BOOK OF ABSTRACTS

10th JUBILEE INTERNATIONAL CONFERENCE ON RADIATION IN VARIOUS FIELDS OF RESEARCH (RAD 2022)
SUMMER EDITION | 25–29.07.2022 | PALMON BAY HOTEL | HERCEG NOVI | MONTENEGRO
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RAD 10th Jubilee Summer Edition
July 25-29, 2022 | Herceg Novi | Montenegro
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Determination of the plasma free fatty acids concentrations in non-treated Type 2 diabetics

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https://doi.org/10.21175/rad.sum.abstr.book.2022.1.1

Free fatty acids (FFA) represent important link between obesity and insulin resistance, as major risk factors for development of type 2 diabetes mellitus (T2D). Elevated FFAs disturb the normal glucose homeostasis, decrease insulin release and reduce the efficiency of glucose uptake in insulin-sensitive tissues and therefore, changed insulin action and secretion. Studies related to FFAs composition in non-treated diabetic individuals are lacking and inconsistent. The main objective of the present study was to investigate the profile and possibly specific composition of plasma FFAs in healthy controls and newly diagnosed type 2 diabetics.

Total of 51 subjects (24 non-treated diabetics and 27 patients classified as healthy controls on the basis of glucose tolerance test), with no active liver and kidney disease were recruited in this study. Classification of patients was made according to criteria used by American Diabetes Association. Standard IFCC protocols were used for analyzing glycated hemoglobin, glucose and other biochemical parameters, while FFA profile, composition and concentrations were determined by gas chromatography.

The FFA profile and composition of healthy controls and non-treated diabetic subjects were different for 3 of 17 fatty acids with 12 to 22 carbons. The most common fatty acids in both groups of patients were C14:0, C16:0, C18:1 and C18:2. Compared to controls, total of saturated of FFA concentrations were higher in newly diagnosed type 2 diabetics except for C20:0 and monounsaturated FFA concentrations were higher in controls except for C18:1. Also, in diabetic population, total polyunsaturated fatty acids were increased compared to controls except for C20:5.

These observations indicate that changes in composition and concentrations of FFA are associated with the development of the disease, therefore, may be used as potential biomarkers in diagnosis of disease.

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Antioxidative defense and life history traits of four larval instars of *Lymantria dispar* L. in static magnetic field

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https://doi.org/10.21175/rad.sum.abstr.book.2022.1.2

Magnetic fields are all around us: in the Universe, on the Earth, among and within organisms, cells, molecules, and single atoms. Fast technological development and modernization of life, increase the level of artificial magnetic fields, thus affecting every living beings. Hence, exposure of organisms to omnipresent magnetic field could represent important stressogenic factor for them. Magnetic sensitivity is very well documented in insects, but there is little research of the effects of magnetic fields on antioxidative defense during their development. The main purpose of this work was to evaluate the effects of static magnetic field (SMF, 230 mT) on antioxidative defense, as well as life history traits of larval instars (from 1st to 4th) of *Lymantria dispar* L. (Lepidoptera). The activity of superoxide dismutase (SOD), catalase (CAT), glutathione reductase (GR), and glutathione-S transferase (GST) in each larval instar was measured spectrophotometrically. Life history traits (mortality, larval mass and development duration) were monitored daily. Magnetic field increased the activity of SOD, CAT, GR, and GST in all larval instars, but these changes were significant only in older larval instars (3rd and 4th), except CAT. During the larval development, mortality was higher in SMF group than the control. Also, we observed a significant increase in mass of 4th larval instar in magnetic field compared to the control. On the other hand, we did not detect a significant influence of SMF on duration of larval instars. The obtained results demonstrate differences in MF susceptibility of younger and older larval instars of *L. dispar*. In conclusion, the applied magnetic field could be considered as a potential stressor influencing life history traits, as well as examined antioxidative biomarkers.

Acknowledgments: This study was supported by the Serbian Ministry of Education, Science and Technological Development (Contract No. 451-03-68/2022-14/ 200007).

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Sex-specific antioxidative strategy and fitness components of *Lymantria dispar* L. in static magnetic field

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https://doi.org/10.21175/rad.sum.abstr.book.2022.1.3

Life on Earth exists under the influence of natural magnetic field (geomagnetic field – 25 to 65 μT). Nowadays, this is not the only magnetic field (MF) whose effects we find and endure in nature. Human activities (electrification, industrial and technological development) are sources of several strong artificial MFs. These MFs have a stressful impact on the life processes in the organisms and should be treated as a kind of environmental pollutant that deserves constantly growing attention. Insects are sensitive to Mfs, showing considerable changes in development, neuroendocrine system, genome, metabolism, antioxidative defence, daily activities, orientation, behavior etc. Static magnetic field (SMF) extensively changes free radical production, increases peroxidation processes of lipid bilayers of cell membranes and expresses a negative influence on insect tissues. Prooxidative stressogenic effect of SMF on insect tissues includes modification of activity of antioxidative enzymes and production of non-enzymatic antioxidants.

The aim of our research was to evaluate differences in fitness components (survival rate, larval mass, development duration) and antioxidative defence strategy (activity of superoxide dismutase - SOD, catalase - CAT, glutathion S-transferase - GST and whole amount of glutathione - GSH) of male and female Gypsy Moth (*Lymantria dispar* Linnaeus, 1758) larvae, after the long-term exposure to SMF (230mT).

Newly hatched male and female larvae of *L. dispar* were exposed to a magnetic field of approximately 230 mT generated by a static double U-shaped magnet (Raytheon, model 6002). It consists of two symmetric halves. Magnetic field has relatively homogenous strength and field was measured by a gausmeter (HIRST – GAUSSMETER GM 05, with probe PT 2837 – Hirst Magnetic Instruments LTD, Tesla House, Tregoniggie, Cornwell, UK). Determination of the differences in activities of antioxidative enzymes and the amount of GSH was done in whole larvae homogenates. SOD was conducted according to the methods described by Mistra & Fridovich (1972). CAT activity was determined according to the method by Beutler (1982). GR activity was measured according to Glatzle *et al.* (1974). GST (antioxidative function) activity was determined according to the method by Habig *et al.* (1974). Determination of the concentrations of reduced GSH was conducted according to Griffith (1980). We also evaluated fitness components daily.

The study provides information on the effects of the long-term exposure of male and female *L. dispar* larvae to the SMF. Such exposure induces significant alterations in their strategy of antioxidative defence that are strikingly sex-specific. Increasing the knowledge of effects of SMF exposure in evolutionary simpler organisms may be the basis for understanding its action in higher organisms and humans.

Acknowledgments: This study was supported by the Serbian Ministry of Education, Science and Technological Development (Contract No. 451-03-68/2022-14/ 200007).

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Gold and polymeric nanoparticles for the delivery of Dexamethasone to the inner ear

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https://doi.org/10.21175/rad.sum.abstr.book.2022.2.1

Background. Sensorineural hearing loss represents one of the most frequent human disabilities, caused by intensive sound and ototoxic drugs (aminoglycosides, cisplatin). Treating inner ear disorders remains difficult due to several anatomical and physiological barriers. Systemic drug delivery is considered as the first line treatment modality for inner ear disorders, but the inner ear's limited blood supply and the relatively poor penetration of the blood– labyrinth barrier (BLB) results in sub-therapeutic concentration of the drug. Corticosteroids (Dexamethasone- Dex) are commonly used to treat inner ear conditions. Due to the limitations of conventional drug delivery, there has been an increased interest to explore the potential of nanoparticles (NPs) as carriers for intracochlear drug delivery. NPs are carriers in the nanoscale range capable to cross the BLB.

Aim. Our aim was to synthesize gold nanoparticles for the delivery of Dex in therapeutical concentrations to the inner ear. The proposed NPs are: Pluronic-coated gold nanoparticles (GNPPlu) and chitosan-coated gold nanoparticles (GNPChit) loaded with Dex. These NPs were characterized in terms of their physico-chemical properties, correlated with the effects on the treated cells: uptake and citotoxicity on inner ear sensorial cells (HEI-OC1 cell line), as well as the potential protective effect on the inner ear cells treated with Cisplatin.

Methods. GNPChit were synthesized using chitosan as both reducing and stabilizing agent. For the fabrication of GNPPlu, citrate-capped spherical gold NPs were stabilized with Pluronic. The colloidal suspensions were then incubated with Dex followed by the elimination of the unloaded drug molecules by centrifugation. The obtained NPs were characterized and their stability in different environmental conditions was monitorized by UV-vis-NIR, transmission electron microscopy (TEM), Zeta-potential and dynamic light scattering (DLS). For the evaluation of the biologic effects of the NPs the HEI-OC1 inner ear neurosensory cell line was used. Cytotoxicity was assessed by MTT. The evaluation of the cellular uptake was done by atomic absorption spectroscopy and transmission electron microscopy (TEM). The production of reactive oxygen species (ROS) after treatment with the NPs with or without Cisplatin was evaluated with the 2',7' –dichlorofluorescein diacetate (DCFDA) test. For the assessment of apoptosis we used the Annexin V- PI test by flow- cytometry. The evaluation of the immunogenic effect, IL6 and TNF alpha were quantified in the cell culture media by ELISA.

Results. GNPPlu had a plasmonic band with the maximum extinction of 521 nm and Zeta potential of -23 mV. The extinction of GNPChit was 523 nm and the Zeta potențialul + 35 mV. GNPPlu-Dex contained 10 µg/ml Dex, while GNPChit-Dex had 32 µg/ml. The release of Dex in cell culture media was 42 % of the loaded concentration in 24h. The atomic absorption spectroscopy showed a gold concentration in the treated cells proportional with the amount of the administered NPs and incubation time, GNPChit showing a better uptake compared with GNPPlu. The reduction of cell viability was proportional with the applied concentration. IC50 was 37.7 µg/ml for GNPPlu; 38.8 µg/ml for GNPPluDex; 24.7 µg/ml for GNPChit and 23.2 µg/ml pentru GNPChit Dex. *TEM*. The internalization of GNPs occured for all types of GNPs applied. They were visualised in endosomes, dispersed in the cytoplasm, autophagosomes (GNPPlu and GNPPlu-Dex) or in the lysosomes (GNPChit si GNPChit-Dex). The administered concentrations didn't result in ultrastructural changes in the studied cells. The treatment with the GNPs did not lead to an increase in ROS production compared to control cells, also the number of apoptotic cells and the cytokine production were not augmented as a result of the administration of GNPs.

Conclusions. The studied NPs showed excellent biocompatibility, biodegradability, low toxicity, low immunogenicity.

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Ceria containing mesoporous bioactive glasses with positive biological functionalities

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https://doi.org/10.21175/rad.sum.abstr.book.2022.2.2

In this work, we report the effect of cerium oxide addition to calcium silicates following a quick sol-gel method, targeting its influence on structural, in vitro bioactive, and biocompatible properties of such kinds of mesoporous bioactive glasses (MBGs). The investigations were made using different techniques, Uv-vis absorption spectroscopy combined with XPS to evaluate the oxidation states of the incorporated cerium ions, XRD combined with HRTEM techniques to demonstrate the formation of nano-sized crystalline ceria into the calcium silicate matrices. SEM-EDS analyses prove a moderate bioactive behavior of the ceria incorporated calcium silicates even if ceria is known to inhibit the bioactive behavior. As a next step, cell viability in vitro studies were undertaken, starting with a 75 μg/mL glass concentration. The obtained results of cell viability for ceria-containing samples showed a good in vitro tolerance, the viability of Human keratinocytes cells being close to 100%. Moreover, it is worth mentioning that when we doubled the glass-ceramic concentration in the culture media (150 μg/mL) the ceria-containing sample enhanced the proliferation rate to 130% after 24 hours of exposure, making this ceria containing MBGs very good candidates for tissue engineering applications.

Keywords: Ceria, MBG, bioactivity, biocompatibility

Acknowledgments: The authors acknowledge the financial support of the Romanian National Authority for Scientific Research and Innovation, CNCS – UEFISCDI, project PN-III-P1-1.1-TE-2021-0388.

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Functionality and usability evaluation of interactive mobile digital medical assistant

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https://doi.org/10.21175/rad.sum.abstr.book.2022.3.1

The creation of digital medical assistants (DMA) with the integration of artificial intelligence and augmented reality is an important element in building a digital medical ecosystem. By DMA we mean a computer program or mobile application that is used for conducting preliminary online counseling of patients in chat with the help of text or speech synthesis based on software scripts and/or artificial intelligence.

The generalization of scientific sources was used to determine the state of integration of digital medical assistants (chatbots) in medicine by means of PubMed and TRIP clinical database for 2000-2021 period, screening of chatbots using Botlist catalog, methods of comparative analysis in choosing a strategy chatbot development, methodology for creating a script chatbot using SendPulse, chatbot with integration of artificial intelligence using Microsoft Power Virtual Agents, as well as a mobile avatar chatbot with augmented reality integration using GuideBot-template GitHub, an online survey using Google Forms and statistical analysis using MedStat.

We have developed and tested the DMA DigitalDoctorsAssistantBot of our own design in accordance with the developed concept and defined functional domains. The prototype is hosted on the MDTECH LMS platform. An optimized combination of technical solutions for the development of digital medical assistants is proposed, namely: SendPulse service; Microsoft Power Virtual Agents; GuideBot-template GitHub. An online survey of 110 students in Bogomolets National Medical University (90 (88.8%) women and 20 (18.2% men) on the design and DMA functionality was conducted. 90% of respondents (99 out of 110) believe that the proposed technology for cognitive training for patients by chatbot is appropriate and progressive, 8.2% of respondents (9 out of 110) said that it is difficult to answer. Our results show that 98.2% (108 out of 110) of surveyed medical students intend to use this technology in their future practice.

Advantages and effective ways of technical implementation of the DMA (interactive mobile chatbot with the ability to integrate artificial intelligence) are analyzed and checked on the prototype as an effective addition to the digital medical ecosystem.

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The potential of *Acmella oleracea* in dermato-cosmetic products – new pharmacological applications

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https://doi.org/10.21175/rad.sum.abstr.book.2022.3.2

With remarkable applications in food industry and a strong scientific background in multidisciplinary research reports, *Acmella oleracea*, from *Asteraceae* family offers o generous range of functional activities which can lead to new pharmacological applications. Already recognized as a strong medicinal plant, with studies that support its health efficient applicability, *Acmella oleracea* does not seem to fulfil its potential and can be ready to be part of new innovative industries, such as dermato-cosmetic field.

Thus, our study focused on obtaining and characterizing extracts from this plant. For this it used three methods for liquid - solid extraction: extraction at room temperature (maceration), ultrasonic assisted extraction and the combined method of ultrasonic assisted extraction - maceration. The performances of these methods were evaluated by calculating the extraction yield in the case of the methods applied according to a series of physical parameters: solid/liquid ratio, extraction time, extractant concentration. The quantitative characterization of the obtained extracts was done by determining the content of flavonoids and total polyphenols.

The extract with the highest polyphenol content will be used in the preparation of new dermato-cosmetic products based on *Acmella oleracea* extract in order to protect the skin from oxidative stress.

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New cosmetic formulations based on N-Prolyl Palmitoyl Tripeptide-56 Acetate and Bakuchiol Complex with anti-aging properties

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https://doi.org/10.21175/rad.sum.abstr.book.2022.4.1

The trend in the cosmetics industry is to research and innovate new ingredients of natural origin and respectively to identify new natural and biodegradable preservatives harmless to the skin and the environment to develop cosmetics without adding chemical ingredients with aggressive potential on the epidermis.

In this context, the objective of this study was to evaluate the biological potential of the active substances introduced into cosmetic preparations (O/W emulsions) to highlight the optimal concentration and combination in the formulation, in terms of antioxidant properties.

The study was performed by applying methods to determine antioxidant activity (determination of antiradical capacity with DPPH radical) and scavenger capacity against the radical cation ABTS. These components are: Bakukiol (BAK) [1- (4-hydroxyphenyl) -3,7-dimethyl-3-vinyl-1,6-octadiene] and Peptide Matrixyl® Morphomics (TPA) [n- prolyl palmitoyl tripeptide-56 acetate]. Bakuchiol is an active substance found in the species *Psoralea corylifolia* which exhibits antioxidant and antibacterial activity and it is an alternative to retinoids. The n-prolyl palmitoyl tripeptide-56 acetate is a small peptide that has been reported to stimulate the production of elastin, fibronectin, glycosaminoglycan, and collagens. Three types of emulsions with different concentrations in active complex were prepared and analyzed (0.5% BAK + 0.5% TPA, 1% BAK + 1% TPA, 1% BAK + 2% TPA). The DPPH and ABTS test was used to evaluate the antioxidant activity of the active complex (BAK / TPA) and emulsions containing this biologically active complex.The results showed that the biologically active complex alone has good antioxidant activity. It has also been shown that the proportions used for the preparation of emulsions with BAK and TPA are suitable for preparation for local use due to their antioxidant effect and potential use in anti-aging therapy.

