact on new technologies and accident prevention. Activities of relevant international organizations are also discussed.

The vascular tumor microenvironment: New challenges and therapeutic targets

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Once solid tumors reach a diameter of a few mm, further growth becomes limited due to lack of oxygen and nutrients and the accumulation of toxic metabolites. Therefore, the capacity to attract surrounding blood vessels, called the "angiogenic switch" or "tumor angiogenesis", is essential for further tumor growth as well as for the spread of tumor cells to distant organs (metastasis). The stimulation of blood vessels toward the tumor is principally mediated by secretion of the vascular endothelial cell growth factor (VEGF) either by the tumor cells or by other cells in the tumor environment like tumor-associated fibroblasts and tumor-associated adipocytes. Different anti-angiogenic compounds have been approved for treatment of solid tumors including monoclonal antibodies (such as cetuximab), fusion proteins (aflibercept) or small molecule kinase inhibitors (dasatinib, sunitinib, nintedanib). More recent findings suggest that a subset of solid tumors is able to form blood vessel-like structures that can support blood flow. This process is called "vasculogenic/vascular mimicry" and represents an attractive therapeutic target for treatment of solid tumors with a high invasive potential and bad prognosis.

Radioactive aerosol particles in different environments and under different meteorological conditions

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Soon after their formation, radioactive nuclides are attached to atmospheric aerosol particles and participate in the formation and growth of the accumulation mode of aerosol particles (from 0.1 to 2 μm). In this talk, the basic features and definitions of radioactive aerosols together with the appropriate instrumentation that is used for studying radioactive aerosol particles and their behavior in the atmosphere will be presented. The behavior of naturally occurring radioactive aerosol particles (especially ^{210}Pb and ^{7}Be) and their behavior in various environments, including the Arctic, will be discussed. Specifically, ^{7}Be with the advantage of relatively easy determination and a life-time long enough to allow for long-distance transport and short enough to prevent long-term accumulation of the isotope in large reservoirs and has been widely used as a tracer in atmospheric science. The consequences of nuclear tests and nuclear accidents due to the dispersion of aerosol particles in short and long distances as well as the size distribution of radioactive aerosol particles in many European countries immediately after the Chernobyl and Fukushima accident will be also presented.

Thermal ionization mass spectrometry measurement of ^{90}Sr as a challenge in Fukushima samples

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Fukushima Dai-ichi Nuclear Power Plant (FDNPP) accident contamination is dominated by the fission products like (I, Te, Be, Cs, Sr isotopes, etc.). Typically, the fission products are neutron rich isotopes therefore beta particles will be released from the nucleus to reach stable isotope configuration. This decay process is commonly accomplished with gamma ray emission therefore gamma-ray spectroscopy is applied primary for fission products determination in samples affected by nuclear accident. However, some fission products such as ^{90}Sr, ^{89}Sr; are pure beta emitters. ^{90}Sr ($t_{1/2}$ = 28.8 y) is one of the most common and hazardous fission products released by a nuclear reactor accident. Due to its chemical similarity to calcium, accumulates in bones and irradiates bone marrow, causing high radio-toxicity. Therefore, to assess ^{90}Sr is important in case of a nuclear disaster. Measurement of ^{90}Sr using radiometric methods is a time-consuming process since it involves a complex sample preparation and analytical separation required to produce reliable data.

Soil samples contaminated with radiocaesium due to Fukushima accident were collected from exclusion zone in Fukushima Prefecture. Soil samples were digested using conc. HNO_3, HF and $HClO_4$. The contamination of ^{90}Sr is significantly lower, by four or five magnitudes than radiocaesium isotopes. A resin called DGA (N,N,N_N_ tetraoctyl-1,5-diglycolamide) and Sr spec resin were used for efficient chemical separation prior to mass spectrometry method.

Thermal ionization mass spectrometry (TIMS) is the technique of choice because of its inherent high precision and accurate measurement of isotopic ratio. Typical abundance sensitivity for strontium isotope ratio measurement with conventional TIMS is about 10^{-7}. By the use of a special lens like the WARP filter for TIMS, an upper limit of 1.0 x 10^{-10} was achieved. A new ^{90}Sr analysis method was developed using the Isotopx Ltd., Phoenix X62 TIMS. The abundance sensitivity for the $^{90}Sr/^{88}Sr$ ratio was 2.1×10^{-10} and this could ensure detection limit of 100 $Bq\cdot kg^{-1}$ (19 $fg\cdot g^{-1}$) ^{90}Sr in Fukushima soil samples. The method has been validated using two certified reference materials e.g. wild berry (IRMM-426) and freshwater lake sediment (NIST-4354). This mass spectrometry method is faster than conventional radiometric techniques.

Dynamics of irradiation: From molecules to nano-objects and from material science to biology

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We discuss microscopic mechanisms of irradiation in clusters and molecules. We consider the case of isolated molecules/clusters [Phys. Reports 337(2000)493] and/or in contact with an environment [Phys. Reports 485(2009) 43]. We use Time Dependent Density Functional Theory (for electrons) coupled to Molecular Dynamics (for ions) and follow explicitly in time both irradiation and response of the system. Examples are taken from free metal clusters, from fullerenes, from molecules of biological interest and from clusters deposited on a surface or embedded in a matrix [Phys. Reports 485(2009) 43, Int. J. Mass Spect. 285(2009) 1430, Eur. Phys. J. D 58 (2010) 131, Rev. Mod. Phys. 82(2010) 1793]. We analyse in particular the properties of emitted electrons (photo electron spectra, angular distributions...) which constitute a key tool of analysis of the properties of irradiated clusters and molecules [Rev. Mod. Phys. 82(2010) 1793, Phys. Reports 562(2015)1]. We also discuss the possibility of pump and probe scenarios (opening the road to manipulation at the molecular scale) with help of dedicated laser pulses, exploring in particular very short times scales down towards the attosecond domain [Phys. Rev. Lett. 111(2013) 033001].

Natural radioactivity in waters in selected regions of uranium ore mining in Poland

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The Sudety Mts. region is characterized by an increased γ-ray background, an enhanced ^{226}Ra level in rocks and uranium ore mining hold in the 1950s and 1960s. Underground water flowing through uranium-containing rocks, as a result of interaction with rocks can "enrich" itself with radioactive elements, which in consequence may penetrate into the human body with consumed water.

10 water samples were studied for the presence of isotopes: ^{222}Rn, ^{226,228}Ra, ^{234,238}U, taken from the vicinity of the former uranium mine in Kletno and Kowary. Radon and radium isotopes content was determined using the WinSpectral a/b 1414 (Wallac) liquid scintillation counter, for radium determination preceded by the radiochemical analysis. The α-spectrometer 7401 VR (Canberra-Packard) was used to determine ^{234,28}U isotopes content of in water samples. Chemical separation of uranium was performed using ion exchange chromatography.

Some of the studied waters were used for drinking purposes. Therefore, the annual effective doses resulting from the ingestion of isotopes with water and the chemical risk associated with the consumption of uranium with water were estimated. The obtained activity concentrations were compared with earlier studies of the radioactivity content in waters of the Sudety Mts.

Indoor and outdoor origins contributing to indoor exposure to radioactive alpha activities in occupied homes

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As radon decays indoors, the immediate radon progeny are generated as charged metal ions, which attach on existing indoor particles. When the attached radon progeny are inhaled, alpha radiation can interact with tissues in the lungs and other organs leading to DNA damage potentially causing cancer. In order to evaluate indoor and outdoor origins contributing to indoor exposure to radioactive particle α-activity from short and long lived progeny, we measured indoor levels of $PM_{2.5}$, radon, particle α-activities from radon progeny in the family rooms and the basements of 25 occupied homes in metropolitan Boston. Outdoor $PM_{2.5}$ filters were collected simultaneously at a HSPH Supersite located in downtown Boston. Particle α-activity from short lived progeny was measured with an electret radon progeny integrating sampling unit, which collects radon progeny on a filter and registers the α-activity from the deposited progeny during sample collection. Particle α-activity from long-lived progeny on particle filters was counted using a low background proportional counter after 1.5 years of storage, followed by sulfur analysis using an energy dispersive X-ray fluorescence spectrometer. Indoor levels of radon (105 Bq/m^3) and short-lived α-activity (63.9 Bq/m^3) were about three times higher in basements, whereas the levels of $PM_{2.5}$ (6.7 $\mu g/m^3$), sulfur (0.2 $\mu g/m^3$) and long-lived α-activity (1.09 mBq/m^3) were at most two times higher in family rooms. Indoor levels of short lived α-activity was positively correlated with radon (R^2=0.55, $p<0.001$; n=25), whereas the short lived α-activity was negatively correlated with indoor/outdoor (I/O) sulfur ratios that is an indicator of infiltration (R^2=0.29, p=0.087; n=11). A regression analysis with indoor sulfur estimated that indoor long lived α-activity was contributed by 42% indoor radon decay and 58% outdoor origin. Since a poor correlation (R^2=0.07, p=0.081; n=42) was found between indoor and outdoor long lived α-activities, indoor levels were predicted with covariates of outdoor levels adjusted with outdoor I/O sulfur ratio and weather variables including ambient temperature, precipitation, and planetary boundary layer height. The relationship between the prediction and indoor levels was moderate (R^2=0.59, $p<0.001$; n=37), indicating that indoor long lived particle α-activity might be mainly dominated by local outdoor origins.

Tritium and carbon-14 in releases of nuclear reactor facilities of various types

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According to INPRO Methodology for Sustainability Assessment of Nuclear Energy Systems, IAEA considers tritium and carbon-14 as ones of the most important factors of environmental impact from nuclear power plants and facilities for reprocessing irradiated fuel. Controlled release of radionuclides into the atmosphere is a legitimate practical method of handling radioactive materials used in the nuclear industry and related areas. An important and necessary component of releases control is continuous monitoring. Tritium and carbon-14 are included in the monitoring program of emissions at more than 90% of European nuclear power plants.

During the operation of a nuclear reactor, ^{14}C is discharged into the atmosphere from the ventilation system pipes. It is mainly produced by neutron activation reactions of ^{17}O, ^{14}N, ^{13}C in the nuclear fuel elements, construction materials, moderator and coolant, also by ternary fission reaction of uranium and plutonium in the nuclear fuel.

Under normal conditions, the entry of tritium into the atmosphere occurs from sources with organized (pipes of the ventilation system) and unorganized (spray pounds and technological reservoirs) emissions. It is produced by neutron activation of ^{2}H, ^{3}He, ^{6}Li, ^{10}B in moderator and coolant, boron control rods and nuclear fuel elements.

To estimate the tritium and ^{14}C intake into the atmosphere as a result of air emissions from European NPPs, the specific emission indexes (GBq / (GWh)) for the last 20 years were calculated. These indexes were obtained from reporting information of the European Commission on annual emissions of European NPPs and IAEA data on the generation of electricity at nuclear power plants. Based on the calculated indexes, all nuclear power plants in Europe were divided into 3 groups: with the best, sustainable and worst practices of tritium and ^{14}C releases.

To estimate the activity of tritium and carbon-14 in releases of the research nuclear reactor, an experimental sampling device these radionuclides was developed. This method allows to measure tritium and ^{14}C concentration via barbotage with lower threshold of sensitivity not higher than 5 Bq/m^3 and 7 Bq/m^{3}respectively.

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Comparison of energy response function of stilbene, BC501 and EJ309 neutron-gamma detection system

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The paper discusses the energy response of a single crystal stilbene and 2 liquid scintillator detector BC501 and EJ309 to a range of neutrons and gamma energies generated using a 1.7MV Tandetron accelerator at IIT Kanpur. Stilbene being a solid-state composite organic detector is used as an alternate choice for combined neutron-gamma detection. Studies have shown that stilbene's light output response is similar to BC501. Works have also claimed a linear response of stilbene to neutrons for neutrons less than 5 MeV. In this work, neutrons are generated using the IIT-Kanpur 1.7MV Tandetron using C(Li^7,n) reaction. Next, we measure the pulse height distribution of various neutron energies incident on stilbene, BC501 and EJ309 of the same dimensions. The response of all the organic crystals of the study to neutrons using the Tandetron is performed on energy spanning the fission neutron energy range. GEANT4 is used for simulating the reaction and detector response behaviour. GEANT4 simulation allows a detailed analysis of detector response physics for the advancement of detector development for nuclear security applications.

Study of photo-neutron dosimetry spectrum using NTDs

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In this work, by high energy photons from medical linear accelerators the induced-photo-neutrons was measured by CR-39 nuclear track detectors NTDs. Coated thin layer of natural boron is used as a converter with LR-115 in order to measure the thermal neutron dose through the (n-α) reaction. CR-39 is used in contact to the coated LR-115 to measure both of fast and thermal neutrons respectively. High Photon energy spectra from Elekta medical linear accelerator of 15 MV were used. From results of this work, the measured thermal neutron dose was relatively smaller than to that of the fast neutron dose in case of direct exposure was cleared. On the other hand, the ratio of fast to that of thermal is less than that of direct exposure in the case of measurements on phantom and upon the use of buildup Perspex sheets.

Core modeling of the research reactor IEA-R1 with the MCNP-6.2 computational code

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The objective of this work is to develop the modeling of the IEA-R1 reactor core with the MCNP-6.2 computational code that was recently acquired. The main advantage of this new version of the code is the performance of burnup calculations of the fuel elements. This modeling will be valid by comparing the thermal and epithermal neutron flux obtained in the calculations with the MCNP-6.2 and the fluxes measured with the activation of gold foils (Au) with and without cadmium coating (Cd) in the same positions of irradiation and, with the same arrangement of fuel elements in the reactor core.

After the validation of this model, the idea is to use it for the burnup calculations of the fuel elements that are fundamental for a correct management of the reactor core. Currently, the management of the core is carried out by deterministic codes that are very old and have many approximations leading to very conservative results, for example, TWODB, HAMMER, and CITATION.

Keywords: Neutron flow, burnup of the fuel element, MCNP-6.2

Study and development of neutron detectors using doped CsI crystals

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In the development of nuclear radiation detectors one must take into consideration the process of interaction of the radiation under study with matter.

In the case of neutron detectors it must be considered that the detection of neutrons is not trivial in view of the lack of charges of these particles and the peculiarity of their interactions with matter. Another difficulty in the detection of neutrons consists in the discrimination of the electronic impulses generated by the neutrons of those generated by other radiations, almost always present. The main propositions of neutron-sensitive detectors consist of gaseous detectors, scintillators and semiconductors. These detectors intrinsically are not sensitive to neutrons, so they need a radiation converter based on nuclear reactions of the type: Neutron + Converter -> Detectable radiation.

Some reactions with neutrons are more used, such as: ^{10}B (n, α), ^{6}Li (n, α) and ^{3}He (n, p).

Neutron-scintillation crystal are being the object of active research in several research centers and having their implementations in several applications.

The development of new radiation detectors using scintillation crystals, which increases response speed, dose and energy accuracy and, at the same time, the feasibility of simplifying and reducing costs in the production process is always necessary.

In the CTR-IPEN laboratory, pure and doped CsI crystals were grown using the Bridgman technique.

This work shows the obtained results using doped CsI scintillator with the converters: Br, Pb, Tl, Li as neutron detectors.

Optical properties and radiation response of Li ion-doped CsI scintillator crystal

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Scintillators are materials that convert the energy of ionizing radiation into a flash of light. Due to the existence of different types of scintillators themselves, they were classified into three groups according to their physicochemical characteristics, namely, inorganic, organic and gaseous scintillators. Among the inorganic crystals, the most used as scintillator are constituted of alkali metals, in particular alkaline iodides. Scintillation materials are used in many applications, such as medical imaging, security, physics, biology, non-destructive inspection and medicine. In this work, lithium doped CsI scintillator crystals were grown using the vertical Bridgman technique. The concentration of the lithium doping element (Li) studied was 10^{-4} M to 10^{-1} M. Analyses were carried out to evaluate the scintillators developed concerning to luminescence emission and optical transmittance. The luminescence emission spectra of these crystals were measured with a monochromator for gamma radiation from ^{137}Cs source excitation. The optical transmittance measurements were made in the CsI;Li crystal, in a spectral region of 200 nm to 1100 nm. Determination of the dopant distribution along the crystalline axis, allowing to identify the region with Li concentration uniformity, which is the region of the crystalline volume indicated for use as radiation detector. The crystals were excited with neutron radiation from AmBe source, with energy range of 1 MeV to 12 MeV. As with neutron sources also generate gamma radiation, which can interfere with the measurement, it is necessary that detector be able to discriminate the presence of such radiation. Accordingly, experiments were performed using gamma radiation in the energy range 59 keV to 1333 keV in order to verify the ability of the detector to discriminate the presence of different types of radiation.

Utilization of wipe methods to determine the areal activity of selected surfaces of the urban infrastructure

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Within the research tasks “Modern methods of detection and identification of dangerous CBRN substances and materials, methods of their decontamination and reduction of hazards, modern means of protection of persons”, they have been looking for an optimum ways to measure areal contamination after a dirty bomb blast containing the radioactive material. To determine the extent of the surface contamination of the surface and the contaminant type we used the wipe method. This method was applied to selected surfaces of the urban infrastructure which were a cobblestone, interlocking pavement, tiles, plastic windowsill, and glass. At the same time, we were monitoring the effect of the detergent agent on the wipe. As the detergent agent, we used 5% aqueous solution of dishwashing liquid, 10 % aqueous solution of RDS 2000, 3 % aqueous solution of ODS-5 detergent and denatured alcohol. The wipe method was used to estimate the areal surface activity value contaminated by lanthanum-140. Based on the results obtained, it can be stated that the wipe method is suitable to estimate the areal surface activity on glass or windowsill, where the efficiency of given method exceeded 80% of the applied activity, but it is useless for the surface of cobblestone or interlocking pavement where the efficiency did not exceed 30 % of applied activity.

Assessment of elemental B content in industrial diamonds using PGAA and Co, Fe, Ni, Cr, Mn and Si using thermal and epithermal NAA with Compton suppression

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A recent assessment of the elemental boron content in a sample lot of boron-doped industrial diamonds was performed using conventional a neutron activation analysis (NAA) and prompt gamma-ray activation analysis (PGAA) facility at the Nuclear Engineering Teaching Laboratory (NETL) at The University of Texas at Austin. For PGAA three different calibration or standardization methods were evaluated for the determination of boron concentration in the diamond matrix including a relative method using a certified reference material (CRM), a modified relative method using a calibration curve, and the k_0 method using carbon as the known internal reference element. The boron measurement results from each method were compared for accuracy as well as consideration of neutron self-shielding effects on the suitability of each method over a range of concentrations. Strengths and weaknesses of each approach were gauged to identify the most cost-effective PGAA measurement technique for long-term, repetitive analysis of similar sample lots of boron-doped industrial diamonds. The measured concentration results for each method agreed to within 5% for the boron content present in the analyzed sample lot. For NAA the elements determined were Co, Fe, Ni, Cr, Mn and Si. A long irradiation procedure with a thermal flux was used for Co, Fe, Ni and Cr as the target nuclei have good thermal cross sections and the activation products of these elements are long lived. A short irradiation procedure with epithermal flux was used for Mn and Si as these elements have larger resonance integrals and their activation products are short lived. Compton suppression was also used for Ni, Cr and Si. Quality control was done using NIST reference materials.

The Ruthenium-106 event, September-October 2017: Review and open questions

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In late September 2017, traces of ^{106}Ru were recorded by air sampling stations in large parts of Europe. In some regions, over 100 mBq/m^3 were measured as one-day means. Although resulting exposure was far below radiological concern, the event aroused considerable interest, because this radionuclide is found only very rarely in environmental media. Earlier events involving ^{106}Ru were the Chernobyl accident and a few incidents in nuclear reprocessing plants.

The main exposure pathway was through inhalation, leading to up to about 0.3 mSv regionally. Other pathways are negligible in comparison. The geographical distribution of exposure and inhalation dose, inferred from monitoring results, is heterogeneous across Europe, reflecting weather conditions at the time. Mainly affected areas are Central to Eastern Europe [https://doi.org/10.1016/j.jenvrad.2019.05.004].

Two years later, the origin of the Ru is still a mystery. The Ru found in 2017 was not associated with other radionuclides except minute traces of ^{103}Ru. Therefore, a reactor accident can be excluded. Meteorological calculations performed by several institutes unanimously led to a plausible region of origin in the Southern to Northern Ural region. However, Russian authorities denied any releases by civilian nuclear installations in the region.

In this presentation, we focus on summarizing dose calculations and the geographical distribution of dose. We also review documented accidents and incidents involving radioactive ruthenium. Finally, we report on talks with Russian authorities about the incident, and speculate about circumstances of the release and its likely origin as *argumentum e silentio*.

Although the incident has happened about 2 half lives of ^{106}Ru ago (376 days), we think that with today's possibilities of radiometric monitoring, and appropriate monitoring scheme, it should still be detectable in the environment in the trace of the plume not too far from the point of emission.

Keywords: Ruthenium-106 incident, dose, nuclear forensics

Radioecological monitoring of aquatic ecosystems in the vicinity of Rooppur NPP (People's Republic of Bangladesh)

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In 2017, the construction of NPP Rooppur with two VVER power units (Russian design) started in the People's Republic of Bangladesh. This NPP project is performed within the IAEA recommendations and supervision. The Rooppur NPP site is located on the east bank of the Padma River, 160 km north-west of the capital city of Dhaka. In 2014-2017, based on a comprehensive survey of the 30-km zone of the Rooppur NPP, a radioecological monitoring system of freshwater ecosystems was created. A detailed program of radioecological monitoring was developed, and observation points were selected and surveyed. The monitoring objects, the list of observable parameters, the monitoring schedule and methods and the regulatory support were identified.

There are significant seasonal differences in climatic characteristics of the considered area, which greatly affect the water regime of Padma. During the monsoon season, the water in the Padma River rises by 6-8 m, and in winter, its level drops to a minimum. So, radioecological monitoring of the considered area was conducted at different times of the year: Aug. (2014), Apr. (2015), Dec. (2016) and Jun. (2017). The survey of freshwater ecosystems was fulfilled in Padma riparian waters, and its streams and canals were examined. A total of 20 observation stations upstream and downstream from the Rooppur NPP site were selected and surveyed. Samples of surface water, sediments and aquatic vegetation, as well as the samples of drinking water, were taken. The radionuclides content in the components of freshwater ecosystems is the following:

- Surface water of the Padma River: ^{40}K – 0.3-2.3 Bq/L, ^{90}Sr – 0.03-0.23 Bq/L, ^{137}Cs – 0.01-1.5 Bq/L, ^{3}H – 0.8-2.1 Bq/L;

- Bottom sediments: ^{40}K – 350-852 Bq/kg, ^{90}Sr – 0.05-3.5 Bq/kg, ^{137}Cs – 0.01-3.1 Bq/kg, ^{3}H – <3 Bq/kg;

- Aquatic flora: ^{40}K – 347-924 Bq/kg, ^{90}Sr – 0.05-3.9 Bq/kg, ^{137}Cs – 0.01-2.6 Bq/kg, ^{3}H – <3 Bq/kg;

- Drinking water: ^{40}K – 0.45-1.1 Bq/L, ^{90}Sr – 0.01-0.07 Bq/L, ^{137}Cs – 0.01-0.08 Bq/L, ^{3}H – 0.4-1.2 Bq/L.

The intervention levels for drinking water according to Russian standard NRB-99/2009 are 4.9 Bq/L for ^{90}Sr, 11 Bq/L for ^{137}Cs and 7600 Bq/L for ^{3}H.

The global natural background of ^{3}H is assumed as 2.2±0.7 Bq/L, and the technogenic background is 5 Bq/L. Thus, ^{3}H content in surface waters of the Padma River near the Rooppur NPP is in the range below the average global value and several orders of magnitude below the level of intervention. The same situation was for ^{90}Sr and ^{137}Cs.

The results of the radioecological monitoring of freshwater ecosystems in the 30-km zone of the Rooppur NPP conducted in 2014-2017, allow concluding that the environmental situation in this region is safe. The established monitoring network will let registering changes in the situation and identifying the impact of the NPP operation on the environmental situation in the region.

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Environmental risk assessment of bauxite residue by determining toxic elements and natural radionuclides

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Bauxite residues (red mud) produced by digestion of bauxite ore during the production of alumina contain naturally occurring radionuclides such as ^{238}U, ^{232}Th and ^{40}K and toxic elements such as Al, Cr, Co, Mn and Ni. In this research, red mud collected from Eti Seydisehir Aluminium Plant in Turkey was studied to determine the concentration of natural radionuclides and some toxic elements. Furthermore, short-term leaching tests of elements and radionuclides were undertaken on the red mud by Toxicity Characteristic Leaching Procedure (TCLP)-1311 method to evaluate in terms of the environmental impact. The activity concentrations of $^{234,235,238}U$, ^{232}Th and ^{40}K, and toxic elements contents in red mud and leachate samples were determined by neutron activation analysis and Compton suppression methods. The method was tested with certified reference materials such as SRM 1632d, 1633c and 2709a from the National Institute of Standards and Technology (NIST). Elemental calibration for NAA was done using NIST traceable liquid standards from Inorganic Ventures with the exception of barium and strontium (NIST 1632d) and cesium and potassium (NIST 2709a). Liquid standards and leachate samples were hermetically heat sealed in polyethylene vials for neutron irradiation. The results which are obtained from reference materials indicated that the method can be successfully applied for the determination of multiple elements. We observed from the obtained results that the major elements in red mud are Fe, Al, Na, Ti and Ca. The concentration of these elements in red mud sample was found significantly high. Other elements such as Th, Zr, Cr, Ni, Ce, V, Nd, Mn, La, Sc and As observed in red mud were found in smaller concentrations compare to the major elements. The results from potential ecological risk factors of red mud except Arsenic were found below the threshold value that indicates these metals (Ni, Cr, Mn and Co) have a low risk to the surrounding environment. On the other hand, it can be observed from the results of both of the leachate samples that there is no significant mobility in elements of under investigated conditions. The results demonstrate that these elements are not easily mobile under environmental conditions. However, it is required to obtain further information about leaching behaviour of these elements for estimating the magnitude of the red mud's environmental impact.

Evaluation of radioactivity in Montenegro soil using a statistical approach

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Surface soil from 47 locations in Montenegro had been previously analyzed for radioactivity due to natural ^{226}Ra, ^{232}Th, ^{40}K and man-made ^{137}Cs, and showed mean activity concentrations around 41.1, 45.8, 500 and 95.2 Bq/kg, respectively. Discriminant Analysis used in the present study for the classification, with activity concentrations of radionuclides as independent variables and Montenegro region (South, Center, North) as grouping variable, showed 76.6% of original grouped cases as correctly classified. For the hazard indices estimated from natural radionuclide activity concentrations – radium equivalent activity (with a mean of 142 Bq/kg), external and internal hazard index (with a mean of 0.39 and 0.5, respectively), as well as external terrestrial gamma absorbed dose rate (with a mean of 67.5 nGy/h – for natural radionuclides only, and 79.3 nGy/h for natural radionuclides and ^{137}Cs) and corresponding annual effective dose (0.08 mSv and around 0.1 mSv, respectively), together with radionuclide activities, the factor analysis was also performed with Principal Component Analysis as the extraction method and Varimax with Kaiser Normalization as the rotation method. Two components were extracted. The first one loaded basically on ^{232}Th and ^{226}Ra activity explained ~80.6% of the total variance, while the second component explaining ~12.2% of the total variance is found to be strongly correlated with ^{137}Cs and ^{40}K activity.

Heavy metals and radionuclides in muscles of fish species in the South Adriatic – Montenegro

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This paper deals with the concentration of Pb, Cd, Cu, Fe, Mn, Ni, Cr and Zn, and activity concentrations of ^{137}Cs, ^{40}K, as well as levels of ^{226}Ra and ^{232}Th through their daughters ^{214}Bi and ^{228}Ac, in muscles of six fish species from the South Adriatic Sea adjacent to Montenegro. Specimens of three mullet species from the Liza genus – Liza aurata (golden grey mullet), Liza saliens (leaping mullet) and Liza ramada (thinlip grey mullet), were caught by a trawl net in the area of Tivat – Boka Kotorska Bay, as well as Merluccius merluccius (European hake), Dicentrarchus labrax (European seabass), Sparus aurata (gilthead sea bream). Element concentrations were determined in a standard procedure using iCAP 6000 ICP-OES and atomic absorption spectrophotometer AA-6800, whilst radionuclide activity concentrations – in a standard HPGe ORTEC gamma spectrometry. The results showed a level of ^{137}Cs somewhat lower than in muscles of previously analyzed the other (mullet) species from the South Adriatic, in contrast to ^{214}Bi level which is mostly found to be slightly higher than its parent (^{226}Ra) level in the other previously analyzed species. Committed effective dose from annual intake of radionuclides due to an adult fish consumption is found to be highest for M. merluccius (13.8 μSv) showing all the radionuclides above minimum detectable activity. In muscle of L. aurata element concentrations were found to be ordered as: Fe>Zn>Cr>Mn>Ni>Cu>Pb>Cd. This species showed concentration of each element higher than the other species (particularly Pb, Fe, Mn, Ni and Cr). The concentration of Zn only could be considered as more or less comparable in all the muscles. No one muscle showed concentration of toxic trace elements Pb and Cd exceeding limits from the national and the EU regulations. A potential health risk associated with Pb and Cd intake due to consumption of analyzed fish species is estimated using the target hazard quotient found to be <=0.055.

Keywords: Fish, radionuclides, essential elements, toxic metals, health risks, Montenegro

On the use of neutron activation analysis to probe the air pollution using plant biomonitoring – Egypt

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A comprehensive characterization of the biomonitoring of metals for air pollution assessment using *Eucalyptus Globulus* and *Ficus Nitida* plants in Cairo and Minoufia cities in Egypt is given. The concentration (ppm) of thirty-two elements was determined in 30 leaves samples by means of epithermal neutron activation analytical technique. The collected samples were irradiated by epithermal neutrons at REGATA -pulsed reactor IBR-2 in Dubna, Russian Federation. The obtained concentrations of; Na, Mg, Al, Cl, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Zn, As, Se, Br, Rb, Sr, Sb, I, Cs, Ba, La, Sm, Tb, Hf, Ta, Au, Th, and U were compared with those published worldwide. The descriptive statistics of the obtained concentration revealed that the concentrations in Minoufia governorate is significantly higher than, those in Cairo, in spite of the intense population, heavy traffic, and vehicles waste disposed in Cairo. The remarkable increase of metals in Minoufia governorate was most probably due to the uncontrolled disposal of industrial and domestic waste. In addition, the study shows the *Ficus Nitida* plant responsiveness to metals is higher than *Eucalyptus Globulus*.