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Applicability of hydroalcoholic extracts of *Alchemilla Vulgaris* in development of high added-value pharmaceutical products

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https://doi.org/10.21175/rad.sum.abstr.book.2022.4.2

Nowadays, attention is focused on the study of plants, and their secondary metabolites as important sources of biologically active compounds (terpenes, phenolic compounds, nitrogen compounds) with applicability in the food, cosmetics, and pharmaceutical industries. Our research focused on *Alchemilla vulgaris*, a European native an unusual herbaceous member of the rose family (Rosaceae) rich in flavonoid compounds.

The processing of the aerial parts of *Alchemilla vulgaris* aimed at obtaining plant extracts loaded with biologically active compounds using different liquid-solid extraction methods: heat reflux extraction (HRE), room temperature extraction (maceration) (M), as conventional techniques and ultrasound assisted extraction (UAE) as an unconventional "green" method.

The yield was determined as a measure of extraction efficiency and it was calculated according to the following parameters: solvent concentration (hydroethanolic solvents% v / v), solid/liquid ratio (m / v) and extraction time. The quantitative characterization of the extracts obtained was done by evaluating the total flavonoid content (TFC) expressed in mg equivalent to quercetin (QE) per gram of extract.

This study showed that the total flavonoid content is influenced by the extraction techniques applied. The highest total flavonoid content in the ethanolic extract of *Alchemilla vulgaris* (86.55 mg equivalent to quercetin / g extract) was found using thermal reflux extraction (HRE) - (extraction time - 60 minutes, hydroethanolic solvents 50% v / v, solid/liquid ratio 1:15).

This rich in flavonoids vegetal extract has been tested in pharmaceutical preparations such as vaginal suppositories.

The results showed that the plant *Alchemilla vulgaris* can be processed to obtain high yields of biologically active compounds, opening new possibilities to become a valuable source of active substances with various applications in pharmaceutical and dermatocosmetic formulation.

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Effects of low-energy electron radiation on the growth and microflora of potatoes

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https://doi.org/10.21175/rad.sum.abstr.book.2022.5.1

The infestation of crops with fungal, viral, and bacterial diseases reduces both the quality and quantity of produce. For potatoes, one of the most common and damaging diseases is Rhizoctonia (contamination by phytopathogenic fungus Rhizoctonia solani Kühn also known as “Black Scurf”) [1]. Ionizing radiation is widely used for mycotoxin decontamination and fungal inactivation in the food and agricultural industries, as well as for phytosanitary treatment where both decreases and increases in the virulence and aggressiveness of phytopathogens are possible [2].

The purpose of the study was to investigate the influence of low-energy electron radiation with 1 MeV on the productivity and phenology of potatoes infected with Rhizoctonia solani Kühn (R. Solani).

Potato tubers (4 ± 1 cm in diameter) with a naturally occurring R. Solani fungus (a fungal sclerosis depth of about 2 mm) were irradiated at doses of 20 to 200 Gy using a linear electron accelerator UELR-1-25-T-001 with 1 MeV energy and an average beam power of 25 kW. The samples were put on duralumin plate (35 cm x 3 cm) directly under the accelerator beam. Tubers were irradiated from two sides to ensure an even distribution of the dose throughout the entire volume.

Geant4 computer simulation, based on the Monte Carlo method, was used for control by the absorbed dose of radiation in the samples. The absorbed charge by the plate and the energy electron spectrum at the accelerator output was recorded for simulation. Only upper layers of tubers affected by sclerosis have been irradiated without affecting the internal component due to the superficial nature of the low-energy electron treatments.

The impact of low-energy electron radiation on the phenology of the irradiated crop, fractional composition, and the degree of phytopathogenic infection of the crop was assessed. Field research was carried out at the experimental field of Siberian Federal Scientific Centre of Agro-BioTechnologies of the Russian Academy of Sciences in Novosibirsk region.

It was found that irradiation of infected R. Solani potato tubers at doses of 20 to 150 Gy delayed their development (onset of growth phases, mass blooms, and blooms), and doses exceeding 200 Gy resulted in complete inhibition of germination.

Crop yields for irradiated samples decreased with the increase in the dose. In the range of 20 to 40 Gy, the average tuber fraction of 40 to 80 g showed a quantitative increase, while at 150 Gy a large fraction of tubers weighing more than 80 g predominated.

Although crop yields decreased with the increase in the dose, the prevalence of both non-sclerotic and sclerotic forms of Rhizoctonia decreased in all irradiated samples. For example, at doses of more than 40 Gy the deepened spotting was eliminated, and at a dose of 150 Gy the tubers of the new potato crop were affected only by net necrosis, while all other potato diseases were inhibited.

Thus, the treatment of seed potatoes at 30 Gy results in a doubling of tuber morbidity, with only a partial reduction in potato yields, making it effective in controlling the phytosanitary status of the new crop.

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Acknowledgments: This research has been supported by the Interdisciplinary Scientific and Educational School of Moscow University “Photonic and Quantum Technologies. Digital medicine”.

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Modern methods of searching for markers of radiation processing of food products

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https://doi.org/10.21175/rad.sum.abstr.book.2022.6.1

The use of sources of ionizing radiation is one of the most effective and universal methods of extending the shelf life of food products, allowing to ensure their microbiological safety while maintaining the organoleptic properties and nutritional integrity of the product. When using radiation treatment, it is important to choose the main physical parameters of the treatment (beam energy, type of radiation, dose and dose rate, etc.) and the irradiation technique. Incorrectly selected physical and technical parameters of radiation treatment, for example, going beyond the “working” dose range, may either not lead to sufficient suppression of pathogenic microflora, or significantly change the physicochemical properties of the product.

In a number of countries, radiation treatment of food is allowed at the legislative level and is regulated by international standards ISO and ASTM [ISO 14470-2014, ISO/ASTM 51431:2005]. According to these documents, a product treated with ionizing radiation is subject to mandatory labeling. However, in order to achieve commercial benefits, food manufacturers violate the requirements for product labeling, for this reason there is a possibility of their secondary processing, which leads to deterioration in the quality of the goods. As a result, in recent years there has been an acute problem in identifying the fact of irradiation of food products, i.e., searching for biochemical markers.

The search for a biochemical marker in irradiated products is a difficult task, since this marker must unambiguously indicate the fact of the presence or absence of irradiation. International studies show that for each category of food products, markers and methods for their identification are specific. Thus, according to [GOST 31672-2012, ASTM 5160] electron-paramagnetic resonance method is widely used to identify irradiation of dry foods as well as products containing bone and cellulose. However, EPR is not applicable to products with high moisture content (fruits and vegetables) and boneless products, since the paramagnetic centers formed there are unstable and after a short time after radiation treatment, it is impossible to say whether the product was irradiated.

To search for biochemical markers in meat and fish products, the method of gas chromatography in combination with mass spectrometry (GC-MS) is actively used, which makes it possible to highly efficiently separate the components of complex mixtures in gas form and identify both known and unknown components [EN 1784. Foodstuffs]. According to [EN 1785. Foodstuffs], the GC-MS method is used to identify markers of irradiation of meat products However, for low-fat products, this marker cannot be identified in sufficient concentrations, so it is necessary to search for alternative markers.

At the Faculty of Physics of Moscow State University, together with the Faculty of Chemistry and Rospotrebnadzor, research is being conducted to search for biochemical markers in products, after their radiation treatment [1-2]. Promising product categories are being studied - chilled and multifunctional products, as well as new promising methods of analysis, such as the fluorometric fingerprint method, based on obtaining multidimensional spectra and subsequent mathematical processing of data and a method for measuring the electro-physical activity of biotissues.

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BOOK OF ABSTRACTS

Hydroponic growth and radionuclide accumulation specificities of Thuja occidentalis 'Pyramidalis Compacta' in Ararat Valley and Dilijan forest zone conditions

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https://doi.org/10.21175/rad.sum.abstr.book.2022.6.2

Thuja occidentalis L. is valuable tree in the ecology of urban ecosystems as a biofilter and a producer of phytoncides. It shows high stability in the air polluted with smoke and dust, thus it can decorate also industrial areas. One of the well-known forms of this tree is Thuja occidentalis 'Pyramidalis Compacta', which is used very often in cities greenings.

The aim of this study was to evaluate the hydroponic growth technology of Thuja pyramidalis as an accelerated sapling cultivation method and the ability of this plant to accumulate radionuclides that are nowadays big ecological problems for the cities, especially those which are near to the nuclear power stations. Our results show that hydroponic growth technology provides in average 1.3-1.4 times yearly increase of height of overground part, root and foliage perimeter. Already third years old saplings have about 30 cm height, 11 mm cingulum diameter, 46 cm foliage perimeter and 23 cm root length and may be transplanted into the soil in their final places. In hydroponic conditions of Ararat Valley saplings of this tree showed increase of the ability to absorb total β–radioactivity with the age. Eight years aged plant's total β-radioactivity level is two times higher from the three years aged one. In absorbed radioactivity the ^{90}Sr is about 6.5-9.5 % and ^{137}Cs is about 2.7-3.4 %. Other RN include technogenic (^{89}Sr, ^{134}Cs, ^{141}Ce, etc.) and natural (^{40}K, ^{234}Th, ^{210}Pb, etc) ones and is about 87.3-91.4 %. From our results it may be proposed that Thuja occidentalis 'Pyramidalis Compacta' may be a valuable tree in city greenings as an accumulator of radionuclides and hydroponic growth technology may be used to receive its saplings in a short time period.

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Spatial fractionation treatment on brain tumor microenvironment using a proton pristine Bragg peak and tumor-targeting LDLR-ligand functionalized high-Z nanoparticles

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https://doi.org/10.21175/rad.sum.abstr.book.2022.7.1

The tumor microenvironment (TME) of glioblastoma malforms (GBMs) contains tumor invasiveness factors, microvascular proliferation, migratory cancer stem cells and infiltrative tumor cells, which leads to tumor recurrence in the absence of effective drug delivery in a Blood Brain Barrier (BBB)-intact TME and radiological invisibility. Low-density lipoprotein receptor (LDLR) is abundant in the blood brain barrier endothelial cells and overexpressed in malignant glioma cells. This study aimed to treat the TME with proton transmission sensitization of LDLR ligand-conjugated gold nanoparticles (ApoB@AuNPs) in an infiltrative F98 glioma rat model. A pristine proton beam was irradiated on TME and tumor mass in three port directions with a Bragg peak behind TME and inside the tumor mass in a rat glioma model. BBB-crossing ApoB@AuNPs were selectively taken up in microvascular endothelial cells proliferation and pericyte invasion, which are therapeutic targets in the GBM-TME. Proton sensitization on the ApoB@AuNPs occurred via Coulomb scattering with traversing proton fluence until BP formation in tumor mass. Proton sensitization treated the TME and bulk tumor volume with enhanced therapeutic efficacy by 67-75% compared to that with protons alone. Immunohistochemistry demonstrated efficient treatment of endothelial cell proliferation and migratory tumor cells of invasive micro vessels in the TME with saving normal tissues. Taken together, these data indicate that combined use of spatial fractionation irradiation with a pristine proton Bragg peak and LDLR ligand-functionalized gold nanoparticles is a promising strategy of precision delivery of therapeutic dose to treat TME of infiltrative malignant glioma while overcoming BBB crossing.

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Combination therapy of Doxorubicin with TTFields and radiation: Newer approaches to combat lung cancer

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https://doi.org/10.21175/rad.sum.abstr.book.2022.7.2

Background. Tumor-treating fields (TTFields) have been used singly or with chemoradiation for treating glioblastoma and mesothelioma but not yet for lung cancer. Survival rates in lung cancer remain abysmal despite advances in early diagnosis and targeted therapies.

Aims and Objectives. We aimed to investigate the effectiveness of TTFields in inhibiting lung cancer growth and metastasis, as well as the therapeutic effectiveness of TTFields alongside radiation and chemosensitivity-enhancing agents in an in vitro model.

Methods. We generated TTFields yielding 0–800 V sine-wave signals, 0.9 V/cm applied electric field intensity, and 150 kHz frequency. The human lung cancer cell lines A549 and H460 were used in this study. Cell viability, colony formation, cell death detection, and cell invasion assays were performed to assess the therapeutic effectiveness of TTFields; sensitization of lung cancer cells to TTFields by doxorubicin (DOX); and the combined effect of TTFields, DOX, and irradiation (IR).

Results. Lung cancer cells showed a nearly 20% decrease in cell viability at 1 V/cm and 150 kHz. In A549 and H460 cells, TTFields increased apoptosis, hindered cell migration and invasion, and improved chemosensitivity to DOX. The combination of DOX and TTFields showed better antitumor results than those of each individually. However, the DOX/TTFields/IR combination was most effective in reducing the viability and migration of lung cancer cells.

Conclusion. TTFields as an adjuvant therapy offers hope for improving lung cancer patient outcomes.

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Plasma miRNAs as biomarkers for radiation-induced cardiac toxicity in Lithuanian lung cancer patients

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https://doi.org/10.21175/rad.sum.abstr.book.2022.7.3

Background. Lung cancer is the second most common malignancy and is the leading cause of cancer death in the world, making up 21% of all cancer deaths [1]. Currently, both non-small cell and small-cell lung cancer have various types of treatment, including radiotherapy as one of the main treatment options in all stages of lung cancer. Despite of that, thoracic radiotherapy for lung cancer has been linked to an increased risk of cardiac-related morbidity and mortality [2]. However, currently available methods that predict radiation-induced cardiac toxicity (RICT) are suboptimal. Prediction could potentially be improved by the identification of additional biomarkers, such as circulating plasma microRNAs (miRNAs). Changes in plasma miRNA concentration could be a useful, non-invasive liquid biopsy tool for improved risk stratification, personalized treatment planning and radiation dose prescription.

The aim of this study was to identify miRNA expression changes in the plasma, taken from lung cancer patients, pre-and post-ionizing radiation treatment, in order to evaluate the effects of treatment on the heart.

Methods. 6 miRNAs (miR-1-3p, miR-21-5p, miR-24-3p, miR-29a-3p, miR-34a-3p, miR-222-3p) were tested for abundance changes in lung cancer patient's plasma samples before and after treatment with ionization. Overall, 10 pairs of plasma samples were collected before and after radiotherapy. MiRNA expression was analyzed using reverse transcription quantitative PGR technique. Cel-miR-39-3p was chosen as exogenous normalization control.

Results. MiR-1-3p, miR-21-5p, miR-24-3p, miR-29a-3p and miR-222-3p were downregulated and miR-34a was upregulated in lung cancer patient's plasma after radiation therapy when compared to pre-treatment values, but none of them showed significant differences. Nevertheless, before treatment, patients with cardio diseases and higher natriuretic peptide serum concentration values had higher miRNAs relative abundance and showed significant differences compared to the norm of these indicators.

In conclusion, our study suggests that identification of miR-1-3p, miR-21-5p, miR-24-3p, miR-29a-3p, miR-34a-3p and miR-222-3p level changes in lung cancer patients could be used to predict RICT and determine personalized ionization dose to reduce toxicity to the heart. To validate these miRNAs as potential biomarkers for radiation-induced cardiac toxicity further analysis is needed.

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Acknowledgments: This study is supported by the National Cancer Institute research fund.

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Covid-19's impact on external beam radiotherapy

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https://doi.org/10.21175/rad.sum.abstr.book.2022.8.1

Background/Aim. The world as we know it has been completely changed by the Coronavirus disease (Covid-19) pandemic. The branch that was most affected by this is the health care system. "Waves" of the pandemic are what made the treatment of oncology patients a real challenge, making it harder for patients to get to radiotherapy (RT) due to reduced capacity of most departments in hospitals. Investigate the impact of the Covid-19 pandemic had on the weekly number of external beam radiotherapy (EBRT) without intentional hypofractionation was the aim of this study.

Methods. The Affidea Radiotherapy Center, Banja Luka (BL), provides RT to the citizens (1.15 million) of the Republic of Srpska (Bosnia and Herzegovina). In total, 32 months were analyzed, 16 months before and 16 during the Covid-19 pandemic. For this epidemiological retrospective study, we assume that the pandemic began on March 1, 2020.

Results. At the annual level, the total number of EBRT fractions in 2020 and 2021 decreased by 9.3 % and 7.3 % compared to 2019, respectively. The average weekly number of EBRT fractions from November 2018 to the end of February 2020, was 683.3 (SD 64.8), and from March 2020 to the end of June 2021, it was 623.4 (SD 92.5). During April 2020, the weekly number of the EBRT decreased by 67.9 % compared to the same period in 2019, while in March 2021 it fell by 42.4 %. During April - May 2020 the weekly EBRT fractions decreased by 15.8 % to 67.9 % compared to the same period in 2019. Another significant decrease in the number of weekly patients occurred at the end of 2020 (November - December 2020), 17.5 % to 26.8 %. In March 2021, we had a new strong "wave" with 20.4 % to 42.4 % decrease. The applied Kolmogorov-Smirnov normality test (sig. $p = 0.06$) indicates the normal distribution of the values of differences (before Covid-19 minus Covid-19 period) of weekly EBRT fractions (mean 59.9, SD 111.5). Therefore, a parametric one-tailed paired samples T-test was performed ($t(60) = 4.463$, $p < 0.05$).

Conclusion. There was a statistically eminent decline in EBRT treatments in BL RT as a result of the first 16 months of the Covid-19 pandemic. The cause of this was the closing of medical departments (diagnosis and treatment) needed for oncology patient and turning them into Covid-19 wards.

Keywords: Covid-19 pandemic, radiotherapy, external beam radiotherapy

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Hierarchical method for assessing the oil-oxidizing capability of oil sluts with radionuclides

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https://doi.org/10.21175/rad.sum.abstr.book.2022.9.1

The objects of the petrochemical industry that have a negative impact on the components of the environment are characterized by the formation of specific toxic waste. They are formed by hydrocarbons and their transformation products, as well as radionuclides.

The uncertainty factor of the initial information, associated with the impossibility of timely identification and zoning of hazards, makes the problem the most dangerous source of formation of additional technogenic flows. They are characterized by a multi-element composition of secondary pollution of territories by polar and high-molecular hydrocarbons, heavy metals and radionuclides.

Multilevel input control of oil sludge and their inventory include:

- operational control, taking into account the list of wastes prohibited for neutralization and disposal, providing for the use of portable devices or kits;
- radiation monitoring of received sludge, including detection of natural radionuclides;
- laboratory control and determination of the chemical composition of sludge with the actual identification of the content of specific substances present and their mixtures.

The aim of this work is to develop a hierarchical method for assessing the oil-oxidizing ability of oil sludge with radionuclides, which evaluates the oil-oxidizing activity of strains at various temperatures, acidities, and pollutants.

The oil-oxidizing ability of oil sludge can be assessed on a 10-point scale based on an expert's opinion. This express method is not reliable and is applicable for preliminary assessment before quantitative analysis.

The number of bacteria in the biopreparation and the residual oil content were taken as criteria for the quantitative analysis of oil-oxidizing activity.

Calibration graphs, individual for each microorganism, are applicable for determining the number of cells. They reflect the dependence of the absorbed light on the number of bacteria, as well as the subsequent gravimetric analysis.

The implementation of this methodological approach involves taking into account soil and landscape conditions, anthropogenic and technogenic factors, temperature, and the presence of radionuclides.

The implementation of the proposed methodological approach involves the consistent implementation of express methods as they are informative and taking into account expertly significant factors in order to protect the population and workers from the effects of radionuclides.

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Characterization of trace elements in unconsolidated shallow marine sediments along Egyptian Mediterranean Sea

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https://doi.org/10.21175/rad.sum.abstr.book.2022.9.2

The present work was carried out to shed light on the distribution of major and trace elements in coastal sediments along the Egyptian coast of the Mediterranean Sea. For this purpose, a total of 99 sediment samples were collected and analyzed by neutron activation analysis and the concentrations of 39 elements were determined in mg/kg. Significant concentrations of Cl, Sn, Zr, and Hf were recorded. Furthermore, the concentrations of rare earth elements were determined to be almost twice the corresponding values in the literature. In addition, the multivariate statistical analysis was implemented to extract more information about the source origin. The sediment quality was assessed using various pollution indices. The obtained data may serve as a baseline data to characterize the coastal sediments in terms of elemental composition.

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Identification of target groups for risk communication on radon exposure as part of the development of a Radon Risk Communication Guide in the Republic of Moldova

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https://doi.org/10.21175/rad.sum.abstr.book.2022.10.1

Communicating messages about the risk of radon exposure to the public and risk prevention is a serious challenge to public health system and society, as radon is not widely known and cannot be perceived as a health risk by the public. The main objectives of radon risk communication are to increase stakeholders, encourage radon testing and home remedies, and stimulate support for decision makers. An essential component of a radon risk communication campaign is identifying the target audience and persuading them to take the necessary steps to protect themselves against radon. One of the simplest and most cost-effective ways to assess awareness is through public surveys.

Two national public surveys (2019-2020 and 2021) on the risk of radon exposure based on RADPAR methodology and AIEA guidelines revealed a rather poor knowledge of the population about this risk and highlighted two main shortcomings: lack of awareness of radon among the general public in the country and lack of awareness and understanding of radon among professionals in various fields. Thus, there are 2 directions in which it is necessary to focus efforts and develop appropriate mechanisms. For target groups in the general public, the communication of risks regarding the dangers of radon exposure should have a rather short but attractive message, while for professional target groups, more concrete and technical information is needed.

The general public includes not only certain age groups, but also layers of people who are not directly related to ensuring health security in their direct activities. So, general public includes (1) general population with target subgroups of youth, parents, smokers and householders, (2) educational institutions with subgroups of all levels of education from kindergartens to universities and (3) non-governmental organizations. In turn, target group of professionals includes (1) industrial professionals (builders, producers, remedial staff), (2) decision makers (politicians, local and central public administrations and financial bodies) and (3) trusted sources (physicians, pharmacists, teachers of disciplines related to radon hazard, media).

Communicating the risk of radon exposure directly to these target groups could reduce the risk of bronchopulmonary cancer associated with residential radon exposure through radon remediation techniques, by building new homes with effective radon prevention technologies. In addition, communicating the risk of radon exposure indirectly to individuals whose actions, either by making decisions or by highlighting the radon problem, would help to increase and improve public awareness and perception and therefore help to prevent and reducing risk of radon exposure in communities.

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Physiological features of the body systems of reindeer in various climatic zones

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https://doi.org/10.21175/rad.sum.abstr.book.2022.10.2

The implementation of a program of state support for the traditional economic activities of the peoples of the North has begun, which is based on the traditional branches of animal husbandry, namely, northern reindeer breeding. Reindeer products are considered environmentally friendly and safe. However, the features of the physiological systems of domestic reindeer in the Republic of Sakha (Yakutia) have not yet been studied enough. We have studied the physiology of the reproduction of domestic reindeer (the morpho-physiology of the system, the physiology of the reproductive cycle, sexual season, pregnancy, childbirth and the postpartum period) and the biophysical characteristics of skin derivatives depending on the natural and climatic habitat: mountain taiga, tundra and forest-tundra zones Yakutia. Groups were formed according to the principle of physiological analogues: from the mountain taiga zone — 350 animals, from the tundra and forest-tundra zones — 380 animals.

Results. It has been established that domestic deer of the mountain taiga and tundra zones belong to the leptosomal type. Physiological indicators of growth and development of deer differ in different zones. So, the animals of the mountain-taiga zone are larger than the deer of the tundra. Observations have shown that in the tundra, forest-tundra and mountain-taiga zones, the periods of calving and the sexual season differ significantly. There were no significant differences in the structure of the genital organs during the sexual cycle in females of the mountain-taiga and tundra natural-climatic breeding zones. In females of all habitats, a day before calving, the harbingers of childbirth are well expressed (edema of the udder, the appearance of colostrum, etc.).

To determine radioactive contamination, the presence of heavy metals (copper, lead, zinc) and to measure the redox potentials of alkaline hydrolysates of reindeer hair/wool from various northern zones, samples were taken from different parts of the animal body (from males, females and cubs). As a result of studies of 100 samples from each of the climatic zone from physiological analogs, no significant differences were found in the thickness, strength, hair color, in the values of the redox potential of the hair of mountain taiga and tundra deer. The potential of the solution upon incubation in the dark was in the range of 55–57 mV, upon irradiation with visible light, the range was 50–53 mV, and then upon incubation in the dark, it returned to the original dark values. In the wool of the cubs, the values of redox potentials did not differ from those of adults. A preliminary analysis of the presence of strontium-90 and cesium-137 same as heavy metals in deer skin derivatives from different habitats did not reveal the presence of radioactive elements.

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Application of physical factors in the treatment of occupation-related compression neuropathies

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https://doi.org/10.21175/rad.sum.abstr.book.2022.10.3

Introduction. Compression neuropathies are injuries to peripheral nerves caused by squeezing or stretching the nerve trunk in a fibrous or bone-fibrous canal or by fibrous tissue. They are characterized by pain, sensory disorders and functional disorders due to chronic compression. They are occupational diseases caused by local vibrations, static physical effort and dynamic physical work. The methods of treating injuries include physical factors.

The aim of the research is to study the application of physical factors in the treatment of occupational compression neuropathies and to assess their effectiveness in improving the health of affected workers.

Materials and Methods. The object of the study is 92 cases of injuries of compression neuropathies in employees of various enterprises in Northern Bulgaria. The persons were hospitalized in the Department of Occupational Diseases and Clinic of Physiotherapy and Rehabilitation, University Hospital - Pleven in the period 2018 - 2021. Clinical, laboratory, functional, imaging and statistical research methods were used. Treatment with physical factors was performed. Modern methods of treatment of compression neuropathies include electrotherapy, magnetic field, therapeutic gymnastics, and shock wave therapy.

Results and Discussion. In 94% of patients there was an improvement in clinical syndromes, performance and performance of daily activities.

Conclusions. Treatment with physical factors is an effective and reliable approach in cases of occupational compression neuropathies.

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Risk communication activities of Japan EMF information on EMF and health issues in Japan

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https://doi.org/10.21175/rad.sum.abstr.book.2022.10.4

Except for a few years immediately after the Fukushima nuclear power plant accident, non-ionizing radiation including extremely low frequency (ELF) electromagnetic fields (EMF), intermediate frequency (IF) EMF and radiofrequency (RF) EMF has stronger health concerns than ionizing radiation has in Japan. In response to the World Health Organization (WHO)'s publication of the Environmental Health Criteria monograph (EHC) No. 238 and WHO Fact Sheet No. 322 on extremely low frequency (ELF) electromagnetic fields, the Japanese Ministry of Economy, Trade and Industry (METI) set up a Working Group on Electric Power Facility and EMF Policy in June 2007. The Working Group compiled their report in which their recommendations to the METI were incorporated. To address issues related to potential long-term effects of ELF-EMF, the Working Group recommended that a neutral and permanent EMF information center should be established to promote risk communication and facilitate peoples' understanding based on scientific evidences. In response to this recommendation, the Japan EMF Information Centre (JEIC) was established in July 2008. JEIC is financed from donations by stakeholders. The Administration Audit Committee was founded in order to ensure and monitor the neutrality and transparency of JEIC operations. The JEIC institutional system is determined to develop itself into a world-class risk communication center with expertise in EMF. JEIC's philosophy and purpose are to provide easy-to-understand scientific information on EMF and its health effects and minimize the gap of risk perception among stakeholders and promote risk communication from a fair perspective. JEIC's activities to achieve its purposes include (1) Disseminations of Science-based information about EMF and Health issues through our website, (2) Organizing public meetings, (3) Q&A by telephone and emails, (4) Creating an EMF information database including EMF research database, (5) Rending services of MF meter, (6) Communication with mass media.

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Level of anxiety and quality of sleep in children living in radioactively contaminated areas

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https://doi.org/10.21175/rad.sum.abstr.book.2022.10.5

Objective was to assess the level of anxiety and characterize the quality of sleep in children living in radioactively contaminated areas in comparison with children who were not affected by the Chornobyl-affected contingents that were quarantined in connection with the COVID-19 pandemic.

Materials and Methods. The indicators of the level of anxiety were studied using the scale of self_assessment of the level of anxiety Ch.D. Spielberger, sleep quality was assessed using a standardized questionnaire for self_completion of PSQI and 137Cs content was measured in children. The main group consisted of 96 children who were quarantined due to the COVID-19 pandemic and permanently lived in radioactively contaminated areas of Zhytomyr and Rivne regions with a soil contamination density of 137Cs from 18 kBq/m2 to 235 kBq/m2. The age of children ranged from 10 to 17 years. Among them were 33 boys and 63 girls. The comparison group consisted of 52 children of similar age, including 26 boys and 26 girls. These children lived permanently in Kyiv and were not victims of the Chornobyl disaster.

Results. It was found that children who were quarantined for COVID-19 (both residents of radioactively contaminated areas and children who do not belong to the contingents affected by the Chornobyl disaster) had an increased level of reactive (RA) and personal anxiety (PA). The comparative analysis showed that children of the same sex of the main group and the comparison group did not differ in terms of PA and RA. At the same time, studies have shown that girls, both in the main group and in the comparison group, were characterized by higher levels of PA and RA than boys. It was determined that poor sleep quality was common in both children living in radioactively contaminated areas (42.71 %) and children in the comparison group (42.44 %). Among the sleep disorders in children of both observation groups, “day dysfunction” was most often detected.

Conclusions. There was a direct correlation between the overall PSQI score and the level of reactive, personal anxiety and the overall PSQI score. Using regression analysis, the presence of a linear association of the level of incorporated 137Cs (Bq) with the indicator of personal anxiety of children living in radioactively contaminated territory ($b = -0.716$, $p < 0.001$) was proved.

Creative aging

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https://doi.org/10.21175/rad.sum.abstr.book.2022.10.6

Introduction. Aging is not declining into decrepitude or pathology. Several pieces of evidence are suggested to support the idea:

1. Canceration occurs in cells of aged patients.

2. Cell fusion analysis has indicated that membrane protein produced in senescent cells showed biphasic DNA synthesis inhibiting-ability for young cells.

3. iPS cells can be obtained from supercentenarians.

4. Spirit grows as aging.

Quotes from notables. Nietze-He who has a WHY to live for can bear almost any HOW. Viktor E. Frankl-Everything can be taken from a man, but one thing: the last of the human freedom-to choose one's attitude in a given set of circumstances. Thomas Mann-An exceptionally difficult external situation which gives man the opportunity to grow spiritually beyond himself.

Spinoza-Emotion, which is suffering, ceases to be suffering as soon as we form a clear and precise picture of it.

There is no reason to pity the old people. It is true that the old man have no possibilities in the future, they have realities they have actualized, the meanings they have realized -and nothing and nobody can ever remove these assets from the past.

Positive attitude enables a person to endure suffering and disappointment as well as enhance enjoyment and satisfaction.

Several role models in Japan and in the world will be presented.

Conclusion. Let's enjoy positive and creative aging.

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Fluorescent and colorimetric chemosensors for cations based on 1,8-naphthalimide core

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.1

1,8-Naphthalimides, as one of the classical dyes and fluorophores, has been widely used in the field of analytical chemistry, material chemistry and biochemistry because of their excellent characteristics such as photostability, good structural flexibility, high fluorescence quantum yields and large Stoke shifts, etc. The optical and fluorescence properties of the substituted 1,8-naphthalimide derivatives, such as the of absorption and emission maxima positions, fluorescence quantum yields as well as fluorescence lifetimes, are all affected by the solvent properties, and their fluorescence emission color can be readily tuned from yellowish green to pure blue.

Here we present a conceptually new fluorophores based on 1,8-naphthalimide. The obtained compounds are highly fluorescent. The presence of O and N atoms in the substituents at positions 4 and 5 afford complex formation with relevant metal ions. The change in their optical properties in presence of such analytes makes them very suitable as a fluorescent and colorimetric chemosensors for cations.

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New powerful building block molecules in 1,8-naphthalimide chemistry

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.2

In recent years, much attention has been paid to the design and preparation of new substituted 1,8-naphthalimide architectures and the studies on the properties of materials. Wide possibilities of changing the optical and fluorescence, thermal, electrochemical, electroluminescent, and photoelectrical properties of 1,8-naphthalimide compounds can be materialized by introducing different electron-donating or electron-accepting moieties at the 1,8-naphthalimide core. At the same time, derivatives of substituted 1,8-naphthalimide have found application in other optoelectronic devices, such as organic light emitting diodes, organic solar cells, as well as in memory devices. 1,8-Naphthalimides can have wide energy gaps and low reduction potentials, making them good candidates for use as *n*-type materials in OLEDs. While many 1,8-naphthalimide derivatives have low luminescent efficiencies at room temperature, due to strong intersystem crossing to their triplet states, 1,8-naphthalimides substituted at the 4 and 5 positions with electron-donating groups can have high fluorescent quantum yields.

In our laboratory, we have developed several new *building block* molecules [1, 2] that have found wide application for the synthesis of various naphthalene based fluorophores and chromophores.

The new dyes are promising candidates for high-tech applications such as OLEDs [1], OFET, visualization of cellular organelles [2], bimodal diagnostic imaging, etc.

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Acknowledgments: Authors are grateful to the Bulgarian National Science Fund project NSF KP 06-N29/12.

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Nanosize effect in niobium monoxide observed by positron lifetime spectroscopy

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.3

This work presents nanosize effect of mean positron lifetime in ordered niobium monoxide (NbO) which contains an abnormally large number of vacancies (25 at.%) on both the niobium and oxygen sublattices and nevertheless is stoichiometric $NbO_{1.00}$ and ordered with very narrow homogeneity range. The aim of present work was to study stability of ordered phase of NbO in a nanocrystalline state.