Keywords: Plant biomonitoring, air pollution, NAA, heavy and trace elements

Interception effect of radiocesium by forests after the Fukushima nuclear accident

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The accident at the Fukushima Dai-ichi Nuclear Power Plant (FDNPP) dispersed radionuclides across large areas of northern Japan in March 2011. Forest areas, except those within the vicinity of residential areas, have been excluded from the decontamination plan and left untouched. Some results from continuous monitoring of radiocesium inventory on the forest floor demonstrated a clear increasing trend for a few years after the deposition because of weathering- and litterfall-derived radiocesium transfers from tree crowns. Thus, exact inventories of forest floor should be estimated at least a few years after the deposition. A higher radiocesium accumulation in forest floors compared to nearby flat lands is sometimes observed and is recognized as the "interception effect of forest." Estimation of this effect is particularly important for people living in vicinities of forests and/or making a living by forestry. Although this effect is estimated from the Chernobyl accident case, few studies comparable to this estimation exist in the case of the FDNPP accident. Estimating the effect for the FDNPP accident is of scientific interest because of the differences in conditions between the Chernobyl and the FDNPP cases, such as vegetation and climate.

Here, we provide data showing ^{137}Cs inventories seven years after the FDNPP accident in nine forest floors, and compare it with those of varied vicinities 50 m outside of the forest boundary. These forests are situated approximately 15–200 km from the FDNPP and they vary in their major constitutive tree species (i.e., Japanese cedar, hinoki cypress, red pine, and mixed broad-leave trees). Four to twelve samples of the surface layer of soil (up to 5 cm), litter, and non-degraded organic layers inside and outside the forests were taken to measure their ^{137}Cs concentrations and the inside/outside ^{137}Cs inventory ratios were calculated.

The results demonstrated that the "interception effect" was partially obvious. Although all the observed inside/outside ^{137}Cs inventory ratios were greater than 1.0 (1.1–3.6, 1.9 on an average), it was statistically significant only in five out of the nine forests. These results appear greater than that of the case of Chernobyl case, where the accumulation amount in forest floor was up to 30% higher than that in nearby grassland. Although the effect was prevalent, a large variation in the forest inventory could sometimes mask the significance. In addition, differences in conditions, particularly in major constitutive tree species, may affect the results. The results will be further discussed using the Japan Atomic Energy Agency's monitoring data nearest to our sampling points.

Using the ^{14}C activity measurements in tree rings near Ignalina Nuclear Power Plant to examine dilution peculiarities of the gaseous releases from the NPP

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Atmospheric ^{14}C is produced by the natural process of cosmic radiation interaction with Earth atmosphere as well as by anthropogenic human activities [1]. Almost double concentration of the anthropogenic radiocarbon appeared in the atmosphere as a result of intensive nuclear weapon testing back in the 1960's. After moratorium of the tests, introduced since 1963, the ^{14}C activity in the global atmosphere is declining. However, considerable amounts of ^{14}C in the nuclear reactors are generated by neutron radiation interaction with ^{17}O, ^{14}N and ^{13}C. It accumulates in reactor vessel components, coolant and cleaning systems, and is partly released into environment mainly in a form of $^{14}CO_2$ and $^{14}CH_4$. RBMK-1500 type graphite moderator reactors were exploited at Ignalina NPP (Lithuania): Unit 1 - 1983-2004; Unit 2 - 1987-2009. Over decades $^{14}CO_2$ gas releases from NPP accumulates in local biosphere by photosynthesis, while increasing overall radiation background.

In order to examine the temporal variations and dilution peculiarities of the released radiocarbon gaseous effluents from Ignalina NPP, there were extracted 9 pine tree cores around the INPP which were separated to 410 tree ring samples (time span 1980-2017) to determine the overall increase of radiocarbon concentration in NPP surroundings as compare to 3 tree cores from background rural area at Vaikšteniai. Paired tree core samples, taken at the unidirectional sampling sites (located to the south direction form INPP at the 1.8 and 5.1 km, to the west direction at the 2.6 and 4 km, and to the north-east direction at 1.9 and 6.6 km), were examined in detail by considering meteorological data records from the Ignalina NPP local meteorological station (2004-2015) in order to trace atmospheric dilution effectiveness of ^{14}C released from the 150 m height INPP ventilation stacks.

Samples were physically and chemically (BABAB) prepared [2], graphitized with AGE-3 (IonPlus AG) [3] and measured at Vilnius Radiocarbon SSAMS (NEC, USA) facility [4].The results showed a pronounced increase of ^{14}C up to 17.8 pMC in the tree rings during INPP exploitation as well during decommission periods. Year-by-year tree rings ^{14}C concentration data analysis of unidirectional samples revealed high variation of the atmospheric dilution conditions, which resulted in average about 130% variation of dilution effectiveness peaked up to about 300% for some years.

Scaling properties of the beryllium-7 activity concentrations in the surface air in Fenno-Scandinavia

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Beryllium-7, a cosmogenic radionuclide, attaches to aerosols promptly after its formation and thereon descends from the upper troposphere and lower stratosphere to the surface. At the surface, this isotope's activity concentration is closely monitored as a part of radioactivity measurements in many countries. Since the abundance of beryllium-7 offers an insight into the processes that take place along its trajectory through the atmosphere, it is considered a tracer of air mass history. For this reason, there is an incentive to fully understand its behaviour and the mechanisms that correlate it to meteorological parameters. Our analysis, therefore, looks into one particular aspect of this question – autocorrelation properties of the beryllium-7 records that imply a manner in which this radionuclide's activity concentration changes with time.

The analysis is performed on the measurements taken at three Fenno-Scandinavian sites north of 55 °N: Helsinki (Finland), Kista (Sweden) and Risoe (Denmark), given here in order of descending latitude. The data are taken from the Radioactivity Monitoring Environmental Data Bank (REMdb) and span 1987-2013 for Helsinki, and 1995-2013 for Kista and Risoe. The Helsinki data series is longer and with a higher temporal resolution (approximately once in two days) than the Kista and Risoe series (approximately once a week). For each site, we investigate the wavelet power spectrum and look into the scaling properties of the time series, as well as its trend and periodicities.

One of the results that the wavelet analysis offers is a power spectrum scaling exponent β, which is related to the decay of the autocorrelation function of a time series, and effectively points to the existence of a temporal trend. A stationary time series is regarded as long-term correlated for β between 0 and 1. Our study gives β values of 0.77, 0.56 and 0.63 for Helsinki, Kista, and Risoe, respectively. This finding implies a trend in all of the investigated beryllium-7 records, with the strongest trend detected for Helsinki. In addition, the investigated wavelet power spectra show local maxima corresponding to characteristic time intervals of the series. The most prominent peak in each spectrum points to the seasonal cycle, i.e. a periodicity of one year.

A further wavelet analysis of the meteorological parameters, such as temperature and precipitation, could shed more light on their possible correlation with the beryllium-7 trends, and, in turn, these findings could allow us to evaluate this radionuclide's full potential as an atmospheric tracer.

Comparison of the beryllium-7, lead-210 and caesium-137 activity concentrations in the surface air along 45 °N in Serbia and Slovenia

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Activity concentrations of cosmogenic beryllium-7, terragenic lead-210 and artificial caesium-137 are closely observed within environmental radioactivity monitoring programmes in Serbia and Slovenia. In this study, we compare the temporal evolution and seasonal cycles of the radionuclides recorded over 1991–2015 in three locations: Belgrade (44.88333 °N; 20.583333 °E; 95 m a.s.l.), the capital of the Republic of Serbia; Krško (45.950414 °N; 15.512261 °E; 204 m a.s.l.), a town in eastern Slovenia, located ~400 km west of Belgrade; and Ljubljana (46.042356 °N; 14.487494 °E; 292 m a.s.l.), the capital of the Republic of Slovenia, located ~500 km west of Belgrade. The latitudes of these three sites differ only slightly, approximately by 1°.

The similarities between the data sets are evident from their measurement ranges and long-term means. For example, the recorded beryllium-7 activity concentrations fall within the ranges reported for different locations in Europe. In the lead-210 series, the observed values are similar to the activity concentrations reported for some neighbouring regions, but around twofold higher than in locations that are under a significant maritime influence, thus removed from this radionuclide's source. The activity concentrations of caesium-137 at all the sites are of the same order of magnitude and agree with the post-Chernobyl picture of the fall-out in Europe.

However, there are some noticeable differences in the seasonal cycles of these radionuclides at the investigated sites. For example, even though the beryllium-7 seasonal cycles in all the sites exhibit a spring/summer maximum and a winter minimum, the timing of the maximum recorded at the Slovenian sites is agreement with other Western European sites of similar latitude in contrast to the Belgrade site that shows an earlier occurrence of the maximum, more in line with European locations further north.

A possible explanation for the observed dissimilarities could lie in the differences of the meteorological patterns in the investigated sites. According to Köppen-Geiger climate classification, Krško and Ljubljana have Warm temperate fully humid climate with warm summers (Cfb), while Belgrade is characterised by Warm temperate fully humid climate with hot summers (Cfa). Belgrade is located deeper in the continental landmass, and its climate has more of midlatitude continental characteristics, in terms of higher summer temperature, more pronounced seasonal temperature amplitude, and lower precipitation, especially during summer months. These differences in climate affect the transport and removal of the radionuclides from the atmosphere and could lead to the observed dissimilarities. Still, a detailed analysis of the radionuclides' time series and their relation to the time series of the meteorological parameters is needed to better understand their interconnexion.

Response of *Lactobacillus spp.* in different physiological states to the oxidative stress induced by H_2O_2 and ionizing radiation

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Oxidative stress is implicated in different degenerative processes, e.g. mutagenesis, cell transformation and cancer; heart attacks, chronic and acute inflammatory diseases, and many others [doi:10.1042/bss0610001]. Oxidative damages of cells are attributable also to ionizing radiation exposure [doi:10.1016/j.canlet.2011.12.012]. Free radicals produced by oncology radiotherapy are often a source of serious side effects [doi:10.1016/j.nut.2012.02.014].

The positive role of probiotics in diminishing the incidence of post-therapy inflammation in cancer patients has been shown in clinical applications [doi:10.3390/nu9050521]. Nevertheless, there is still limited evidence in both quality and sample size, suggesting that certain antioxidant supplements may reduce adverse reactions and toxicities [doi:10.1016/j.nut.2012.02.014].

This study was aimed at evaluating the resistance of *Lactobacillus* spp. towards oxidative stress induced by 1 mM H_2O_2 and ionising radiation with absorbed doses in the total volume (2-30Gy), simulating a radio-therapy course for oncology patient. *L. acidophylus* ATCC 314, *L. plantarum* ATCC 14917 and *L. lactis*ATCC 49032 were tested in different physiological states, determined by cultivation conditions: aerobic or anaerobic, in De Man, Rogosa and Sharpe (MRS) or Tryptone Soya Broth (TSB), at 30 °C or 37 °C, respectively. Both media were amended with Tween 80 in order to enhance the bacterial resistance to H_2O_2. Aerobic cultivation was operated in two ways, i.e., on the rotary shaker or in the bioreactor RTS-1 (Biosan, Latvia), thus, providing completely different aeration mode.

The stress response of lactobacilli was evaluated by growth kinetic parameters, number of colony forming units, dehydrogenase activity, as well as antagonistic activity against *Escherichia coli*. The metabolic response of lactobacilli to media with H_2O_2 was estimated by FTIR spectroscopy.

The results of this study showed the strong species-specific tolerance of *Lactobacillus* spp. to the oxidative stress under sertain cultivation conditions. In further studies this approach will bring us closer to the development of more effective probiotic preparations applied for reducing the side effects of radiotherapy.

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Raman spectroscopy of NETosis: Search for spectral biomarker

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NETosis is one of the first protected mechanisms of the immune systems. Neutrophils extracellular traps (NETs) were first described in 2004 by Brinkmann and his colleagues who observed the release of web-like structures by neutrophils after stimulation with phorbolmyristate acetate (PMA). NETosis is the third type of phagocytic antimicrobial protection along with phagocytosis and degranulation. Daily neutrophils fight to protect our body; however, they have some negative influence that may destroy our immune system. Among them are various autoimmune diseases (Systemic lupus erythematosus), preeclampsia, ulcerative colitis, thrombosis.

Raman spectroscopy is a powerful diagnostic tool in life sciences based on vibrational spectroscopy that can detect a specific chemical fingerprint of molecules. Furthermore, it is non-invasive technique, suitable for chemically selective cell imaging and one can avoid many problems associated with the fluorescence microscopy, like photobleaching and photoinduced damage of living organisms due to the presence of exogenous tags. Thereby, study of netosis by Raman spectroscopy method looks as an attractive and proper technique.

The main aim of this study is to reveal a spectral biomarker in neutrophil activation by measuring and comparing the Raman spectra of activated (biologically and chemically) and non-activated neutrophil granulocytes, which will be more detailed in the report.

Trace elements in moss samples using Neutron Activation Analysis

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Mosses are used as bioindicators during the last decades. They collect and retain elements through wet and dry deposition. All the elements are absorbed entirely by moss surface, as there are no roots, in contrast to higher plants. The advantages of the moss technique, such as the simplicity, the low cost of the sample collection and the ease of the analysis make mosses an ideal tool for the determination of the concentrations of trace elements.

Ninety-five samples of *Hypnum cupressiforme* Hedw. were collected in Northern Greece during the summer period of 2016. The moss sampling was performed according to the requirements of the Protocol of the European Survey ICP Vegetation. Mosses were analyzed using the Neutron Activation Analysis (NAA) technique and the concentrations of trace elements were determined. The chemical composition database of the moss samples was further used for the application of source apportionment by Positive Matrix Factorization (PMF), and specifically by the EPA PMF 5.0 model. In total thirty species were used for source apportionment (Na, Mg, Al, Si, Cl, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, As, Br, Rb, Sr, Mo, Cd, Sb, Cs, Ba, La, Ce, Tb, Hf, Ta and Th).

Finally, information about the elemental deposition from the atmosphere to terrestrial systems over the North Greece was provided through the high sampling density. The source apportionment results revealed contribution from five sources: Soil Dust, Aged Sea Salt, Vehicular Traffic, Heavy Oil Combustion and Mining Activities, with Soil Dust displaying the highest contribution to the measured metal concentrations among all other sources.

Assessment of natural radionuclide levels for tea samples in Najaf, Iraq

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In this paper, twenty tea samples that are available in Najaf Markets were tested for their radioactivity contents using gamma-ray spectroscopic measurements NaI(Tl) "3× 3".The specific activity of ^{238}U, ^{232}Th and ^{40}K from tea samples, ranged from 2.87±1.75 to 22.03±1.95 Bq/kg, 5.80±3.45 to 64.74±5.12 Bq/kg and 630.00±13.08 to 1354.67±25.82 Bq/kg respectively. Radium equivalent activity, absorbed dose and various hazard indexes were also calculated to assess the radiation hazard. The lowest value of Ra_{eq} and absorbed dose are 75.45 Bq/kg and 38.20 nG/h while the highest values are 206.35 Bq/kg and 100.65 nG/h. all calculated values for hazard indexes were less than unity.

The tensile breaking strength of *Phragmites australis* (Cav.) Trin. ex Steud leaves as a chronic irradiation effect

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Previously held studies have shown a statistical dependence between of tensile breaking strength leaves *Phragmites australis* (Cav.) Trin. Ex Steud (common reed) and the radionuclide contamination of aquatic ecosystems. Unfortunately, there was no established reliable connection between the strength of the leaves and their irradiation dose, since the accumulation of radionuclides directly into the test leaves was not investigated. The aim of this research is to assess the tensile breaking strength of leaves common reed in depending on the level of chronic internal irradiation by incorporated radionuclides and depending on the accumulated leaves of plant mineral nutrition macroelements. Samples of leaves were taken in six aquatic ecosystems in the Chornobyl exclusion zone. The specific activity of 40K, 90Sr and 137Cs was measured, the accumulation of macro elements of plant mineral nutrition Ca, K, Mg, Na, NH4, as well as Conductivity (mS/cm) and pH. In samples of were measurement tension breaking strenght of common reed leaves. The specific activity of radionuclides and the content of macroelements were carried out directly in the leaves of the samples tested for tensile breaking strength. Measurements of specific activity of 90Sr and 137Cs were carried out using the method of laboratory beta radiometry. The analysis was performed by using a spectrometer of beta energy radiation and gamma spectrometer. Based on the measurement results, the irradiation dose rate of internal radiation of common reed leaves was calculated. The proportion of 40K in the total irradiation dose varies from 0.3 to 10 mcG/h. In this case, the total irradiation dose varies from 0.11 to 2.8 mcG/h. Macroelements of plant mineral nutrition act as antagonists to the damaging effects of ionizing radiation, as evidenced by the inverse correlation between the tensile breaking strength value and the accumulated common reed leaves macroelements. Statistical comparison of samples of leaf strength data with the content of macroelements showed that they belong to the same general population based on the variation coefficient. Pairwise of the samples comparison on the basis of tensile breaking strength common reed leaves taken from surveillance places were made with methods statistical analysis by Kolmogorov-Smirnov and median comparison. The analysis showed that the leading factor establishing the belonging to the populations is irradiation dose. The results of research indicate that the tensile breaking strength of common reed leaves can be considered a reliable test for the irradiation dose of leaves obtained from incorporated radionuclides. The damaging effect of ionizing radiation leads to an increase in the tensile breaking strength of the leaves, and the enrichment with macroelements of mineral nutrition has a radioprotective effect. At the same time, no difference in the effect of the dose from 90Sr and 137Cs on the studied trait was found.

Elemental analysis of TSP samples from Helsinki, Finland for the 1995–2005 period

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In the current study, weekly filters collected in Helsinki, Finland during 1995 - 2005 underwent energy dispersive X-ray Fluorescense (ED-XRF) analysis, for the determination of their content in Pb, Br, Zn, Cu, Ni, Fe, Mn, Cr, V, Ti, Ca, K, Cl, S, Si, Al and Na.

In the Scandinavian countries, the atmospheric background deposition levels decreases as one moves towards the north. This pattern is especially pronounced in the case of lead, vanadium and cadmium. The highest concentrations for those elements are mainly found in samples from South Finland, where Helsinki is located.

The analysis indicates that the observed concentrations of Pb remain relative stable throughout the period 1995 - 2005 with a slight increase trend and values ranging between 7 - 53 ng m^{-3}. Vanadium, which is mainly emitted from coal and oil burning and from refineries, had a clear decline trend. But V, along with other metals such as Zn and Pb, can be characterized as being road-specific heavy metal. Close to roads these metals are mainly derived from combustion residues and losses from fuels and engine, transmission oils and abrasion from tires. V had a relatively high correlation with Ni while its correlation with Pb and Zn was weak. This fact possibly indicates heavy oil source either from the industry or from shipping emissions. The observed concentration of V ranges between 0.37 - 24 ng m^{-3}.

For the elements of Cu and Zn, a high correlation coefficient was observed. The high correlation is an index of traffic source. The average concentration of Cu equals with 30 ng m^{-3} and of Zn with 46 ng m^{-3}. Due to the stabilizing effect of the cold sea surface during the summer months, the difference between winter and summer in air concentrations of elements such as Cu, Zn is small.

The results also indicated a clear declined trend for Fe and Ca, an element which is related to construction works. A slight decrease for Ti and Si was also observed. The correlation coefficients between these elements indicate the existence of soil source. The observed average concentration of Fe, Ca, Ti and Si in the present study equal with 162 ng m^{-3}, 136 ng m^{-3}, 12 ng m^{-3} and 224 ng m^{-3} respectively.

A decreased trend in sulphur was also observed, with values ranging between 135 - 2008 ng m^{-3}. The levels of harmful atmospheric S are currently low in Finland as compared with those in many other European areas. The observed decrease is the result of reductions of emissions from energy production, reduced use of industrial fuel oil, the introduction of new alternative energy sources, as well as improvements in the production methods in many industries.

The Metro Radon project as support for the implementation of the Basic Safety Standards

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The European EURATOM Basic Safety Standards (BSS; EC 2014, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2014:013:FULL&from=EN) include, among many other fields of radiation protection, regulation about radon in dwellings and workplaces. Three articles are dedicated to radon - radon in workplaces (Art. 54), indoor exposure to radon (Art. 74) and the radon action plan (Art. 103). In addition, Annex XVIII provides a list of items to be considered in the national action plan. Article 103 states that Member States (MS) shall identify areas, where the radon concentration in a significant number of buildings is expected to exceed the relevant national reference level. Reference levels for dwellings and work places alike have to be set to 300 Bq/m³ in annual mean, at highest. Article 54 requires that in those defined areas of Art. 103, radon measurements have to be carried out in all workplaces in ground floors and basement. According to article 74, MS shall ensure that local and national information is made available on indoor exposure and the associated health risks, on the importance to perform radon measurements, and that action should be promoted to identify dwellings with radon concentrations exceeding the reference level. These requirements make (among others) radon measurements, radon surveys and radon mapping (delineation of radon priority areas) necessary and obligatory in all MS for the implementation of the European BSS.

Decisions on action to be taken complying with the items of the radon action plan have to be reliable and transparent, not least because they may imply considerable economical and political costs. A quality assured decision entails a chain of QAed technical steps, starting from correct radon measurement and calibration, possibly modelling steps, inclusion of supporting quantities, statistical procedures and mapping, until evaluation of results which only enables decision. In many cases, the relevant item is not a certain measurement result, but conclusions and decisions, as so to say consumer end products, to which it contributes in a chain possibly consisting of many technical links or aggregation levels. The “consumers” or end users are the stakeholders concerned or affected by the radon hazard itself, and in consequence, by regulation and action which is intended to counter the hazard. Among them are building industry, administrations and regulators, radon instrumentation and measurement industry, and of course the general public.

For a number of these links, QA has been considered still not adequate or sufficient. This was a major motivation for the Metro Radon project on the EMPIR platform of EURADOS, funded by EU’s Horizon 2020.

Metro Radon includes links of this chain which can be identified as genuinely metrological tasks, such as correct calibration or availability of primary standards, until tasks which concern modelling and finally enable correct decision making.

This presentation provides an overview on the structure of Metro Radon and gives a few examples of the chain links addressed above.

Measurement of radon and thoron concentration levels in Disi soil (in Jordan) using CR-39 detectors

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In this study, the concentration of radon and thoron was measured during the summer of 2015, using solid state nuclear tracks detectors which are known as CR-39 detectors in five locations (Al Tuwaiseh, Al Munayshier, Al Ghal, Al Twyel and Al Fateh) of Disi soil, south of Amman, Jordan. A total of 130 dosimeters were used in this study, 100 dosimeters of them were distributed in soil of five locations at a depth of 50 cm, 20 dosimeters were placed in soil of two locations (Al Tuwaiseh and Al Fateh) at different depths (20, 40, 60, 80 and 100 cm) and the last 10 dosimeters were used in laboratory to determine the exhalation rate of radon after collecting the soil samples at a depth of 50 cm from five locations in Disi soil. The porosity, the moisture and grain size for the soil samples were measured. The dosimeters in study field were left for 20 days while the dosimeters in laboratory were left for 50 days. After exposure time, the detectors were collected from the dosimeters. These detectors were washed in distilled water and chemically etched using 30% of KOH solution at temperature of 70°C for 8 hours. Then an optical microscope was used to count the number of tracks on each CR-39 detector surface. After that, the radon and thoron concentrations and the radon exhalation rates were measured.

The results indicated that the highest value of radon concentration, thoron concentration, radon exhalation rates and porosity was 6.45±2.85 kBq/m^3, 0.82±0.52 kBq/m^3, 234.58 mBq.m^{-2}.h^{-1} and 41.7±4.7%, respectively. All of these highest values were in Al Ghal location but the moisture of soil has the lowest values in Al Ghal 0.23±0.08 %. The lowest values of radon concentration, thoron concentration, radon exhalation rates and porosity were 2.37±0.20 kBq/m^3, 0.45±0.29 kBq/m^3, 145.26 mBq.m^{-2}.h^{-1} and 35.2±0.2 %, respectively; all of these values were in Al Fateh location except thoron concentration in Al Twyel location but the moisture of soil was the highest value in Al Fateh location 0.65±0.15 %. The results showed that the radon concentrations were greater than the thoron concentrations, Also the radon and thoron concentrations increase with depth.

A compact electronic system for a photodiode neutron detector

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The demand for portable neutron detectors is on the rise, and for that purpose, low cost boron-10 has been frequently used instead of helium-3, which is usually employed in large and expensive detectors. Portable detectors are of interest in some applications, such as neutron dosimeters or inspection systems targeted in the detection of fissile material and drugs in airports. In this work a portable thermal neutron detection system was developed which is based on a commercial silicon photodiode coupled to a boron converter; this prototype is then plugged into a portable electronic system. The boron layer was produced by pulsed laser deposition, either on a thin glass slide or on the photodiode itself. The boron deposition in the photodiode was made directly in the active area of the detector, so before and after the deposition process a characterization of the device regarding both the dark current and the operation voltage was performed using an americium source. Finally, both configurations were tested. The neutron detection process occurs by detecting the alpha and lithium particles produced by the interaction of the incoming neutron with the boron-10 nuclides. These heavy ions then interact with the active area of the reverse-biased photodiode, producing an electric signal that has to be preamplified and then properly amplified by the portable electronic system, which in turn produces an output that can either be sent to a multichannel analyzer or to a digital counter. The integrated circuit of the low noise preamplifier transforms the detector's current pulse into a voltage pulse with amplitude proportional to the charge carried by the current pulse. The shaper-driver consists of a differentiator and an integrator and is responsible for filtering and further amplifying the preamplifier signal, generating a NIM-compatible energy output pulse. The performance of the photodiode-amplifier set for alpha particles was successively tested using a ^{243}Am radioactive source. Initial tests were made using the boron-deposited glass, and the electronic signal was properly read. However, when the same system was tested using the boron deposited directly in the photodiode, the output signal couldn't be read, due to the fact that during the deposition process there was an increase in the dark current and a decrease in the operation bias. In this way, a new portable electronic system was developed using a hybrid integrated amplifier circuit. This new electronic setup allowed the use of both configurations, and was tested both with alpha-emitting Americium and neutron-emitting AmBe sources. In conclusion, both portable electronic systems have proven suitable for the thermal neutron detector developed.

Development of radiation detector with three different sensors for space applications

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In this paper, the performance of the novel radiation sensor — called "NürFET" — which measures Total Ionizing Dose (TID) on mission orbit is to be studied; and, NürFET is to be compared with two different sensors with demonstrated performance in various space missions previously. The radiation detector designed by the Scientific and Technological Research Council of Turkey, Space Technologies Research Institute (TÜBİTAK UZAY) has been named as MURaD and it is to contain three distinctive sensors, namely the Nuclear Radiation Sensing Field Effect Transistor (NürFET), the p- channel RADFET, and the Floating Gate Dosimeter (FGDOS) to measure TID comparatively. The detector which contains three different sensors is to be exposed to gamma radiation on ground via a Co-60 source and the functional and/or parametric test results obtained by this procedure is to be presented in the final version of this paper.

Keywords: NürFET, dosimeter, space radiation, total ionizing dose, p-channel MOSFET, RADFET, Floating Gate MOSFET

A novel He3-free detector for thermal neutrons to be used for hydrological observations: Limitations and emerging opportunities

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The measurement of secondary cosmic ray neutrons has been established as a unique approach for intermediate scale observation of land surface hydrogen pools. Originally developed for soil moisture measurements, it has shown also promising applications for snow, biomass and canopy interception. The measurements are generally performed using moderated proportional counters filled with Helium-3 or Boron. The moderation is obtained by adding shielding material (mostly polyethylene) around the counter.

In the present contribution, we show the development and the tests conducted on an alternative detector based on scintillators. This technology overcomes the problems related with the Helium-3 shortage and, in general, of the large dimensions of gas-based detectors. More than one year of lab and field tests in three different sites will be presented: lab and field tests in lowland in Potsdam (Germany), high mountain at the Environmental Research Station Schneefernerhaus near the summit of Zugspitze Mountain (Germany) and finally the Kaunertal glacier (Austria). Our data are compared with other standard detectors available at the experimental sites.

The new detector shows reliable thermal neutron monitoring, but also the capability to identify different neutron energies ranges and additional particles (gamma rays and high-energy particles) providing new opportunities for hydrological observations at different spatial scales. In addition, the use of high energy particles for correcting the signal from atmospheric variations (air pressure and primary cosmic-ray flux) is explored.

Finally, the economical scalability of this type of detectors and their possible use in practical applications is discussed.

Radiation hard Monolithic CMOS sensors with small electrode size for the ATLAS experiment in the HL-LHC

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The upgrade of the ATLAS experiment for the High-Luminosity LHC requires the installation of a new Inner Tracker detector to cope with the 5 fold increase in luminosity and a 10 fold increase in number of interactions per bunch crossing. Several Monolithic Active Pixel Sensor prototypes, MALTA and TJ-Monopix, have been developed with the 180 nm TowerJazz CMOS imaging technology. This combines the engineering of high-resistivity substrates with on-chip high-voltage biasing to achieve a large depleted active sensor volumes, to meet the radiation hardness requirements (1.5x10^15 1 MeV neq/cm2) of the outer barrel layers of the ITK Pixel detector. MALTA combines low noise (ENC<20 e-) and low power operation (1uW/pixel) with a fast signal response (25 ns bunch crossing) in small pixel size (36.4 x 36.4 um2), and a small collection electrode (3um), with a novel high-speed asynchronous readout architecture to cope with the high hit rates expected at HL-LHC. The latest prototype of this technology, dubbed Mini-MALTA, addresses the pixel in-efficiencies observed in previous designs to meet the radiation hardness requirements. This contribution will present the results from characterisation in particle beam tests that show full efficiency up to 1E15 neq/cm2 and 70 Mrad.

Comprehensive characterisation of Tyndall National Institute RADFETs for commercial applications in various fields

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Radiation Sensing Field Effect Transistors (RADFETs), also known as MOSFET dosimeters or pMOS dosimeters, have found applications in space, high-energy physics laboratories, and radiotherapy clinics. The RADFET is a discrete p-channel MOSFET with a thick gate oxide (typically from 100 nm to over 1 μm), optimised for radiation sensitivity. Radiation induces charges in the gate oxide, which cause the shift of the threshold voltage proportional to the radiation dose. The main good features of the RADFET are small size, simple/immediate/non-destructive read-out, electronic signal, and small cost when produced in volume. The main shortcoming is limited sensitivity, which precludes the use of standard RADFET designs in applications requiring minimum detectable dose lower than approx. 1 cGy.