Polycrystalline NbO powder with the average particle size of about 25 μm have been synthesized by the solid-phase sintering method from a mixture of metallic niobium Nb and niobium pentoxide Nb_2O_5 powders at 1673 K in vacuum of about 1.2 mPa. Synthesized powder of NbO was applied to fragmentation by high-energy ball milling in a Retsch PM 200 planetary mill. The particle size and strain contributions to diffraction line broadening were evaluated by the Williamson-Hall method. The minimum particle size reached by milling after 8 hours approaches (20±10) nm and microstarins value is equal to 0.69±0.05%.

The measurements of positron annihilation lifetime spectroscopy (PALS) spectra of polycrystalline NbO were performed at the GiPS setup at the radiation source ELBE (**E**lectron **L**inac for beams with high **B**rilliance and low **E**mittance) at Helmhotz-Zentrum Dresden-Rossendorf. The advantages of this setup are the absence of typical contributions from the positron source, a good timing resolution (< 180 ps FWHM) as well as a perfect signal-to-noise ratio in positron lifetime spectra. This allows for recording high-quality spectra and simplifies the data analysis. Positron lifetime spectra of nanocrystalline powder of NbO was measured by means of a fast-fast spectrometer with a time resolution of 230 ps (FWHM) and a total number of coincidence counts of about $1 \cdot 10^6$ each. They were numerically evaluated by multicomponent fits using PALSfit (Ver. 2.80). For the positron annihilation studies a ^{22}NaCl positron source with an activity of about 1 to 2 MBq stacked between two identical specimen plates was used.

Surprisingly, in coarse-grained and nanocrystalline NbO two components in positron lifetime spectra with close lifetime values were observed. According to calculations, the short component of about 171 ps with 83 % of intensity in coarse-grained NbO and of about 195 ps with 51 % of intensity in nanocrystalline NbO can be ascribed to delocalized positron states in fully ordered compound. Such long lifetime for free positron can be understood taking into account low electron density of free electrons in NbO with a lot of structural vacanices (25 at.%) on both sublattices.

Second, long component of about 336 ps with 17 % of intensity in coarse-grained NbO and of about 345 ps with 49 % of intensity should be ascribed to localized trapping state in clusters of niobium and oxygen vacancies on the surface of interfaces and particles of NbO powders. Such ascription is supported by increasing of the specific surface area value by three orders of magnitude (from about 0.01 for coarse-grained NbO to about 7.60 m^2/g for nanocrystalline NbO) from second hand. Such huge increase in a specific surface area leads to a huge increase in the intensity of the second long positron lifetime component. No change in atomic-vacancy structure was found when going from coarse-grained to nanocrystalline NbO.

Acknowledgments: This work was financially supported by the RSF (project N 19-73-20012).
We thank group from ELBE Centre (W. Anwand) and Graz University (W. Sprengel) for help during the experiments.

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Mössbauer investigation on mechanochemically treated waste materials toward their sustainable reuse

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.4

Resource efficiency and circular economy principles need to be a leading factor in research investigations on advanced materials preparation. In this regard, the principles of the circular economy on the waste-derived and reused materials are a potential to save raw resources and to decrease significantly the environmental impact.

The presented paper investigates the possibility to reuse damaged Fe-based amorphous metallic glasses for waste water remediation. In this study, mechanochemical activation is applied as a green and sustainable method for preparation of highly active and selective catalysts. Series of mechanochemical experiments (high energy ball milling) have been designed to activate studied metallic glasses, but to preserve their amorphous structure. According to previous investigations, preservation of amorphous structure is expected to be more beneficial for waste water remediation ability of metallic glasses. Therefore, detailed physicochemical study of the structure evolution of mechanochemicaly treated materials has to be done in order to reveal the effect and mechanism of mechanoactivation on the iron-based metallic glasses behavior. Numerous advanced laboratory methods were used as X-Ray Diffraction and thermal analysis, Mössbauer spectroscopy, X-Ray Photoelectron Spectroscopy, Scanning Electron Microscopy. As the important aspect in dealing with amorphous materials is the local structural disorder, Mössbauer Spectroscopy is the main investigation method used in this study. The strength of the method is to ensure high resolution investigation of the local atomic ordering, hyperfine magnetic and electrical interactions, chemical environment, etc.

Studied materials are damaged Fe-based metallic glasses with chemical composition $Fe_{81}B_{13.5}Si_{3.5}C_2$ and heterogeneities in their amorphous structure. Materials are treated in a planetary ball mill in order to improve their catalytic behaviour. The catalytic tests are performed with a model Fenton reaction of Methyl orange azo-dye degradation. Physicochemical analysis follows material changes after ball milling and catalytic tests. Sample characterization revealed significant variations in catalytic performance of studied samples as a result of material transformation under ball milling. It is obtained that the formation of local atomic Fe-rich and Fe-deficit clusters randomly distributed in the amorphous alloy is highly beneficial for improvement of dye degradation ability of studied ribbons.

This study is a step forwards the design of sustainable materials with improved characteristics, which is one of the major challenges of modern science.

Acknowledgments: The authors gratefully acknowledge the financial support of the Bulgarian National Science Fund at the Ministry of Education and Science - Project № КП-06-КОСТ/18/ 2019 and the project COST Action CA 18112 “Mechanochemistry for Sustainable Industry” (Mech@SustInd), supported by COST (European Cooperation in Science and Technology). Financial support from the Bulgarian Academy of Sciences (Bilateral grant agreement between BAS and University of Belgrade, ICTM) is gratefully acknowledged.

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Effect of Al doping on structural, morphological and gas sensing properties of electrochemically deposited ZnO films on quartz resonators

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.5

This poster presents experimental results for Al-doped ZnO thin films synthesized by electrochemical deposition method on one of the gold electrodes of AT-cut quartz resonators, vibrating at 10 MHz. The surface morphology, average roughness and gas sensing properties to ammonia and ethanol were studied. The SEM micrographs show a strong influence between the shape and size of the particles in the layers and the concentration of $Al_2(SO_4)_3$. The calculations from average roughness show that the average roughness of the electrochemical layers increases with the increase of $Al_2(SO_4)_3$ in the solution. The results show linear relationship between the concentration of $Al_2(SO_4)_3$ in the solution and the aluminum content in the layers. SEM micrographs also show a strong influence between the size and shape of the particles in the layers and the concentration of $Al_2(SO_4)_3$, as from particles in the form of "nano-rods" the layers pass into those containing mainly "nano-walls". The nanostructured layers were produced at temperature 70°C and deposition time of 20 minutes from aqueous electrolyte containing $ZnCl_2$, KCl and $Al_2(SO_4)_3$. The structural and morphological properties of the Al-doped ZnO films were characterized by Scanning Electron Microscopy (SEM) and Optical Profilometry. The sensing properties to both gas analytes were studied by Quartz Microbalance Method. The sensitivity of the layers depends mainly on their developed surface.

Acknowledgments: This research is funded by Bulgarian National Science Fund (BNSF) under the project КП – 06 – Н38/7 (12.2019).

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Structural and optical properties of nanostructured ZrO_2 films deposited electrochemically on SnO_2 glass substrates

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.6

This work present the influence of the deposition temperature of the aqueous solution (containing $ZrOCl_2$ - 5mM and KCl - 100 mM) on the properties of ZrO_2 films obtained by electrochemical deposition on SnO_2 covered glass substrates is studied. Temperatures of the deposited layers are in the range from 60 to 80°C. Through the implementation of X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), optical profilometry, UV-VIS-NIR and photoluminescence spectroscopy, the temperature dependence of ZnO films properties is revealed. The XRD spectra show the polycrystalline nature of the films at all studied deposition substrate with the typical characteristic reflexes of the ZrO_2. Calculations for the size of the crystallites from the diffraction maxima and the average roughness show that no dependence is observed between them and the deposition temperature. The SEM micrographs show that the ZrO_2 layers are composed mainly of grains of relatively regular shape, as their size increases with increasing deposition temperature. It is demonstrated that the deposition temperature almost no effect on the reflectance and transmittance spectra of the ZrO_2 layers. The low values of the diffuse reflectance and transmittance in the spectral range from 380 to 800 nm could be beneficial for application of similar films as antireflective layers of thin films solar cells.

Acknowledgments: This research is funded by Bulgarian National Science Fund (BNSF) under the project КП – 06 – Н38/7 (12.2019). Research equipment of Distributed Research Infrastructure INFRAMAT, part of Bulgarian National Roadmap for Research Infrastructures, supported by Bulgarian Ministry of Education and Science, was used in this investigation.

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Neutron radiation damage in NbO microcrystals

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.7

The study of the radiation damage in different materials is in great interest of numerous investigations. The understanding of the number of displaced atoms and the value of threshold energy is important not only in order to understand the susceptibility to radiation damage, but also to scientific knowledge about ordering and disordering of nonstoichiometric crystal structure of the interesting materials. Carbides (NbC_y [1], VC_y, TiC_y) and oxides (TiO_y, NbO_y, VO_y) which can contained up to 15-25 % vacancies in both sublattices belong to those compounds.

It was shown [2, 3] that crystals, which contained of about 25 % vacancies, demonstrated low threshold energy. For examples: V_6C_5 and $V_{61}O_{80}$ 5.4 eV and 7.8 eV, respectively.

Niobium monoxide contains huge number of vacancies (25 at.%) on both the metal and non-metal sublattices. It was estimated, that single crystal of NbO has threshold energy (E_d) about 3 eV. Neutron diffraction study allows us to obtain reliable information on the oxygen distribution, since the amplitude of coherent scattering of oxygen nearly equal those of niobium (b_O=0.575x 10^{-12}, b_{Nb}= 0.71x10^{-12} cm).

The purpose of this work was to study of atoms displacement in NbO_y microcrystals under the neutron irradiation. Polycrystalline NbO powder with the average particle size of about 25 μm have been synthesized by the solid-phase sintering method from a mixture of metallic niobium Nb and niobium pentoxide Nb_2O_5 powders at 1673 K in vacuum of about 10^{-3} Pa.

Irradiation was carried out on the vertical "wet" channel of the NPS IVV-2M. During irradiation the ampoule with the powder was in the water cavity of the NPS. The water temperature was 343 K. The neutron diffraction data were obtained by using high-resolution neutron diffractometer D-7a, λ=0.1532 nm. The specimens were irradiated to total fluence of about 10^{18} and 10^{19} n/cm² by fast neutrons (about 1 MeV).

According to neutron-diffraction data the initial NbO_y powder has cubic structure (space group *Pm*-3*m*) and lattice constant is equal to a_{B1} = 421.1 pm. After neutron irradiation the crystal structure remained unchanged, but lattice constant *a* raised.

It was established, that irradiation of nonstoichometric polycrystal NbO to total fluence of 10^{19} n/cm² by fast neutrons leads to elementary cell expanding and increasing of the oscillations of ions in lattice. Threshold of the atoms was not observed.

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Acknowledgments: This work was financially supported by the RSF (project No. 19-73-20012).
We thank group from Nuclear Reactor Operations Department (Zarechney, Russia) for the experiment assistance.

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Epithelioid hemangioendothelioma: diagnostics and treatment – a one-center experience

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.8

Epithelioid hemangioendothelioma (EGE) is a rare vascular tumor originating from vascular endothelial or preendothelial cells. The frequency of occurrence is less than 1% of all vascular tumors. Due to the rare occurrence, despite the diagnostic criteria described in the literature, the probability of an erroneous diagnosis is high.

Purpose was to evaluate the results of diagnosis and treatment of liver EGE.

Materials and Methods. At A.V. Vishnevsky National Medical Research Center of Surgery accumulated experience in the diagnosis and treatment of 12 patients with morphologically verified EGE of the liver (aged 21 to 70, women predominated - 9 (75%). Preoperative examination: ultrasound, MSCT and/or MRI.

Results. Clinical manifestations of liver EGE were nonspecific. Pain in the right upper quadrant of the anterior abdominal wall, nausea, vomiting, hepatomegaly, splenomegaly (4 cases), weight loss (3 cases), jaundice (2 cases) were noted. Approximately half of the cases were asymptomatic. The duration of clinical manifestations before diagnosis varied from 3 months to 2 years.

The size of the lesions varied from 13 mm in diameter to a large volumetric confluent lesion. There were multiple in 10 observations. Three patients had bilobar multiple lesions. In 11 cases, retraction of the liver contour was determined at the site of the lesion localization.

Ultrasound. The lesions were defined as multiple peripheral compactly located (almost merging) solid nodes of reduced or mixed echogenicity with a hypoechoic rim, accompanied by capsule retraction. A dimly expressed (due to the small caliber of the vessels) peripheral vascular rim was located in large lesions at duplex scanning.

MSCT. Rounded lesions, hypodense in the central part and hyper- or isodense to the liver parenchyma along the periphery (sign “target”) visualized in the native phase. The detected foci differed in the nature of the accumulation of the contrast agent. More often, the lesiobs accumulated a contrast agent in the peripheral regions in the form of a rim or a target in the arterial phase with progression of accumulation to the portal and delayed phases. Rarely, progressive accumulation of the contrast agent throughout the volume of the lesion was noted. In 9 cases, in patients with multiple lesions, the formation of a chain of spherical growths of tumor tissue (nodules) connected by narrow (3–7 mm in diameter) threads was noted (symptom “rosary”, Rozengauz E.V. et al., 2020). If this pattern was not evident in the axial section, it could be identified and followed up with multiplanar reconstruction.

MRI. The foci were characterized by low signal intensity on T1 WI. There were hyperintense relative to the unchanged liver parenchyma and form a “white target” pattern: the central parts with a high-intensity signal, and the peripheral parts were slightly hyperintense on T2 WI.

Surgery was in 9 patients: hemihepatectomy - 5 (55.6%); resection of two and three segments of the liver - 4 (44.4%).

With bilobar lesions, patients undergo dynamic ultrasound monitoring within 11 to 24 months. Despite the fact that, according to the literature, EGE chemotherapy is considered ineffective, in 1 case it was decided to perform TACE (Oxaliplatin 75 mg + Lipoidol 7.5 ml). According to the results of which, a significant positive trend was noted (regression of tumors by an average of 30% of their volume).

All the patients are observed in the postoperative period from 6 months to 5 years. All patients are currently alive. 5-year cumulative survival - 100%.

Conclusion. EGE is a rare mesenchymal liver tumor. With an integrated approach to its diagnosis and treatment, good immediate and long-term results are possible.

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Electrochemical testing of materials from chimney soot as a source

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.9

Due to the increasing ecologic and energetic requirements, the burning equipment should work in different conditions. This means lowering the temperature of the exhaust gases. It will lead to better performance but the problem appears is increased rate of soot deposition. The composition of soot is known but the quantity of different compounds is varying in wide range depends on the temperature and fuel burned.

To being made of useful material the soot is collected and subjected to organic synthesis. The purpose of this is increasing of molecular weight of hydrocarbons without thermal treating. The media used is distilled water. After precipitation, the dissolved compounds are removed during careful pumping trough 45 μm syringe filter. The precipitation process is repeated 3 times. The obtained material is oxychlorinated by adding concentrated HCl and after that a H_2O_2. The applied concentration is 1ml of 37% HCl per gram carbon material and 6% H_2O_2 in stoichiometric quantity.

The material was dried and half of the quantity is treated with Mg to create random type (RMgCl) Grignard reagent in diethyl ether media. The obtained Grignard reagent is then mixed with other part of the halogenated material. Its created C-C bonds increasing the molecular weight of the polymers received. The material is investigated by FTIR, SEM, XPS, Raman and is subjected to electrochemical testing behavior, and the studies were performed before and after the synthesis.

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The study of energy transfer between of Ce and Eu ions in (Pb,Gd)3(Al,Ga)5012 epitaxial films

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.10

Rare-earth-doped garnets are of interest for application as scintillators and phosphors. The incorporation of Eu^{3+} ions into YAG:Ce^{3+} nanoparticles helps to increase the photoluminescence intensity in the red spectral region owing to the presence of a narrow emission peak of Eu^{3+} ions at a wavelength of 610 nm [1]. A Ce^{3+} luminescence band in the green-yellow spectral region, and a weaker, narrow emission lines of Eu^{3+}, peaking in 580-720 nm region with the most intensive line at 708 nm, were observed in the $Gd_3(Al,Ga)_5O_{12}$:Ce,Eu single crystal, but no energy transfer from Ce to Eu was detected [2]. The objectives of this work were to grow epitaxial $(Pb,Gd)_3(Al,Ga)_5O_{12}$:Ce^{3+},Eu^{3+} films and study optical absorption, photoluminescence, and photoluminescence excitation in the films.

Epitaxial $(Pb,Gd)_3(Al,Ga)_5O_{12}$:Ce, Eu films were grown by liquid-phase epitaxy on (111)-oriented single crystal $Gd_3Ga_5O_{12}$ substrates from a supercooled high-temperature $PbO–B_2O_3$ – based melt solution with gadolinium oxide $C(Gd_2O_3)$ concentration were 0.4 mol %, $C(Al_2O_3)$ concentration of 4.5 mol %, $C(CeO_2)$ of 0.2 mol %, and $C(Eu_2O_3)$ of 0.05 mol % in the mixture. Transmission spectra of the films were measured on a Perkin-Elmer Lambda 900 spectrophotometer at room temperature in the wavelength ranges from 200 to 600 and from 1700 to 3000 nm. Photoluminescence spectra at excitation wavelengths of 165 and 440 nm were obtained using a Heraeus D-200 VUV deuterium lamp and McPherson 234/302 monochromator. Photoluminescence excitation spectra at emission wavelengths of 540 and 600 nm were measured at 80 K in the range 200–500 nm using a DDS-400 deuterium lamp and DMR-4 monochromator. Luminescence spectra of the films under electron excitation were measured using a pulsed nonmonochromatic beam from a Radan-303A generator with a maximum energy of 120 keV, current density of 10 A/cm^2, and pulse duration of 200 ps. The 300-K luminescence was detected using an Andor Shamrock 303i spectrograph and Andor iStar iCCD camera in the range 350– 720 nm in time window 0–2 ms after an excitation pulse [3].

The optical absorption, photoluminescence, luminescence and excitation spectra were measured and analyzed. From absorption spectra, we have found absorption peak wavelengths of the constituent ions of the films—Pb^{2+} (271 nm), Gd^{3+} (273 nm), Ce^{3+} (340 and 443 nm), and Eu^{3+} (392 and 394 nm)—and identified the absorption bands of Eu^{3+} ions in the near-IR spectral region. The present results on the luminescence properties of epitaxial $(Pb,Gd)_3(Al,Ga)_5O_{12}$:Ce^{3+},Eu^{3+} films demonstrate that the addition of europium to the composition of $(Pb,Gd)_3(Al,Ga)_5O_{12}$:Ce^{3+} films is accompanied by the formation of narrow emission bands in the red spectral region, due to Eu^{3+} $^5D_0 - {}^7F_J$ transitions, and essentially complete quenching of cerium luminescence, which is caused by energy transfer from Ce^{3+} to Eu^{3+}.

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New bright UV-C phosphors based on $Y_{1-x}Sc_xPO_4$ solid solutions

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.11

Compounds with bright luminescence in the UV spectral region attract attention due to their application in photocatalysis and photochemistry, for disinfection, as persistent phosphors and scintillating detectors [1-3]. UV phosphors with the emission in the UV-C range (<280 nm) are of particular interest for medical applications. Their excellent bactericide properties are determined by high spectral overlap of the UV-C range and the germicidal effectiveness curve [3]. An intense emission in the UV-C spectral range is usually observed for wide-bandgap (E_g > 7 eV) phosphors doped with Ce^{3+} or Pr^{3+} rare-earth elements (REE) as well as Bi^{3+} ions [4]. Compounds with intrinsic emission are also in the scope of interest for the UV phosphor applications, however, the luminescence of this type suffers from quenching processes at room temperature in the majority of compounds.

Solid solutions allow tailoring of phosphor properties for specific demands. The fluctuations of the energies of the electronic states, forming the conduction band bottom and valence band top, introduced by the electronic states of substitutional atoms promotes localization of charge carries, thus increasing the probability of radiative relaxation and enhancing thermal stability. Here, we present the results of our studies of structural and luminescence properties of undoped $Y_{1-x}Sc_xPO_4$ solid solutions. An intense emission in the UV-C spectral region has been detected in the $Y_{1-x}Sc_xPO_4$ solid solutions ($x \neq 0$). Spectral position of the emission band depends on the Y/Sc ratio, thus allowing to tune the emission wavelength for specific application. The emission is characterized by excellent thermal stability and high quantum yield at 300 K. The origin and characteristics of the luminescence are discussed in the presentation. Numerical simulation of substitutional atoms spatial distribution is performed using Monte-Carlo method. The simulation describes the fluctuations of potential at the conduction band bottom in case of the absence or presence of correlations in Sc/Y atoms distributions. It is shown that the ScSc correlation is preferable for excitations localization in $Y_{1-x}Sc_xPO_4$ solid solutions with low Sc content.

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Acknowledgments: This work was supported by the Russian Science Foundation under grant 21-12-00219.

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Influence of proton irradiation on the optical properties of garnet $Gd_3Al_xGa_{5-x}O_{12}$ (x = 0,1,2,3) single crystals

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.12

The Ce-doped garnet scintillating crystals with general formula $Gd_3(Al,Ga)_5O_{12}$ (GAGG) are perspective for medical applications, e.g., in a single photon emission computed tomography and in high-energy physics [1-2]. These crystals attract attention due to the combination of high density, chemical stability, very high light yield and reasonable energy resolution. Radiation resistance is an essential parameter for scintillators. It was shown that GAGG crystals demonstrate induced absorption under irradiation with electrons and protons [3,4]. Previous studies were mainly focused on GAGG compositions with x = 2,3, which are considered as most perspective for application as scintillators. Here we present the study of the influence of the undoped $Gd_3Al_xGa_{5-x}O_{12}$ (x = 0,1,2,3) mixed crystals composition on their radiation resistance under proton beam irradiation.

Single crystals of $Gd_3Al_xGa_{5-x}O_{12}$ (x = 0,1,2,3) were grown by the Czochralski method at Fomos-Materials (Moscow, Russia). Absorption spectra were measured using PerkinElmer Lambda 950 spectrophotometer with spectral resolution 0.2 nm. The experimental absorption spectra were corrected using Fresnel formulas on reflection losses considering multiple reflections between crystal surfaces. Spectral dependence of refractive indices needed for the correction were calculated from the Brewster's law on the basis of the multiangle dependences of the *p*-polarized light reflection measurements and from the measurements of the spectral dependences of the reflection at the incidence angle close to normal on the spectrophotometer Cary-5000 (Agilent Technologies) with universal measurement accessory UMA. $Gd_3Al_xGa_{5-x}O_{12}$ single crystals were irradiated by protons with energy 6.7 MeV from 120 cm cyclotron at Skobeltsyn Institute of Nuclear Physics. Irradiation of the samples was performed at ambient conditions. Crystals were mounted at specialized thick aluminum cuvette, which was placed 5 cm away from Al exit window of accelerator. Beam diameter in the region of crystals location was formed using quadrupole lenses of the accelerator and tantalum diaphragm placed in front of the irradiated crystals with transverse dimension in the area of the crystals of about 3 cm. Proton beam fluence at the crystals surface was measured using current integrator as $1.4 \cdot 10^{14}$ protons/cm^2. The accuracy of the measured fluence was estimated at 30% and was determined mainly by the uncontrolled flow of secondary electrons formed in crystals and cuvette parts, which were hit by a beam of accelerated protons. The samples were irradiated for 4 hours. It is shown that the irradiation results in the appearance of additional absorption bands in the transparency region of the crystals. In particular, two bands of induced absorption were detected peaking at 3.0 and 3.9 eV. The intensity of the bands depends on the crystal's composition. It is shown that the bands intensity decreases with the increase of aluminum content in the mixed crystal. The origin of such dependence is discussed in the presentation.

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Acknowledgments: This research was supported by Russian Foundation for Basic Research №20-02-00688.

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Structural and optical properties of ternary and quaternary ZnSe-based crystals

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.13

A set of ZnSe-based crystals was grown using a modified Bridgman-Stockbarger method emphasising the well-known grown from melt technique. Magnesium (Mg), Manganese(Mn), chromium (Cr), cobalt (Co) and Berylium (Be) ions were introduced to the initial batch in favour of its incorporation into the ZnSe lattice. Admixtured atoms are believed to substitute Zn atoms in their sublattice. Capability for employing +2 electronic charge suggests ease of such substitution. Not fully-filled d-subshell of Mn/Cr/Co-ions promises optical transmissions unavailable by pure II-VI semiconductors. This phenomenon of d-d transitions allows both for the determination of the strength of the crystal field of the host material (ZnSe in this case) and influence on photoluminescence spectra. However, due to transmissions between Mn(2+) ground and excited states being forbidden, samples with Cr and Co dopants were used for a more accurate determination of crystal field strength. Splitting of spectroscopic terms of doping atoms did not occur when ZnSe host material has an admixture of elements with empty (Mg, Be) or fully filled (Cd) d-subshell, as those samples may be considered as a control group.

The highlight of the proposed presentation is the determination of TMs concentration by means of Energy Dispersive X-ray Spectroscopy (EDS), photoelectrons' and Auger spectroscopies (XPS/AES) as well as optical properties of obtained bulk crystals. We used UV-IR transmission measurements, Raman and FTIR spectrometers for the evaluation of TMs' influence on the ZnSe host material. Raman spectroscopy shows massive changes in intensities of both acoustical and optical modes for Mn/Cr/Co-doped ZnSe crystals. On the other hand, the effects of the magnesium doping in II-VI crystal are best visible by the decreases in the energy bandgap, which was proven with both transmittance spectra as well as temperature dependant photoluminescence.

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Polyurethane/ferrites composite materials: A study on antimicrobial activity

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.14

Polyurethane (PU) nanocomposites are highly utilized in biomedical devices/implants due to their excellent mechanical properties, good biocompatibility, and low cytotoxicity. These PU nanocomposites with silver nanoparticles are well known potent antimicrobial agents. Biocompatible magnetic nanoparticles such as ferrites has also gained attention especially in various fields of drug delivery, biosensing and magnetic resonance imaging which requires highly specific magnetic nanoparticle (MNP) properties such as uniform size distribution, less agglomeration and stability in the biological medium. Among MNP, copper and zinc ferrites have been broadly applicable in biomedical, optoelectronic, catalysis and drug delivery. With a view to design PU/ferrites nanocomposites and to explore their antimicrobial potential, the present preliminary study reports the preparation of PU nanocomposites with copper ferrite and zinc ferrite (1 wt.%) and with the same composition. The nanocomposites were characterized using water absorption and swelling measurements. The antimicrobial activity of these composites was investigated against four bacterial strains: *Staphylococcus aureus*, *Enterococcus faecium*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*, and one *Candida* strain, *C. albicans* and compared with those of PU nanocomposites with silver ferrite nanoparticles. PU nanocomposites based on zinc and copper ferrites did not show antimicrobial activity, on the contrary they supported microbial attachment and growth. However, PU nanocomposites with silver ferrite did not show significant antibacterial activity but show antifungal activity and it is related with hydrophilicity of the prepared materials.

Acknowledgments: The authors would like to thank the Ministry of Education, Science and Technological Development of the Republic of Serbia (Grant No: 451-03-68/2022-14/200026) for financial support.

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Luminescence of F_2-dimer centers in fast-neutron irradiated Al_2O_3 single crystals

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.15

Harsh environment of future fusion reactors seriously limits the range of suitable construction and diagnostics materials due to their insufficient resistance against prolonged irradiation. One of the promising candidates for using as optical window material in such environment is aluminium oxide, in the form of single crystal or polycrystalline ceramics, which has high tolerance to neutron irradiation in addition to good mechanical and optical properties. Improvement of radiation resistance requires detailed understanding of the early stages of radiation damage evolution: formation of primary lattice defects, their aggregation and thermal annealing.

This paper presents the study of radiation damage-related luminescence in α-Al_2O_3 single crystals irradiated by fast fission neutrons (energy > 0.1 MeV at ~60 °C, fluence ~6.9 ×10^{18} n/cm^2), which previously had been investigated by us via methods of optical absorption and EPR [1-2]. The primary object of interest was luminescence of simplest point defect clusters – oxygen vacancy dimers (F_2-type centers, see also [3]). Photoluminescent characteristics have been measured at room temperature and 78 K. Emission spectra have been registered in the region 1.6–4.4 eV (775–280 nm) and the excitation spectra - in the region 2.5–6 eV (496–206 nm).

Luminescence spectra were registered at the excitation in the maxima of dimer-related optical absorption bands at 2.75, 3.45, and 4.07 eV attributed to F_2^{2+}, F_2^+ and F_2 centers, respectively. For each exciting energy, emission spectra are qualitatively rather similar at both 295 K and 78 K, being up to several times (in case of F_2-excitation) weaker at room temperature. Excitation at 2.75 eV produces a wide strong emission band centered around 2.1 eV, with rather asymmetric shape at 295 K. Excitation at 3.45 eV produces the main narrow band at 3.2 eV and a weaker band at ~2.6 eV. Excitation at 4.05 eV produces the main narrow band at 3.8 eV (coincides with the emission of F^+ centers) and a weaker band at ~2.4 eV. Excitation spectra for these emissions are complicated at both temperatures, having several excitation bands each, which in some cases coincide for the emissions related to different color centers. This complexity could be the result of the existence of several radiative transitions within dimer centers of the same type, energy transfer between different types of dimers, and/or influence of reabsorption.

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Self-assembly and crystallization of block copolymers on surfaces exposed to a well-controlled solvent vapor environment and observed by AFM

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.16

In this work, we report on the fabrication of structured surfaces with significant antimicrobial potential through the employment of a state-of-the-art methodology for processing of poly(4-vinylpyridine)-*block*-polybutadiene (P4VP-*b*-PB) and poly(2-vinylpyridine)-*block*-polybutadiene (P2VP-*b*-PB) block copolymers in thin films. This methodology is based on solvent vapor annealing in a rather confined environment (C-SVA) and promotes structuring of copolymers on surfaces via the self-assembly process. Our results have shown that the films processed with the C-SVA method exhibited a surface covered with periodic parallel stripe domains, while their as spin cast analogues displayed a surface covered with randomly oriented structures of irregular shape. Moreover, each stripe consisted of darker and lighter domains that corresponded to the softer rubbery PB blocks and to the stiffer, rather semicrystalline P4VP, respectively P2VP blocks. These observations pointed towards the existence of a lamellar morphology, in contrast to the as spin cast block copolymer films that displayed no periodic, well-defined structures.

Acknowledgments: The authors acknowledge the financial support of the Romanian National Authority for Scientific Research and Innovation, CNCS – UEFISCDI, project no. PN-III-P1-1.1-TE-2021-0388.

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Novel NASICON-type $Na_{3.6}Lu_{1.8-x}(PO_4)_3$:$xEu^{3+}$ phosphors: Structure and luminescence

Nataliya Krutyak[1,2], Dmitry Spassky[1,3], Dina Deyneko[4], Andrey Antropov[4], Vladimir A. Morozov[4], Vitali Nagirnyi[1]

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.17

The development of the lighting industry possesses more and more challenges in a field of phosphors, which are used for white LEDs. The main challenges are related to the achievement of high temperature stability and perfect color characteristics of the phosphors emission. The search for phosphors emitting in red, green or blue regions of the spectrum and satisfying the requirements remains relevant. Nowadays, phosphates are an excellent matrix among inorganic phosphors due to simple synthesis conditions, good chemical stability, and low cost. Recently, phosphates with a NASICON-based structure have demonstrated availability for application as phosphors for white pcLEDs [1]. Here we present first results of a study of structure and luminescence of undoped and Eu^{3+}-doped $Na_{3.6}Lu_{1.8}(PO_4)_3$ phosphates.

$Na_{3.6}Lu_{1.8-x}(PO_4)_3$:$xEu^{3+}$ (x = 0.0-0.7) solid solutions were synthesized by a high-temperature solid-state route. Powder X-ray diffraction study revealed that homogeneous solid solutions with a NASICON-type structure were formed at $0 \le x \le 0.7$. Luminescence and luminescence excitation spectra in the UV region were measured using a laboratory setup based on a LOT-Oriel MS-257 spectrograph in the temperature range 80–500 K. Luminescent spectroscopy in the VUV region was performed using specialized setup with Shamrock 303i (Andor Technology) monochromator.

The refinement indicates structural disorder caused by displacement of a part of *Lu* cations along *c* axis inside $(Lu/Na)O_6$ octahedra. It is confirmed by the broadened emission lines of Eu^{3+} ions, which substitutes Lu cations. The optimal concentration of europium in NLPO:xEu^{3+} phosphates was determined as x = 0.5. It is shown that the concentration quenching of Eu^{3+} emission is due to dipole-dipole interaction. The enhanced temperature stability of Eu^{3+} emission was obtained at excitation energy 3.23 eV, which corresponds to the energies of $^7F_0 \rightarrow {}^5L_7$ and $^7F_1 \rightarrow {}^5G_J$ transitions. It is suggested that the emission quenching, which occurs for the $^7F_0 \rightarrow {}^5L_7$ transition is compensated due to the intensity increase of the $^7F_1 \rightarrow {}^5G_J$ transition as a result of the $^7F_1$ level population increase with temperature rise.

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Acknowledgments: The research was performed within the project MOBJD613.