Tyndall National Institute has been developing RADFETs for almost three decades. The technology has recently been transferred to a start-up company Varadis. We present results of electrical and radiation characterisation steps done on Varadis commercial RADFET products. We discuss critical issues in relation to the optimum use of RADFETs and possible methods for lowering the minimum detectable dose.

Electronic reader design with RadFET (p-MOSFET) dosimeter sensor

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In this study, a new reader has been designed to measure the amount of radiation dose detected by RadFET (pMOSFET) sensor. The designed reader calculates the voltage shifts of the pMOSFET as the threshold voltage (V_th) to determine radiation dose and display it on the Touch TFT LCD screen placed on the printed electronic circuit. It has been developed more in particular to be easily used in radiotherapy and other healthcare field which have radiation sources. The electronic board has also been developed to adjust and read the data for SiO_2 and Er_3O_2 sensor structured RadFETs. The electronic card has been designed with STM32F103 series processor that has 12-bit ADC structure. In addition, specific bluetooth circuit has been designed for communication. Thus, dose measurements versus date graph, personal details (name, age etc.) can be sent to personal computers and devices such as smart phones and tablets. Dose measurements can be currently kept by internal and external memory units on the designed electronic circuit.

Keywords: Dosimeter, silicon dioxide SiO_2, erbium oxide (Er_3O_2), microcontroller, sise measuring, radiation dosimeters, pMOSFET dosimeters, RADFETs

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Radiation induced defects in CMOS SPADs sensors

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Radiation-induced defects constitute a big concern for photons detectors dedicated to accelerators and space applications. Radiation can impact the crystalline structure of the sensor and create new defects responsible for the deterioration of the device performance.

This paper aims to provide a better understanding of defects creation in Single-Photon Avalanche Diodes (SPADs). We investigated defects induced by proton irradiations on different SPAD layout, manufactured in a 150 nm CMOS process. Specifically, we focused on the irradiation effects on the Dark Count Rate (DCR).

DCR level, as well as its distribution and temporal fluctuation, is an excellent probe to study of induced defects. In fact, the high internal gain of SPADs devices makes them extremely sensitive to the presence of defects in the silicon structure. These act as hot-spots for electron-hole generation that through an avalanche multiplication mechanism result in current pulses, even in dark conditions.

At this purpose, we irradiated several devices at the LNS-INFN Laboratory (Italy) with protons of 21, 35 and 60 MeV and a wide range of fluencies.

By studying the DCR increase as a function of the SPADs geometry (perimeter, area and active volume), we identified the main damage contribution as bulk defects located in depletion region, while only a small contribution due to SiO_2 interface defects.

Low temperature measurements showed that current increase is mainly dominated by defects with energy levels close to the mid-gap. According to Shockley-Read-Hall, they act as efficient DCR generation centres.

After irradiation, long-time acquisition showed that, beyond the increase in the mean dark current, a large fraction of SPADs exhibit discrete DCR temporal fluctuation. This phenomenon, called Random Telegraph Noise (RTN), is well known in the radiation hardness field, but it is still not totally understood. A possible mechanism capable of explaining such behaviours involves the presence of multi-stable defects, that in the case of proton irradiated devices could be dopant related vacancy complexes as V-P or di-vacancy (V-V) defects.

For a deep understanding of this phenomenon, we measured its behaviour in irradiated SPADs, such as amplitudes, discrete levels, and switching times. Furthermore, we investigate the defects concentration by measuring both the DCR level and the RTN occurrence for different isochronal annealing temperatures.

By combining these results, we can reasonably assume the prevalence of phosphors-vacancies based defects in term of dark current and RTN contribution. Beyond the defects type, the nature of such defects, being cluster or point defects, still need to be clarified and is currently under investigation by comparing the effects induced by particle of different Non Ionizing Energy Loss (NIEL), i.e. proton of different energies and electrons.

Development of MOS-FET dosimetry for high radiation environments

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A set of MOS-FET dosimeters optimized for high dose environments at particle physics experiments and nuclear reactors was produced by NURDAM. Various oxide thicknesses ranging from 40 nm to 800 nm were employed to study sensitivity and dynamic range of the dosimeters. The sensors were exposed to ionization doses of up to 100 kGy of reactor gammas in two different ways; several sets of samples with different oxide thickness were exposed to fixed total ionizing doses, while for one set an online dose measurement was carried out during the irradiation. The dependence of sensitivity on irradiation dose was precisely characterized over the entire dose range for all samples. The saturation and breakdown voltage for different oxide thicknesses was also determined.

Stacked-NürFETs fabrication and characterization

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The conventional Nuclear Radiation Sensing Field Effect Transistors (NuRFETs) have not been able to sense and detect very low radiation at the mil-rad range, which is needed for medical personnel in medical applications and low radiation environments. In this work further investigation of a design method, where NurFETs are coupled in a stacked structure, in order to increase radiation sensitivity is reported. The stacked NurFETs with SiO_2 gate dielectric has been fabricated and the possible usages of the device as a dosimeter for radiation sense materials and medical applications are discussed. The sensitivity of the fabricated stacked NurFETs is multiple times the single NurFETs. The device characteristics have been compared to an experimentally fabricated and conventional single device.

Determination of minimum detectable dose and the effect of different filters on TLD 100H main thermoluminescence peak

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Thermoluminescence dosimeters have been an important tool for measuring the ionizing radiation dose in the field of personnel, clinical, environmental and space applications. In this study, minimum detectable dose of newly synthesized Mg,Cu,P doped LiF (TLD 100H) dosimeter for main TL peak have been determined using thermoluminescence method as a preliminary work. Additionally, thermoluminescence glow curves of TLD 100H dosimeters were recorded using different four filters in order to investigate the effect of different filter packs on TL glow peaks. It was observed that TLD 100H dosimeter has two glow peaks at 125°C and 290°C and two shoulders at 180°C and 230°C.

Keywords: Thermoluminescence, TLD-100H, dosimeter, filter packs, minimum detectable dose

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Electrical characteristics and alpha particle detection performance of newly developed pin photodiode

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The silicon PIN photodiodes with various active areas (3.5 x 3.5mm², 5x5 mm², 7x7mm²) were designed and fabricated by using conventional photolithography process at Center of Nuclear Radiation Detectors Research and Application (NÜRDAM) for investigation of electrical characteristics and alpha particle detection performance. To get the device specifications and advantages, the current-voltage (I-V) and the capacitance-voltage (C-V) measurements were carried out in the photoconductive mode and those Si-PIN photodiodes were used to detect alpha particles from different radioactive sources in a vacuum at the room temperature. Dark current and capacitance of each photodiode were measured and found as (- 6.97 nA) – (- 19.10 nA) and (23pF) – (61 pF) respectively, at 5 volts. The possibilities of improving the parameters of the newly developed PIN photodiodes were discussed in detail this study.

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Novel reader circuit design for PIN photodiodes

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Silicon PIN photodiodes are used in various applications. PIN photodiodes produced in Nuclear Radiation Detectors Application and Research Center (NÜRDAM) PIN photodiodes are used for radiation detection by operating in photoconductive mode and applying reverse bias. However, since they produce very low (na) currents, it is not possible to read with measuring instruments. Therefore, the circuit consists of the steps of first converting the current to voltage and then increasing the voltage. Thanks to the amplifiers with high gain and very low noise ratios, the noise generated by the PIN photodiode is reduced and the resulting value is readable.

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Optical characteristics of as-grown and annealed $Gd_3Al_2Ga_3O_{12}$:Ce crystals under electron irradiation

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$Gd_3Al_2Ga_3O_{12}$:Ce (GAGG:Ce) are garnet crystals that are considered for application as scintillators. GAGG:Ce is characterized by short decay time (τ < 100 ns), high light yield (up to 50,000 ph/MeV), also its emission band corresponds to the sensitivity spectrum of conventional SiPMs. These properties allow application of GAGG:Ce in medical positron-emission tomography and also for fundamental studies at hadron colliders. The presence of delayed scintillation decay components is a serious obstacle for application of these crystals. However, co-doping of GAGG:Ce with divalent ions allows to optimize scintillation kinetics and makes them suitable for high rate applications [*Engineering of Scintillation Materials and Radiation, Springer Proceedings in Physics, 2017*]. Radiation hardness is another important characteristic, which is required for high rate application. The radiation hardness of garnets such as LuAG:Ce and YAG:Ce is known to be very high even in the extremely harsh conditions [*IEEE Trans. Nuclear Science, 63, 2 (2016) 586-590*]. Recently GAGG:Ce optical properties were studied under proton irradiation (24 GeV, fluence of $3 \cdot 10^{15}$ cm^{-2}) [*Nuclear Inst. and Methods in Physics Research, A 916 (2019) 226–229*]. The irradiation response to different types of ionizing radiation is necessary both for determination of GAGG:Ce applicability and for the study of its defect structure [*Radiation effects in solids, Interscience Publishers, New York, 1957*].

Here, we present the results of our study of the optical and photoluminescence properties of GAGG:Ce crystals irradiated by electron beam. All investigated samples were cut from crystals grown in JSC "Fomos-Materials" Co. using Czochralski method in Ir crucibles. The studies were performed on as-grown samples and on samples annealed in oxygen and vacuum.

Electron irradiation was performed at the Center of Physical Measurements Investigations of IPCE RAS using the linear accelerator (energy 4.5 MeV, flux $4 \cdot 10^{12}$ $cm^{-2} \cdot s^{-1}$, fluence $1.2 \cdot 10^{16}$ cm^{-2}). ***Optical properties*** of samples were studied using UV-Vis-NIR spectrophotometer "Cary-5000" (Agilent Technologies) at non-polarized light. ***Luminescent properties*** were studied using specialized set-up. A 150 W xenon lamp was used as an excitation source. The sample was placed into vacuum optical cryostat Cryotrade LN-120. The luminescence was registered using LOT-Oriel MS-257 spectrometer equipped with CCD detector.

It was shown that post growth annealing in vacuum has insignificant effect on GAGG:Ce optical properties. Annealing in oxygen leads to increase of absorption in near UV and visible wavelength regions. The defect structure has been also studied using luminescence spectroscopy, that allowed to obtain deeper insight to their origin. Electron irradiation did not result in significant changes of optical properties of GAGG:Ce. Therefore, obtained results show high rate of radiation hardness of GAGG:Ce crystals.

Co-60 gamma irradiation effects on the crystallographic, morphological and electrical characteristics of Eu_2O_3 thin films

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Rare earth oxides (REO's) play an important role in semiconductor technology. Europium oxide (Eu_2O_3) is one of the REO and it has been used in many applications such as optoelectronics, telecommunications, microelectronics and optical devices. However, in this study, Eu_2O_3 MOS capacitors have been fabricated by using Electron Beam Evaporation (E-Beam) technique and Co-60 gamma irradiation effects on them have been investigated. Pre-and post-Co-60 gamma irradiation, the crystallographic and morphological of the Eu_2O_3 films have been analyzed by X-ray Diffraction and Atomic Force Microscopy. The electrical properties of the devices have been investigated using measuring C-V, G/ω-V and J-V characteristics. The results show that Eu_2O_3 rare earth materials can be good candidate for microelectronic applications and radiation sensors.

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Sensing characteristics of SnO_2 thin film gas sensor

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The Pt-doped SnO_2 thin film detector sensitivities for different gases including the propanol, carbon dioxide, acetoneand oxygen have been investigated incorporating the structural evolution of the thin film. The crystallographic structure of the SnO_2 layer significantly varied with increasing the Pt concentration and grain size of the film decrease with Pt content. The highest gas sensitivity of the films exhibits for the oxygen gases. In addition, the oxygen sensitivity of the sensors increases with Pt concentration up to specific operation temperature. This variation may be due to the different contributions of the spillover and Fermi energy control mechanisms to sensor sensitivities. The present results have depicted that the sensor design should be carefully configured to promote the sensing responses of the gas sensors.

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Irradiation effect on Er_2O_3/n-Si structure under high gamma dose

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The RadFETs radiation sensors widely used in radiotherapy clinics, high energy physics laboratories, space applications, are composed of basic MOS structure, and their performances are evaluated with these forms due to easy production. SiO_2 is used as sensitive region in commercial RadFETs, and the minimum readable dose of these devices with high sensitivity is limited to ~10 mGy. On the other hand, the sensitivities of MOS capacitors produced with some high-k materials such as La_2O_3, Yb_2O_3 under ^{60}Co radioactive source are found to be higher than that of the SiO_2 MOS [IEEE T. Nucl. Sci., 63(2),7454835, (1301-1305), J. Vac. Sci. Technol. A, 35(6), 061511 (1-7)]. The Er_2O_3 with the sensitivity of 61 mV/Gy and high dielectric constant of ~9-14 is one of the outstanding dielectrics to improve sensor sensitivity [IEEE T. Nucl. Sci., 63(2),7454848, (1284-1293)]. Since the motilities of the positive charges that occur as a result of the interaction of gate oxide with the radiation are lower than the negatives, they are expected to be more trapped in the structure. This leads to the shifting of the C-V curve of a MOS capacitor to the left side relative to the characteristic obtained from the non-irradiated device. However, the C-V curve of the Er_2O_3 MOS capacitor shifted to the right with the effect of irradiation up to 16 Gy, then to the left with increasing radiation dose. The investigation of the cause of this unexpected right shift is very important for the improvement of new generation high-RadFETs. In this study, Er_2O_3 films were grown on n type Si wafers by RF magnetron sputtering technique. The samples were irradiated by ^{60}Co radioactive source with the doses of 1 kGy, 25 kGy, 50 kGy in the Turkish Atomic Energy Authority. The crystal structures of the samples were analysed by XRD technique at the 20^o-80^o 2θ ranges. A Physical Electronics-PHI 5000 VersaProbe with monochromatic Al Kα X-ray radiation source (1486.6 eV) was used to analyse the chemical composition and bonding structures of the Er_2O_3/Si samples. Depth profiling of the films was taken by using Ar^+ (1 keV) sputtering. The binding energy of the C 1s attributed to the surface contaminant was corrected to 284.8 eV. While the Er_2O_3 film showed the amorphous structure, the peaks of the cubic phase of the Er_2O_3 were observed with irradiation and the peaks intensities increased with increasing radiation dose. The Er 4d spectra of the Er_2O_3/Si films were fitted two peaks indicating Er-Er and Er-O bonds except interface. The binding energies shifted to higher values with increasing depth from the surface due to possible $ErSiO_x$ formation at interface. This undesired parasitic layer formation was observed in the XPS spectra taken from the Er_2O_3/Si interface. A decrease in the peak areas and a reduction in the peak intensities were observed in some spectra.

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Co-60 gamma radiation influences on the electrochemical, physical and electrical characteristics of rare-earth dysprosium Oxide (Dy_2O_3)

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This abstract has been withdrawn upon the request of the authors.

Possible usage of the temperature sensor structure as a dosimeter

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The basis of measuring radiation doses is the interaction of radiation with matter. When radiation passes through a substance, it loses some or all of its energy by interacting with atoms or molecules of matter. A change in the structure of the substance occurs due to chemical, photochemical, ionization, phosphorescence and fluorescence events. The structure of temperature sensors is very similar to interdigited radiation sensors. The frequency of collision of current carrying electrons carrying current with atoms in conductive material increases due to defects caused by radiation. The excess of these defects on the line path makes it difficult to conduct the current and these defect chanced resistance values. Resistance changes have been investigated before and after radiation current-voltage *(I-V)* measurements.

Keywords: Platinum- temperature sensor; mask design, trimming point

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Recycling of hazelnut shell: Synthesis of boron carbide by carbothermic reaction

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Boron carbide is a typical non-oxide advanced ceramic that used in different industrial applications due to its hardness, high refractoriness low density and good neutron absorption cross-section [doi:10.1016/0955-2219(90)90048-K]. It is used in wear resistance applications, in light weight armor plates [doi:10.1006/jssc.1997.7316], in nuclear industry as neutron absorber [doi:10.1515/HTMP.1986.7.2-3.133], and in the aerospace industry as a rocket propellant [http://inis.iaea.org/search/search.aspx?orig_q=RN:23057613]. In the present study, boron carbide was prepared using boric acid and hazelnut shell activated carbon by a carbothermic reduction method at 1400 °C. Two different methods were applied to obtain activated carbon for this study; activated carbon production using hazelnut shells (procedure I) and sulfuric acid treatment of hazelnut shells (procedure II). The formation of boron carbide was proven by Fourier transformation infrared spectroscopy (FTIR) and X-ray diffraction (XRD), also morphological examination was done by scanning electron microscopy (SEM). The average grain size was found as 30 and 7 nm for procedure II and procedure I, respectively. In addition, the calculated lattice parameters were closely matched with the reported values in JCPDS card. It was found that hazelnut shell can be used as an alternative carbon source for boron carbide synthesis.

Keywords: Boron carbide, hazelnut shell, carbothermic reduction, activated carbon

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CdZnTe solid-state detector characterization for its use as a spectro-dosemeter

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Concerning ionising radiation monitoring in the environment in areas which, by normal means, are inaccessible, e.g. in contaminated areas after a nuclear or radiological incident, the use of highly mobile systems, comprising of unmanned airborne vehicles equipped with ionising radiation detectors, is advised in order to protect the health and the life of first responders. As a promising candidate, the compact solid-state spectrometer based on CdZnTe is characterised by performing the irradiations in the reference radionuclide radiation fields of PTB. The energy dependent conversion coefficients are derived from recorded pulse-height spectra, and they enable calculation of the operational radiation protection quantity, ambient dose equivalent rate, directly from the spectrum without deconvolution. The validity of the conversion coefficients was evaluated by determining the deviation of the calculated Ra-226 radionuclide dose rate from the reference ambient dose equivalent rate available at the Underground Dosimetry Laboratory (UDO II) of PTB. By employing the derived conversion coefficients, detector „linearity“ (dose rate dependence of the response) was checked in the Cs-137 reference fields of different ambient dose equivalent rates ranging from 25 nSv/h up to 1 µSv/h. The deviation of the calculated Ra-226 dose rate from the reference value achieved was +2%.

GAGG:Ce scintillation fibers for high energy physics applications

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Single crystal scintillation fibers are prospective in designing radiation detectors for the next generation of electromagnetic calorimeters to be exploited in high-luminosity hog-energy physics experiments. The crystalline fibers enable a dual signal readout mode to synchronously record the scintillation light and the Cherenkov radiation. These novel fiber-based detectors consist of long single crystal rods, thus, the light propagation conditions in these fiber-like structures are of crucial importance. Crystal compositional fluctuations, cracks, inclusions and other defects act as scattering centers and lead to a decrease in the optical transparency and the light output. Therefore, it is important to characterize the scintillating fibers on a microscopic scale.

In this work, wide-field and confocal microscopy were used to study the light output uniformity of Czochralski-grown cerium-doped gadolinium aluminum gallium garnet (GAGG:Ce) fibers. The surface morphology of the crystals was measured using atomic force microscopy. Defects associated with Czochralski growth process have been observed on a micrometer scale as alternating plains exhibiting luminescence intensity variations, though all samples demonstrated good homogeneity on a large scale. Meanwhile, the light attenuation length was found to vary in nominally identical fibers. A negative correlation between surface roughness and light attenuation length was revealed. The influence of crystal growth defects and the importance of surface polishing quality on light propagation are discussed.

Radiation destruction of TF-1 type glasses when irradiated with 21 MeV electrons

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The heavy flint (TF-1) type glasses irradiated with 21 MeV electrons under various environmental conditions were studied. The aim of the work was to study the formation of cracks in the volume of glasses at low electron flux densities $<5 \cdot 10^{10}$ $cm^{-2} \cdot s^{-1}$ with temperature variation and the introduction of macroscopic defects in the form of large cracks in the irradiated samples. Samples of glasses had dimensions of 45x50x50 mm. Irradiation of glasses with 21 MeV electrons was performed at the Mikrotron ST accelerator (IMET RAS). The glass was irradiated at a temperature of 300 and 600K. Large cracks - defects in the glass were injected by heating in the microwave oven. Acoustic emission (AE) was measured in glasses completely immersed in water, and the speed of propagation of an acoustic wave in air at 300K. It was established that under normal conditions of irradiation of the original glass, without visible internal damage, the destruction of the glass in the form of large cracks occurs with a fluence of ~ $7.10^{13} cm^{-2}$ and covers the entire volume of the glass. If there is a defect in the volume of glass in the form of a single transverse crack, the destruction of the glass is limited to some volume enclosed between the surface, with the sides of which the electron beam enters, and the surface bounded by a crack. Penetration of radiation damage beyond the transverse crack is not observed. Irradiation of glasses at high temperatures leads to an increase in the fluence, at which radiation destruction is observed. However, when such glasses are cooled, they are spontaneously destroyed near room temperatures. At the same time, along with large cracks, filamentary are observed. Irradiation at high temperatures leads to opalescence of the glass, which disappears at 300K after some time.Measurements of the propagation velocity of the acoustic wave in irradiated glasses show that the density of the glasses decreases. This result is consistent with the known phenomenon of glass swelling during radiation exposure. Measurements of AE showed that in irradiated glasses under the influence of water, the amplitude and frequency of the signal follow a sharp increase. This may mean that microcracks develop in the irradiated samples on the glass surface under the influence of water. In the absence of water, an increase in AE in irradiated glasses is practically not observed. These phenomena can be explained with the involvement of the well-known Rebinder effect, when mechanical stresses take place in irradiated glasses and under the action of water (surface-active medium) accelerated surface microcracks develop. The experimental results allow us to conclude that the irradiated glasses, both before radiation destruction and after it, are in a nonequilibrium state. Such glasses being under the influence of the external environment will always undergo further changes with subsequent mechanical destruction.

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CdZnTe bulk crystal growth and surface processing technology at METU-CGL

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The study of $Cd_{1-x}Zn_xTe$ bulk-crystal growth and surface processing technology at METU-CGL (Crystal Growth Laboratory) began in 2012. The initial R&D efforts were started with growing CdZnTe ingots up to 15 mm diameter in three-zone vertical Bridgman furnace. Following the promising development in terms of single crystal yield, a new vertical gradient freeze multi-zone furnace setup was designed and developed to accommodate production of 60 mm diameter CdZnTe ingots.

Currently, METU-CGL is capable of producing 60 mm diameter ingots with one large grain and a few small grains. CdZnTe material is continuously grown in order to serve as either substrate material ($Cd_{0.96}Zn_{0.04}Te$) for infrared detectors or material ($Cd_{0.90}Zn_{0.10}Te$) for x-ray/gamma-ray detectors. As a typical yield, 2-3 oriented wafers per radial slice are retrieved from the grown ingots. The target wafer dimensions are 20 mm x 20 mm; however, larger or smaller crystals can be obtained based on the application of interest. The crystalline quality of the produced crystals is way below 50 arcsec of FWHM values from the DCRC measurements and the EPD values are typically mid-$10^4/cm^2$. Not only limited to CdZnTe bulk growth technology, but METU-CGL is also capable of slicing and surface processing technologies including optimized lapping, rough mechanical polishing, and final chemo-mechanical polishing steps with an emphasis on surface roughness and subsurface damage. Achievable surface roughness values of produced wafers are well below 0.5 nm (R_{rms}). Various state-of-the-art characterization techniques including TEM and APT were conducted to study nanoscale defects in CdZnTe as a material property. This paper reviews many aspects of the CdZnTe bulk-growth, surface finishing, and characterization technologies at METU-CGL and the laboratory infrastructure as well.

Optical characteristics of $La_3Ga_{5,5}Ta_{0,5}O_{14}$ and $Ca_3TaGa_3Si_2O_{14}$ crystals under electron and proton irradiation

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$La_3Ga_{5,5}Ta_{0,5}O_{14}$ (LGT) and $Ca_3TaGa_3Si_2O_{14}$ (CTGS) are crystals with $Ca_3Ga_2Ge_4O_{14}$ structure, point group of symmetry 32. LGT belongs to disordered type-crystals, CTGS to ordered one. These crystals are considered now both for piezoelectric applications including middle and high-temperature regions and optical applications including non-linear optics [*Cryst.Rep. 16, 2 (2016) 275-284, IOP Conf. Ser.: Mater. Sci. Eng. 169 (2017) 1-6, Cer. Society Japan 124, 5 (2016) 523-527, Cryst. Eng. Comm 16 (2014) 10286-10291*].

The irradiation response of these materials is poorly investigated [*Rad.&Applications 1, 3 (2016) 171-176*] but it is necessary both for determination of their viability in natural or occurring radiation and for the study of their defect structure [*Radiation effects in solids, Interscience Publishers, New York, 1957*]. Study of structure and defects formation in multicomponent oxide single-crystal dielectric materials is the nontrivial task. The anisotropy of structure leads to various phenomena, e.g. dichroism. Absorption spectra in near UV and visible regions are sensitive to the point defects and their associations in crystal structure. Each absorption band is associated with specific type or group of point defects. For LGT and CTGS three absorption bands are observed at λ ~290 nm, at λ ~360 nm and λ ~(460-480) [*Cryst.Rep. 16, 2 (2016) 275-284, IOP Conf. Ser.: Mater. Sci. Eng. 169 (2017) 1-6*]. According [*E. Zabelina, PhD Dissertation*] the absorption band at λ ~(460-480) nm is identified with oxygen defects and F-centers (Vo^{++}, $2e^-$). The origin of two other bands is still not clear. The study of the irradiation effects on ion structures is a roductive method for investigation of the origin of the defect structure and mechanisms of its formation [*Radiation effects in solids, Interscience Publishers, New York, 1957*].

Here, we present the results of our study of LGT and CTGS optical properties under electron and proton irradiations. All investigated samples were cut from crystals grown in JSC "Fomos-Materials" Co. using Czochralski method in iridium crucibles. ***Electron irradiation*** was performed at the Center of Physical Measurements Investigations of IPCE RAS using the linear accelerator (energy 6 MeV, flux $4 \cdot 10^{12}$ $cm^{-2} \cdot s^{-1}$, fluences up to $1.2 \cdot 10^{16}$ cm^{-2}). ***Proton irradiation*** was performed on linear accelerator I-2 at the Center of Collective Use "Kamiks" of ITEP (energy 20 MeV, flux $1 \cdot 10^{11}$ $cm^{-2} \cdot s^{-1}$, fluence $1 \cdot 10^{14}$ cm^{-2}). ***Optical properties*** of samples were measured using UV-Vis-NIR spectrophotometer "Cary-5000" (Agilent Technologies) at non-polarized light taking into account the dichroism (with sample rotation by 90° around the light direction). After irradiation, all samples changed color, become more colored with a grayish tint. Irradiation both with protons and electrons leads to increase of absorption in all investigated wave-length region. The most significant effects are observed in the region of (250-450) nm. The greatest increase in absorption in the region of (250-500) nm is observed after the electron irradiation fluence of $4 \cdot 10^{15}$ cm^{-2}. The subsequent increase of fluence didn't lead to the further increase of absorption.

Methods for managing textural properties of nanopowders to create a drug delivery system based on SiO_2, SiO_2-MnO_2

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Nanopowders (NP) are widely used in pharmaceuticals, biomedicine and biotechnology. The developing application of NP is targeted drug delivery that allows increasing the effectiveness of traditional medicines.

The targeted drug delivery system allows the drug to be encapsulated within the structure, therefore, it is necessary to achieve maximum loading capacity of the nanocarrier for efficient delivery process. The loading capacity depends on the pore volume and specific surface area (S_{BET}). Among the diverse nano-carriers, one of the most promising systems for targeted drug delivery is SiO_2 NPs that have the ability to vary the textural properties for different applications.

In this paper, methods for controlling the textural properties of SiO_2, SiO_2-MnO_2NPs by doping at the stage of the preparation and ultrasonic treatment (sonication) of aqueous NP's suspensions are investigated.

Pure SiO_2 NP and SiO_2-MnO_2NPs with 0.1, 3, 5% dopant mass concentration were prepared by a pulsed electron beam evaporation in low-pressure gas (4 Pa) on NANOBIM-2 installation.

Analysis of the textural properties were carried out using the following analytical methods: microscopy on a JEM 2100 transmission microscope, Brunauer-Emmett-Teller method to define the S_{BET} and porosity on Micromeritics TriStar 3000 installation

It was shown that doping at the stage of producing NPs allows controlling both S_{BET} and pore volume. For example, adding small concentrations of the dopant MnO_2 leads to a decrease in S_{BET} from 125.40 to 75.78 m^2/g, while maintaining a relatively equal size and pore volume of 20 nm and 0.36 cm^3/g, respectively. A further increase in the dopant concentration leads to an increase in $S_{BET}$of the NPs to 176.35 m^2/g with 5% doping.

Methods have been proposed to control the porosity of produced NPs due to the external sonication. To study the effect of ultrasonic processing time on the textural properties of NPs, samples of NP suspensions were sonicated in an ultrasonic bath PSB-2835-05 with a capacity of 100 W for 40 - 100 min. It was concluded that specific surface area and porosity of samples decreased monotonically as the sonication time increased.

Thus, the work proposed different methods for managing the textural properties of the SiO_2, SiO_2-MnO_2NPs to create an effective drug delivery system with the required loading capacity and to expand the application of the NP.

Production and characterization of Al_2O_3+Ag composite nanopowders

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Due to the specific abilities of silver, its combination with other substances, such as antibiotics or other nanoparticles (NPs), enhances the sharing properties compared to each component separately.

The aim of the work is to produce and study the properties of aluminum oxide coated with silver.

The relevance of the work is the need of new materials for the development of new treatment methods of various diseases and pathologies, as well as for the development of biotechnology.

The radiation technology for producing a nanoscale silver coating under nanosecond electron beam irradiation was used (0.5MeV, 60ns). According to calculations, to obtain the entire coating of Al_2O_3 with a diameter of ~50 nm, the ratio of the base and silver in$AgNO_3$should be ~1:2 by weight. The composition of the suspension: 69g of sorbite (six-atom alcohol) was dissolved in 100 ml of distilled water, 0.6 g of silver nitrate and 0.7 g of aluminum oxide were added to the resulting solution.

From the results of microscopic and EDX analyses, it was found that the average particle size for Ag50c+Al_2O_3 powder (settled for 15 hours) was 50 nm, for Ag+Al_2O_3 (settled for 4 days) – 80 nm. It was also obtained that in some areas silver covered almost the entire surface of the aluminum oxide NPs (the share of silver coating Ag50c+Al_2O_3 was 2-3%), in other areas the coating was partial (Ag+Al_2O_3 – from 16 to 40%).