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Simple and fast method for characterization of clay materials

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.18

Clay represents a type of material that has been used since long ago. In the present they are used in large variety of industries such as food, construction, ceramics, pharmaceuticals etc. The domain in which a certain type of clay is used depends on their chemical and mineralogical composition which determines its properties. In certain domains these characteristics have to strictly abide by imposed standards of stability and safety. This study aims to realize a fast elemental composition analysis for clay materials for which the XRF spectrometry was used because it is a modern technique which proved its usefulness in studies from different domains, as it does not require any preprocessing of the samples, is time and cost efficient and it does not produce waste. In the case of this study the aim of this method was the determination of heavy metals compositions present in clays. The results presented are collected from over a hundred samples of clay and were obtained by using a Bruker Tracer 5i XRF spectrometer. The samples were acquired from the commercial market, originating from both Romania and other countries. The place of origin is actually very important for clay, as it determines certain compositions or properties, which may affect or limit their utilization. Given the fact that the influence of radioactivity, be it natural or artificial is also an important factor to take into consideration, the samples were also analyzed with the gamma spectroscopy method for a complete overview and characterization, which may be used for determining the use of each type of clay.

Keywords: Clay, XRF spectrometry, gamma spectroscopy

Declaration of competing interest: The authors declare that they have no competing financial interests or personal relationships that could have influenced the work reported in this paper.

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Acknowledgments: This work has been funded by the project PN 19 06 02 04, phase 9/2022 and phase 10/2022.
This work was sponsored by the Gritsablare Company from Constanta (http://www.gritsablare.ro) and the authors would like to express their sincere appreciation for providing some of the materials used in this study.

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Experimental study regarding new methods of radioactive decontamination and clean-up for materials that were contaminated with hydrogen-3 used in research laboratory

Diana Chiper[1], Catalin Stelian Tuta[1], George Gabriel Bubueanu[1], Cristian Postolache[1], Alexandra-Diana Chiper[2], Ioana-Cristina Chiper[2]

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.19

The purpose of this present work consists of finding a more efficient and less expensive decontamination method for surfaces contaminated with Tritium-labelled compounds. In the experiments there were used the polymeric hydrogels, DeconGel type 1102 and type 1108. This paper presents the methods and facilities used, as well as the results obtained and their interpretation. All the experiments were conducted within Tritium Laboratory (TRITIULAB) from DRMR department from Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH). This paper aims to develop new methods and protocols of decontamination for Tritium laboratories' facilities improving at the same time radiological security measures to meet EU requirements. In accordance with these requirements, we chose a polymeric hydrogel, DeconGel, because the method is easy, does not damage the surfaces and, at the same time, does not cause pollution, while the costs involved and necessary storage space are minimal. After considering all these aspects, it was decided that DeconGel is a possibility with high chance of success for our research. The experiments are based on measurements realized on a certain number of materials (types of surfaces) that are often found in facilities specifically designed for radioactive research, which were afterwards gathered and interpreted. For each sample of materials, we made a comparison between the results obtained from the classic decontamination method (with wetted smears) and the one using the polymeric hydrogel. The paper will further develop, in a more detailed manner, the steps, utensils and chemical compounds used in the experiment. All the materials studied originate from the Radionuclides and Radiation Metrology Departament (DRMR)-NIPNE, TRITIULAB-NIPNE. The polymeric hydrogels were procured from CBI Polymers from USA.

Keywords: Polymeric hydrogel, decontamination, tritium, hot cell, radioisotopes

Declaration of competing interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Acknowledgments: The costs of this experiment are supported by the Romanian National Project-PN 09 37 02 06, PN 19 06 02 04, faza 9/2022 si faza 10/2022.

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Band gap engineering in novel fluorite-type rare earth high-entropy oxides (RE-HEOs) with computational and experimental validation for photocatalytic water splitting applications

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.20

Five different rare-earth-based nanocrystalline high entropy oxides (HEOs) with fluorite type of structure and average crystallite sizes between 6 and 8 nm were prepared and their photocatalytic behaviour towards AZO dye degradation and photoelectrochemical water splitting for hydrogen generation was examined. The cationic site in the fluorite lattice consists of five equimolar elements selected from the group of rare-earth elements including La, Ce, Pr, Eu, and Gd and second-row transition metals, Y and Zr. Studied HEOs exhibit bandgaps in the range from 1.91 eV to 3.0 eV and appropriate valence and conduction bands for water splitting. They reveal high photocatalytic activity that is mostly attributed to the accessibility of more photocatalytic active sites which provided radicals responsible for the AZO dye degradation. The materials successfully produce hydrogen by photocatalytic water splitting, suggesting the potential of HEOs as new photocatalysts. The photocatalytic performances of all studied HEOs outperform the single fluorite oxides or equivalent mixed oxides. The $Ce_{0.2}Zr_{0.2}La_{0.2}Pr_{0.2}Y_{0.2}O_2$ (CZLPY) engender hydrogen in 9.2 μmolmg^{-1} per hour that is much higher content than for pristine CeO_2 material which amounts to 0.8 μmolmg^{-1} per hour. The explanation of the obtained experimental results is supported by density functional theory (DFT) calculations. The density of states (DOS) and the projected DOS after high-entropy equimolar doping (CZLPY) of starting pristine CeO_2 indicated that the bandgap is significantly reduced from 3.48 to 2.71 eV due to Pr 4f and O 2p orbital mixing. DFT calculation also disclose that a strong interaction between AZO dye methylene blue (MB) and CZLPY(111) is responsible for observed higher photodegradation of MB by CZLPY compared to pristine CeO_2. This occurs due to the existence of three solid bondings of MB with the surface of CZLPY(111) compared to only one solid bonding with the surface of CeO_2 (111).

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Experimental setup for elemental analysis using prompt gamma rays at research reactor IBR-2

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https://doi.org/10.21175/rad.sum.abstr.book.2022.11.21

The new experimental setup has been built at the 11b channel of the IBR-2 research reactor at FLNP, JINR, to study the elemental composition of samples by registration of prompt gamma emission during thermal neutron capture. The setup consists of a curved mirror neutron guide and a radiation-resistant HPGe high-purity germanium detector. The detector is surrounded by lead shielding to suppress the natural background gamma level. The sample is placed in a vacuum channel and surrounded by a LiF shield to suppress the gamma background generated by scattered neutrons. This work presents characteristics of the experimental setup. An example of hydrogen concentration determining in a diamond powder made by detonation synthesis is given and on its basis, the sensitivity of the setup is calculated being ~4μg.

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The smart and active personal radiation monitor

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https://doi.org/10.21175/rad.sum.abstr.book.2022.12.1

Radiation protection of radiation workers is generally provided by the monthly follows up of TLD dosimeters. However, this method does not allow institutes or workers to monitor their dose rates instantly or identify locations which might cause stochastic effects. With improvements in IoT technologies and miniaturized radiation detection techniques, it is possible to monitor dose rates along with location and time information. This work focuses on the development of an IoT radiation detector as well as a monitoring system. The device consists of a Geiger-Müller Tube detector which can count both gamma rays and electrons efficiently with sufficiently large energy sensitivity for medical applications. This dose rate information is sent over Wi-Fi or Bluetooth to the database with time and location information which are encrypted. The time and location information allows institutes to map their radiation environment as well as react precisely and in a timely manner. These capabilities will provide support for ensuring the ALARA which calls for, as low as reasonably achievable, doses. The motivations behind this work are to build an affordable and smart radiation monitoring device, raise awareness of radiation workers and institutes, and increase safety precautions in radiation environments.

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Evaluation of radiosensitivity and *in vitro* immunoreactivity of *Streptococcus agalactiae* strains γ- irradiated in different conditions

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https://doi.org/10.21175/rad.sum.abstr.book.2022.12.2

Introduction. In this study we have investigated the influence of a series of factors on the stability of *Streptococcus agalactiae* strains suspensions submitted to gamma irradiations treatment for future applications like developing external positive controls for rapid identification kits or as main component of gamma inactivated vaccines. We have investigated the influence of preparing protocols and storage conditions after gamma irradiation on the viability of the bacterial cells and, also, their response to common analytical biochemical assays (ELISA, Identification rapid test cassettes).

S. agalactiae, or Group B *Streptococcus* (GBS) is a major cause of bacterial infection associated with birth. Usually, the microorganism is acquired by newborns during delivery, from GBS-colonized mother.

Most of these rapid tests are lacking associated positive control. In order to develop a safe, reactive and stable positive control, we tested gamma irradiation as inactivation method in bacterial suspensions of *Streptococcus agalactiae* – the group representative.

Experimental. Radiosensitivity values was determined by irradiation of *S.agalactiae* strains in liquid matrix after exposing to doses ranged between 25 Gy and 3 kGy.

For determination of gamma irradiation effect on antigen stability and the interaction with specific antibody, ELISA tests have been performed to *S. agalactiae* suspensions after exposing the suspensions to doses between 3 kGy to 25 kGy.

The irradiations treatments have been performed at research irradiator, Gamma Chamber (GC) 5000 with ^{60}Co source.

Results and Discussion. The calculated D_{10} value was ~ 50 Gy. Doses up to 10 kGy proved to not significantly affect the immune-reactivity in vitro. We chose 5 kGy as optimum dose that inactivates a 10^{13} UFC / mL suspension of *S. agalactiae*, while still keeping its antibody binding properties for at least 6 months, after storing at room temperature or in the refrigerator.

Conclusion. Our results can be applied for preparing a ready to use, external positive control for rapid GBS tests and also have the potential of being further exploited for developing irradiated vaccines.

Acknowledgments: This research was supported by Gamma-Plus, code P_40_276, SMIS2014 107514, Ctr. No. 139/27.09.2016.

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Use of Gd(III) MRI contrast agent as an *in vivo* probe for Zn(II)

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https://doi.org/10.21175/rad.sum.abstr.book.2022.13.1

Magnetic Resonance Imaging (MRI) is an important medical imaging modality, which is used extensively for the visualization of tissue or organ function. The modality exploits the different relaxation times of protons in different tissues/environments. Notwithstanding the excellent images that are possible, there is a need for contrast agents, which can enhance this visualization and study organ function. To be successful, an MRI contrast agent has to be safe and tissue-specific. The commercially available contrast agents are based on Gd^{3+}, which has 7 unpaired electrons, rapid water exchange, and favorable electronic properties. However free $Gd^{3+}$is too toxic to be used on its own. It, therefore, has to be coordinated by an organic ligand in order to reduce its toxicity. The most widely used contrast agent is $[Gd(DTPA)]^{2+}$. In our study, we are looking at a novel ligand [1] in which the effect of Gd^{3+}can be switched on and off by the presence of Zn^{2+}.

In the absence of Zn^{2+}, the Gd^{3+} is exposed to water and so, by exchange affects the bulk water relaxation. However, in the presence of Zn^{2+}, the ligand folds around the Gd^{3+} and so the relaxivity is reduced. In this way, the ligand can be used as an *in vivo* probe for Zn^{2+}.

Potentiometric results for this system will be discussed together with *in vivo* simulations.

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Monomolecular bimodal imaging probes (MoBIPs)

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https://doi.org/10.21175/rad.sum.abstr.book.2022.13.2

Bimodal imaging probes have raised particular interest in the clinical field, where the combination of two techniques, namely positron emission tomography (PET) and fluorescence optical imaging (OI), helps surgeons both in preoperative tumor identification and localization, as well as in intraoperative fluorescence guided surgery (FGS).

In our laboratory we aim at developing new MoBIPSs, based on a combination of strategically selected fluorescent dye and a macrobicyclic chelator. The two imaging techniques are complementary and provide a highly synergistic diagnostic, both for preclinical and clinical use. The radiotracer which was employed consists of a sarcophagine cage that has recently been proved as the best chelator for Cu(II) ions. As fluorescent dyes we have used naphthalene- and perylene-based derivatives with electron-donor substituents at the peri-positions leads to formation of a push-pull system with desired optical properties. We explored different designs for linking the two modalities – more traditionally by spacer, and also directly. All new MoBIPs were characterized by various spectroscopic techniques and their applicability as bimodal sensors for diagnostic imaging was demonstrated.

Acknowledgments: Authors are grateful to the Bulgarian National Science Fund project NSF KP 06-N29/12.

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Improvement of prostate cancer contrast in MRI using complex nanoparticles in the animal model

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https://doi.org/10.21175/rad.sum.abstr.book.2022.13.3

Magnetic Resonance Imaging (MRI) has been used for early cancer detection and treatment monitoring due to its excellent soft tissue contrast, yet in clinical settings contrast agents are used for cancer diagnosis. While MRI contrast may be provided solely by tissues themselves, due to differences in their relaxation times, contrast agents shortening *T1* and *T2* relaxation times further improve detection of small pathologies such as early stages breast cancers (1,2).

To further improve tumor contrast we have developed new core/shell $NaDyF_4/NaGdF_4$ nanoparticles changing both T_1 and T_2 relaxation times of surrounding water molecules. We also investigated toxicity, biodistribution and clearance of the new contrast agent. The relaxation times (T_1 and T_2) of the nanoparticles with various core/shell sizes and concentrations were measured at 9.4T to find the optimum T_1/T_2 ratio for MRI. T_1- and T_2-weighted images using core/shell nanoparticles of the animal models of prostate cancer were collected and combined to provide enhanced contrast.

We imaged mice with prostate cancer before and after an injection of a non-targeted NaDyF4/NaGdF4 nanoparticle. We employed both an IR TrueFISP pulse sequence (*T1* -weighted images), and an MSME pulse sequence (*T2* -weighted images), using a 9.4T MRI system. We have also subtracted the *T1* -weighted from the *T2* -weighted images.

The results showed that the contrast agents consisting of the core/shell nanoparticles provided improved tumor contrast when the T_1 and T_2-weighted MR pulse sequences were applied. Injection of non-targeted NaDyF4/NaGdF4 nanoparticle in a mouse with prostate cancer increases tumor contrast using IR TrueFISP (*T1* -weighted) pulse sequence comparing to no-contrast MRI. Decrease in the contrast for an image utilizing a MSME (*T2* -weighted) pulse sequence was observed. The image subtraction showed a further increase in cancer contrast.

In summary, the studies showed that the new contrast agents when combined with image subtraction may allow earlier detection of cancerous tissues than standard T_1- or T_2-only contrast.

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Acknowledgments: This work was funded by the National Science Center, Poland. Grant numbers: Harmonia no. 2018/30/M/NZ5/00844.

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Feasibility of converting a retired linear accelerator for delivering electron FLASH irradiation at different source to skin distance

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https://doi.org/10.21175/rad.sum.abstr.book.2022.14.1

Objective. This study aims to modify a retired linear accelerator (LINAC) making it capable of delivery electron beam at FLASH dose rate (or sometimes called Ultra-high dose rate, UHDR) (>40 Gy/s) for future FLASH research purpose.

Methods. A retired Varian Clinac 2100 CD LINAC was modified to serve research purpose only. The LINAC was operated in service mode. 10 MV photon mode was selected but the target was retracted with interlock acknowledgment. The carousel was set to empty port manually. The air drive, steering servo and dose-rate servo was switched off. The gun current and modulator charge rate were optimized to produce achievable maximum output dose rate of 10 MeV electron. The absolute and relative measurements of surface dose rate and dose profiles were carried out in solid water phantom with Gafchromic film and optically stimulated luminescence (OSL) dosimeters.

Results. The dose rates at the isocenter for a wide jaws-opened field at internal ionization chamber, 50cm, 80cm 100cm source to skin distance (SSD) was recorded at ~20,000 Gy/s, ~1110 Gy/s, ~430 Gy/s and ~280 Gy/, respectively. There was no significant difference between measurement of Gafchromic film and OSL dosimeter, all were within +/-2.3%.

Conclusion. The retired LINAC is successfully modified and being well above capable of delivering electron beam at Flash dose rate at different SSD. This high feasibility strongly widens future scope of investigation.

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Spectral properties of human hair

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https://doi.org/10.21175/rad.sum.abstr.book.2022.14.2

The absorption spectrum of a human hair is important for medicine, as it allows you to determine the melanin concentration. The experimental setup consists of an optical microscope with a SIGET digital attachment and a computer for the measurement results processing. The data were processed using the MATHCAD Windows application. A picture of white light passing through the hair was photographed. The MATHCAD allows to divide this picture into components in the red, green and blue parts of the spectrum.

The transmission, reflection and absorption spectra of different (blond, brown, brunette and gray) hairs were measured. According to the data obtained, the refractive and absorption indices were determined, that makes it possible to determine the melanin concentration in the hair.

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Low-frequency electromagnetic fields can influence proliferation, viability, gene expression and protein secretion of adipose-derived mesenchymal stem cells

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https://doi.org/10.21175/rad.sum.abstr.book.2022.14.3

Low-frequency electromagnetic fields (LF-EMF) can positively and negatively affect mesenchymal stem cells by influencing specific factors and proteins secretion. It has an impact on cellular processes and stem cell fate determination. The purpose of the present study was to investigate the effect of LF-EMF with continuous exposure on adipose-derived mesenchymal stem cells. Results have shown proliferation decrease (76.6 Hz; 12h) and then its increase with exposure time (76.6 Hz; 24h), a 3-fold increase of FGF-2 protein secretion (50Hz; 48h), and a decrease in cell viability (76.6 Hz; 12h, 24h). Also, relative gene expression of the stem cell surface (CD105, CD44, CD90) and stemness (OCT4, SOX2) markers have been changed under EMF influence (76.6 Hz; 12h, 24h). Collectively, the presented results show that EMF influence stem cells functioning and their physiological processes thus altering their fate. In the context of basic studies on EMF effects on stem cell biology, adjusting EMF parameters that cause a specific effect on stem cells is crucial.