Evaluation of antibacterial ability was carried out by counting of living and dead wine yeast with the help of Hemocytometerand light microscopy. Measurements were carried out for 3 days at a concentration of NPs 100 μg/cm².Every day a number of cells in a suspension with composite was almost 2 times less (42-58%) than in the control sample. The obtained data showed a high antibacterial ability, which exceeds the properties of separate aluminum oxide (7-18%) and silver (11-40%) on yeast. The error of the method is 3%.

Thus, a sufficiently high efficiency of the method for producing composite NP, the ability to control the deposition process and the type of silver coating by changing the deposition time are determined. In addition, high biological activity of NP was experimentally established.

The effect of Co-60 gamma irradiation on coal fly-ash geopolymer set times

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Operations involving grout, mortar and concrete are commonly used in radioactive waste management. Materials based on Portland cement (OPC) have numerous applications, ranging from construction of facilities, radioactive shielding, production of different casings and containers, to waste conditioning procedures (solidification, cementation, grouting). These materials are well known and well standardized, and regulated both internationally and at the national level. OPC is readily available, cost effective and comes in formulations suited for the construction industry. In nuclear and radioactive waste management industries, some challenges with the use of OPC based materials have been recognized (including the durability of concrete under thermal stress, long term stability of OPC binders, and radiolysis of contained water), and have been addressed either by optimizing OPC material formulations, or by using alternative binders. One promising alternative binder is geopolymer, a type of alkali activated binder, solidified by cross linking aluminosilicates into an amorphous matrix. Geopolymer is formed by activation of fine powder with pozzolanic properties with an alkali solution of sodium silicate (water glass). During geopolymerization, water acts primarily as a solvent, unlike the reactions during the setting of OPC, where hydration plays a key role. Various base materials, ranging from metakaolin to byproducts such as fly-ash and blast furnace slag, can be used. Coal fly-ash is an inexpensive raw material with low CO_2 footprint (compared to OPC), with potential applications in radioactive waste conditioning. To our knowledge, the effect of ionizing radiation on geopolymer set time hasn't been explored. We have measured the initial and final set time for fly-ash geopolymer paste, based on the SRPS EN 196-3 standard, irradiated by gamma rays in a Co-60 reference field on position with air kerma rate of 3.42 mGy/s. The binder paste was prepared using fly-ash from TENT B power plant's electrostatic filters without further sieving, activated by water glass with module 1.5 and mixed with distilled water until satisfactory flow was obtained, and poured into sample and control molds. Initial and final set times for irradiated sample and non irradiated control were determined by Vicat apparatus. The irradiated sample demonstrated 11% shorter initial set time, and 16% shorter final set time, compared to control. These set times allow satisfactory working times for geopolymer grouts and mortars. The effect of ionizing radiation on set times and other properties of coal fly-ash based materials must be accounted for in all stages of application, from small scale testing and simulations, to full scale tests and production environments.

Unique approaches to the optimization of liquid crystal material orientation

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Different optoelectronic devices such as displays, spatial light modulators, optical limiters, etc. contain the main functional element based on the liquid crystal (LC) mesophase. LC molecules have no regularity in the centers of the masses, but can be ordered in the direction. In order to align the LC molecules along the preferred direction so many method can be used. Among the different methods and approaches to find the optimized orientation of the inertial LC molecules the nanotechnology approach has shown the best results. This approach permits to increase the transparency, to decrease the resistivity and the number of the functional layers in the sandwich LC structures. Thus it leads to decrease the applied bias voltage and improve the speed. The effect is based on the fact that the LC elements can be considered without direct orienting layers, under the condition when the ITO conducting coating can make two roles; as the conducting layer and as the orienting (alignment) layer simultaneously [DOI:10.1364/OE.24.00A270, https://novapublishers.com/shop/surface-structuration-and-its-advantages-in-optoelectronics/].

In the current paper, we continue our steps in the direction to find the best way of LC molecule orientation. It is proposed to consider the pure ITO coating and ITO with the carbon nanotubes (CNTs) covalently bounded with the ITO surface atoms. The switching of the LC can be improved with good advantage; furthermore the novel relief depended on the angle, at which the CNTs have been deposited, can be used for the optical limiting of the laser irradiation in order to vary the reflecting losses.

The use of Mössbauer spectroscopy for the analysis of products formed by the reaction of reactive dyes on wood's surface

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Aqueous solutions of metal salts are gaining increasing interest from the wood finishing industries due to their capacity to change the color of wood surface, while preserving its natural appearance. These solutions, when applied on wood's surface, can react with the polyphenols present naturally in wood, by forming colored complexes. Considering that the resulting color depends on the structures of the complexes formed, many factors can influence the color hue and the color intensity obtained at wood's surface. These factors include the type of phenolic compounds present in wood and the type of metal salt used in addition to other experimental factors (e.g.: wood's moisture content, wood surface preparation, drying temperature). The objective of this work was to determine the differences in the structures of products formed by the reaction of iron salts with the polyphenols present in oak heartwood. Iron acetate (II), iron sulfate (II), iron sulfate (III) and iron citrate (III) were selected. Mössbauer spectroscopy analysis was performed directly on wood samples in form of powder with a particle size inferior to 60 mesh. The results obtained in this study depended on the iron oxidation state and the environment of the products obtained. We have been using the iron salts with the same oxidation state and different counterion or the same counterion with different oxidation states. A better knowledge of the reaction mechanisms and the factors influencing them will allow the use of reactive dyes in the wood industries with a better control of the resulting colors.

Application of 2D NMR spectroscopy for structural elucidation of complex polysaccharide from sugar maple bark

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Nuclear magnetic resonance spectroscopy (NMR) is one of the most powerful non-destructive methods for the study of carbohydrates. Both structure and conformation of the carbohydrate can be determined from ^{1}H and ^{13}C one dimensional (1D) NMR techniques, while different two-dimensional (2D) NMR techniques are available for further structural elucidation. NMR spectroscopy applies the radiation from radio wave region to collect the signals related to the interaction between the atomic nuclei spins and the applied radiation frequency. Parameters characteristic for the anomeric protons and conformation of constitutive monosaccharides are available form 1H NMR spectra. The aim of this study was to determine the structure of complex polysaccharide isolated from bark of sugar maple, (Acer saccharum), a Canadian species known for its sap, which is the source of maple syrup production. The crude polysaccharide, obtained by hot water extraction and ethanol precipitation was concentrated in crude form by a combination of membrane ultrafiltration. It was further purified by Sephadex G-100 and DEAE-Sephadex G-25 column chromatography. HP-SEC, FT-IR and ^{1}H NMR data allowed for its determination as a heteropolysaccharide with an average molecular weight of 21 kDa that is mainly composed of D-glucose, D-mannose and L-rhamnose with mass percentages of 87.15%, 9.78%, and 3.07%, respectively. ^{1}H-^{1}H NOESY (nuclear overhauser effect spectroscopy) and ^{1}H-^{1}H ROESY are based on correlations arising from the interactions of protons spacially proximate. The both experiments provide information about protons which are close in space, usually only observed between protons within monosaccharides or across the glycosidic This information is valuable for determination of the configuration of the glycosidic bond. The selective irradiation of the anomeric proton causes a variation in intensity of the signal relative of the adjacent protons, which allowed the configuration analysis of the glycosidic bond of the studied polysaccharide.

Radiobiological research and dosimetry using a flat alpha source

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The use of heavy ions from particle accelerators and radiation sources has attracted a lot of interest for biophysical experiments over the past years. The radiobiological effects of charged heavy particles on a cellular or molecular level are of fundamental importance in the field of biomedical applications, especially in hadron therapy and space radiation biology. Beams of protons and heavy ions are generated in accelerators, while alpha particles are available from sources.

The radiobiological effects of alpha particles have attracted a lot of interest due to their large linear energy transfer (LET), and due to the fact that their deposit of dose can be conveniently controlled facilitating studies on the radiation-induced biological effects. In order to evaluate the dose *D*, the alpha-particle fluence needs to be determined, either theoretically or experimentally. Theoretical determination relies on the activity of the source provided by the manufacturer, while experimental determination is usually available through counting the number of particles by silicon detectors.

However, alpha-particle source used for our radiobiological experiments have a 2π geometry, and therefore the alpha particles do not travel in the same direction. In the determination of the fluence, most of the alpha particles would be lost. What's more the fraction of alpha particles reaching the target depends on the solid angle, which would decrease as the distance between the source and the target increases. Furthermore, some alpha particles might not be able to reach the target because the distance between source and the cell exceeds the ranges of the alpha particles.

Due to the limited range of alpha particles in the atmosphere, in vitro radiobiological experiments cannot be performed with high accuracy in terms of dose and selected exposure time. The present paper describes the design and dosimetry of an alpha-particle flat source of ^{241}Am which is suitable for *in vitro* radiobiological studies. A flat source with an activity of 2 MBq and diameter F= 50 mm covered with a 1μm layer of Au was used in cell survival studies. The dosimetry of the alpha source using silicon surface barrier detectors and Gaphromic foil showed that the alpha particle of ~4.9 MeV energy after passing distance of few mm in air reached the Mylar foil forming the bottom of the Petri dish with cells. After passing through a 4 mm of air and 6 μm Mylar foil, the energy of alpha particles is reduced to ~4 MeV to irradiate the cells.

The alpha irradiation effect was demonstrated by the evaluation of cell survival in human cells.

The development of high temperature and mass-separation methods for selective production of medical radionuclides

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The use of radionuclides decaying with the emission of different types of particles and gamma rays of different energies is a very effective tool for diagnostic and therapy of many kinds of malignant tumors and other diseases at an early stage of their appearance. Now for production of radionuclides for medicine high current cyclotrons are widely used. One of the important characteristics of cyclotron produced radionuclides is emission of positrons that allows using them for the PET (Positron Emission Tomography) diagnostics. At NRCKI-PNPI (National Research Center "Kurchatov Institute" - Petersburg Nuclear Physics Institute), a high current cyclotron C-80 was started. The planned beam parameters are: the proton energy up to 80 MeV and the beam intensity up to 100 μA. The radioisotope complex RIC-80 (Radioactive Isotopes at cyclotron C-80), which is constructed at the beam of C-80, will allow to produce practically all radionuclides obtained for medicine with accelerators. An important feature of the RIC-80 facility is the installing of an on-line mass-separator connected to one of the target stations. It will allow the production of separated radionuclides of a very high purity. For the RIC-80 use a new method of a high-temperature separation of the target materials and produced radioactive isotopes was proposed. The results of this method exploration for the production of generator radionuclide ^{82}Sr and radioisotope ^{177}Lu are presented. The possibility of the developed method use for further isotope purification with the mass-separator for selection of ^{82}Sr, ^{177}Lu and other radionuclides is discussed. One of the goals of RIC-80 is the production of alpha-particle emitters ^{223,224}Ra and ^{225}Ac. For the purpose of a high purity ^{223,224}Ra, ^{225}Ac obtaining the electromagnetic mass-separator will be utilized as well. The results of target and ion source tests for the production of radioisotopes ^{223,224}Ra and ^{225}Ac by different methods, including one with the mass-separator use, are presented.

Study of proton and photon-induced reactions on nat-Mo

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Around 2011 a sudden shutdown of two reactors used for the production of medical radioisotopes, made the nuclear community look for alternative ways of radionuclides production to meet the requirement. 99m-Tc is a very important medical radionuclide since it is exploited in almost 80% of diagnostic techniques in nuclear medicine. As an alternative to reactor-based 99-Mo/99m-Tc generator technology, many research groups have suggested the direct production of 99m-Tc through accelerators.

In this presentation, we discuss our experimental work on the production of 99-Mo (half-life = 65.94 h) which is the generator parent of a medically important radionuclide 99m-Tc (half-life = 6 h) through proton and photon-induced reactions on a nat-Mo target. Such production is much more cost-effective compared with production on an enriched 100-Mo target. It may increase the amount of impurities produced though. Therefore it is of vital importance to quantify the effect.

At 9-26 MeV energy range for proton-induced production on nat-Mo, there is a large discrepancy in the cross-section data available for the production of radioactive impurities, hence this work was conducted to contribute data in this range helping to resolve the discrepancy. Using a proton beam from the AIC-144 cyclotron in Cyclotron Centre Bronowice, Cracow, Poland, we studied target yield and the cross-section for the production of long-lived radionuclides produced in the nat-Mo target at the energy range 19-26 MeV. Target yield was derived using the measured activity of produced radionuclides. The total production cross sections for all produced long-lived radioisotopes are presented and compared with the previously available data, showing good agreement with most of them.

Production of 99-Mo/99m-Tc via photo-nuclear reactions was another of our research topics. Since photon-induced reaction on nat-Mo is studied at 10-20 MeV ranges and available data on photo-production are very scarce. Hence we exploited here bremsstrahlung radiation of a 538 MeV electron beam accelerated in the linac of the SOLARIS Synchrotron facility in Cracow, Poland and extracted onto a tungsten plate. The activity of long-lived radionuclides produced from nat-Mo(γ, x) reactions were analyzed, just like in case of proton-induced reactions, using gamma-ray spectroscopy with HPGe detector. The amount of 99-Mo was determined from the intensity of the 181.06 and 739.5 keV spectral lines.

Pre-clinical analysis of boron neutron capture therapy of cancer

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Boron Neutron Capture Therapy (BNCT) is a noninvasive therapeutic modality for treating locally invasive malignant tumors such as primary brain tumors and recurrent head and neck cancer, for example, anaplastic astrocytoma or glioblastoma. The development of BNCT requires an integrated approach with the participation of specialists from various fields, including physicists, biologists, chemists and doctors. At the BINP SB RAS, a source of accelerator-type epithermal neutrons was proposed and constructed. We carried out a series of preclinical experiments on BNCT on cell cultures and laboratory animals. We used immunodeficient 8-10 week old male SCID mice of the SPF status. 18-21 days before the start of the experiment, U87 human glioblastoma cells were prepared, brought to concentration of 100 thousand cells in 1 μl and injected intracranially to obtain intracerebral mass formation. BPA L-p-borfenylalanine and BSH borkaptat were used as a drug for targeted delivery of boron B^{10} monoisotope.

To assess the effectiveness of the accumulation of BPA and BSH in the tumor and constructing the kinetic curves of excretion of drugs, we investigated the tissues of the organs of laboratory animals (blood, kidneys, liver, brain and tumor). The boron content was determined by the ICP OES method on an iCAP-6500 spectrometer (Thermo) after acid digestion in a MARS-5 microwave system (we used HNO_3, H_2O_2, $HClO_4$ and their mixtures). We checked the accuracy and specificity by analyzing the reference material and using spike method. The calibration function was built using a single-element solution of boron ions «GSO 7345-96». The registration of emission spectra was performed under the conditions recommended by the manufacturer. We used the method of sequential dilutions.

We identified organs and tissues in which the accumulation of B^{10} is maximal. We find out the ratio of accumulated B^{10} in the tumor and brain tissue. The optimal times of exposure were chosen when the ratio of accumulated B^{10} in the tumor and brain is maximal.

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Comparison of computational and experimental dose rates in neutron activation analysis facilities

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The vast majority of radiation protection guidelines in nuclear facilities usually relate to one to a few sources of radiation in very controlled environments. Currently, there are over a 110 research reactors where neutron activation analysis (NAA) is a major research and teaching component. Although there are many reports and research articles detailing the safety procedures at power reactors and government-run research facilities, few if any reports have been published specifically for NAA laboratories. This leads to little or no formal protocols to minimize exposure. In particular, NAA can yield a wide variety of exposures due to different types of samples and neutron fluxes. Unlike any other type of radiation laboratories, an NAA lab can contain a large variety of radioactive isotopes as a result of activation products with varying degrees of half-lives and with different strengths of gamma-rays and beta particles. The Nuclear Engineering Teaching Laboratory (NETL) at The University of Texas currently operates the newest TRIGA Mark II university reactor in the USA. The reactor has in-core irradiation facilities and five beam ports with steady state operation at power levels up to 1.0 MW or pulsing mode operation up to 1.5 MW for 10 microseconds. At the center of the reactor, a maximum neutron flux of 2×10^{13} n cm^2 s^{-1} can be achieved. The flexibility allows the reactor to be used for numerous NAA experiments at varying reactor power, neutron flux, and times. Typically, it is difficult to predict exposure rates for each irradiation run. Using MCNP 6.2, a Monte Carlo code developed by Los Alamos National Laboratory (LANL) for neutron, photon, and electron transport, dose rates were computed. The simulation is divided into two different models. The first model is used to computationally irradiate sample materials in several positions in the TRIGA reactor core using a variety of NIST standard reference materials and typical NAA samples. It is important to model the reactor, as the neutron energies will vary from fast to epithermal to thermal, which will affect the sample activation due to neutron capture cross sections. The computational results from MCNP were validated by irradiating NIST and engineering samples inside the TRIGA reactor. Radiation monitors were placed around the NAA laboratory to measure beta and gamma doses. These computational doses were validated to the computational doses. Using this information a database will be developed for accurately predicting the expected doses to researchers working at research reactors and develop better radiation protection standards at NAA facilities.

Characterisation of radioactive particles in coal ash via electron microscopy and synchrotron-based techniques

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Radionuclides in coal ash can occur at levels well above background, enough to raise potential human and environmental concerns. The human and environmental impact of these radionuclides is a function of the mode of occurrence, size, morphology and species. These physicochemical properties determine the mobility, leaching rate and bioavailability of the radionuclides. This work assessed the mode of occurrence, size, morphology, species and impact of natural radionuclides in Nigerian coal ash using state of the art techniques: scanning electron microscopy (SEM) coupled with energy dispersive spectroscopy (EDS) and synchrotron-based techniques (μ-XRF, μ-XANES and ptychography). Prior to synchrotron analysis, individual radioactive particles were lifted out using a micro manipulation system coupled to the SEM; the particles were then secured in Kapton tape, ready for analysis.

Results from the SEM-EDS analysis showed that uranium and thorium accessory minerals (monazite and zircon) with weathered surfaces are homogeneously distributed in the fly ash samples, with particle sizes ranging from 10 to 50 microns. The monazite particles contain about 4% and 2% Thorium and Uranium respectively, shown by the μ-XRF to be heterogeneously distributed and more depleted around the particle edges, a sign of leaching. Natural Uranium particles were also found in the fly ash samples and μ-XANES revealed oxidation state IV. Ptychographic analysis of the uranium particle showed it to have high surface area with dense internal structure and tendency to further fragment into smaller bits. These micron size particles when inhaled can lead to respiratory diseases and lung cancer. Disposal of the fly ash into the environment can also lead to radioecological effects through leaching.

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Clinical significance of accreditation standards in laboratory for radioactivity application and diagnostics

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Background. Standardization of conditions under the principles of good clinical practice (GCP), monitoring of modern medicine according to evidence based medicine (EBM) and good laboratory practice (GLP) reduces the possibility of action of various factors. The aim of this study is introducing the participants with clinical significance of accreditation and application of good clinical practice as well as activities on constant improving of health care quality in medical institutions.

Methods. The quality system is realized in accordance with the principles of focusing on users-doctors and patients, providing quality and timely services, informing and improving, following the progress of clinical-biochemical diagnostics, introducing modern and efficient testing methods, rational laboratory diagnostics, accurate and timely findings.

Results. Participants will acquire professional knowledge and skills related to measures of improving the quality of health services, which refers to the improvement of all processes and services by eliminating unnecessary steps and activities through rationalization, applying Deming's PDCA concept to all activities related to quality. Also the topic will cover health services that are needed to patients like accreditation, safety and effectiveness of therapy. Accreditation represents a public recognition to a healthcare institution for achievements the requirements of national standards and provides safe and secure high quality health services. Accreditation implies: the fulfillment of the quality management system, the technical requirements, the competence for all laboratory tasks (the testing methods are appropriated) according to the ISO 15189 standard. ISO15189,2014- (QM / QA) is standard for medical laboratories with a special requirement of the entire laboratory testing and the standard for POCT-ISO22870: 2006 Point of care testing also be mentioned.

Safety – which means good clinical practice, good laboratory practice, good hygiene practice, practice of maintaining medical and related equipment, good practice of education and training, focus on patient and patient accessibility, equity and efficiency also will be mentioned. Effectiveness of therapy according to clinical pathways and guidelines according to DRG (diseases related group), also interventions which will be applied to yield best positive results will be discussed.

Conclusions. Measures for improving the quality of health services in medical institutions refer on the fundamental facility and factors of quality such as: personnel, education and training of employees, dependence on adequate equipment, innovation of services, quality and standardization of performed services through the application of quality management system. The importance of accreditation is going through the improvement of the organization of health services, fulfillment the requirements of the service users, recognition of competence, improvement of leadership and management.

Keywords: Accreditation, laboratory medicine, QMS, TQM, GLP, Deming-PDCA, health care, patients

Personalized dose assessment for a patient with incompletely blocked thyroid in iodine misadministration accident

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In July 2017, a medical accident occurred in South Korea, in which ^{131}I-iodide solution was misadministered to a wrong patient. Although International Commission on Radiological Protection (ICRP) has provided reference dose coefficients for iodine radiopharmaceuticals on the assumption of complete thyroid blockade, which is not achievable practically, the reference data have limited reliability on dose estimation of the patient, whose thyroid was incompletely blocked. Therefore, we conducted a personalized dose assessment by estimating the patient-specific thyroid biokinetics. Initially, bioassay monitoring of more than 4 times, including whole-body, thyroid, and urine sample measurements was conducted, and a patient-specific transfer coefficient in iodine biokinetic model was determined by means of statistical comparison with the calculation results of compartment models(predicted values). After determining the transfer coefficient for the patient, the patient-specific dose coefficients were calculated in accordance with latest recommendations of ICRP. The methodology developed in this study, including calculation algorithm and modules, were comprehensively verified using the reference values of ICRP and other methodologies. As the calculation results, the patient-specific transfer coefficient determined in this study (0.10) was statistically well fitted with measurement results, and the thyroid absorbed dose was finally evaluated as 21.2 Gy. This thyroid dose calculated based on personalized dose assessment was differed greatly (by about 9 Gy) from the dose simply calculated using ICRP dose coefficients. In conclusion, through the personalized dose assessment, we could avoid a considerable underestimation of thyroid dose and improve the reliability not only by clarifying the individual-specific biokinetics but also by adopting recent recommendations for radiation protection and latest dosimetric data.

Investigation of integral dose in pelvic region using different planning treatment techniques

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Although radiotherapy is an important part of cancer treatment, it can cause cancer development. In the past 10 years, it has been shown that radiotherapy has a small but statistically significant contribution to the development of secondary cancers.

The increase in the integral dose, which is defined as the dose taken by the tissues other than the target tissue, increases the risk of secondary cancer related to radiotherapy in long-term patients. Although the formation of secondary radiation outside the treatment area during radiotherapy is known, the differences due to the new treatment techniques have not been evaluated as dosimetric and still remain hypothetical.

In this study, we aimed to measure and compare the integral dose in vivo in radiotherapy with treatment techniques (3D Conformal Radiotherapy, Intensity Modulated Radiotherapy, Intensity Modulated Arc Therapy).Thermally stimulated luminescence materials have been an important tool in measuring the ionizing radiation dose. Due to some advantages of the thermoluminescence dosimeters in the field of personal, clinical, environmental and space applications, many studies have been carried out to produce more efficient TL dosimeters in recent years. In order to do this, in-vivo dosimetry systems, TLD-100H dosimeters as a Thermoluminescent Dosimeter (TLD) was used to compare the treatment schedule with the TPS dose. Pelvic region, where high energy is used more and high dose applications are made more, is selected as the target treatment area. After special treatment planning for different treatment techniques, the volume determined in rando phantom was irradiated. In vivo dosimetry was placed in 10 localizations outside the treatment area. Doses to which the organs in the out of area areas were exposed were determined. The planned dose values of TLD dosimeters and treatment planning system (TPS) dose values were compared.

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Physical and technical aspects of intraoperative electron radiation therapy: Future perspectives

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Intra Operative Electron Radiation Therapy (IORT) is a technique that allows the patient to be irradiated directly during a surgical operation, using a moveable linear electron accelerator in the operating room. The radiation dose is usually delivered to the surgical bed in a single fraction to-treat the tumor after-surgery, either to treat portions of tumors that remain after a partial resection, or to irradiate tissue that is adjacent to the surgical site and is suspected of containing microscopic tumor cells.

Since IOERT is performed at the time of a surgical procedure, when normal tissue and organs are not present in the treated area, a higher dose of radiation can be delivered to the diseased area, thus increasing the local control of the disease.

IORT was for many years performed using stationary linear accelerators located either in a shielded section of an operating room (OR), or in a shielded radiotherapy treatment room. Now, new technology has made it possible to use mobile accelerator units that can be moved to any OR within a hospital. Linacs now in use provide electron beams with energies between 4 and 12 MeV. Beam energies typically increase in steps of 2MeV or 3 MeV, which increases penetration from around 7mm to 1cm per step. Recently, teams of physicists and engineers at NCBJ, Swierk, have been developing a new, flexible, moderate-cost IOERT machine for use in Poland and other emerging markets. The device, named IntraLine, is now undergoing testing prior to receiving CE approval. Main characteristics of this accelerator will be presented in this work. The design of the new mobile units differs from that of conventional linear accelerators in several important ways. In particular, mobile IORT units are designed for use in an unshielded OR. In order to prevent excessive radiation exposure in surrounding rooms, maximum beam energy is limited to 10 – 12 MeV, and a beam stopper must be designed for every unit. Electron beam applicators for IORT are also designed specifically for use in surgical areas; treatment is performed under sterile conditions; and the radiation is delivered in a single fraction. In addition, the treatment head should have a range of motion that provides flexibility in delivering a dose of radiation to an anesthetized patient.

The uncertainties in the dosimetry of IOERT are slightly higher than those in external beam therapy (2.1%), but the possible unexpected deviations from intended dose due to set-up uncertainties such as incorrect assessment of target dimensions, gaps, blood pooling, etc. reported for IORT are around 4-12% .The uncertainties in target assessment and applicator placement could be reduced by on-line imaging and treatment planning and therefore give reason for further development of appropriate tools.

Measurements of the radiation attenuation in bolus materials with silicone based rubber for applications in radiotherapy

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Radiotherapy uses directly or indirectly ionizing radiation to destroy the DNA of cancer cells, so that they no longer reproduce and eventually lead to their death and thus to destroy tumors. The simplest modern linear accelerator is using a photon beam that has the energy of 6 MV. Some types of cancers are in the depth of the tissue, but also at the surface of the skin. The photon beam is not depositing enough radiation doses at the surface of the intended volume of treatment. As a result, by using a tissue like material named bolus, we can ensure the full coverage of treatment area [Radiation Protection Dosimetry, 162 (1-2) (2014) 167-170, Radiation Measurements, 32(3), (2000) 201-204]. Our research is based on using different silicone rubbers, to replace the expensive commercially bolus.

The materials used in the research are silicone based rubbers with the commercially name GS530SP01K1 and GS528C1G500 from Prochima [http://www.prochima.it/cristal-rubber.html]. From each silicone rubber material we made 6 sheets of square shape (12 cm x 12 cm) and with the thickness of 3 mm. They were irradiated using a CLINAC Unique Performance from Varian with a photon beam with 2 Gy to simulate a single session of radiation treatment. We measured the attenuation of the radiation with an ArcCheck phantom in a single point and profile dose, for each silicone rubber material. After irradiating the bolus with 50 Gy, which is the dose for a normal radiation treatment, the measurements were redone to see whether there is any change in attenuation of the bolus.

The obtained experimental results show that the bolus materials used in these measurements are stable and the difference between the measurements of the attenuation of radiation before and after irradiation with 50 Gy are around 1%. These preliminary results suggest that the silicone rubber bolus can be made with ease for the uniqueness of each patient; it is cheap and can be used as bolus material in radiotherapy and radioprotection.

Keywords: Radiotherapy and radioprotection, bolus materials, absorbed dose, photon beams, linear accelerator

Dose in the HDR brachytherapy for gynecological cancer with the use of thermoluminescence dosimetry

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Planning treatment in brachytherapy in accordance with the recommendations of the TG-43 research group takes into account that patient tissues and applicators used for irradiation have a water density. All dose calculations that take into account the scattering of radiation and the radiological effect of non-homogeneous materials other than water are beyond the formalism of TG-43, although such phenomena occur and can become a significant cause of deviations for dose distributions.

In order to ensure uniformity of calculations in clinical practice, Task Group 186 (TG-186) was created. In 2012, the group issued a report [Medical Physics 39 (10), 6208–6236] describing the use of the Model-based Dose Calculation Algorithm (MBDCA) and creates clearly defined recommendations for planning, based on the current state of knowledge.

Thermoluminescent detectors (TLDs), especially those made of LiF phosphor doped with magnesium and titanium (LiF:Mg,Ti) are a convenient dosimetric tool due to their small size and wide range of measured doses. Their features enable to place them inside the body and measure doses absorbed in selected points simulating organs of a human body. The results may be compared with doses calculated by the planning system.

A gynecological tumor was selected for the experiment, so that the detectors can be easily inserted inside the patient body. Thanks to this tumor location, the impact of applicator density and dissipative medium (water, tissue) on the dose distribution can be checked. Vaginal CT/MR multi channel applicator from Nucletron with a diameter of 35 mm was selected. The experiment consisted in locating the TLDs on the applicator, at equal intervals, on the opposite sides of the applicator.

For gynecological cancer plans made in accordance with the assumptions of the TG-186 protocol, to which proper tissue and applicator densities were introduced, and for the clinical TG-43 protocol, doses were measured using the TLD technique for HDR brachytherapy with Iridium source ^{192}Ir. Although the difference between algorithms has been registered, they do not exceed the 5% permitted difference in clinical dosimetry. Significant differences between the algorithms (about 30%) were noticed only further away from the target in the low dose region (<50%). Although these differences can not be considered clinically significant in view of the acceptance criteria of the plan, the accuracy of the calculations offered by MBDCA may be useful in cases such as re-irradiation of the tumor as well as in the risk assessment of secondary cancer. This algorithm will also be describable in cases where precise dosimetry of critical organs is needed. These results emphasize the need to use more accurate computational algorithms and implement them in clinical practice.