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Comparative dosimetric analysis of advanced VMAT and IMRT with a standard 3D conformal radiation planning technique for pancreatic cancer

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https://doi.org/10.21175/rad.sum.abstr.book.2022.14.4

Purpose. To evaluate the adjuvant radiation treatment results and dosimetric parameters obtained with a volumetric modulated arc therapy (VMAT), intensity-modulated radiation therapy (IMRT) and conventional three-dimensional conformal radiation therapy (3D-CRT) in patient with pancreatic cancer.

Materials and Methods. A patient aged 66 years with operated advanced pancreatic cancer were treated with radiation therapy at the Department of Radiation Oncology, the University Clinical Center Kragujevac in the 2022 year. Using CT and MRI scans, the radiation oncologist contoured the CTV (clinical target volume) plus 10-mm margins in all directions, PTV (planning target volume) as well as OARs (organ at risk): kidneys, liver, bowel and spinal cord. The total dose was 45 Gy in 25 fractions.

Results. Dosimetric parameters between the corresponding VMAT, IMRT and 3D-CRT clinical plans were compared. With all three techniques, the dose coverage of planning target volume (PTV) satisfied the set criteria. The best sparing for the liver and the bowel gave VMAT plan, while for the spinal cord and left kidney that is the 3D-CRT plan. The right kidney is equally well spared with the application of both VMAT and 3D-CRT techniques. The VMAT, IMRT and 3D-CRT plans had similar homogeneity indices (HI) and conformity indices (CI), but for VMAT plan had comparable improved CI.

Conclusion. Based on the obtained parameters, all three techniques gave satisfactory results, but regardless of advanced techniques, the choice was 3D-CRT, due to the simplicity of the treatment. Radiation therapy was effective for symptomatic palliation in patient and played an important part in the survival benefit.

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The ISOLPHARM project at LNL: A new production method of high specific activity radionuclides towards innovative radiopharmaceuticals

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https://doi.org/10.21175/rad.sum.abstr.book.2022.14.5

Radionuclides of interest in nuclear medicine are generally produced in cyclotrons or nuclear reactors, with associated issues such as highly enriched target costs and undesired contaminants (carrier-added). In this context, the ISOLPHARM project (ISOL technique for RadioPHARMaceuticals) at INFN-LNL (Istituto Nazionale di Fisica Nucleare-Laboratori Nazionali di Legnaro) aims at producing high purity (no-carrier added) radionuclides for nuclear medicine applications. Besides being operated for nuclear physics studies, the facility may play a pivotal role in producing medically relevant radionuclides employing the ISOL (Isotope Separation On-Line) technique. This technique will enable the production of radiopharmaceuticals hardly obtained in standard production facilities.

Both traditional and innovative radionuclides from many different regions of the nuclide chart will be produced with high specific activities, going beyond the state of art of the radiopharmaceuticals research.

ISOLPHARM is a comprehensive project started at INFN–LNL and developed in collaboration with many University departments, with the aim of performing feasibility study on this technology to produce very high specific activity beta-emitting radionuclides as radiopharmaceutical precursors. This innovative technique will open a new pathway towards the production and application of radiopharmaceuticals that typically cannot be obtained in the standard production facilities, with lower costs than traditional methods and reduced environmental impact. As an example, 111-Ag, a β^- emitter (360 keV with mean tissue penetration of 1 mm) with a medium half-life (7.45 d) and a low percentage of γ-emission, can be produced in carrier-free form only when a costly 110-Pd enriched target is used with classical irradiation methods. Alternatively, the ISOL method could be suitable to produce 111-Ag with high purity and high production rate. The ISOLPHARM project has three main goals, based on the application of the ISOLPHARM method to the production of 111Ag radionuclides as radiopharmaceuticals precursors:

-Physics: production of 111-Ag, spectroscopy studies, laser ionization of Ag. Involved groups: INFN-LNL, INFN-PV, INFN-PD, associated members of UniPd, UniPv, UniBs and UniSi,

-Radiochemistry: synthesis and characterization of chelators, linkers, targeting agents and purification of isotopes. Involved groups: INFN-LNL, associated members of UniPd and USL-IRCCS Reggio Emilia,

-Biology: biological characterization on cells, scaffold production and 3D cell cultures, in vitro and in vivo studies. Involved groups: INFN-LNL, INFN-TIFPA, INFN-LNS, associated members of UniPd, UniTn and USL-IRCCS Reggio Emilia.

In this contribution the experimental activity performed in the last 3 years will be presented.

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Measurement of the radioactive nuclides for the medical linear accelerators based on the spectroscopy using an in-situ HPGe detector

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https://doi.org/10.21175/rad.sum.abstr.book.2022.14.6

Introduction. One of the usual methods for treating cancer is radiotherapy using the medical linear accelerator (LINAC). Photon beam treatment generally uses 6 or 10, 15 MV. When X-ray energy above 8 MV is used, photoneutrons are generated by the photonuclear reaction, activating LINAC components. The components inside the LINAC head part are activated and should be handled as radioactive waste when disposed of the LINAC. Spectroscopy is a necessary procedure to judge the radionuclides while disposing of the LINAC or replacing the components. In this study, we measured the radioactive nuclides using an in-situ High Purity Germanium (HPGe) detector for the real-disposed LINACs and components.

Materials and Methods. Herein, we conducted the spectroscopy and measured the surface dose rate for the disposed of LINACs. (LINAC by Manufacturer: 1 Siemens, 2 Varian, 1 Elekta) After dismantling the LINAC, the components were evaluated by classifying them by parts. Then, we measured the dose rate using a survey meter (ESM FH 40 GL, Thermo Inc, Germany) and radionuclides using a portable HPGe detector (GC2018, Canberra Inc, USA & Trans-SPEC–DX100, Ametek Ortec, USA). We measured the dose rate at the surface and up to 5 cm from the surface by a 1 cm gap. For the Spectroscopy, the HPGe detector was positioned in front of the component and measured for 30 min for each component. In addition, the length of installation and use of the linear accelerator, energy, operating load, intensity-controlled radiation therapy ratio, and manufacturer/model name was investigated.

Results and Discussion. As a result of the evaluation of the components of the head part, about 20 nuclides were identified, including those with a half-life of 200 days or longer, such as ^{54}Mn, ^{60}Co, ^{65}Zn, ^{122}Sb, and ^{198}Au. The dose rate of major components such as the target, primary collimator, and flattening filter was measured as high as 2.39 to 26.9 μSv/hr, and a tendency to drop on a logarithmic scale was confirmed as the measurement distance increased by 1 cm up to 5 cm. As a result of measuring the dose rate after five weeks for parts with high dose rates, it was confirmed to be 2.21 to 7.05 μSv/hr. The number of discriminated nuclides was small in the case of equipment in an institution with a relatively small number of patients to be treated or the equipment operation period was not long, and the overall cps (count per seconds) of the spectrum acquired using the HPGe detector tended to be low. And the primary factor of the activation is the energy which is mainly used for treatment. Even using the 10 or 15 MV while the leading energy is 6 MV, the activation level was found not to be high.

Conclusion. In this study, we measured immediate radionuclide analysis and dose rate evaluation using an In-situ HPGe detector and a survey meter for the medical LINACs. The difference in the level of radiation and the type of nuclide was confirmed depending on the period of use, energy, and workload. As a result of the dose rate evaluation, one μSv/h after about three days, excluding significant radiation components such as targets and filters, It was confirmed that it decreased to below. Therefore, in the process of relocating for the dismantling of the LINAC, it is considered to be safe exposure management when carried out 3 to 5 hours after stopping the operation.

Acknowledgments: This study supported by the Nuclear Safety and Security Commission (No. 2003013) and by National Research Foundation of Korea (NRF) grant funded by the Korea government (Ministry of Sciences and ICT) (No. 2020M2D9A309417013).

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Control of the position of the spinal canal during head and neck radiotherapy

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https://doi.org/10.21175/rad.sum.abstr.book.2022.14.7

Head and neck cancers are often located near an important anatomical structure such as the spinal cord, brain stem, etc., making the treatment difficult. The primary method of treating head and neck tumors is surgery, often combined with pre-or postoperative radiotherapy. Patients have been irradiated approximately 30 fractions, depending on the dosage. The correct patient position during radiotherapy is crucial for its effectiveness of radiotherapy. During the reconstruction of the patient's position, the spine tends to some rotation in the cervicothoracic section in relation to the reference CT. These studies focused on head and neck cancers, particularly the doses absorbed in the canal and spinal cord. This research aimed to check whether the stabilization and verification of the patient's position are sufficient to make a treatment plan correctly and safely during radiotherapy. It has been assessed by comparing the dose distribution in the spinal canal calculated in the TPS Treatment Planning System based on CT and the distribution of the dose delivered during the treatment and calculated based on the CT-CBCT fusion.

Materials and Methods. 30 Patients were randomly selected from the group treated for head and neck cancers using IMRT or VMAT techniques. According to the clinical protocol, the maximum dose in the spinal cord structure must not exceed the point value of 45 Gy. 926 CBCT images were analyzed for spinal canal mobility. A rigid fusion CT was performed with all CBCT scans. It was assumed that the movement of the core is analogous to the spinal canal, and its possible other movements are negligible. The structures of the spinal canal were transferred from CBCT to CT, and the dose distribution was subsequently calculated in the Eclipse TPS system. Structure of the spinal canal was divided into four parts on CBCT and CT to assess in which region the most significant changes occur, both in the position of structure and in the received dose.

Results and Discussion. The percentage difference between the total doses of DCBCT and the planned dose of DCT ranges from -3.14% to 26.01%. The maximum dose decrease by 1.74 Gy and the maximum increase by 5.92 Gy at the end of radiotherapy treatment. In 43% of patients, the differences between DCT and DCBCT were not statistically significant. At the same time 17 patients were not irradiated as scheduled. In eight of them, the maximum dose exceeds 45 Gy, but a difference (DCBCT - DCT) < 1Gy. It is different for another nine of them (DCBCT - DCT)> 1 Gy throughout treatment. The data showed that if (DCT - DCBCT) <0.65 Gy in the canal, the DCT does not differ statistically from DCBCT, However, for the entire study group, as a result of the Student's t-test, we obtain a value of p = 0.76, allows (based on the maximum point doses) to define the therapy as carried out correctly. The mean of relative difference dose value does not exceed 0.5 Gy, which corresponds to 1.8% relative value the difference to the mean DCT. The mean DCT and DCBCT values of 43.29 Gy and 42.8 Gy. None of the patients achieved a dose greater than 45 Gy in the spinal cord.

The data obtained with using the Offline Review shows that when the average PITCH vector value for a patient exceeds 0.5 °, DCBCT is statistically different from DCT. Most frequently exceeding the value of | 0.5 mm | / | 0.5 ° | vectors are VRT translation and PITCH rotation.

The most significant changes in the spinal canal arrangement occur in the C3-C4 segment. Larger dose changes were also recorded in the same area.

Conclusion. The maximum doses of 0.5 cm3 and 1 cm3 spinal canal volumes showed less variability. There was no close correlation between the dose change value and the value of the translation or rotation vectors. However, a concentration of positioning errors was observed. These shifts may be partly related to the tilting of the head back and the bending of the neck towards the radiation source.

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Patient specific dosimetry for CyberKnife® S7 system using ionization chamber: Our initial three-month experience

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https://doi.org/10.21175/rad.sum.abstr.book.2022.14.8

Patient specific quality assurance (QA) is an important part of comprehensive QA program for advanced radiotherapy, such as intensity modulated radiotherapy (IMRT), or volumetrically modulated arc therapy (VMAT). This quality control procedure ensures proper treatment plan delivery to the patient. Predominantly it is done by patient specific dosimetric measurements in point, plane, or volume of interest (PSD), depending on available equipment and methodology. Since PSD requires time on the machine, it can be replaced by a surrogate method such as MU calculation but remains an important part of machine commissioning.

Stereotactic radiosurgery is an advance radiotherapy method that requires submillimetre accuracy in positioning and secondary collimation and as such has much stricter tolerances for commissioning and machine QA. Dedicated systems such as GammaKnife (Elekta AB, Stockholm, SE) therefore do not routinely require PSD. Another dedicated radiosurgery device, the CyberKnife® S7 system (Accuray Inc. Sunnyvale, CA), was installed in Radiochirurgia Zagreb in early November 2021, with first patients treated mid-December. During commissioning, a PSD procedure was designed using local equipment available at the time: end-to-end stereotactic phantom StereoPhan (SunNuclear, Melbourne, FL) and PTW Farmer ionization chamber (PTW Freiburg, Freiburg, DE) with PCElectrometer (SunNuclear, Melbourne, FL).

In this work, we present our results of PSD measurements during first three-months of clinical work using CyberKnife® S7 (CK). All treatment plans tested in this research were clinical non-isocentric non-coplanar plans optimized using VOLO optimizer on Precision 3.3 treatment planning system (TPS) (Accuray Inc., Sunnyvale, CA). Result of testing is in the form of percentage dose difference normalized to planned dose. Average dose difference over all tested plans was -3% (±2%). Considering known issues in small field dosimetry for relatively large detectors (smallest CK field has a nominal diameter of 5 mm, while Farmer chamber has length of 23 mm and a diameter of 6.1mm) treatment plans were further split into three groups, according to the weighted average of collimator size of below 13mm, between 13 and 23 mm, and over 23 mm. The normalized difference between measured and planned dose was found to be -4% (±2%), -3% (±2%) and -1.5% (±0.7%) for groups one, two and three, respectively. Most of the outliers are caused by using smaller collimator apertures (< 13mm). Small field effects such as the volume averaging effect and lack of lateral particle equilibrium contribute to a lower signal, while the high dose gradient contributes to the uncertainty of the measurement. We consistently measure dose, which is lower than calculated in the TPS, confirming the inadequacy of Farmer chamber for PSD utilizing small fields.

This work describes measurements done during first months of our clinical work, which were marked by some logistical challenges regarding equipment delivery. While the dosimetric accuracy of this method is questionable, it provided a valuable experience for the medical physics staff working with CK. Starting from the end of April 2022 a 2D diode SRS array is routinely used in our institution for the purpose of PSD with very good results (all tested plans have a gamma passing rate over 95% for 3%, 2mm global normalization, 10% threshold), while film dosimetry is in the process of being commissioned. Comparison of results of these different methods will be further investigated.

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The low-frequency electromagnetic field (50 Hz) influences the vulnerability to other stress factors – the role of oxidant/antioxidant balance in rat's brain

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https://doi.org/10.21175/rad.sum.abstr.book.2022.15.1

The brain is an organ extremely sensitive to oxidative stress. The results of studies concerning the effect of extremely low-frequency electromagnetic fields (ELF-EMF) on oxidative stress and antioxidant defence are often contradictory or insufficient.

We hypothesized that the influence of ELF-EMF (50 Hz) on oxidant/antioxidant balance in the rat's brain may be different depending on the intensity of the field. Moreover, ELF-EMF may trigger an adaptive response – the increase of antioxidant defence or sensitization of the organism to subsequent stress events due to the enhancement of oxidative stress. The aim of the study was to determine the effect of ELF-EMF on the level of oxidant and antioxidant markers as well as its long-term impact on the oxidative mechanisms induced in response to other stress factors.

Wistar adult rats were exposed for 1, 2, or 3 weeks (1 h/day) to ELF-EMF of 1 or 7 mT.

The levels of protein carbonyl groups (CP), 8-isoprostanes (8-epi PGF2α) and total antioxidant capacity (TAC) were determined in a rat's prefrontal cortex after each exposure to ELF-EMF. Moreover, we evaluated the impact of ELF-EMF on the change in the markers level in response to subsequent stress factor - open-field test.

We have shown that repeated exposure to ELF-EMF changed the oxidative/antioxidative status depending on the intensity of the field. 1 mT ELF-EMF caused weak and temporary changes in the oxidative status in the brain, however, 7 mT EMF moved the balance into a higher level of oxidative stress. The changes in the oxidative status after 1 mT EMF were enough to reduce, and after 7 mT EMF to intensify oxidative processes in response to the next stress. We concluded that the organism might adapt to "weak" EMF, while "strong" EMF exceeds the adaptive capacity of the organism and sensitizes it to subsequent stress, thus may increase the risk of nervous system diseases.

Acknowledgments: Grant from National Science Centre, Poland, no. 2017/25/B/NZ7/00638 and project no. POWR.03.05.00-00-Z302/17 Universitas Copernicana Thoruniensis In Futuro, a part of the programme Knowledge Education Development.