Using the luminescent dyes for the assessment of liposome transport properties as the boron carrier for boron neutron capture therapy

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High effectiveness of Boron Neutron Capture Therapy (BNCT) makes actual the investigation aimed at creating transport systems for the targeted delivery of boron-containing agents. Liposomes are currently among promising boron carrier for BNCT. Existing liposomal technologies allows to vary their characteristics for modifying transport options changing particle diameter, surface charge, lipid composition, the presence of vector molecules on the outer part of the liposomal membrane. The structure of liposomes can include in their composition hydrophobic and lipophilic boron-containing agents at the same time, which increases the content of boron atoms in them. Methods for rapid assessment of dynamic absorption and localization of substances delivered in their composition are required for experiments to improve liposomal drug delivery systems. Such a method of labeling the lipid membrane of liposomes and their internal contents is a great interest in view of the presence of a large number of various luminescent dyes and highly efficient methods for assessing their intracellular localization (confocal microscopy). Using the rapid freezing of target organs and the preparation of cryosections from them makes it possible to perform an express assessment of the liposomes transport properties for a large volume of material.

The blue region of the spectrum for labeling liposomes did not use in our experiments leaving it for the nuclear dyes (Hoechst 33342, DAPI). Nile red was used for labeling liposomal membranes (excitation/emission maxima ~552/636 nm), PKH-26 (excitation/emission maxima ~551/567 nm), TopFluor PC (excitation/emission maxima ~495/503 nm). High molecular dextran derivatives FITC-Dextran (excitation/emission maxima ~495/520 nm), Rhodamine B isothiocyanate–Dextran (excitation/emission ~570⁄590 nm) were used for labeling internal water core liposomes. The combination of the proposed luminescent labels allows to selectively assess the localization of the labels of liposomes delivered in the lipid and aqueous phases and makes it possible to extrapolate these data with respect to hydrophilic and lyophilic boron-containing agents. The remaining free region of the spectrum lying in the far red range allows to use it for determining the localization of liposomes in certain organelles, for example, mitochondria (MitoTracker Deep Red for mitochondria, Liso Tracker Deep Red for lysosomes, etc).

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Influence of the distance between implanted sources on the local control probability

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One of the second most predominant types of skin tumors in the head and neck regional is lip cancer. It normally affects men over the age of 50 and in 95% of the cases the majority of the tumors are located in the lower lip. In very advanced tumors where surgery is not possible, radiotherapy (external beam or brachytherapy) alone or associated with chemotherapy is the unique therapeutic option. For early T1-T2N0M0 stages lip cancer preferably used brachytherapy as a kind of radiotherapy where radioactive sources are placed inside or in contact with the tumor offers a smaller treatment volume adapted to the tumor requirements in comparison to external beam irradiation.

The prescription dose coverage of tumor has a strong influence on the tumor local control, TCP. The analysis and use of these data allows proceeding to the optimization of radiation therapy plans in terms of sum dose, uniformity or degree of coverage sum course dose to achieve the maximum value of TCP and the maximum recurrence-free period.

The aim of this research is to investigate the influence of distant between implanted applicators in recommended range on the value of TCP.

In the range of this investigation, five plans were modeled by means interstitial high-dose brachytherapy (HDR) with different distant (0.8-1.2 cm relative to each other) between implanted sources for one patient with T2N0M0 stage lip cancer. The patient were treated in a mode of hyperfractionation with a fraction dose of 5 Gy to a total dose of 45 Gy (9 fractions) on a Multisource HDR with a 60Co source. The creation of treatment dosimetric plans was carried out by Multisouce HDRplus 3.0.4software.

For comparison of different treatment plans, the criterion of tumor control probability (TCP) was used. TCP was calculated using the Niemierko model. The following parameters were used: alpha/beta = 10 Gy, TCD_50 = 45 Gy, g_50 = 8.7. The TCD_50 value was taken for HDR brachytherapy from Ref. [Acta Otorrinolaringol Esp. 2016; 67(5): 282-287].

TCPs were calculated based on DVHs calculated for different implants positions. According to calculation results the distances 0.8 and 1.2 result in TCP values lower than 30%. The distances 0.9–1.1 result in TCP values equal to 99.9%.

Implementation of the EPID-based in vivo dosimetry system for the patient plan quality assurance

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Purpose. The in vivo dosimetry is designed to measure the radiation dose received by the patient during the radiotherapy procedure. It provides additional information about the quality of treatment regarding to traditional phantom verification methods, as it allows to estimate the dose of each fraction. In vivo dosimetry based on EPID measurements of the linear accelerator additionally has a number of advantages over other in vivo dosimetry methods, as it is not invasive and allows to evaluate 2D and 3D dose distribution in the patient's body. This work is aimed to study the feasibility of radiation therapy plans in each fraction using EPID-based portal dosimetry by the PerFraction (Sun Nuclear corp) software.

Methods and materials. Measurements were carried out using the built-in Electronic Portal Imager Device (EPID) of Elekta Synergy linear accelerator (Elekta AB) for portal dosimetry. Dosimetric planning of different localization and fractionations was carried out on Monaco v5.10 (Elekta AB). The completed plan's information in the form of the CT images, the names of the structures and parameters of each beam were loaded to the PerFraction software server, which produces the primary pre-planned independent assessments of the plan by the built-in GPU-based calculation algorithm. Further the assessment of each fraction was produced by PerFraction based on the received log-files from linear accelerator. The 2D dose distribution estimation was carried out directly on the basis of the EPID measurements. The evaluation results were presented as a comparison of the calculated and measured doses at the point, as well as gamma analysis of the dose distribution in the patient structures.

Results. As a result of the study, several cases were identified when one or more fractions for the entire course of therapy did not meet the stated convergence criteria. For instance, in a case of SBRT prostate cancer the difference between planned and measured point dose of second beam was about 9% and D95(PTV) difference Δ%(TPS-QA)>9.17%. It is possible to make an assumption about the photon beam output instability or about the patient's positioning errors.

Designing the medical set-up of the proton beam of the Institute for Nuclear Research

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Proton beam therapy is one of the promising methods of treatment of tumors. Therefore, the development of systems for the formation of therapeutic proton beams is an urgent and important scientific task. The Institute for nuclear research (INR) of the RAS is conducting research on methods for creating such systems of formation on the basis of a proton linac. The existing beam formation system of the INR involves the use of passive proton scattering. The profile, energy spectrum and depth-dose distribution of the therapeutic beam are determined by a double scattering system, as well as a set of collimators, boluses and proton energy modulators. The calculation of the forming devices is made by analytical methods with subsequent verification of the beam tracing by programs that implement algorithms of the Monte Carlo method. On the basis of one of these programs SRNA was developed an original program for the calculation of designs of energy modulators - ridge filters. As a result of the research, a beam installation was assembled, which allows to adjust to the current parameters of the initial beam of the INR linac. The system of formation of a therapeutic proton beam in a wide range of parameters of these beams was tested. The results of the experiments showed their good compliance with the preliminary calculations.

Radiation-induced skin pigmentation after accelerated partial breast irradiation: Dose volume histogram analysis

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Breast cancer is the most common malignancy disease among women all over the world. The last observations show a tendency to age decreasing of patients with this diagnosis. Therefore, organ-preserving methods of treatment are becoming more and more relevant. This indicates the importance of their development. Lumpectomy with the subsequent brachytherapy is the most promising treatment of this disease in the early stages. Due to this treatment, the time of postoperative therapy decreases several times. And it is also possible to reduce - the radiation exposure to the organs at risk (OARs). One of the main OAR is the skin, which is often located closest to the tumor bed. In this regard, it is necessary to monitor its radiation exposure more carefully.

In 2017, the protocol for the breast cancer treatment with high dose rate (HDR) brachytherapy was adopted in A. Tsyb Medical Radiological Research Centre – branch of the National Medical Research Radiological Centre of the Ministry of Health of the Russian Federation. There is the mode of 10 x 3.4 Gy continuously for 5 days, 2 fractions per day with a break of at least 6 hours. According to this protocol, the maximum allowable radiation exposure for the skin does not exceed 34 Gy.

By May 2019, 28 patients were treated with a mean follow-up 10.5 months, the median of the study is 11 months. Among these patients, 7 had seceded with time toxic effects on the skin in the form of pigmentation. The results of the dose volume histogram (DVH) were analysed.

D_{max} for these patients were: 2 of them had 34.6 Gy (EQD_2 = 44.7 Gy), 34 (43.5), 33.8 (43.1), 33.6 (42.7), and other 2 – 33.3 (42.2). Such parameters as $D_{0.01cc}$, $D_{0.1cc}$, D_{1cc} and D_{2cc} were analysed.

They are:

- $D_{0.01cc}$: 33.4 Gy (EQD_2 = 42.4 Gy), 2- 33 (41.6), 3 – 32 (39.7) and 31 (37.8);

- $D_{0.1cc}$: 32 Gy (EQD_2 = 39.7 Gy), 31.8 (39.3), 31 (97.8), 2 – 30 (36.0), 29 (34.2) and 27 (30.8);

- D_{1cc}: 29 Gy (EQD_2 = 34.2 Gy), 4- 27 (30.8), 26 (29.1) and 24 (25.9); - D_{2cc}: 27.7 Gy (EQD_2 = 32 Gy), 26 (29.1), 25 (27.5), 2 – 24 (25.9), 23 (24.4) and 20 (20).

Among all patients, there were those who had the same values or more, but they did not have any toxic effects. Therefore, the expected effects, as well as the results of treatment, are very individual and depend on many factors. We can only try to minimise them. So, it is necessary to be careful with the values of $D_{max} \geq$ 33 Gy, $D_{0.01cc} \geq 32$, $D_{0.1cc} \geq 30$, $D_{1cc} \geq 27$ and $D_{2cc} \geq 24$.

Preliminary evaluation of ArcCHECK® detector's usefulness for treatment plan verification in brachytherapy

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To ensure the safety and effectiveness of radiotherapy, an important element of the pre-trial investigation is to verify the planned treatment. In brachytherapy, verification is methodologically complicated because of the difficulty of measuring the dose distribution around the system of sources placed inside the irradiated object. The presented work attempts to assess the suitability of the ArcCHECK® detector to verify planned brachytherapy treatment. For this purpose, a Monte Carlo simulation of the treatment plan was carried out for a specially prepared phantom, which was then implemented in the ArcCHECK® detector. The measurement of the dose distribution in the ArcCHECK® detector is obtained by 1386 semiconductor diodes located around the cylindrical chamber of the device. Directly measured quantity is the dose distribution on the phantom surface, while the dose distribution inside is mathematically reconstructed. The dose distribution measured in the detector on the surface of the cylindrical phantom was compared with the dose distribution calculated in the Monte Carlo simulation performed in the EGSnrc program. The construction of the phantom makes it possible to place radiochrome films in it, transversally to the axis of the cylinder, which register the dose distribution within the phantom in the plane in which the film has been placed. The spatial distribution, reconstructed by the software, was then also compared both with the dose distribution registered by the radiochrome film and calculated in the simulation. Combined validation of measurement results from the ArcCHECK® device both with Monte Carlo simulation and measurement performed with radiochrome films provides a solid basis for the initial assessment of the reliability of the verification of brachytherapy treatment plans by the ArcCHECK® detector, and the suitability of this detector for the verification of planned therapeutic treatment.

Applying MTF, NPS and DQE calculations to assess the exposure conditions in digital mammography studies

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Image quality requirements in mammography are very high. Significant improvements in mammography systems i have been achieved with the introduction of active matrix flat-panel detectors. However, evaluation of image quality in mammography still often relies on subjective methods, such as visual assessment of phantom images. In this work, a methodology for determining Modulation Transfer Function (MTF), Normalized Noise Power Spectrum (NNPS) and Detective Quantum Efficiency (DQE) in mammography was developed for a digital detector conforming to the standards of the International Electrotechnical Commission (IEC 62220-1-2:2007).

The Siemens Mammomat Inspiration digital mammography system was used in our study at the Oncology Center in Warsaw. Consistent with the IEC standard recommending added aluminum filtration of substantial thickness, we used a 2 mm Al filter. System operations were performed using settings that permitted acquisition of raw images, without applying any additional postprocessing (i.e. “for processing”).

Air kerma was measured using a calibrated radiation meter (Piranha Black 457, RTI Electronics AB, Sweden) as a function of tube loading. Image registration was performed for different tube loading values. The dependence of photon fluence on the average pixel values was determined based on the dependence of air kerma and the average value of pixels on tube loading.

Spatial resolution was characterized by evaluating pre-sampled MTF parallel and perpendicular to the anode-cathode axis using the edge test device. The edge was constructed and produced at the National Center for Nuclear Research. Edge quality was confirmed using an electron microscope. The procedure for calculating MTF was written in software we developed, and will be described in another paper. MTF was determined based on the edge images, using the photon fluence relationship from the mean pixel value.

NPS required in DQE estimation was calculated from images measured for clinically-used exposure conditions.

On the basis of MTF, NPS and air kerma measurements, DQE was determined. Measurements and calculations were performed for different radiation qualities, including various anode / filter combinations (Mo/Mo, Mo/Rh, W/Rh) and high voltage values (26 ÷ 34 kV). This approach allowed for objective assessment of the impact of a range of exposure parameters on the quality of the obtained image.

A novel method to improve learning efficiency of artificial neural network algorithm to estimate dose distribution for radiation treatment

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Introduction. Both the accuracy and the speed of dose calculation are crucial a clinical field of radiation treatment. This study intended to apply an artificial neural network (ANN) to develop a real-time computing algorithm for dose calculation for radiation treatment. In order to assess the feasibility of using neural network, a neural network algorithm was constructed and compared with the results obtained with Monte Carlo calculations.

Methods. First of all, a step known as learning process is necessary. We considered the data set with the pairs of a point-wise dose and its position for training an ANN. The ANN was modeled using the Neural Network tool of MATLAB 7.0 (Mathworks, USA). It was constructed with the three layers including one hidden layer. From the investigation of basic characteristic of learning algorithm of neural network, it is noted that the steep dose gradient in the penumbra region causes the inefficient learning performance and propagate the error in to the whole region of radiation field. A novel method was contrived introducing the intermediate tuning stage in which the weight of hidden layer unit is firstly optimized considering an analytic function with less steep gradient as a dummy target/output and transferred to the original target dose distribution.

Results. It provided the successful escapement from the local minima. Except for the penumbra region, the error was less than 5%. By using the dose data measured by 1.5cm interval, the dose distribution was successfully calculated by 0.5cm mesh size. It is indicated that the feasibility of using neural network was verified.

Conclusions. It is expected to a neural network could be developed successfully to achieve a real-time calculation of dose distribution in the human body by using the novel method.

Advisability of eye lens dosimetry in nuclear medicine

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Changing the individual dose limit for the lens of the eye from a value of 150 mSv per year (ICRP, 2007) to a level of 20 mSv (average over defined periods of five years or 50 mSv in a single year) (ICRP, 2011) means that issues related to routine eye lens dosimetry become interesting from the point of view of radiation protection. The discussion about exposure received by eye lenses of workers occupationally exposed to ionising radiation has been going on for some time already. Its origin is largely associated with radiobiological aspects and thus with the deterministic effects that the ionising radiation is able to induce at the cellular level in the lens of the eye. We are talking here about the cataract. In the present ICRP approach, cataract induction is a deterministic effect with a definite threshold (ICRP, 2010). This threshold is between 0.5 and 2 Gy for acute exposure, and 5-6 Gy for prolonged exposure (ICRP, 2010). This could mean that the dosimeter designed to measure the doses at the level of the eye lens may become the next dosimeter routinely worn by nuclear medicine workers occupationally exposed to ionising radiation. The dosimeters currently used in nuclear medicine are: the personal dosimeter and the ring dosimeter. Will this also be the case for nuclear medicine employees? In this interdisciplinary branch of medicine, the factors that cause the highest risk of radiation exposure of personnel are: the process of manual handling, i.e. the process of preparing a radiopharmaceutical called labelling. Most of radiopharmaceuticals used in nuclear medicine are labelled manually. In Poland, the exception from this rule is when radiopharmaceuticals are produced for the needs of positron emission tomography (PET), which are labelled using automatic processes. Manual procedures also include the process of radiopharmaceutical injection to the patients. The aim of the work was to assess the exposure of eye lenses of workers in nuclear medicine as well as the personnel in centers that produce radiopharmaceuticals for PET diagnostics, from the viewpoint of advisability of routine eye lens exposure monitoring, taking into account changes in the dose limit for the lens of the eye. The results of own measurements of the personal dose equivalent $H_p(3)$, carried out in five nuclear medicine departments in Poland as well as in two centers producing radiopharmaceuticals for PET, were subject to analysis. The analysis includes two most frequently used radionuclides for diagnostic purposes, namely ^{99m}Tc, ^{18}F and the less frequently used ^{68}Ga, in addition to ^{131}I, which is used for therapeutic purposes. Dosimetric measurements were made using thermoluminescent detectors of domestic manufacture. Estimated analysis of the annual exposure makes it possible to indicate cases where the maximum annual value of personal dose equivalent, in terms of $H_p(3)$, exceeds threefold the new limit value specified at 20 mSv/year.

Radiological risk assessment of phosphate mining in El-Sebaiya locality, Aswan zone, Egypt

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In the present work, the specific activity concentrations of natural radionuclides of ^{238}U and ^{232}Th chains members and ^{40}K were measured by using gamma-ray spectrometric technique based on high-resolution hyper-pure germanium detectors (**HPGe**) in phosphate samples collected from El-Sebaiya area. The external hazard index($\mathbf{H_{ex}}$),the external absorbed dose rates(**D**), the annual effective doses (**E**) and the excess lifetime cancer risk (**ELCR**) due to gamma radiation from the samples have been calculated and compared with the average worldwide values. The evaluations of the associated radiological hazards from these materials on the workers during the mining processes in the El-Sebaiya area were carried out.

Lung cancer incidence and cancer risk from radioactivity – some data for the capital of Montenegro

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There is an interest in evaluating and predicting risks due to existing radiation exposure situation, such as radon inhalation or exposure to external terrestrial radiation indoors and outdoors – as the greatest contributors to annual effective dose coming from natural radiation sources. That is particularly related to radon exposure and an evaluation of its role in initiating lung cancer, although risk projections have serious limitations being affected by the other important agents contributing to the cancer risk. Cancer risk due to radon inhalation and terrestrial gamma radiation in Podgorica, the capital of Montenegro, is considered here together with available epidemiological data, showing that among cancers diagnosed in Montenegro lung cancer is one of the most common. Previous analysis indicated that the lung cancer incidence rate increases from year to year, ~6% annually in the period from 1978 to 2005, with an average standardized incidence rate of 20.8 per hundred thousand. The incidence rate of lung cancer in Podgorica in 2009 evaluated in the present study was found to be around 34.9. Diagnosed cancer types were non-small cell lung cancer in 37%, small cell lung cancer 22%, adenocarcinoma 17%, and mixed – adeno- and non-small cell 24%. Excess lifetime cancer risk due to terrestrial gamma radiation outdoors in the urban area of Podgorica (14 locations) is estimated to be in the range ($\times 10^{-3}$) from 0.17 to 0.69, with an average of 0.33, while the risk of lung cancer due to lifetime radon inhalation (153 homes in the region of the Podgorica municipality) – from ~0.04 to ~8.8%, with an average of ~0.8% and median of ~0.4%.

Uncertainties in internal dose assessment for intake of tritiated water

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Internal dose caused by inhalation of tritiated water (HTO), accounting for about one third of annual dose for workers of heavy water reactor in South Korea, is generally calculated using urine concentration and reference data such as dose coefficients, and thus expressed as a single value. On the aspect of dosimetry for specific-individual, however, the single dose value has always involved inevitable uncertainties arising from an inter-individual variability and a lack of knowledge, relevant to reference parameters. Moreover, subjective factors in dose calculation procedures-such as an interpolation method of urine concentration and a definition of source region-could also introduce a significant uncertainty. To avoid an excessive exposure which could not be tolerated, and further to prioritize the factors reducing the uncertainty, therefore, it is necessary to quantify the uncertainty in internal dose of HTO.

In this study, for uncertainty assessment, the internal dose of HTO was derived as a probabilistic distribution rather than a single value; it was achieved by propagating the probabilistic distributions of underlying uncertainty factors (e.g. biokinetic transfer rates, volume of total body water, etc.), which were established on the basis of extensive experimental data. As an example result, it was found that the dose of HTO was lognormally distributed with the geometric standard deviation of 1.67 in a wide range, in which 5-percentile and 95-percentile values differ by a factor of 4.5. Considering the central value of the dose distribution as an individual's dose, the actual dose can be regarded as known to within a factor of less than 2.1. The single dose value calculated by recommended data (conventional method) was located at 12-percentile of the dose distribution; this pointed out that the conventional method could underestimate significantly the actual dose. The uncertainties, which could be subjectively introduced by selection in terms of calculation procedures, was also quantified by the relative comparison of doses, but the difference in doses according to different selection was within 10 %. Sensitivity analysis via rank correlation coefficients indicated that the radiation weighting factors and the excretion rate of tritium from body were most impactful parameters on the HTO dose assessment. The method of uncertainty assessment in this study could be applied to other nuclides or cases.

A novel class of small molecular inhibitors with radioprotective properties

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The goal of this study was to develop novel radioprotective agents targeting intrinsic apoptotic pathway and thus decreasing the radiation-induced damage. For that purpose, we designed, synthetized and analyzed ten new compounds based on the 1-(4-(2-alkyl)piperazin-1-yl)-3-aryloxypropan leading structure. The cytotoxicity of newly synthetized substances was tested in vitro on cell lines derived from different progenitor cells by WST-1 proliferation assay. MTT test was utilized to assess IC 50 and maximum tolerated concentrations of novel compounds in A-549 cells. On the other hand, screening for radioprotective properties was performed using flow-cytometry in MOLT-4 cells exposed to 60 Co ionizing radiation. Selected candidates underwent in vivo testing in C57Bl/6J mice having a positive impact on their immunological status. In summary, we report here promising compounds with radioprotective effect in vivo.

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Nuclear state liability for damage resulting from nuclear activities

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Nowadays much is discussed about issues related to the preservation of the environment, what can be done to improve it, what should be avoided. In this discussion comes the question of the potential of nuclear energy. One of them is the potential for electric power generation, more cheaply and with less impact to the environment. However, much has already been seen in the world as regards damages that may result from an accident in these plants. In the event of an accident that causes effective damage, either to the environment or to the population, both the Brazilian and foreign standards as predict liability for remedying. The Brazilian Federal Constitution of 1988 determines the competence of the Union to operate nuclear services and installations, being State monopoly activities related to nuclear material and its derivatives. Besides that, CF/88 attributed liability strictu senso for nuclear damage. The Vienna Convention on Civil Liability for nuclear damage, dated May 21, 1993, which was promulgated in Brazil by Decree No. 911/1993, provides that the operator is responsible for nuclear damages, in the case of Brazil, the operator is the State entity (Federal Autarchy) responsible for the operation. Thus, in cases of nuclear damage the State should be held liable objectively. And here issues begin to arise such as: Is the State always responsible? Is there any possibility of exclusion the State liability? This paper aims to analyze the constitutional text and the infra-constitutional rules, correlating the nuclear and environmental legislation to respond to these and other questions.

Keywords: Brazilian Environmental and Nuclear Laws, civil liability, strict liability of the State, IAEA

Preventive treatment of drying chamber with UV radiation and ozonization for protection against spoilage of raw smoked sausages

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Introduction. The problem of antimicrobial protection of products due to the wide spread of diseases associated with the use of infected meat products is relevant for the meat processing industry. Therefore, the aim of our work was to study the effectiveness of using UV irradiation and its combination with ozone during the disinfection of air in the chamber for the mandatory drying of raw smoked sausages that undergo microbial spoilage during storage.

Materials and methods. The biocidal effect on microorganisms was created using a UV irradiator OBN-150 and an ozonizer-irradiator OZUF. The change in the total number of microbes and separately molds before and after inactivation was determined using the air collector PU-1B with Petri dishes placed there with the nutrient medium, which took into account the growth of microbes after thermal incubation. The data were processed statistically for $p \leq 0.05$. The disinfection exposure was 30, 60, 90 min.

Results When comparing the concentrations of all microorganisms and molds, before and after the 30-minute treatment of the chamber with OBN-150 UV irradiator, there was a decrease in microbes by 1.3 and 1.1 times, respectively. Under the action of the UV-irradiator-ozonizer OZUF, the reduction in the total number of microorganisms by 3.1 times was revealed, and the molds by 1.5 times, i.e. biocide 30 minutes treatment by UV rays and ozone was greater.

The reduction in the total number of microorganisms and separately molds after a 60-minute disinfection in the drying chamber with OBN-150 was, respectively, 3.2 and 1.2 times. Treatment of the chamber with OZUF led to a decrease in these characteristics by 4.7 and 4.2 times.

As a result of the longest 90-minute UV irradiation with OBN-150, the total number of microorganisms eventually decreased from 23.9% to 75.7%, and molds from 9.7% to 56.3%. With OZUF these values reached 90.3% of the dying off of the total microbiota of air and 84.5% of the molds.

Conclusion. Thus, the treatment of the chamber with irradiators after 30, 60, and 90 min caused an increasing biocidal action with a dominant effect of OZUF, i.e. when with UV rays were combined with ozone. At the same time, molds were more resistant to the harmful effects of irradiators than bacteria. After the application of irradiation, the organoleptic properties of the raw smoked sausage did not change, and its shelf-life without spoilage increased.

Keywords: Disinfection, drying chamber, ozone, shelf-life, spoilage, sausage, UV-irradiation

Application of the Monte Carlo method and the empirical approximate formulas by Taylor and Berger for the calculation of the Build-up factor in the fields of gamma and X radiation

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During the construction of nuclear facilities, radiotherapy centers, hospitals with radiological diagnostic facilities, and radioactive waste storage facilities, complex requirements for protection against ionizing radiation have been set up. In its basic principles, modern approaches in the design of radiation protection procedures were derived from empirical conclusions that were obtained by solving practical problems encountered by nuclear engineers and physicists. In the radiation protection projections, as well as in the formation of different technical and technological procedures in the radiation environment, one of the most important characteristics is the build-up factor of the material used. Based on experimental and theoretical research, empirical formulas for calculating the build-up factors are used to solve practical problems in radiation protection. With the development of information and computer technologies for calculating the build-up factor, other numerical methods are also used, of which a very attractive and efficient Monte Carlo calculation method is used. In this paper, the calculations with the empirical approximate formulas by Taylor and Berger, as well as the results obtained by using the software based on the Monte Carlo method, were used to determine the build-up of the factors in the protection of gamma and X radiation for several selected materials (lead, water, iron, etc.). By comparing the results obtained with the empirical approximations and Monte Carlo calculations, certain conclusions have been drawn that direct us to new critical considerations about the usefulness of using the chosen method of calculation for the build-up factor of materials found in modern technological processes using sources of gamma and X radiation.

Efficiency of using the fluorescent method for the determination of conformational changes of bovine serum albumin in water quality assessment

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Purpose of Research. To study the properties of water from different sources using the fluorescent method for determining conformational changes of bovine serum albumin (BSA).

Objects and Methods. A solution of BSA (Sigma-Aldrich) at a concentration of 7 mg/ml was prepared using water from the following sources:

- tap water of the laboratory of combined effects of the Institute of Radiobiology;
- distilled water;
- consecrated water in the church;
- store bottled water "VitaoxyV" enriched with oxygen in a concentration of 3-6 mg/l;
- water from a spring near the village Slobidka Stolbtsy district Minsk region Belarus.

The presence of conformational changes (tertiary and quaternary structures) of BSA was judged by the change in the values of the intrinsic fluorescence. Registration of the intensity spectrum of the intrinsic fluorescence was carried out on a spectrofluorimeter CM 2203 Solar (Belarus). Conditions of registration: the length of the excitation 280 nm, the registration range of 300-400 nm, the spectral slit width of excitation and fluorescence of 3 nm. The analysis of the obtained data was performed using the software package of the specified spectrofluorimeter (H – peak height in the spectrum maximum; I – spectrum area).

Results and Discussion. Based on the data obtained the values of the intrinsic fluorescence BSA, when used as a solvent of various types of water, were as follows:

- tap water: H = 21.86, I = 1 366.18;
- distilled water: H = 28.36, I = 1 874.54;
- consecrated water: H = 28.53, I = 1 825.98;
- store bottled water “VitaoxyV”: H = 31.66, I = 2 107.39;
- spring water: H = 33.67, I = 2 234.10.

Consequently, in water from different sources albumin takes a specific spatial structure for each water and the maximum values of the intrinsic fluorescence BSA is observed when the protein is found in the spring water.

Currently, the scientific community is actively discussing the properties of ordinary and structured water containing a large number of geometrically correct figures of "clusters". According to experts, the factors that lead to changes in the structure and properties of water include various mechanical effects; radiations and fields (electric, magnetic, gravitational, bioenergetic effect of man), etc. Such structured water becomes active and carries new properties. When conducting an experimental comparison of the structuring action of the above factors, it was shown that the maximum impact was a combination of vortex with a magnetic field. In nature vortex (turbulence, eddy flows) provided by stones and violations of the bottom structure, that create obstacles to the flow of water in the river or a spring source.

Conclusion

1. The fluorescent method of determining the values of the intrinsic fluorescence of the bovine serum albumin can be used to determine the identity (differences) of the biophysical properties of different types of water.
2. The maximum effect of the structuring action on water influence nature itself.

Changes of reproductive parameters of *D. melanogaster* females under the influence of Wi-Fi EMR router at different stages of development

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Objective. To study the changes of reproductive parameters of Drosophila melanogaster after exposure to electromagnetic radiation of the radio frequency range (EMR RF) 2.4 GHz from the router of Wi-Fi wireless communication system at different stages of development.

Materials and methods. After synchronization of populations of D. melanogaster Canton-S and Hsp22 lines, departed flies were counted, separated by sex and placed on an irradiation. Wireless Wi-Fi router operating at the 2.4 GHz frequency served as the installation of irradiation.

After irradiation, the lines of flies were planted in vials for mating in a sex ratio of 1:1 for 3 days.

The analysis included such indicators as the number of pupae, the number of departed individuals, the ratio of male and female, the dynamics of flies' departure.

Results and discussion. When analyzing the dynamics of flies' departure in each control group, were observed two peaks: on the 10^{th} and 13^{th} days after the beginning of Drosophila mating. In the groups "larva irradiation" peaks of flies' departure were displaced by 3 days. In the groups "imago irradiation" highs of flies' departure were on the 12^{th} and 14^{th} days.

Irradiation of the Canton-S line at the larval stages had an impact on the number of pupae: a significant increase by 39.63% (at $p \leq 0.05$) compared with the control group, however, the number of didn't departure of flies also increased – by 156.00% relative to the control.

During the irradiation of the Canton-S line at the imago stage, there was also a significant increase in the number of pupae (by 84.47%). It is worth noting that the number of didn't departure of flies increased significantly by 1426.40%.

Irradiation of the Hsp22 line at the stages of larval development did not have a significant effect on the number of pupae of offspring, but the number of didn't departure of flies was increased by 120.71%. The number of pupae under irradiation of Hsp22 line flies at the adult stage significantly increased by 73.55% relative to the control, but also increased (by 810.71%) and the number of didn't departure of Drosophila.

Conclusions. In the experimental lines, high mortality of offspring from parents irradiated at the stage of imago was noted. Exposure to EMR RF (2.4 GHz) had an impact on fertility – there was an increase in the number of offspring relative to control. In the irradiated groups was observed the shift of the maxima of the departure of flies for 2-3 days.

Evaluation of fertility of *D. melanogaster* individuals of the first-third generation contained in the conditions of constant influence of EMR of Wi-Fi router

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The aim of the work was to assess the fertility of individuals Drosophila melanogaster of three generations (F1 – F3), who were under the constant influence of electromagnetic radiation of the radio frequency range (EMR RF) 2.4 GHz from the router of wireless Wi-Fi.

Materials and methods. After synchronization of populations of D. melanogaster of Canton-S, Hsp22 and Hsp70 lines departed flies counted, separated by sex and put on irradiation. Wireless Wi-Fi router operating at the 2.4 GHz frequency served as the installation of irradiation.

The lines were divided into the following groups: “control” and “irradiation”. Control groups were kept in standard room conditions. The “irradiation” groups were exposed to constant (throughout all three generations of F1 – F3 flies) EMR 2.4 GHz from the Wi-Fi router under standard room conditions.

The analysis of F1– F3 included such indicators as the number of pupae, the number of departed individuals, and the ratio of male and female.

Results and discussion. In the analysis of the offspring of irradiated Drosophila F1, a significant increase in the number of pupae by 79.29% relative to the control was noted. However, the number of did not departed Drosophila increased by 459.09%.

Generation F2 of the Canton-S line is also characterized by a decrease in reproductive performance: a significant increase in the number of pupae by 44.41% and did not departed Drosophila by 65.71%.

In Drosophila F3 generation there is a high mortality at the pupal stage – the indicator increased by 1629.03% relative to control.

The number of did not departed Drosophila line Hsp22 significantly increased by 1067.27% in F1, 713.33% in F2 and by 468.97% in F3. The number of pupae increases by 61.69%, 69.55% and 51.57% in generations F1-F3, respectively (relative to control).

In the analysis of Drosophila line Hsp70, constantly irradiated EMR 2.4 RF GHz was noted the following:

- in the generation F1 significantly increased both the number of pupae (77.53%) and the number of non-hatched Drosophila (1175.00%) relative to control;

- in the generation of F2 noted the relative stabilization of mortality of Drosophila at the pupae stage (figure increased by 290.91% relative to control);

- in the generation F3 is characterized by a jump in the high mortality of Drosophila at the pupae stage (1133.33% more than the control groups).

Conclusions. The impact of the Wi-Fi wireless router had an impact on the survival of the offspring of the Canton-S, Hsp22 and Hsp70 lines at the pupal stage – fertility increased, but the survival of the individuals fell. Such dynamics can be seen in all three generations to varying degrees.

The influence of electromagnetic fields of anthropogenic origin on the molecule of bovine serum albumin

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Purpose of Research. To study conformational changes of bovine serum albumin (BSA) under the action of electromagnetic fields of industrial frequency by fluorescent method.

Reagents and equipment:

- bidistilled water (BW);
- BSA solution (0.66 mg/ml) prepared on BW;
- phosphate buffer (PB) pH=7.48;
- BSA solution (0.66 mg/m)l prepared on PB;
- alcohol solution of probe 1-anilino-8-naftalinsulfonate (0.4 mg/ml);
- source of calibrated magnetic field of industrial frequency (50 Hz) with a magnetic flux density of 0.5 mT;
- spectrofluorimeter CM 2203 Solar.

Research plan:

- 1st solution: BW;
- 2nd solution: BW was irradiated on the magnetic installation for 1 hour, and then it was used for the preparation of BSA aqueous solution;
- 3rd solution: BSA aqueous solution was irradiated on the magnetic installation for 1 hour;
- 4th solution: PB;
- 5th solution: PB was irradiated on the magnetic installation for 1 hour, and then it was used for the preparation of BSA buffer solution;
- 6th solution: BSA buffer solution was irradiated on the magnetic installation for 1 hour.

The presence of conformational changes (tertiary and quaternary structures) of BSA was judged by the change in the values of an intrinsic fluorescence (λ_{excit} = 280 nm) and a probe fluorescence (λ_{excit} = 320 nm). The studies were carried out on the spectrofluorometer at a stable temperature + 23° C. Analysis of the obtained data was carried out using the GraphPad Prizm 4.0 Program.

Results and Discussions. When comparing values of maxima of the intrinsic fluorescence of the 2nd and 3rd solutions with such values of the 1st solution is observed:

- increasing values of the 2nd solution by 7.4 %; increasing values of the 3rd solution by 17.0 %.

When comparing the values of maxima of the probe fluorescence of the 2nd and 3rd solutions with such values of the 1st solution is observed:

- increasing values of the 2nd solution by 1.0 %; increasing values of the 3rd solution by 16.3 %.

When comparing the values of maxima of the intrinsic fluorescence of the 5th and 6th solutions with such values of the 4th solution is observed:

- increasing values of the 5th solution by 2.9 %; increasing values of the 6th solution by 8.6 %.

When comparing the values of maxima of the probe fluorescence of the 5th and 6th solutions with such values of the 4th solution is observed:

- increasing values of the 5th solution by 3.0 %; increasing values of the 6th solution by 7.1 %.

So, if the buffer (water) is irradiated at first, and then it is used for the preparation of BSA solution, the maximum changes in values of the intrinsic and the probe fluorescence of the protein are observed.

Conclusions. Possibly one of the mechanisms of action of electromagnetic fields of industrial frequency can be structural (cluster) changes in water (buffer).

Radioprotective effect of Co(II) inosinate on the blood system cells of C57Bl/6 mice after single exposure to γ-radiation

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The search and study of new radioprotective compounds capable of modifying the damaging effects of ionizing radiation is important issue of radiobiology. In recent years, the synthesis of metal complexes with more effective chelating ligands is in progress. Inosine, as a purine nucleoside, is a precursor of adenosine triphosphate, with metal ions forms low-toxic and membrane-permeable complexes.

The aim of this research was to study of the anti-radiation properties of inosine and inosinate cobalt (II) after acute single exposure γ-radiation.

The experiment was performed in C57Bl/6 mice of both sexes aged 2-2.5 months. To assess the effect of the test compound on the recovery of peripheral blood parameters, the animals were irradiated at a dose of 5 Gy, the observation was carried out for 30 days. To assess the effect of the test compound on the level of micronuclei in polychromatophilic erythrocytes of the bone marrow and the level of cell death of peripheral blood lymphocytes, the animals were irradiated at a dose of 1.5 Gy, the animals were removed from the experiment on the 2nd day after irradiation.

Solutions of inosine and Co(II) inosinate were administered intraperitoneally to animals of the experimental groups at a dose of 45 mg/kg 15 minutes after irradiation.

The Co(II) inosinate, was provided by the Institute of Radiation Problems of the National Academy of Sciences of Azerbaijan.

The erythropoietic activity of the test compound was noted, but no significant effect was found on the restoration of the cellular composition of peripheral blood leukocytes in animals one month after irradiation at dose of 5 Gy.

In the bone marrow of mice which were injected the solution of inosine, a decrease in erythrocytes with micronuclei was observed to 1.04% at 1.8% in the irradiated control group. Also, a decrease in the number of cells with micronuclei was observed in groups of animals which were injected Co(II) inosinate to 0.90%.

In the group whose animals received an intraperitoneal injection of inosine after irradiation a reduced number of lymphocytes at the stage of early and late apoptosis (10.78 % and 4.58%) compared with the group of irradiated animals (13.14% and 5.26%) was noted. In the group of animals treated with Co(II) inosinate also showed a decrease in level of early and late apoptosis to 8.94% and 4.46%, respectively.

Thus, the some protective properties of Co(II) inosinate on the blood system cells of C57Bl/6 mice after acute single exposure γ-radiation was shown.

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Preliminary risk assessment study – Neurobiological effects in experimental long-time exposure to low GSM radiation

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Purpose. Due to continuous rise of mobile phone users, at an increasingly younger age, our preliminary study aimed to assess the possible neurobiological effects of chronic exposure to microwaves, at frequencies and power levels similar to GSM signals. For this purpose, rats were irradiated in their daily habitat.

Materials and Methods. Twenty male Wistar rats (3 months old) were exposed to GSM 860–890 MHz, 4 hours daily, for 36 weeks. They were compared with sham exposed rats. The medium exposure value of microwave field power density was ≈60 mW/m2 and medium whole body SAR ≈ 0.15 W/kg. Two types of behavioral tests (open field test and elevated pulse maze) and transmission electron microscopy on brain samples were performed after 3 and respectively 9 months of exposure.

Results. Exposed rats presented decreased locomotor activity and increased emotionality as compared to sham exposed animals. Transmission electron microscopy examination, performed after 3 and 9 months of exposure, showed neurodegenerative alterations in hippocampus and frontal cortex. Severity of alterations seems to be related to duration of exposure.

Conclusions. These preliminary results suggest that long-term and low-dose cumulative microwave radiation could cause, in rats, ultrastructural changes in neurons and glia and stress behaviour. Further studies are needed to pursue the interaction of mobile phone radiations with the central nervous system at molecular level.

Keywords: Behavioral tests, low power GSM, neurodegenerative damage, increased emotionality, transmission electron microscopy

Assessment of radio-frequency radiation from selected mobile base stations in Zaria and Environs, Nigeria

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Base transceiver stations (BTS) or mobile base stations produce non-ionizing (RF) energy that is radiated through its antennas into space. There are health effects that can occur when the human body is exposed to high levels of radio frequency (RF) energy. The health implication associated with exposure from telecommunication masts is demanding attention due to the expansion of telecommunication networks and base station installation. In this study, power density from various telecommunication masts of different network providers were measured using a spectrum analyser 2658A B and K precision model. RF radiations within a radial distance of 100 m around some selected areas in Kaduna State were measured. The measured values range between 9.29 nWm-2 to 58.08 nWm-2 with a mean value of 23.52 nWm-2, although values fluctuated due to the influence of other factors including wave interference from other electromagnetic sources around reference base stations. The results show that radiation exposure level is below the standard limit of 4.5 Wm-2 for 900 MHz system set by the International Commission on Non-ionizing Radiation Protection (ICNIRP) and other regulatory agencies. This shows that the exposure levels in these areas are low and as such will not pose significant health risks to the people living in the study area.

Blue light reducing software applications for mobile phone screens: Measurement of spectral characteristics and biological parameters

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The displays of the majority of electronic devices are nowadays illuminated by Light-Emitting Diodes (LEDs) or Organic Light-Emitting Diodes (OLEDs). These types of light sources have certain advantages regarding colour variety, contrast, resolution and the ability to construct thinner screens. Nevertheless, recent research raises concern of possible negative biological impact of these display types on visual health and the circadian rhythm. The biological basis of the concern lies on the emission spectra of the light sources. The white LEDs used as backlights in LED screens have a characteristic emission spectrum with a peak at 450 nm and the Red-Green-Blue (RGB) OLED emission spectrum has a blue peak. Both of them are very close to the 460nm where the melanopsin retina pigment presents the maximum absorption.

In order to reduce the blue light emission, several techniques have been developed including hardware adjustments, external filters and software applications that control the emission display characteristics.

This study aims to record the performance of several available software applications on different mobile phone models. The spectral power distributions of the mobile phone screen were recorded by means of a commercial radiospectrometer, without and with the use of the blue light reducing software application, for various blue light filtering levels depending on the application. Several photometric and circadian parameters were calculated from the available spectra such as circadian light input, photopic illuminance and efficacy as proposed by Escofet and Bara [Lighting Res. Technol. 2017; Vol. 49: 481–496].

The results of the study are the recordings of the respective differences in mobile screen output with and without the use of the blue light reduction application, presented in terms of spectral power and biologically relevant parameters. Analysis of the measuring procedure and the obtained results leads to an evaluation of application performance variation depending on mobile phone type and a standardised measurement protocol in order to have comparable results that could be used for blue light reducing software applications performance evaluation.

Use of commercial and UV-induced phages for protection of chicken mince from contamination by microorganisms

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Introduction. Poultry meat is a popular product. Experts predict that by 2020 it will occupy 1 place in the total consumption of meat products. However, after the consumption of products obtained from sick poultry or secondary contamination by bacteria, often causes outbreaks of food infections in humans. Contaminants are phage-sensitive and lysogenic (carrying a prophage) microbes that can be destroyed by commercial bacteriophages (BPs) or UV-induced BPs from lysogens. Therefore, at the stage 1, the aim of our work was to study the effect of commercial BPs on artificially contaminated chicken mince (CM).

Materials and methods. In our research we used 4 BPs from "Microgen" manufacturer, Moscow: Coliproteus bacteriophage, Pyobacteriophage, Intesti-bacteriophage, Staphylococcal bacteriophage. As test CM contaminating strains we used *Proteus vulgaris*, *E. coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Salmonella enterica Typhimurium*. Also the organoleptic and physicochemical properties of the contaminated CM with BPs and without them were studied. Lytic activity of BPs was estimated according to Appelman. Sensitivity of the cultures was assessed by presence of lysis zones on nutrient agar and optical density in a photocolorimeter. Statistical analysis was carried out using parametric criteria.

Results. Lytic effect of BPs was revealed after 24 hours of incubation at 37°C and was different by titer (10^{-4} - 10^{-7}). The greatest activity was revealed in the mixture of Pyobacteriophage with *Pseudomonas aeruginosa*: complete lysis was observed. When the CM was artificially contaminated with microbes, it was revealed, that BPs lysed host bacteria: around the piece of meat an inhibition zone of growth and large number of negative BP colonies appeared.

These data matched the results on the photocolorimeter. Titers of the BPs were on average one log unit higher than in control. Probably, the protein substrate of CM promoted lysis of the bacteria and their death, which protected the CM.

Physicochemical and organoleptic properties of the CM with BP didn't change during storage at + 2 ... + 4 ° C.

Conclusion. Evidence suggests that BP can prolong the shelf life and, therefore, sales of poultry products, inhibiting the growth of bacteria and reducing the risks of microbial spoilage. Therefore, in order to increase the shelf life of poultry products, it is advisable to continue research on the use of commercial BP for the contaminant destruction, which can also be caused by UV induced BP (stage 2 of research). In this case, the death of the bacteria from BPs and UV-rays will occur.

Keywords: Bacteria, chicken mince, contamination, food infection, phages, protection, UV-induction

Gamma and neutron irradiated animal archive: Evaluation of cancer incidence

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While it is well known that protracted and fractionated ionizing radiation are less hazardous for animal health than acute radiation exposures, this effect varies for different fractionation schedules and total doses as well as for different health effects. Using the Northwestern University Radiation Archive for animals (NURA) we selected as a source of data a series of 10 individual Janus studies. Experimental work was conducted by Argonne National Laboratories from 1972-1989 to explore the effects of neutron and gamma irradiation on over 50,000 B6CF1 mice; data were subsequently digitized and made publicly available for studies like the one described here. Animal data selection was done after a rigorous statistical testing on control mice which determined which studies could be compared to one another. As expected, comparisons between acute and fractionated radiation showed benefits of fractionation across all doses and qualities of radiation. Fractionation significantly delayed death of animals separated into four categories of causes of death: tumors, non-tumors, lymphomas, and unknown causes. Females died earlier than males showing as causes of death lymphomas, non-tumors, unknown causes, and tumors other than lung tumors. Males were at a higher risk to die from lung tumors than females, which is opposite from observations seen in human data. Importantly, this study has systematically cross-compared outcomes of different modes of protraction across a wide span of total doses. This work shows that protraction modulates survival and disease status differently for different total doses.

Radiation biology models arising from irradiated animal studies

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Irradiated animal studies have been used for different types of mathematical and computational models. One of the interesting new modeling approaches was postulated by the Japanese team of collaborators – Drs Bando, Wada and Manabe, whose main interest is to explain dose and dose rate effects through the mutation acquisition probability as a function that does not depend on DNA damage alone. Using both the concept of average dose and dose rate for doubling of the background germ line mutations and the concept of DDREF this model tries to explain radiation induced mutations first and postulates that probability of cancer incidence depends not only on induction but on persistence of these mutations. "Whack a mole (WAM)" concept insists that radiation exposures and cellular processes that kill mutated cells are as important as those that introduce the mutations. In effect, WAM claims that only a combination of mutations present at a specific moment in the specific cells of the irradiated organism contributes to that organism's chance for cancer development at that specific moment. WAM theory for mutation rate relies on terms that connect dose and dose rate both with proliferation (and increase in the overall numbers of mutated cells, if any mutated cells are present in the organism) and cell death (and decrease in number of mutated cells). Thus, when multiple radiation exposures are considered (e.g. fractionation), the period between fractions that permits cell repair and recovery is included in the model as a time variable that modulates mutation burden. E.g. exposure to a specific fraction induces certain number of mutations that are added to the already existing pool of mutations, but it also triggers certain rate of repair and cell death that decrease number of mutations. With time, both cell death and repair may slow down or return to the background levels and the mutation burden becomes "fixed" until the next radiation exposure. By insisting on cell death as factor that reduces the odds for cancer development and does not depend only on exposures to high doses of radiation, WAM model separates mutation accumulation from the linear quadratic formula that is focused on cell death only as it occurs in parallel to mutation induction itself and depends insists on high dose/high dose rate.

Analysis of the capabilities of the programs Fiji, IPLab and DARFI in the study of DNA repair abilities in the cells of patients with a mosaic form of ataxia telangiectasia

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DNA repair processes preserve the integrity of the genome, so many cell's systems are responsible for repairing DNA damage. One of the most severe damage of DNA is double-stranded DNA breaks. Protein ATM is a key repair kinase of such damage.

Some proteins, such as DNA repair proteins, microtubule organization centers and kinetochores are localized in separate foci inside the cells. The study of the kinetics of formation and elimination of foci is one of the most significant and popular areas in the DNA repair field. In addition to the number of foci of DNA repair proteins, important parameters of DNA damage are foci area and foci fluorescence intensity. Also an important characteristic is the fluorescence intensity's distribution - intensity ranges, which allow to assess the homogeneity of the cell population, as well to identify the peaks of the intensity in the population.

To obtain the necessary foci data, scientists often use programs for fluorescent images analysis. In the course of this work, we tested three programs for analysis of fluorescent images of cell cultures obtained with immunofluorescence microscopy: IPLab 3.6 (software for integrating microscope functions and image analysis, developed by Scanalytics), Fiji (image processing package, ImageJ distribution, facilitating scientific image analysis) and DARFI (algorithm for automatic analysis of fluorescent images of cell nuclei with foci).

As a result of the study, the subjective nature of the IPLab program was identified; therefore we conducted the main study in the Fiji and DARFI programs. Our conclusion is that of the three assessed programs, Fiji is most suitable for measuring the intensity of fluorescence of nuclei stained with DAPI or other fluorescent markers. Fiji is also suitable for counting the number of foci, however, DARFI has a simpler interface. DARFI also allows a fine tuning of various parameters and in general provide a less subjective approach for foci analysis.

The DNA repair study was performed on three cell lines of patients with ataxia telangiectasia (AT), characterized by natural disruptions in the functioning of the ATM kinase. The study of the features of ATM kinase's DNA reparation processes in patient cells is relevant not only in determining the diagnosis of AT, but also in determining the severity of the disease.

The obtained data of the DNA repair features in the studied cell lines and their comparison with the cell picture of patients showed significant differences in fluorescence intensity, area and number of foci of pATMSer1981 and p53BP1 between a healthy donor and patients and also between AT cell lines depending on the severity of the disease form. We observed less severe DNA repair disruption in cell lines with partial ATM kinase inhibition than in a severe form of AT. Our conclusion is that to obtain a complete picture of DNA repair functionality one need to take into account such features as the fluorescence intensity and the foci area.

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Analysis of radiation effects of irradiated chicken eggs and meat with high-energy nanosecond electron beams

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Chicken and eggs are considered the most common product in the world. According to statistics, Russia produces more than 4 million tons of meat per month, and this value is growing annually. At the same time, poultry farms annually suffer losses due to diseases of chickens. This requires the introduction of innovative technologies in the poultry industry to reduce negative losses. Currently, the use of ionizing radiation at doses of 5-25 kGy is aimed at processing agricultural products to reduce microorganism's contamination in order to increase shelf life. At the same time, radiation processing of food and hatching eggs is limited due to the reduction in the quality of irradiated food and eggs with doses of more than 3 kGy The use of the radiation surface disinfection method will allow using of ionizing radiation sources for the treatment with high doses of only the surface layer of food, without the irradiation of the internal component of the product.

The experiments on the irradiation of chicken meat and eggs were carried out on the accelerator URT-0.5 and URT-1. The dose control of the treated products was performed using COAD (F) R-5/50 film dosimeters and thermoluminescent dosimeters.

When studying the effect of nanosecond electron beam (NEB) irradiation on food chicken eggs, no significant changes in the structure and physicochemical properties were revealed. This is primarily due to the low mileage of electrons, which does not allow to collect a large dose in chicken eggs. Thus, radiation processing on the URT installations will reduce the main problem of radiation processing technology.

To study the damaging radiation effect of the NEB on the hatching egg tissue and the emerging embryo, ovoscopy and macroscopic analysis of the quality of the hatching eggs were performed, and incubation was carried out using standard technology used in industrial poultry farming, the percentage of hatching eggs was evaluated and the quality and health of the young were evaluated daily the cultivation period to the period of slaughter (37 days). We investigated the biochemical, immunological and hematological parameters of blood of broiler chickens to identify possible metabolic and physiological disorders. The pathological-anatomical research of the chickens from the experimental and control groups after slaughter was conducted. Chickens from eggs subjected to NEB treatment showed higher activity in behavioral reactions than chickens from the control group. No significant effect of stimulation or suppression of chickens was detected after the treatment of NEB eggs with a dose in the yolk of 40 cGy. The obtained results allow us to conclude about the absence of the occurrence of radiation-induced complications of embryo development and diseases of chickens. Moreover, small doses of bremsstrahlung had a favorable effect on the rate of hatching, which is of great importance in industrial poultry farming.

In the study of physico-chemical parameters of chicken meat after NEB treatment there were no significant changes in the experimental samples compared with the control ones. Tendencies in the change of indices up or down with an increase in the absorbed dose from 2 to 10 kGy were also not detected. It was found that in samples of meat treated with absorbed dose 5 kGy and above by NEB, there is damage to cellular proteins, which is manifested by stratification of myofibrils, violation of striation, fibrillation of fibers, as well as disruption of the structure of the cell membrane - sarcolemma. These effects were noted only in the surface layers of meat (up to 2 mm). In addition, signs of protein damage in the surface layers of muscle cells indirectly indicate that a dose of NEB has been reached on the surface of the meat, providing damage to the protein in bacterial cells, which essentially confirms the antimicrobial effect of NEB. In general, these changes in the surface layers of meat under the influence of NEB above 5 kGy should not have a negative effect on product quality, since the depth of penetration of electrons and, accordingly, the depth of affected tissues is extremely small.

High and rapidly growing demand for poultry products requires the introduction of innovative technologies to improve safety and efficiency in the poultry industry. Estimates show that radiation surface disinfection at URT-type accelerators leads to significant economic efficiency. Experiments show that chicken eggs treated with radiation surface disinfection of NEB do not fall under the type of product that requires Radura label. It is important to note that the introduction of the method of stimulating small doses of radiation in the agricultural sector requires additional in-depth studies of the increase in fertility or biomass of animals from the point of view of their favorableness and utility.

Estimation of minimal effective doses of γ-irradiation on rat peripheral blood reaction

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The experiments were conducted on rats (142 males) “Wistar”, with a body weight of 230-250 g at the age of 2.5-3 months. Prolonged irradiation of animals was carried out on the installation of a panoramic type "Experiment" (Russia) with a source of γ-radiation 137Cs in three modes of exposure. In the first mode, under continuous exposure conditions for 20 hours, the total absorbed dose was 4.8 mGy with an absorbed dose rate of 4 μGy/min. The second experimental group consisted of animals exposed to ionizing radiation at a dose of 3.3 cGy with an absorbed dose rate of 27.5 μGy/ min. As a comparison group, we used rats that received the lowest possible exposure level in our conditions, which was an order of magnitude lower — 0.48 mGy over 20 hours. The number of animals in the groups was 30–45 taking into account repeated replications. Analysis of the acid resistance of erythrocyte membranes and the activity of the enzymatic antioxidant system in the same rats was performed before exposure, as well as at different times after the end of irradiation by spectrophotometry on a UNICO 2804 spectrophotometer (USA). The maximum single blood loss did not exceed 3% of the circulating blood volume.

According to our results, prolonged γ-radiation at low doses (dose rate 4 μGy/min, total dose 4.8 mGy) under continuous irradiation conditions (20 hours) caused unidirectional changes in irradiated animals, the maximum severity of which recorded at the end of the first day. At the same time, young physiologically defective cells with lower hemolytic resistance and decreased activity of the main antioxidant enzymes entered the blood from the organs of erythropoiesis. The detected effect was recorded up to 3 weeks of observation.

Increasing the radiation dose to 3.3 cGy (absorbed dose rate 27.5 μGy/min for 20 hours in continuous mode) caused pronounced and long-lasting changes in the physiological state of red blood cells, affecting the parameters of the antioxidant defense system.

In the group of animals irradiated at a dose of 0.48 mGy, on the 3rd day after the end of irradiation, only a short-term decrease in the activity of superoxide dismutase is recorded, whereas in animals irradiated at a dose of 4.8 mGy, the maximum changes in most erythrocytes were found.

The cumulative analysis of the results we obtained shows that the minimum “threshold” doses of radiation that cause systemic reactions of hemopoiesis are very low and are in the range of units of milligrays.

Radioprotective and anti-stress properties of the drug “Pronumol”

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The key role of nitric oxide (NO) in maintaining vascular tone, normal blood circulation and tissue fluids, regulating the activity of immune cells, signaling in the nervous system, as well as in the development of shock, inflammation, and cell apoptosis is established. At physiological concentrations, NO is an antioxidant that inhibits the development of radical oxidative reactions (Odonnell V.B. 1997). In the body, nitric oxide is synthesized enzymatically from l-arginine. Mice of F1 hybrids (CBAxC57Bl) weighing 18–20 g were used in experiments. Irradiation of animals was carried out on the Gamma-Cell facility (Canada) with an absorbed dose rate of 1 Gy/min. As a stressful effect, the animals were kept for a long time (within 24 hours) in conditions of limited mobility in narrow individual cells without food and water. Mice were fed for 7 days before exposure to irradiation or stress with food enriched with l-arginine or “Pronumol” (0.8 mg/g and 2.0 mg/g feed, respectively) equivalent in l-arginine content. Studies were performed immediately after the stress exposure or 24 hours after irradiation. The degree of DNA damage was estimated by the kinetic method, determining the percentage of double-stranded fragments after controlled alkaline unwinding of DNA. The level of lipid peroxidation (LPO) in the body was assessed by the content of MDA in the blood serum. For statistical processing, the methods of variation statistics were used. The significance of differences between groups was assessed using Student's t-test and the Wilcoxon-Mann-Whitney U-test.

Results. Exposure to radiation and stress led to the emptying of lymphoid organs, increased the level of DNA degradation in the thymus, and increased the content of MDA in the serum of mice. A day after irradiation at a dose of 1 Gy, the number of cells in the thymus decreased by 57.4%, and after stress exposure by 33.3%. Feeding animals with l-arginine did not have a significant effect on the thymus cellularity, while “Pronumol” protected the thymus from emptying under both effects, and it was much more effective under stress. The content of double-stranded DNA fragments decreased from 83.4% (control) to 68.9% (irradiation) and to 71.4% (stress). The level of POL in the body increased by 36.3% (exposure) and 28.1% (stress). Arginine and Pronumol protected thymus DNA from degradation induced by radiation and stress, had an antioxidant effect. The results indicate that arginine is a moderate protector in its activity. The most pronounced anti-radiation and anti-stress properties of the drug “Pronumol”, which is based on nucleic acids and protein protamine, enriched with l-arginine. The advantage of arginine and “Pronumol” is the absence of toxicity.

Oxidative stress in the brain tissues after blood circulation disorders and its compensation by LED radiation

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Acute blood circulation disorders in the brain can be provoked by heart muscle diseases, including the radiation sickness and the heart ischemia. Oxidative stress is a typical molecular reaction on the circulation pathologies. Experiments on white rats could proof that the radiation sickness of the heart and adrenalin modeling of the heart ischemia give nonspecific consequences in the form the oxidative stress.

The investigations of contents of products of protein oxidative modification (POM) and peroxide oxidation of lipids (POL) both in the brain and in the heart tissues demonstrated the effects of dramatic increase of these products in the control samples affected by the pathological processes in the internal organs and restoration of their contents up to the intact samples treated by low-power red light (the spectral peak at 650 nm, the power density, 5 $mWcm^{-2}$, the area of irradiation is 2 cm^2, continuous mode of radiation) and by near infrared radiation (810 nm, the power density: 5 $mWcm^{-2}$, the area of irradiation is 2 cm^2, continuous mode of radiation). The experiment lasted 7 days with one phototherapeutic treatment per day. Sampling was done at the seventh day. The contents of the molecular POM products were measured in the homogenized brain and muscles tissues samples by using the standard spectrophotometrical method described in the article [Lasers Med Sci. 2018 Jan;33(1). P.159-164].

Both low-power red light and near infrared radiation treatments can restore the normal level of the oxidative processes in the brain tissues by phototherapeutic procedures.

Oligofractionated irradiation of the solid Ehrlich ascites carcinoma in mice with a pencil scanning beam of protons

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The effect of irradiation with a pencil scanning beam of protons at the total doses of 60 and 80 Gy on the growth of solid Ehrlich ascites carcinoma (EAC), the duration of remission, frequency of recurrence, radiation-induced skin damage, and the mean life span (MLS) in tumor-bearing mice have been studied.

Male mice of the SHK colony (body weight 24– 28g) were kept under standard vivarium conditions. The solid form of EAC grafted intramuscularly into the femur of the left hind paw served as the tumor model. Irradiation was carried out at the therapeutic proton synchrotron accelerator "Prometeus" (Russia, Protvino) with a pencil scanning beam of protons from two opposite directions. A gross tumor volume (GTV) that is equal to the average size of 0.47 cm^3 was specified using a specially developed 3D planning system. GTV was irradiated according to the model of high-dose oligofractionation with two fractions of 30 Gy or 40 Gy each with an interval of 24 h.

Differences in the growth rate of EAC it was not revealed within a month at radiation in doses of 60 Gy or 80 Gy. Regression of the tumor was observed in 77% of the mice in the 60 Gy group and in 100% – in the 80 Gy group. The maximum life expectancy for a group of 80 Gy was 21 months compared with 15 months in a group of 60 Gy. The median life span (the time during which 50% of the mice die) for a group of 40+40 Gy – 154 days, and for 30+30 Gy – 114 days. The irradiation according to the 40 + 40 Gy scheme was much more effective against relapses: 60% of mice from 8 to 21 months were without tumors compared to 30% in the group of 60 Gy. The MLS of mice in both groups was about the same: for mice with relapses – 108 days, and without – 270 days. Radiation reactions of the skin began to appear on the 12th day after irradiation in mice that received 80 Gy, while these reactions were more pronounced in terms of both the frequency of occurrence and the severity of the course than in the group of 60 Gy. Acute radiation reactions quickly regressed and the woolen cover was restored to 37 days in 45% of the mice, and skin changes were completely absent 3 months after irradiation. The irradiation of GTV at a dose of 80 Gy led to the complete regression of tumor nodes, a twofold decrease in the frequency of recurrences without affecting the MLS of mice with and without relapses but increased the median of life span by 35 % compared with a group of 60 Gy.

The results of these experiments show that the model of solid EAC in mice can be used not only for the study of tumor growth upon various proton oligofractionated irradiation regimes but also for the observation of tumor relapses and other remote radiotherapy consequences. The tested system of positioning and three-dimensional planning of irradiation of the mice and the suggested schemes for hypofractionated irradiation demonstrate the possibilities of the new proton synchrotron.

Possibility of application of proton therapy complex “Protemeus” for radiobiological investigation on animals

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Proton therapy is one of the most accurate and modern methods of radiotherapy and radiosurgery. Protons can reduce the radiation load on surrounding tissues up to 30-50% in comparison with gamma rays. Therefore, in cases of tumors located near critical organs (for example head and neck cancer), proton therapy is the most advantageous of the available types of treatment for many patients. Given the advantages of this type of treatment over radiation therapy, using gamma radiation and electron beams, proton therapy is increasingly being used in the treatment of cancer. There is an increase of proton therapy centres around the world.

In the world, active work is being carried out aimed at increasing the accuracy of dose delivery to the tumor, reducing the time that patients stay under the influence of radiation and increasing the availability of this method for a larger range of patients. New proton accelerators, as well as more cost-effective and accurate immobilization systems for patients are being developed for these purposes.

Our company produces and researches the proton therapy complex “Prometheus”. This complex consists of a compact synchrotron with a diameter of 5 meters and a mass of 15 tons, an integrated X-ray tube and detector, a chair for immobilizing a patient, and software. The installation is capable of accelerating protons in the energy range of 30-330 MeV. Irradiation of target objects is carried out in a pulsed mode by scanning with a thin beam of a given volume. The diameter of the beam depends on the energy and is 5 - 20 mm.

Two proton therapy complexes “Prometheus” operating in the Russia, successfully developed and produced two synchrotrons for the proton therapy complex “Radiance 330”. Two of these complexes have already been introduced in the Massachusetts General Hospital (Boston, MA, US) and McLaren Health Care Hospital (Flint, MI, US) for patient treatment. Also one proton therapy complex Prometheus was delivered to Slovakia for radiobiological studies and possible applications in the future for therapeutic purposes.

On this complex, it is possible not only to conduct sessions of radiation therapy for patients, but also to perform physical and biological experiments on different objects. This report presents the main characteristics of the installation, different modes of irradiation of objects and number of biological experiments.

Tumor stem cells

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Most of the cancers are still incurable human diseases. All malignant tumors are a heterogeneous population of cells with different biological properties. There are two dominant concepts to explain tumor heterogeneity: the theory of tumor stem cells (CSCs), also called the hierarchical model and the stochastic model.

CSCs constitute only a small percentage (0.05-1%) of tumor cells within a tumor mass containing heterogeneous population of tumor cells within the tumor microenvironment. CSCs are closely related to pathological features which result in worse clinical prognosis. CSCs are distinguished by the pronounced expression of anti-apoptotic proteins and the high activity of chemoresistance mediators - ABC-1,2,5. desregulation of signaling pathways Notch, Hedgehog, Wnt. CSCs harbor endogenous resistance mechanisms against radiation and chemotherapy which gives CSCs a survival advantage over differentiated counterparts.

The currently known 40 CSC surface markers can express on the hESCs, adult stem cells, and normal tissue cells. Of the 40 CSC markers, approximately 83% (33 out of 40 CSC markers) are rarely expressed on normal tissue cells. 9 of these are already approved as drug target molecules by FDA.

Although genetic mutations are closely associated with cancer, the plasticity of cancer is more affected by their microenvironment rather than mutation during the reprogramming process. The surrounding microenvironment critically affects cancers by regulating CSC physiologies.

Despite the multilateral approaches, recent studies have pointed out the limitations of CSC targeting strategies. Diversity of CSCs may be generated by distinct stemness or reprogramming signaling activations, resulting in divergent expression patterns or CSC markers. Therefore, development of CSC- specific targeting strategies using marker-dependently sorted CSCs and targeting of a single CSC marker or signaling node is not proper strategy due to CSC heterogeneity.

Recent findings demonstrate that the CSCs can be newly generated from the differentiated non-CSCs by reprogramming mechanism through which even CSCs with different characteristics could emerge. CSCs not only serve as the origin of tumor formation but also drive heterogeneity of cell composition inside the tumor and CSCs themselves as well.

Therefore, controlling a variety of reprogramming mechanisms should be combined to prevent de novo generation of the different types of CSCs. Also certain microenvironment-specific or subtype-specific core transcription factors -epigenetic modifier networks should be identified and considered as a potential target.

Results for immunomagnetic cell separation based on different protocols and magnetic force

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Isolation of cell subsets from full peripheral blood is very important step for evaluating the immune system function in clinical medicine. Many years ago standard protocols for cell separation include only separation based on density gradient, and without purified cells based on cell surface markers. Today's, modern biotechnology allows identification and purification more and more purified of cell population for every vonted cell subsets. These techniques involved usage of monoclonal antibodies labeled with magnetic beads, metal columns and power magnet from different companies. In this investigation, we tested for first time total yield and viability of CD56 (NK) and CD4+ (Helper) cells population from peripheral blood cells using 3 type of magnet system for cell separation. In the research, we used monoclonal antibodies labeled with Miltenyi Magnetic beads for cell separation. The effect and influence of the strength of the magnetic field on the yield and viability of isolated cells was studied in particular with the help of 3 types of magnets; including "Mojo Sort" from BioLegens company (USA), Dynabeads system (Germany) and from Stem cell companies (UK) used currently for cellular isolation. Cell viability after cell separation was analyzed using LDH cytotoxic assay previously standardized by Jurisic V, 1999. The measurement of the field produced by a ring magnet of the outer radius R1 and an inner radius R2 made in a laboratory of electromagnetic of the Institute of Physics at the Faculty of Science in Kragujevac. We measured the magnetic field using a gaussmeter with estimated precision of ± 5%. The results showed that the yield of the cell was dependent on the strength of the magnet and the type of magnetic field by using identical antibodies. In current research we use only different magnet but antibodies identical. With a more powerful magnet and with a cylindrical magnetic field, certainly more CD56 + cells and CD4+ cell are isolated. Results also indicated that different system including columns with positive and negative selection and using a metal labeling antibodies in comparison to biotin labeled cocktail, induced more cell membrane damage measured by LDH release assay after cell isolation ($p < 0.05$, Mann-Whitney U-test). Based on obtained results further investigation is still needed to be standardized these techniques and also to achieve much better separation including higher number of obtained cells with minimal cell membrane damage.

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Possibilities of MR DTI for the planning of neuro-saving operations in local prostate cancer

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Introduction. MRI for detecting adenocarcinoma and assessing changes makes possible evaluation of focal tumors and correlation with the capsule thus shifting the percentage of cancer to minimal forms. MRI helps verification using MR-target or fusion biopsy. Accurate diagnosis makes possible to use SRT and neuro-sparing surgery. In order to choose a treatment method, it is vital to evaluate the ratio of the tumor node to the capsule and to evaluate nerve bundle locations.

Objective. Developing MRI studies for patients with verified cancer with DTI evaluation to assess neurosparing surgery options.

Materials and Methods. 63 patients with verified adenocarcinoma were examined within the capsule according to the MRI study. According to histology, carcinomas of the 3 + 4 Gleason (65%) prevailed. 21% corresponded to Gleason 4 + 3. 14% showed 8 Gleason tumor.

Results. At the first stage the spatial prevalence of the tumor was estimated by PI-RADSv2: 11% of cases the tumor was located in the AZ; 14% in PZpm and 85% in PZpl segments. None of the foci exceeded 1.5 cm3. At the second stage DTI was performed with an analysis of the relationship of the nerve bundles to the gland's tumor areas.

In all cases, MR DTI made it possible to estimate the ratio of the tumor to the adjacent nerve tracts. With the intimate arrangement of the node to the capsule and the proximity of the neural bundles, SRT was the method of choice (81%). In 19% of patients, the tumor site to nerve bundles ratio allowed a neurosparing prostateactomy to be performed.

Conclusion. MRI with DTI allows not only tumor site visualization in the gland structure and evaluation of the involvement of the capsule in the process, but also evaluation of the correlation of the tumor and nerve tracts, providing all the necessary information to select the optimal treatment strategy.

Case Report: Synchronous breast and cervical cancer togetherness

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Introduction. Because of rising within the range of old patients and enhancements in diagnostic techniques metachronous primary malignancies are getting more and more. Synchronous tumours are tumours seen within 6 months after the diagnosis of primary tumour (1). Among females, breast cancer is that the commonest cancer and cervical cancer is that the fourth commonest cancer (2). Synchronous occurrence of each cancers area unit seldom rumoured because etiological factors are not similar. It has been discovered that somebody with a growth external additional in danger of developing another malignancy than would be expected by mere probability. We aimed to present this rare case and our treatment approach with the literature.

Case. A 57-year-old woman presented with a postmenopausal haemorrhage. There is no cancer patient in her family history and no comorbid illness. The gynaecological examination of the patient 4-5 cm cervical mass, bilateral parametrium involvement was performed (20.12.2012). The pathology of the patient who underwent probe curettage was reported as adenosquamous carcinoma. LMWK (+), CEA (+), p53 (+), Vimentin (-), p63 (-), CK5/6 (-), ER (-), PR (-) were detected. The patient was referred to our clinic for chemoradiotherapy with the diagnosis of stage 2-B cervical cancer. We wanted 18-FDG PET CT for the staging purposes. 18-FDG PET CT images were taken during a staging of the patient cervical filling, diameter 8.3x5.7 cm (SUV:16.3), paraaortic lymph node involvement, with the invasion of the parameter. Bilateral internal/external iliac lymph nodes (SUV:7.2) were detected in the pelvis. A 9 mm nodular lesion in the lower outer quadrant of the left breast (SUV:5.3) and a 9 mm lymph node in the left axillary (SUV:1.9) were observed. Second primary malignancy reported as. The patient's stage was 3-B. In blood tests CEA:53.1 ng/ml; CA15-3:43.5U/ml, CA12-5:115.4 U/ml higher than normal values. Mammography and breast MRI were performed. A mass of 10x8 mm in the middle outer quadrant of the left breast was evaluated. A trucut biopsy was performed and the patient was diagnosed with invasive ductal cancer. After discussion in our tumour board meeting, it was recommended to proceed with upfront surgery for the breast carcinoma and administer concurrent chemoradiation for cervical cancer.

In 07.02.2013, breast-conserving surgery and sentinel lymph node biopsy were performed. Invasive Ductal Carcinoma, nuclear grade:II, histological grade:II, tumour diameter:1 cm, sentinel lymph node biopsy: 0+/5, surgical margin negative, estrogen receptor (+), progesterone receptor (+), cerbB2: (-). Breast cancer was stage-1 (T1N0M0). Concomitant chemoradiotherapy was started with Cisplatin 50 mg/m^2. The pelvis received 28 frx/180 cGy/day 5040 cGy; paraaortic lymph nodes 25 frx/180 cGy/day 4500 cGy radiotherapy. The patient had nausea, vomiting, anorexia from the first week, and diarrhoea at the 3rd week. Her symptoms were controlled with antiemetic and antidiarrheal treatment. HDR 4x6 Gy brachytherapy was performed after external radiotherapy.

Radiotherapy was started on 11.06.2013 for the patient who did not plan chemotherapy for the diagnosis of breast cancer (T1N0M0). 25 frx/200 cGy/day 5000 cGy radiotherapy for the whole breast and 5 frx/200 cGy/day 1000 cGy boost to the tumour bed was given. Aromatase inhibitor was started.

28.05.2014 control PET CT: Left lung upper lobe anterior (SUV:6.4) metastasis was detected. Left upper lobe segmentectomy was performed in thoracic surgery. It was a breast metastasis. Systemic chemotherapy was initiated upon findings consistent with metastasis.

On 03.07.2015, PET CT: Mediastinal newly developed lymph nodes. The chemotherapy scheme was changed, and after 6 cycles, complete response to the treatment was found. Hormonotherapy continued with estrogen receptor antagonist all 2 years. The patient came to the last check on 07.01.2019. She continues her disease-free follow-up since 2017.

Conclusion. We noticed these synchronous tumours with 18-FDG PET CT scanning. In synchronous tumours, treatment for two tumours at the same time cannot be performed. It is essential to achieve that the patient receives the specific treatment for each of the two tumours. In our case, early stage breast cancer had metastasis to lung. Advanced stage cervical cancer was cured. The case was very interesting for this reason. Synchronous tumours occur with exposure to similar carcinogens. This is why it is interesting to see breast and cervical cancer together. In our case, we have shown that synchronous double malignancy cancers can be successfully treated. And our patient from 72 months is still alive.

Age increase and weight reduction effects on bone mineral density and content

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Dual energy x-ray absorptiometry (DXA) scan is considered to be the gold standard for diagnosing and monitoring bone loss and evaluating the degree of osteoporosis. The DXA scan calculates bone density based on the amount of radiation absorbed by the bone, and compares patient's bone strength and bone density to that of young adults with normal bone density and to other persons of the same age. DXA evaluates total body bone mineral density (BMD) expressed in grams (gr) and bone mineral content (BMC) expressed in gr/cm^2, as well as regional BMD and BMC values for the arms, legs, hips, head and trunk (which includes ribs, pelvis, thoracic spine, and lumbar spine). BMD is typically expressed in T-scores. Normal BMD T-score is greater than -1, and in osteoporosis BMD is characterized with T-score below -2.5. This study evaluated lumbar spine and hip bone lost for a period of 12 years, where in the last three years there was a reduction of the total body mass for mean 14 kg and evaluation was performed on total and regional BMC and BMD values.

Mean value L_1-L_4 vertebra BMD 1.13±0.06 kg/m^2 reduced to 1.05±0.04 kg/m^2 ($p<0.001$) and mean value L1-L4 vertebra BMC 55.12±5.89 gr reduced to 54.25±6.2 gr ($p<0.001$) for 12 years period. Last 3 years change of spine BMD was associated with reduction of the mean L_4 lumbal vertebra T-score from -0.7 to -1.7 indicating developed osteopenia on this vertebra. Also the highest reduction of BMC of mean 22.08% was detected on L_4.

Neck mean BMD basal value was 0.88±0.08 kg/m^2 and reduced significantly for 12 years to 0.74±0.07 kg/m^2 ($p<0.001$). Trochanter mean BMD basal value was 0.71±0.08 kg/m^2 and reduced significantly in 12 years to 0.64±0.03 kg/m^2 ($p<0.02$). Total hip mean BMD basal value was 0.89±0.08 kg/m^2 and reduced to 0.74±0.09 kg/m^2 ($p<0.001$). Total hip mean BMC 25.34±4.62 gr reduced to 22.16±2.92 gr ($p<0.46$). Total hip mean BMD lowered for mean value of 13.71%, BMC lowered for 13.61% and % of BMD reduction was 13.48%. The last three years regional BMD values were with T-score in normal range and reduced to osteopenic levels with significance of $p<0.014$ for arms BMD change, $p<0.01$ for trunk, $p<0.033$ for pelvis, $p<0.027$ for ribs, and $p<0.05$ for total BMD change. Legs BMD values stayed in normal range.

It can be concluded that age, as well as the weight reduction influenced negatively on hip, spine and regional BMD and lowered it significantly from the normal values to osteopenic values, indicating the need of bone BMC and BMD reduction prevention. Bone densitometry is a very safe, painless and quick test that can measure bone strength and predict fracture risk before the patient develops osteoporosis and hence effective preventive therapy can be started. Bone density tests are also used to monitor the response to particular medications. Our experiences in body composition and osteoporosis DXA assessment were evaluated in this study.

Key words: Dual energy x-ray absorptiometry, body composition, bone mineral density, bone mineral content

Remodelling of collagen fibers in the uninvolved human colon mucosa 10 cm and 20 cm away from the malignant tumor

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Changes in morphology and organization of collagen fibers contribute to the formation of a microenvironment which facilitate tumor progression through the impact on migration and polarization of the cells. Changes in morphology and organization of collagen fibers in cancer, itself, are the subject of numerous studies, while it is far less known about the changes in collagen fibers in the uninvolved mucosa away from cancer.

The aim of our study was to analyse changes in morphology and organization of collagen fibers in the uninvolved colonic mucosa 10 cm and 20 cm away from the cancer, in comparison with healthy subjects, using second hamronic genaration (SHG) imaging and multiple complementary methods for quantification. Tissue samples 10 cm and 20 cm away from the colon cancer were obtained from 15 patients, during colonoscopy at the Department of gastrointestinal endoscopy, University Hospital Center "Dr Dragiša Mišovic-Dedinje", Belgrade, Serbia, from patients suspected to suffer from colon cancer based on clinical symptoms. As a control, 20 samples of colon mucosa were collected from the patients who were indicated colonoscopy and were without any pathological finding or diagnosed only with uncomplicated haemorrhoids.

For collagen fiber visualisation and analysis nonlinear laser scanning microscopy with SHG detection was used. CT-FIRE and CURVE-ALIGN, an open-source software packages, were used to assessed individual collagen fibers and calculate important parameters as length, straightness, width and overall alignment. The anisotropy of SHG images was used to quantify alignment of collagen molecules inside fibers. The anisotropy parameter β was calculated on the same microscope with addition of polarizer, based on intensity of SHG signal when the analysing polarizer is oriented parallel and perpendicular to the laser polarization. To analyse organization and degradation of collagen fibers, immunohistochemical staining with anti-LOX, anti-MMP2 and anti-MMP9 antibody was used.

Using CT-FIRE and CurveAlign software, on whole SHG images, we showed that the width and length of collagen fibers are statistically higher 10 cm and 20 cm away from cancer (5±0.7, 5.32±0.58 and 55.12±2.73, 56.28±5.12), compared with healthy subjects (4.49±0.43 and 52.12±2.98). Also, the collagen fibers 10 cm and 20 cm away from the cancer were significantly more orderly align (0.47±0.19 and 0.59±0.19), compared with healthy lamina propria (0.36±0.20). Anisotropy parameter β is significantly lower 10 cm and 20 cm away from the cancer (0.26±0.05, 0.34±0.09), compared with healthy lamina propria (0.39±0.09), indicating changes in organisation of collagen molecular within fibers. Expression of LOX and MMP2 were significantly higher 10 cm and 20 cm away from the cancer, compared with healthy mucosa. Using different, complementary approaches we detected changes in morphology and organization of collagen fibers 10 cm and 20 cm away from colon cancer, compared with healthy subjects.

A new concept for skin rejuvenation and skin repair and acne management. Fluorescence via eosin, safran and blue light

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Clinical results on more than 300 patients concerning acne, scaring, rosacea and skin rejuvenation show stunning results, without really being able to explain the exact mechanisms of action.

Safran and eosin have been used in medicine to stain human tissues for decades.

Irradiating a gel containing safran and eosin with blue light induces fluorescence and energy transfer to the living tissue. This method is actually used in medicine for acne treatment, rosacea and skin rejuvenation.

The energy transmitted by the fluorescence induces collagen synthesis and renewal of the epidermis, permitting even scar removal without previous laser treatment.

Mechanisms of action of fluorescence on living tissue, energy transfer will be discussed from a physical and medical point of view, trying to have a new insight into this multidisciplinary field.

Multiple metastatic basal cell carcinoma (MMBCC): Role and usefulness of 18FDG-PET and Tc 99m – MDP bone scan in locating metastatic foci: Case report

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Background. MMBCC begin longstanding BCC lesions reccurent after treatment. MMBCC have higher incidence of the more aggressive histological patterns. BCC's with aggressive histology 2.5 to 44%.We thought to determine the usefulness of 18 FDG-PET and Tc 99m-MDP to diagnose distant metastases of BCC. The aim of this case report is to present a case arising on the left malar area that metastasized to the regional lymph nodes, liver and multiple bones and diagnosed by comparing two different radiopharmaceutic agents.

Materials and methods. 65 years old man with BCC at the left upper eyelid resected, primarily reconstructed with a local advancement flap. Pathological diagnosis was adenoid and infiltrative solid type of BCC. April 2005 recurrent tumor was noted at the right medial canthus. Pathological diagnosis was BCC focally differentiated baso-squamous type. Tumor found to be invaded lacrimal gland and nasal bone. March 2006 he had epistaxis and biopsied from frontal sinus, sphenoid sinus and medial wall of the left orbita. Pathological result was basosquamous cell carcinoma infiltrated tissues. July 2008 he had left maxillectomy and was diagnosed morfeiform type BCC and infiltrated to the maxilla, with subcutaneous and perineural invasion. June 2009 he had examined by Tc 99 m-MDP bone scan to evaluate bone metastases and than 18FDGPET/CT imaging was performed.

Results and conclusion. Bone scan demonstrated multiple metastatic foci. 18 FDG PET/CT revealed FDG uptake at the floor of left orbita. More foci diagnosed at the left jugulodigastric lymphatic nodes, one focus at liver and multiple metastatic foci at bones. MMBCC is a rare complication of BCC with high morbidity and mortality. MMBCC often begin with long –standing primary BCC lesions that are either large or recurrent after treatment. 18FDG PET/CT is highly effective diagnostic technique to demonstrate local recurrence and distant metastases of BCC.

Keywords: Multiple Metastatic Basal Cell Carcinoma (Mbcc), 18fdg Pet Ct, Tc 99m- Mdp Bone Scan

18FDG PET-CT findings in a case with cervix adenocarcinoma

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Introduction and purpose. 18 FDG PET / CT widely used for the diagnosis of many malignant lesions staging, evaluation of treatment response and relapse-residual disease research. In most malignant lesions, increased FDG uptake was observed but some may exhibit lower FDG uptake. In some malign lesions significant FDG uptake may not be observed. In some histopathological subtypes of cervix adenocarcinomas FDG uptake is also low too. We wanted to discuss the case of cervix-uteri adenocarcinoma of which has 18 FDG PET / CT studies performed before treatment and after treatment.

Method and findings. 44 years old diagnosed with cervix-uteri adenocarcinoma 18 FDG PET / CT scans were requested from the patient for staging. 18 FDG PET / CT images showed slightly elevated FDG uptake at the cervix-uteri mass lesion (SUVmax = 5.1) Intraabdominal lymphatic stations and in other parts of the body does not have any pathological feature of FDG involvement. A second 18 FDG PET / CT scan was requested. After treatment 18 FDG PET / CT showed complete regression of the mass in the cervix-uterine lesion and in this region FDG uptake was normal.

Discussion and conclusion. Adenocarcinoma of the cervix represents approximately 5-9% of all cervical cancers and squamous cell cervical tumors. It has been described in the literature that it shows the lower density FDG uptake. In our case cervix - mass lesion in adenocarcinoma of uterus more than expected in malignant processes low density FDG uptake was observed.

If the cases are known 18 FDG PET / CT with oncological indications, the histopathological type of the tumor should be considered.

More attention should be paid to the details like; lower FDG affinity, fasting time, blood glucose level, radiopharmaceutical dose, technical details. And also detailed examination of equivalent CT images, late imaging of the necessary sites and possible interpretation of images may be useful in preventing negativity.

Keywords: 18 FDG PET / CT, cervical cancer, adenocarcinom

Accuracy of functional methods for detecting coronary artery disease with asymmetric dimethylarginine (adma), myocardial perfusion scintigraphy, or both as shifted test in detecting asymptomatic endothelial dysfunction in patients with systemic lupus erythematosus

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Introduction. The purpose of this research was to compare the diagnostic values of laboratory variables, to present quantitative evaluations of the diagnostic test with reference to sensitivity, and specificity, the predictive value of the positive and negative test and precision of the test for Asymmetric dimethylarginine (ADMA), assessed with myocardial perfusion scintigraphy (MPS), acute phase reactant, in early diagnosis of untreated Systemic Lupus Erythematosus (SLE), to determine whether ADMA changes depend on the disease evolution. ADMA is used as an indicator for endothelial dysfunction.

Methods. Using the ELISA technology of DLD-Diagnostika-GMBH, ADMA, the serum has been examined in 70 participants (35 SLE who were not treated, 35 controls). In the same time we determined the sensitivity, specificity, predictive value for positive and negative test and accuracy.

Results. Out of 35 examined patients with SLE, in 13 we found the presence of ADMA (sensitivity of the test 37.14%). Myocardial Perfusion Scintigraphy appeared in 17 patients (sensitivity of the test 48.57%). Four patients were ADMA and MPS positive. Among 18 MPS negative patients, 9 patients were ADMA positive. Among 17 MPS positive SLE, the presence of ADMA was found in 4 patients. Among 18 MPS negative SLE, ADMA appeared in 9 patients. In the healthy control group, 8 patients were ADMA positive.

Conclusion. ADMA has low sensitivity, but high specificity from MPS at untreated SLE with coronary artery disease.

Keywords: Asymmetric dimethylarginine (ADMA), systemic lupus erythematosus, coronary artery disease

Variation of oblique fissure of the right lung on sagittal Computed Tomography

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Aims and objectives. The fissures of the lung field are sometimes various and especially at right lung field. In this preliminary research, we analyzed the fissure of right lung sagittal image with MPR (multiplanar reconstruction) on CT (computed tomography).

Materials and methods. In 50 cases (male: 28, female: 22, mean 67 y.o.) with no particular disease, we analyzed the right oblique (so called major fissure) and horizontal fissure (so called minor fissure) by sagittal image on CT reconstructed by MPR.

While the cursor was moved from lateral to medial, oblique fissure and horizontal fissure were analyzed in sagittal image.

Results. Oblique fissure and horizontal fissure almost run smoothly at outer right lung field. At inner right lung field, upper oblique fissure mostly run to the end with cross point① with horizontal fissure. Lower oblique fissure runs from near diaphragm to central portion②. Angle between ① and ② is various, and reveal anterior (20 cases) (Fig 1.a), vertical (15 cases) (Fig.1.b), posterior (6 cases). 5 cases were not able to calibrate angle (N.C.), and 4 cases were no detectable fissure (N.D.).

Angle of anterior and vertical is sometimes indistinguishable, because this part of oblique fissure was usually anterior at lateral part, and gradually change to vertical at inner part. Point ① is sometimes accordant to origin of right main or upper pulmonary artery, and point ② is to right inferior pulmonary artery at inner part.

Discussion. The sagittal image of oblique and horizontal fissure of the right lung is various. In sagittal centro-medial field, area made by ① and ② was thought to be triangle and is located near mediastinal structure. The significance of triangle area is unknown; however, it may decide the pulmonary axis, and might be useful for further consideration of spread disease of adjacent organ such as lung, heart, esophagus, great and minor vessel, or fluid extension. Number of cases is a few, and histological evidence is not revealed, further investigation is required.

Conclusion. We analyzed the variation of right lung fissure in sagittal image on CT reconstructed by MPR, and triangle area was preliminary revealed by fissure variation in centro-medial area.

Analysis and change of vitamin status 25 (OH) D3 in relation to the gender and age of patients from Kragujevac and the environment during the change of seasons

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Introduction. Vitamin D deficiency has been linked to many chronic diseases in last few years, such as: cardiovascular diseases, diabetes, depression, MS, few types of cancers. The status of vitamin D is influenced by various factors, such as latitude, age, pigmentation, exposure to sunlight and the use of sunscreen, vitamin D intake via foods and supplements.

Methods. The test includes 6440 samples of patient serums of both genders from 0 to > 81 in the period from January 1 to December 31 2017. Serum aliquots are extracted within two hours of venipuncture and analyzed on the COBAS E601 technique electrochemiluminescence in the Laboratory Diagnostics Service KC Kragujevac.

Results. the study obtained the median value of 25 OH D3 for men 22.38 ng / ml, and 22.82 ng / ml for woman. Median values for different age groups are: 0-18 22.09 ng / ml, 19-40 20.09 ng / ml, 40-61 21.14 ng / ml, 61-80 22.20 ng / ml and > 81 14.84 ng / ml. Using Mann-Whitney test for the comparison of the value of 25 OH D3 median gave the significantly different values ($p<0.05$) for all age groups except for age groups 19-40 and 41-60 that do not show static significant differences ($p>0.05$). The concentration of 25OH D3 is the lowest in March (median 14.98 ng / ml), and highest in July (median 32.50 ng / ml). Comparison of values of medians for different seasons (winter 15.44 ng / ml, spring 21.35 ng / ml, summer 31.07 ng / ml and autumn 22.45 ng / ml), show statistically significant differences ($p<0.05$ Mann-Whitney test).

Conclusion. Patients examined in KC Kragujevac show vitamin D deficiency for age group >81 years. Vitamin D values vary during change of seasons. Accordingly, the use of supplements and moderate exposure to the Sun is recommended especially for the older population.

Keywords: 25OH D3, gender, age, change of seasons

Does chronic low dose exposure to ionizing radiation and antineoplatic drugs of hospital workers lead to increased micronuclei frequency, oxidative stress and changes in complete blood count?

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Background. Hospital workers at the Oncology Department are occupationally exposed to low-doses of ionizing radiation (Irad) and antineoplastic drugs during preparation and administration of therapeutic procedures. Due to the known carcinogenicity of those agents, party through the formation of reactive oxygen species (ROS), medical workers are potentially at health risk. Therefore, the aim of this study was to evaluate the level of DNA damage in blood through monitoring the frequency of micronuclei and the oxidative stress parameters. Complete blood count was also evaluated in order to analyze possible effect of low dose radiation and exposure to antineoplatic drugs on bone marrow. The influence of smoking as confounding factor was also evaluated.

Methodology. The study population included 115 subjects: 53 working in radiotherapy unit, 37 nurses handling the antineoplastic drugs and 25 unexposed healthy volunteers as control. The frequency of micronuclei (MN) was analyzed by cytokinesis-block test. The extent of oxidative stress was evaluated by spectrophotometric measuring the level of thiobarbituric acid reactive substances (TBARS) in plasma and the activity of catalase (CAT) in erythrocytes.

Results. Groups of hospital workers exposed to different agents had increased MN, level of lipid peroxidation and CAT activity compared to the control group. Proliferation index was inversely to DNA damage. Depending on working conditions, MN frequency in the group handling the antineoplastic drugs were higher compared to group exposed to Irad (14.77±12.65 vs.13.26±9.77). Additionally, subgroups of smokers had higher values of examined oxidative stress parameters. Smokers in control group also had increased DNA damage than non-smokers ((MN: 11.51±8.22 vs. 9.23±8.25). Significant difference in hemoglobin level found between control group and workers exposed to antineoplestics (137.08 ±12.36g/l vs. 130.20±11.66 g/l) indicates that drug exposure may lead to hemoglobin decline. There was no difference in white cells count as well as platelets count between control and exposed groups.

Conclusions. Obtained results have shown that hospital workers occupationally exposed to low-doses of IRad as well as those handling the antineoplastic drugs had increased DNA damage that is manifested through increased MN frequency. During the occupational exposure the activity of antioxidant enzyme CAT was increased as a protection against the increased production of ROS, with evident cofounding influence of cigarette smoking on the degree of produced oxidative stress.

The working conditions of hospital workers exposed to physical and chemical agents in our investigation influence to risk for health. Also, lifestyle habits could lead to additional hazard to soundness.

Cryosurgery method in the treatment of patients with skin cancer of the head

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Introduction. Non-melanoma skin cancers are the most common in the world among all skin malignant tumors. The proportion of basal cell carcinoma (BCC) and squamous cell carci-noma (SCC) of the skin accounts for about 97% of cases of non-melanoma skin tumors, and BCC is found 3-5 times more often than SCC. Skin tumors of the head and neck have a special clinical significance, affecting structures and organs with individual anatomical relief and vital functions.

The aim of the study. Improving the results of treatment of patients with cancer of the head and neck by determination the indications for cryosurgery treatment of these tumors on the basis of a complex study of the immediate and long-term results of treatment.

Materials and methods. Cryosurgery treatment was performed on 236 patients with BCC (222) and SCC (14) of skin of the head and neck, including neoplasms with symbol T1 - 100, T2 - 88, T3 - 7, and 41 patients had recurrences of skin cancer after various treatment modality.

Results. In stage I of basal cell and squamous cell skin carcinoma, the recurrence rate after cryosurgery treatment was 3%, in stage II - 5.3%. All recurrent tumors were successfully removed. After cryosurgery treatment of recurrent skin cancer, the frequency of recurrent relapses of the disease depended on the size of the recurrent tumor. The best aesthetic and long-term results were observed with neoplasms with clear boundaries smaller than 1 cm in size. Surgical removal of the tumor was performed when the disease recurred again. Good aesthetic and functional results were achieved after cryosurgery.

Conclusion. The cryosurgery is the method of choice and the optimal kind of treatment for most patients with stage I basal cell and squamous cell skin carcinoma of the head. For treatment of more advanced and recurrent forms of skin cancer, the method of cryosurgery can be applied in a number of patients according with the developed indications.

Keywords: Skin cancer, cryosurgery treatment

Recurrent exposure of patients with chronic conditions in a small private medical center

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One of the topics recently proposed by the International Atomic Energy Agency (IAEA) on the medical exposure to ionizing radiation is the recurrent exposure of patients with chronic conditions, at short intervals, using highly irradiating procedures such as CT examinations and interventional procedures (cardiological and non-cardiological). An IAEA study presents that the number of patients who have received cumulative effective doses (CED) in the 50-500 mSv range, over a period of 1-5 years, has increased a lot in recent years.

Based on these considerations, we performed a study referring to the evaluation of CED due to recurrent CT exposures, performed with a CT unit GE Bright Speed 16, in a private medical center focused on the follow-up on the evolution of malignant diseases of the patients, during the treatment process. Justification of these recurrent exposures is in accordance with clinical protocol for every type of treatment that impose, as regular control, a CT exam at 6 months after surgery, or a CT exam at every 3 months for verification of response of the chemotherapy, or in case of immunization treatment for breast cancer or melanoma, a CT exam at every 2-3 weeks. The total annual number of CT exams in Academica Medical Centre is around 2500, that represents a small number in comparison with emergency or county hospitals.

In our study, we analyzed a patient group of 350 persons, that performed 500 CT examinations. 52 patients from the total number (14.8%) presented recurrent exposures, being scanned 2 till 10 times. For these patients (27 women and 25 men), the total number of scans is 198, that represents 39.6% from the total exams number. For the group with recurrent exposure, the most patients (30 persons) were scanned 2-3 times, but there were 6 patients who were scanned 8-10 times. Regarding the time interval between consecutive scans, the majority of recurrent CT exams were performed within an interval of 1 month - 1 year, the exam types being trunk scans (39.9%), thorax-abdomen scans (11.6%) and abdomen-pelvis scans (9.1%), some of the most irradiating procedures. There were patients who received a CED of 128 mSv in only 5 months or 402 mSv in 1 year and 4 months.

The existence of an electronic system for individual registration of medical exposures at Academica Medical Center has allowed the evaluation of the CED, but only at local level. To have a real image of CED for every patient from Romania, it is necessary to create an electronic system at national level for individual registration of medical exposures, to be available to every referrer. Regarding the radiation protection of patients, the referrers must analyze, for every patient, the possibility of using non-ionizing imaging modalities (e.g. MRI or ultrasound) in place of CT exams. Taking into account the high values of CED received by the patients as in our study, an optimization of CT exams is needed, by using the concept of diagnostic reference levels.

Evaluation of cyto/genotoxic effects of X-rays in buccal mucosal cells in children subjected to sinus radiographs

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The buccal micronucleus (BMN) assay is a minimally invasive method for studying DNA damage, chromosomal instability and cell death in human buccal mucosal tissue. The biomarkers measured in this assay have been linked with increased risk of accelerated ageing, cancer as well as neurodegenerative diseases. Ionizing radiation is a powerful physical agent capable of inducing both mutations and chromosomal aberrations. Since even low-dose ionising radiation is capable of inducing genomic instability favouring carcinogenesis, special precaution should be made when performing diagnostic procedures in children. Hence, present study aims to investigate effects of diagnostic X-ray exposure on buccal epithelia cells using the BMN assay in children subjected to sinus radiographs. Furthermore, physical dosimetry was employed to evaluate the degree of radiological exposure using radiophotoluminescent (RPL) glass dosimetry systems developed for medical purposes. This preliminary study comprised a random sample of 12 children all with medical conditions, which warranted their radiographic examination. They were between the ages of 6 and 15 years (12.1±2.9) with the body mass index of 17.8±2.8 kg/m^2. For the physical dosimetry, the dosimeters were positioned on the occiput (primary beam) and below the tongue with the following parameters: the voltage of the X-ray 75 kV, the quantity of charge was 28 mAs and the time of irradiation was 22 ms. As for the biological dosimetry, the BMN assay was conducted on children samples that were taken immediately before and two weeks after the X-ray examination. Micronuclei as well as other biomarkers of DNA damage (nuclear buds and the so-called 'broken eggs') and genomic instability, cytokinetic failure or cell death (normal basal cells, normal differentiated cells, binucleated cells, cells with condensed chromatin, pyknotic cells, cells with karyorrhectic chromatin and karyolitic cells) were scored and classified according to HUMNxl criteria. Doses measured using RPL dosimetry systems were in the range of 379-1106 μGy, and 3-42 μGy in the primary beam and below the tongue, respectively. The results obtained after diagnostic X-rays did not show significant changes in any of the BMN assay parameters tested but revealed that inter-individual differences existed for each monitored child. Although we did not observe any significant changes in parameters tested, some of the measured parameters showed small increases in their values after the radiological examination indicating that further studies with larger samples should be done. For now, it seems that sinus radiographs may not be a factor that induces chromosomal instability.

Changes in the immune system after long-term radiation for cervical cancer treatment

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Purpose of research. Immunity of patients with cervical cancer was compared in groups with radiation injuries and without any complications in the long term after combined radiation therapy. Immune disorders were revealed depending on the difference in radiation doses, as well as not related to differences in radiation doses.

Materials and methods. 173 women were examined with radiation injuries (intrapelvic fibrosis, cystitis, rectitis) 1-20 years after the course of combined treatment. 37 women made a control group without radiation injuries of radiation therapy. The combined therapy included irradiation of the zone of intersection of uterine and ureter vessels, point A; area of *parametrial* and lymph node metastasis, point B; zone of the nearest location of the cervix to the bladder and rectum, point V and R. The total focal dose of radiation was in the group with radiation damage: p.A 77±12 Gy; p.B 54±8 Gy; p.V 48±15 Gy; p.R 39±11 Gy. The total focal dose of radiation was in the group of patients without radiation injury: p.A 69±14 Gy; p.B 51±6 Gy; p.V 46±11 Gy; p.R 37±9 Gy. The relative and absolute number of T-helpers, T-cytotoxic, T -, B -, NK-cells, phagocytes and their functional state were estimated in the immune status.

Results. A statistically significant link between the decrease in immunity and the total focal dose of radiation is revealed in the group without radiation damage (mainly with the dose given on pp. V and R). The number of T-helpers and the ratio of T-helpers/T-cytotoxic, primary immune response (concentration of IgM), phagocytosis are reduced; the percentage and number of NK cells are increased. Some differences in the reactivity of the immune system, which were identified, in partially may be due to differences in the total focal dose of radiation, summed to pp. A and B. Some revealed violations can be explained by differences in individual tolerance, contributing to the development of radiation damage in some patients, and the degree of their severity.

Conclusion. The results justify the need for strict compliance with the recommended tolerance doses. However, immune disorders in some patients are detected even with the general observance of tolerance in doses. The search and introduction of new treatments is also a prerequisite for reducing radiation exposure without reducing the effectiveness of therapy.

The long-term effect of therapeutic irradiation on the bone marrow cells after the treatment of Hodgkin's lymphoma

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Introduction. Bone marrow is now believed to perform the functions of the primary and secondary organ of the immune system. Irradiation is known to significantly reduce the number of cells in irradiated organs, tissues and bone marrow. However, at present, the influence of the program of radical gamma therapy on the immune cells of the bone marrow in the long term after treatment of Hodgkin's lymphoma has not been studied enough.

The objective of research. Total number of myelocariocytes and types of immunocompetent cells was evaluated in the bone marrow of patients with continuous long-term remission after radiotherapy for Hodgkin's disease.

Materials and Methods. Twenty five Hodgkin's disease patients were examined in 13-25-year remission achieved by the program of radical gamma therapy at dose 40 Gy. Total number of myelocariocytes and types of immunocompetent cells was evaluated in the bone marrow in that group of patients. It was estimated that about 25-30% of bone marrow was exposed to radiation. Status of sternum (irradiated) and iliac (unirradiated) bone marrow was evaluated.

Total cellularity, lymphocyte pool, population and subpopulation composition of immunocompetent cells was studied in the match biopsy specimens of marrow (breastbone and iliac bone). The bone marrow of 7 patients with lymphadenitis was evaluated as a control close to normal.

Immunophenotyping was performed with flow cytofluorimetry (FACScan) by Simulset programme using monoclonal antibodies of Leu series (Becton Dickinson) and double fluorescent staining – PE, FITC (Simultest IMK Plus and Acute Leukemia kits): CD45/CD14, CD3/CD4, CD3/CD19, CD4/CD8, CD16CD56/CD8, CD38/CD8.

Results. The mean number of myelocariocytes in unirradiated iliac bone marrow was 41.7 ± 6.4*10^9 cell/l, i.e. near low of the normal level. The numbers of lymphocytes were 4.0±0.67*10^9 cell/l and 8.6±1.2*10^9 cell/l for irradiated and unirradiated marrow, respectively. There were all types of immunocompetent cells found in the bone marrow: T-, B-, NK-cells. There were all types of immunocompetent cells found in the bone marrow: T-, B-, NK-cells. Their levels were higher in unirradiated iliac bone than in irradiated breastbone. Content of total count myelokaryocytes, of progenitor cells (CD38+), T-cells (CD3+), T-helpers (CD4+), T-killers (CD8+), NK-cells (CD16+CD56+) in the intact bone marrow was similar to those in group reactive lymphadenites, while the number of B-cells in group of lymphadenites was much higher.

Conclusion. Thus, the bone marrow of patients with Hodgkin's disease in long-term continuous remission that was achieved by radical gamma-therapy showed hypoplasia of bone marrow, especially in the irradiated areas. In the unirradiated bone marrow the impairment was less pronounced.

Peroxide scavenging enzymes and lipid peroxidation in children affected by celiac disease

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Celiac disease (CD) is an autoimmune enteropathy provoked by wheat gluten and related proteins from other grains. It can result in a severe damage of intestinal mucosa, malabsorption and predisposition to gastrointestinal malignancy. So far, the only treatment for the patients is a lifelong gluten free diet (GFD). It is well known that oxidative stress has been implicated in the pathogenesis of celiac disease (CD). There is a growing body of evidence indicating that antioxidant (AO) capacity of CD patients is reduced. This study involved intestinal biopsies and peripheral blood samples from 67 paediatric patients with different severity of the mucosal lesion. The activities of catalase (CAT) and glutathione peroxidase (GPx), as well as the concentration of lipid hydroperoxides (LOOH) were determined.

The CAT activity in the blood of patients with heavily damaged mucosa (partial or subtotal villous atrophy) increased significantly ($P<0.05$), while at the same time GPx activity decreased ($P<0.001$), comparing to the patients with healthy mucosa. Elevated LOOH levels were found in the blood samples from the patients with partial ($P<0.001$) and subtotal ($P<0.05$) villous atrophy, comparing to the patients with healthy mucosa.

The CAT activity did not vary significantly in the intestinal mucosa. GPx activity decreased in the biopsy specimens from the patients with partial ($P<0.01$) and subtotal ($P<0.05$) villous atrophy, when compared to the patients with healthy mucosa. LOOH levels were significantly elevated in biopsy specimens from patients with heavily damaged mucosa ($P<0.001$). Even in patients with milder mucosal damage (intraepithelial lymphocytosis or crypt hyperplasia), LOOH level was significantly higher than in patients with healthy mucosa ($P<0.01$).

Relative CAT and GPx protein levels in peripheral blood and intestinal mucosa did not vary significantly between the analyzed groups.

The alterations of AO status not only in the intestinal mucosa, bat also in the blood strongly correlate with the histological lesion, suggesting that they are of systemic character.

Seriously impaired AO capacity for degradation of LOOH in CD patients found in this studymay persist even after several years of gluten free diet.

Treadmill running changes gene expression of catecholamine biosynthetic enzymes only in the left adrenal medulla of adult rats

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The literature data confirm that the right brain hemisphere is more susceptible to traumatic influences than the left one, but the left adrenal gland recieves more cerebral neural inputs than the right one. The aim of this study was to examine whether there is asymmetry in sympathoadrenomedullary activity in the conditions of daily intense exercise. For this reason, in this study we examined how intense physical activity affects gene expression of catecholamine biosynthetic enzymes: tyrosine hydroxylase (TH) and dopamine-ß-hydroxylase (DBH) as an index for sympathoadrenomedullary activity in right and left adrenal medulla of adult rats. We applied a model of chronic forced running (CFR:12-weeks treadmill running), which by the intensity and duration could simulate intense physical activity. The investigated parameters were quantified by real-time PCR with TaqMan probes and Western blot analysis. The animals exposed to CFR showed decreased levels of TH mRNA by 97.5% ($p<0.001$, t-test), TH protein by 15% ($p<0.5$, t-test), DBH mRNA by 94% ($p<0.001$, t-test) and DBH protein by 30% ($p<0.05$, t-test) in the left adrenal medulla. However, we did not find changes in gene expression of catecholamine biosynthesising enzymes in the right adrenal medulla in animals exposed to CFR. The asymmetric decrease in the gene expression of TH and DBH in the adrenal medulla suggests a higher impact of sympathoadrenomedullary input in the left than in the right medulla. A significant decrease in gene expression of all examined catecholamine biosynthetic enzymes in left adrenal medulla may confirm that the right brain hemisphere was more vulnerable to intense physical activity.

Interrelationship of prefrontal brain-derived neurotrophic factor and neuroendocrine system during chronic restraint stress

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The hypothalamic–pituitary–adrenal (HPA) axis plays an important role in adaptation of the organism to stress. Because of a key role of neuroendocrine system in response to a stressful situation, as well as significantly impact of stress on neuronal plasticity, in this work we investigated how chronic restraint stress (CRS: 2 hours × 14 days) affected the protein levels of brain-derived neurotrophic factor (BDNF) in the prefrontal cortex (PFC), as well as concentration of adrenocorticotropic hormone (ACTH) and corticosterone (CORT) in the plasma. In addition, the aim of this study was to determine possible correlation between levels of BDNF in the PFC and plasma CORT levels of animals exposed to CRS. We found that CRS increases levels of prefrontal BDNF protein by 25% and levels of CORT by 280%, but decreases levels of ACTH by 18%. Also, we recorded low but significant positive correlation between prefrontal BDNF levels and concentrations of CORT in the plasma of *chronically stressed rats*. Our data confirm that prefrontal BDNF might be an important regulator involved in the adaptive strategy of the HPA axis to maintain adequate reactivity in stress conditions provoked by CRS.

In silico screening for GSK-3ß inhibitors as potential radioprotectors

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Molecular targeted radioprotectors can play a role in pharmacologic prophylaxis protecting the normal tissues during radiotherapy of cancer patients. Glycogen-synthase kinase-3ß (GSK-3ß) has a crucial role in regulation of radiation-induced apoptosis and small molecule inhibitors of GSK-3ß were shown to protect irradiated hippocampal neurons from apoptosis [Radiat Res. 2014 May;181(5):445-51]. Inhibitory effect of flavonoids on GSK-3ß was reported in several studies [J Med Food. 2011 Apr;14(4):325-33].

The Tim Tec Flavonoids database (http://www.timtec.net/flavonoid-derivatives.html) was subjected to an EIIP/AQVN virtual screening [Expert Opin Drug Discov. 2011 Dec;6(12):1263-70] in order to find the candidate inhibitors of GSK-3β. As a result of this analysis, 49 flavonoids and their derivatives were selected as candidate inhibitors of GSK-3β. Further filtering of these compounds by means of 3D QSAR and molecular docking revealed three compounds as most promising candidates for GSK-3β inhibitors proposed for further experimental evaluation. The identified compounds may have potential to ameliorate apoptosis as GSK-3β inhibitors.

ESR Investigation of X-ray Exposed Pharmaceutics

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Introduction. X-ray radiation having short wavelength and high penetration capability is used in several areas nowadays. Especially, it is used for security in several control points such as passenger screening at airports, shopping centers, etc. with evolving technologies [Drug Dev Ind Pharm.2015;41:953-6]. X-ray exposure can create reactive molecular fragments and induced radical types which can be determined previously by Electron Spin Resonance (ESR) spectroscopy [. J Pharm Sci.1994;83:1643-4, Appl Radiat Isot.1996;47:1569-72]. ESR is a non-destructive, highly sensitive spectroscopic technique allowing direct observation of free radicals and enabling differences between different radical types. Thus this method is accepted to be one of the most reliable methodologies for identifying free radicals and can provide valuable information about structural and chemical properties for especially stable radical species formed in drugs after X-ray exposure [Polym.2008;5:33-43].

In this study, physicochemical properties and formed radicals of X-ray exposed anti-diabetics (metformin HCl, pioglitazone HCl) and proton pump inhibitors (PPI) (lansoprazole, pantoprazole sesquihydrate) were investigated before and after X-ray irradiation.

Methods. Organoleptic properties (color, odor, and appearance) were investigated before and after X-ray exposure. The spectroscopic features of radiolytic intermediates produced in X-ray irradiated (0.24; 1.2 and 58 mGy) and non-irradiated drug samples were investigated after 1 hour at room temperature by using ESR spectroscopy.

Results. Organoleptic features were found exactly the same before and after different irradiation doses. Unirradiated drug samples indicated ESR spectra with relatively low-intensity ESR resonance lines. Seven resonance peaks were recorded for each anti-diabetics before X-ray irradiation. Additionally, ten and fourteen resonance peaks were recorded for pantoprazole sesquihydrate and lansoprazole containing commercial drugs before X-ray irradiation, respectively. The spectrum pattern remained nearly the same at higher absorbed doses. As ESR spectra of irradiated samples were recorded approximately one hour after the irradiation process, the lifetime of the free radicals induced upon irradiation can be relatively short. Therefore, no significant change in ESR spectra pattern could be observed.

Conclusion. X-ray has not affected antidiabetics and PPI's and no radical formation was observed in both groups. The x-ray can be used at security areas safely, according to these data.

Comparison between two labeled EDTMP radiopharmaceuticals with ^{153}Sm and ^{177}Lu

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^{177}Lu and ^{153}Sm are perspective radionuclides in terms of applying in nuclear medicine. High-energy beta particles and the relatively half-life of the radionuclide are used to achieve an effective palliative treatment of bone metastases. The technology-targeted delivery of the radionuclide to the pathological area is used to minimize radiation exposure to healthy organs and tissues. This result is achieved by the rapid delivery of the radiopharmaceutical to the tumor cells. For example, different complexes are used for bones cancer treatment like ^{153}Sm-EDTMP and ^{177}Lu-EDTMP. This complex is concentrated in the skeleton in proportion to osteoblastic activity. Pathological foci, where the accumulation is intense, can be visualized in studies in the gamma camera which allows scintigraphy of the patient and monitor the treatment process. In this work, the effect of the drug carrier EDTMP (i.e. ethylene diamine tetramethylene phosphate) on the ionic form of ^{177}Lu and ^{153}Sm is presented. The absorbed doses in different organs and tissues of ^{177}Lu and ^{153}Sm in ionic form and labelled with EDTMP are determined by IDAC-Dose 2.1 (Internal Dose Assessment by Computer) software. WinAct software is used to calculate cumulative activity [1,2]. ^{177}Lu and ^{153}Sm are lanthanide radionuclide which actively accumulates in the liver and bone when uses in ionic form. In the case of labelling with EDTMP, the distribution and elimination of the drug occur according to the kinetics of the carrier, (i.e. ethylene diamine tetramethylene phosphate). The using of osteotropic (Describing any drug etc. that is attracted to, and targets bone) complex allows creating a large dose in the pathological areas and minimizing damages in healthy organs and tissues. ^{177}Lu and ^{153}Sm labelled with EDTMP are decreasing the liver dose absorption and increasing the bone surface absorption for more effective treatment and minimize side effect. The effective dose per administered activity was estimated to be 0.189 mSv/ MBq for ^{177}Lu-ionic form, 0.232 mSv/MBq for ^{153}Sm-ionic form and 0.242 mSv/MBq for ^{177}Lu-EDTMP and 0.139 mSv/MBq for ^{153}sm-EDTMP. Figure 1 shows the direct effect of EDTMP in absorbed dose distribution for different organs and tissues. Also, even in ionic form the distribution of ^{177}Lu is better than ^{153}Sm more absorbed in bone surface, red bone marrow, and kidney with low absorption in live.

Wild apple fruit extract as active substance in UV protection cream – Investigation of *in vivo* hypopigmentation efficacy

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Use of dermocosmetic creams containing active and safe natural active substances represents a good basis for prevention and/or treatment of UV-related-skin-diseases. Extract of wild apple fruit can be potentially used as a good and safe hypopigmentation substance in many dermocosmetic products in the treatment of skin changes or for lightening of dark spots appearing on the skin due to oxidative stress and/or photodamage. Therefore, the aim of this study was to investigate a content of polyphenols and fruit acids, as good lightening and anti-irritating active substances, in cream with oil extract of wild apple fruit (*Mali sylvestris fructus,* (L.) Mill., Rosaceae), originated from Serbia, as well as *in vivo* hypopigmentation efficacy of this cream. Cream was made with 6% of wild apple fruit oil extract (obtained by sunflower oil as a solvent and digestion as extraction method in drug:extract ratio D:E=1:5) and stabilized with conventional non-ionic mixed emulsifier (EmulgadeSE). Content of polyphenols-PPs and fruit acids-FAs into formulated cream after preparation was investigated using HPLC analysis. *In vivo* estimation of hypopigmentation efficacy after 7 days of cream application, after artificially induced skin hyperpigmentation (by dihydroxyacetone), was investigated employing the biophysical methods on the skin of healthy volunteers (by measuring melanin index-MI and erythema index-EI). Formulated cream revealed satisfying content of polyphenols (36.07 mgPPs/100g cream) and fruit acids (120.30mgFAs/100g cream) after preparation. Application of cream with wild apple fruit oil extract, as a good source of these bioactive agents, after artificial skin hyperpigmentation induced significant decrease of MI (ΔMI was -22.40±16.68 after 3 days and -30.40±12.32 after 7 days) and EI (ΔEI was -25.00±29.91 after 3 days and -26.60±38.79 after 7 days). Formulated cream with wild apple fruit oil extract demonstrated good hypopigmentation and anti-irritating effects on human skin after cream application after artificially induced skin hyperpigmentation, probably due to the synergistic effects of polyphenols and fruit acids from extract. Therefore, UV protection cream with wild apple fruit oil extract, as active hypopigmentation substance, and stabilized with non-ionic emulsifier, might be suitable for possible usage for prevention of oxidative stress-related skin damages, for skin hyperpigmentation lightening and for UV skin protection.

Keywords: Wild apple fruit oil extract, polyphenols and fruit acids, UV protection cream, *in vivo* hypopigmentation efficacy

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Skin photoprotection products with wild apple fruit extracts as source of bioactive polyphenols: A comparison of polar and non-polar solvents

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Ultraviolet radiation is one of the main causes for the development of oxidative stress-related skin damages and photoaging. Oxidative stress generates free radicals which lead to the skin changes. Polyphenols of natural origin represent good bioactive antioxidant substances and might prevent oxidative stress damage by free radicals neutralization. Application of plant extracts as a good source of polyphenols (including phenols, flavonoids, tannins and anthocyanins) for skin photoprotection is a novel preventive and therapeutic strategy against UV-related-skin-diseases. Therefore, the aim of this study was preparation of different fruit extracts from wild apple fruit (*Malus sylvestris fructus,* (L.) Mill., Rosaceae), originated from Serbia; examination of total content of phenols - TPC, flavonoids - TFC, tannins - TTC and anthocyanins - TAC; as well as comparative analysis of contents of polyphenols in extracts obtained by polar and non-polar solvents. The liquid extracts were prepared in drug extract ratio - 1:5, at temperature of 22±2°C, by maceration as extraction method and using two different solvents (purified water as polar solvent and virgine olive oil as non-polar solvent). TPC was determined according to the Folin-Ciocalteau method and expressed as gallic acid equivalent - GAE; TFC by Markham's methods and expressed as rutin equivalent - RE; TTC by vanillin test and expressed as catechin equivalent - CE and percentage content of anthocyanins by Eur.Ph.6.0. Water extract showed similar content of TP (585.65±23.32 mgGAC/100g of dry drug-dd) and better content of TA (4.88±0.92 %) compared to oil extract (TPC was 400.47±39.12 mgGAC/100g dd and TAC 0.70±0.05 %). Extraction of flavonoids and tannins from wild apple fruit was better with oil as non-polar solvent, so oil extract showed much better content of TF (182.22±27.12 mgRE/100g dd) and TT (2263.64±167.92 mgCE/100g dd) compared to water extract (TFC was 6.03±1.23 mgRE/100g dd and TTC 709.09±89.45 mgCE/100g dd). Our results demonstrated that bioactive polyphenols are quite abundant in wild apple fruit extracts, which might indicate that wild apple fruit extracts have the potential for usage as natural source of polyphenols in UV-skin-protection products. Non-polar solvent (virgine olive oil) was better solvent for extraction compared to polar solvent (purified water), and oil extract might be more effective than water extract due to the better content of polyphenols. Future development of skin photoprotection products with wild apple fruit extracts as a source of bioactive polyphenols might be justified.

Keywords: Polyphenols of natural origin, wild apple fruit extracts, polar and non-polar solvents, maceration, skin photoprotection products

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Study of the regulatory effect of LED lighting of different spectral composition on the formation and growth of the lateral roots of Arabidopsis thaliana using an optimized method of plant cultivation

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Studies of the plant root system phototropic reactions are very important for the modernization of closed plant cultivation systems. Such systems are used both in terrestrial conditions, and outside the Earth's orbit. However, most such studies were conducted using seedlings, while the features of the plant development are especially interesting. In this connection, tropisms of the lateral roots have been poorly studied. However according to the latest data there are significant differences in the development regulation of the main and lateral roots. Therefore the identification of the basic features of growth and spatial orientation of the lateral roots of the Arabidopsis thaliana model plant is an actual task today.

A new method of A. thaliana cultivation was created. This method allows to simplify observations and analysis of the root system. The proposed technique is applicable for conducting ground and onboard experiments to study tropical reactions of the plant root system. Compartments of plant growth chamber were equipped with Luminescent lamp or Light Emitting Diodes (LED) generated Photosynthetically Active Radiation (PAR) with different spectrum and different ratio of wavelengths (5 variants).

It was found that the number of lateral roots was greater under the LED lighting. This parameter was varied depending on the spectral composition of the LED illumination. Thus, the maximum number of lateral roots was observed in plants under LED light with high proportion of Red light in the spectrum. At the same time, an increase in the Red light of more than 60% led to a significant reduction in the formation of lateral roots. In the same time this spectral composition stimulated their elongation to the maximum. LED lighting with the highest Green and lowest Far red light was significantly reduced root growth and development.

Thus, differences in the spectral composition of the LED light, which necessary for maximum stimulation of the initiation and further growth of the A. thaliana lateral roots are showed. It is proposed that regulation of phytohormone synthesis and transport as well as cell signalling processes change under LED lighting with different spectrum and changes the root systems structure.

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