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Hippocampal mineralocorticoid and glucocorticoid receptors as mediators of the bidirectional effect of low-frequency electromagnetic field on the stress response

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https://doi.org/10.21175/rad.sum.abstr.book.2022.15.2

Recently we have found that the intensity and direction of shifts in hypothalamic–pituitary–adrenal (HPA) axis activity during repeated exposure to low-frequency electromagnetic field (50 Hz) ELF-EMF (1 and 7 mT) depend on the value of magnetic flux density. ELF-EMF of 1 mT led to adaptation to this stressor while 7 mT increased stress response. Accordingly, 1 mT ELF-EMF caused the beneficial shut-off of the HPA axis activity in response to another stress factor (open-field) and 7 mT ELF-EMF induced adrenal exhaustion. We suggest that the ELF-EMF-induced changes in HPA axis activity are related to hippocampal mineralocorticoid/glucocorticoid (MR/GR) dual-receptor system function.

The exposure (7-day, 1h/day) of adult rats to ELF-EMF (1 mT and 7 mT) was repeated 3 times. The level of MR and GR receptors in the hippocampus was analysed after each exposure to ELF-EMF. Moreover, we evaluated the impact of ELF-EMF on the change in the level of the receptors in response to subsequent stress factor - open-field test.

We have found an increase of MR and a decrease in GR receptors density in the hippocampus in rats exposed to ELF-EMF of 1 mT, however, in the 7 mT group the level of MRs was not detectable and the diminish of GR receptors level was more profound. After the open-field test, we observed almost complete restoration of GR level and further increase of MR receptors level in the 1 mT ELF-EMF exposed group. In the 7 mT group, such an effect was not observed.

The MR expression in the 1 mT ELF-EMF group represents an endogenous adaptive mechanism, which suggests the potentially protective impact of the ‘low” intensity ELF-EMF on the brain. The strong imbalance between MR/GR receptors expression after exposure to 7 mT ELF-EMF resulting in the disturbance of HPA axis activity may cause some harmful processes leading to nervous system disorders.

Acknowledgments: Grant from National Science Centre, Poland, no. 2017/25/B/NZ7/00638 and project no. POWR.03.05.00-00-Z302/17 Universitas Copernicana Thoruniensis In Futuro, a part of the programme Knowledge Education Development.

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The long-term effects of a single exposure to low-frequency electromagnetic field (50 Hz) – can it influence the response to other stress factors?

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https://doi.org/10.21175/rad.sum.abstr.book.2022.15.3

The low-frequency electromagnetic field (50 Hz) (ELF-EMF) can modify some crucial neuronal processes. Many studies have suggested an association between chronic ELF-EMF exposure and anxiety and/or depression. Existing data indicate that exposure to ELF-EMF may count as a mild stress situation and could be a factor in the development of disturbances of the brain stress system: the sympatho-adrenomedullary (SAM) system, which apart from HPA axis is one of two major components of the stress system in the organism. Our research has been directed toward verifying whether ELF-EMF single exposure changes the SAM system activity in response to subsequent stress factors.

An electromagnetic field (ELF-EMF) with the domination of magnetic components was generated by a 20 cm diameter coil composed of 282 turns of copper wire. The coil and variable autotransformer power supply produced homogeneous, sine-wave alternating EMF at 50 Hz and with intensities 1 and 7 mT. Each rat (3-month-old Wistar male) was placed in an opaque plastic box. The boxes were put into the centre of the EMF coil or sham exposure system (control). Animals were able to move freely within their chambers. Animals were divided into groups: 1) animals exposed to ELF-MF (50 Hz) of low (1 mT) or high density (7 mT) for one week, 8h/day. 2) Control animals were subjected to the same experimental procedure as the respective animals exposed to ELF-EMF except for magnetic field exposure. The open-field (OF) test was performed immediately and 1 month after the exposure to 1 mT ELF-EMF and additionally 2 and 3 months after the exposure to 7 mT ELF-EMF as well as in control groups.

The open-field (OF)-induced level of noradrenaline (NA) in the locus coeruleus, hypothalamus and adrenal glands was measured using HPLC. We also evaluated the impact of ELF-EMF exposure on behavioural changes occurring in response to subsequent stress factor - open-field (OF) test in animals previously exposed to ELF-EMF or control conditions.

We have found that the single ELF-EMF exposure results in different (dose-dependent) activation of the SAM system in response to another stress factor. A single exposure to ELF-EMF with a value of 1 mT resulted in a slight increase in noradrenaline level after OF in locus coeruleus, hypothalamus and adrenal glands. However, 1 month after exposure the level of the measured parameter was not significantly different from the control level, thus further observations were not provided. The characteristic of the response may indicate that in the organism some endogenous adaptive processes in response to ELF-EMF of low intensity are activated. ELF-EMF of 7 mT led to sustained stimulation of stress system activity after OF test to the end of observation (3 months after exposure), indicating that the stronger field - 7 mT is a factor, which can be recognised as harmful to the organism. Moreover, we also observed profound changes in the behaviour in the open-field test in rats exposed to EMF of 7 mT – their activity level was higher relative to both control and exposed to EMF of 1 mT animals. In animals exposed to 1 mT ELF-EMF, the distance moved and velocity did not differ from values noticed in control ones. The longest distance travelled and the highest velocity in OF was found in rats exposed to 7 mT ELF-EMF immediately after exposure to ELF-EMF. With time from ELF-EMF exposure, a decrease in the values of these parameters in OF was observed. We concluded that exposure to ELF-EMF of 7 mT can establish a new “set-point” for stress systems activity and move it into sensitization. Thus it can modify the response to other stress factors. Our research provided the new comprehensive data on the impact of ELF-EMF on mammalian organisms with reference to SAM system activity. There are new important data for reliable risk assessment of the exposure to ELF-EMF on human organisms.

Acknowledgments: Grant from National Science Centre, Poland, no. 2017/25/B/NZ7/00638.

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A new non-toxic liquid scintillator for fast neutrons detection

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https://doi.org/10.21175/rad.sum.abstr.book.2022.16.1

This work concerns the development of prototypes of 'new generation' scintillation detectors for fast neutrons. Traditional fast neutron scintillators are made of aromatic compounds such as anthracene or benzene. Despite these materials offer high detection properties, they are very toxic, flammable and difficult to manage in large quantities. For these reasons, research in recent years has focused on finding new types of scintillators with optimal detection properties, low safety risks and no waste disposal issues. Supporting this field, this research concerns the study of scintillation properties of new liquid materials with the final purpose of developing a fully characterized scintillation detector. The main goal is to find a material which, on the one hand is non-toxic and non-flammable and, on the other hand, has high cross section for fast neutrons, high light yield, transparency, stability for temperature and pressure and high discrimination capabilities among different radiation types. In order to find the best material, the first step is the study of optical properties of several liquid compounds. The optical analysis consists in the study of the emission spectrum, which is strictly related to self-absorption properties and scintillation yield of the liquids under investigation. By studying the scintillation spectrum and absorption properties of the compounds in the UV range, it is possible to select the best materials for the scintillation detector. From a preliminary study we chose the TMTPS (1,5-tetraphenyltetramethyltrisiloxane) doped with the PPO as primary dye.

Once the compound is optically characterized, the following step is the design of a suitable scintillation detector composed of a PMT coupled with the chosen liquid and the test of its detection properties with standard γ sources. Finally, the response of the detector to different radiation types, including neutrons, is analysed and radiation-discrimination capabilities are evaluated through Pulse Shape Discrimination (PSD) techniques. In order to perform this analysis we used both neutrons from Am-Be sources and 7Li(p,n)7Be reaction. PSD capabilities and light yield have been observed to strongly depend on the primary dye percentage. For this reason, the energy and PSD analysis have been conducted for more than one solution with an increasing dye percentage. Results of this work are promising for the development of a non-toxic and non-flammable innovative scintillation detector with excellent performances in terms of light yield and PSD.

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Influence of neutron irradiation conditions on maximal frequency of infrared absorption spectra of LiF:OH

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https://doi.org/10.21175/rad.sum.abstr.book.2022.16.2

For many solids operating under the radiation conditions, the study of their behavior at the neutron irradiation is of urgent interest. The work considers the influence of neutron irradiation conditions on infrared absorption spectra of lithium fluoride crystals containing different amounts of hydroxyl and metallic impurities. The investigations were carried out for discovering new peculiarities under the extreme irradiation conditions of LiF – being a very important material for practical applications. IR absorption spectra of irradiated LiF crystals were registered by double-beam spectrometer Specord 75-IR and by vacuum Furie spectrometer Vertex 70V. In the crystals with hydroxyl impurity after the action of neutron radiation, the quite clear bands are appeared in the region of 1900-2200 cm ^{1}. The used doses varied from 10^{14} to $3x10^{17}$n/cm^{2}. We investigated LiF crystals differing both in qualitative and quantitative contain of OH- ions. With the increase of irradiation dose, the maximum IR absorption of all investigated groups of crystals was shifted to the region of low energies. As it is known, at the neutron irradiation of LiF the increase of lattice parameter takes place. In our crystals the lattice parameter was increased from 4.026 (5) Á for non-irradiated sample to 4.032(5) Á in the case of irradiation at 90 K. The comparison of IR bands for the crystals of two different groups irradiated at the same dose shows that the absorption band for the crystals of one of these groups is shifted to the region of lower frequencies. Such shift is difficult to explain only by the change of lattice parameter, as at 3.1017n/cm^{2} for crystals of both groups at the irradiation temperature 90K the parameter is: a=4.032(0)Á and a=4.032(5)Á, respectively. These values are practically similar, but the maxima of IR absorption are different. Probably, the noticed shift of bands is connected also with anharmonic interactions of the vibrating oscillators themselves, the number of which, as well as the lattice parameter, depend on irradiation conditions.

Keywords: Neutron irradiation, IR spectroscopy, LiF:OH single crystal, lattice parameters

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A neutron collimating structure for an anisotropic proton beam generated secondary particle source

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https://doi.org/10.21175/rad.sum.abstr.book.2022.16.3

Middle East Technical University Defocusing Beamline delivers 15-30 MeV protons from a cyclotron to a 21.50 x 15.44 cm^2 test table for electronics and materials irradiation studies, using defocusing quadruples and two collimators. Around 10% of this beam gets stopped at the first collimator, and the subsequent proton-stainless steel interactions release highly energetic secondary neutrons (≤ 23 MeV), gamma rays (≤ 14 MeV), electrons and positrons (≤ 7 MeV) in particle fluxes exceeding 10^7 particles/cm^2/s. A secondary measurement system was designed and constructed around this collimator to provide radiation shielding in all but one direction, reduce the flux and energy of the produced secondaries, funnel neutrons into a 10 cm diameter beam and direct them to a testing area. This system consists of a moderating unit composed of special grade high-density concrete, a neutron funnel sandwiched between lead-based gamma-filtering plates, and a test station. A sample rotating mechanism, a beta-gamma Geiger counter, and a neutron detector are placed at the test station. This secondary measurement station provides a neutron beam with energies up to 5 MeV and adjustable 4000-10,000 neutrons/s fluence for various neutron irradiation studies.

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Device for determining the elemental composition by means of inelastic scattering of fast neutrons by matter at the EG-5 accelerator (Dubna)

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https://doi.org/10.21175/rad.sum.abstr.book.2022.16.4

A new nuclear physics facility that allows determining the elemental composition of materials is developing at the FLNP JINR (Dubna, Russia) at the moment. The method is based on the inelastic interaction of fast neutrons with matter. An analysis of the Y-quanta spectra from inelastic scattering of fast neutrons makes it possible to carry out a quantitative analysis of almost all elements of the periodic table, excluding unstable elements and noble gases, using the available tabular values of the Y-quantum spectra, energies and intensities of gamma transitions (schemes of emission of levels and their population directly in the course of the reaction). The first experimental results have been obtained.

The setup presented in [1] was used as a prototype. The authors of [1] succeeded in increasing the selectivity of the measurement of Y-quanta fluxes in the extracted and filtered beam of fast neutrons of the reactor due to special measurement geometry. Registration of Y-quanta was carried out by germanium-lithium detectors with working volumes of 30-40 cm3 (resolution 2-4 keV for Y-quanta with an energy of 1.2 MeV). The Y-radiation spectra for most elements were measured in the energy range from 0.12 to 3.4 MeV. Similar parameters are expected to be achieved at the installation, which is being developed by the authors of the work.

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Radioisotope power supply for printed electronic devices based on ZrO_2 nanoparticles

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https://doi.org/10.21175/rad.sum.abstr.book.2022.16.5

At the present stage of development of electronics, a tendency has been formed to reduce the size and power consumption of radio-electronic devices. Subvolt nanoelectronics and microsystem technology are gaining more and more mass. Accordingly, the requirements for power supplies also change: power requirements are reduced, but service life and dimensions become critical, and most importantly, scalability to the low-dimensional range, flexibility and transparency, if possible, as well as economic efficiency and manufacturability. The main of these requirements, in particular, the service life of autonomy, is satisfied only by radioisotope power supplies.

The working idea of this study is to use radiolysis and the high chemical activity of the surface of nanoparticles to convert chemical energy into electrical energy.

The hydrated surface of nanoparticles with a radioactive core is actually a nanoreactor of ions and radicals. In this work, nanoparticles based on ZrO_2 with a small content (3 mol%) of Y_2O_3 were taken as the core.

A polymer film filled with ZrO_2-based nanopowder was deposited on a glass substrate by the tape-casting method. Then electrodes were sprayed on top in the form of an interdigital structure. Field electrodes were applied on the reverse side of the glass with conductive glue.

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^{18}F-fluorodeoxyglucose positron emission tomography coupled with computed tomography (FDG PET/CT) in women with endometriosis

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https://doi.org/10.21175/rad.sum.abstr.book.2022.17.1

Introduction. Endometriosis is a common gynaecologic condition occurring in 5% to 10% of women of reproductive age and may also be present in 2-5% of postmenopausal women. In case of endometriosis, both inflammation and active fibrosis may lead to increased glucose metabolism which is detected on functional positron emission tomography (PET) imaging with 18F-fluorodeoxyglucose (FDG). The potential role of FDG PET to evaluate the extent of endometriosis or follow-up treatment appears actually limited since many lesions may show a low FDG uptake. In contrast, visible FDG foci corresponding to lesions of endometriosis may mimic foci of newly diagnosed or recurrent malignancies, the most frequent indication for this recent imaging modality of nuclear medicine. This interference may potentially lead to an inaccurate impact on patient's management. Therefore, endometriosis could be anticipated as a cause of false positive suspicion of malignant lesions on FDG PET in female patients referred for characterisation of abnormal images, in particular adnexal masses, or for cancer staging or restaging. In cooperation between our hospital and St Elisabeth Oncology Institute in Bratislava, Slovakia, we recently analysed the interference of known or suspected endometriosis in reporting FDG PET/CT performed in another indication.

Results. The PET/CT images of 18 women with known (n = 15) or suspected (n = 3) endometriosis were analysed. Based on clinical follow-up and results of other imaging, biopsy, and/or postsurgical histology, the presence of lesions of endometriosis at the time of FDG PET/CT was confirmed in 13 of 18 patients (72%). The patient-based detection rate of FDG PET/CT in patients with confirmed lesions of endometriosis was 8/13 (62%; confidence interval, 32%-86%). On per-lesion/site basis, FDG PET/CT detected 11 of 20 sites of endometriosis (55%). By quantifying the intensity of FDG uptake in the foci, the SUVmax of these lesions/sites ranged between 1.8 and 5.3 (median, 3.8). In 9 of 18 patients (50%), a total of 13 non-endometriosis-related lesions/sites were detected by FDG PET/CT; their SUVmax ranged between 2.7 and 23 (median, 9.4).

Conclusion. The interference of known or suspected endometriosis in reporting FDG PET/CT performed in another indication was limited but possible and should be kept in mind, even in postmenopausal women, as the oldest patient with FDG-positive endometriosis in our series was aged 63 years. The lesions of endometriosis showed inconstant FDG uptake with overlap of SUVmax with low-grade malignancies. In our series, the greatest SUVmax value of lesions of endometriosis was 5.3, somewhat higher than the threshold of 4 previously proposed for identification of malignant transformation of endometriosis itself.

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Standardization of the labelling process of [68Ga]gallium-PSMA-11 for PET/CT imaging of prostate cancer among radiopharmacies in France

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https://doi.org/10.21175/rad.sum.abstr.book.2022.17.2

In the European Union, the use of new and/or unregistered medicinal products which are not investigational agents of a clinical trial is possible via expanded access programs or compassionate use program.

This authorization is issued by medicine agencies under the following conditions:

- the medicinal product is intended to treat, prevent or diagnose serious/rare diseases;
- there is no appropriate alternative available on the market;
- their efficacy and safety are presumed according to the current scientific knowledge, the implementation of the treatment cannot be postponed and the patient cannot enter clinical trials.

For drugs which require extemporaneous preparation due to their stability or their physical properties (e.g. radionuclides), it is not possible to supply them from a single pharmaceutical establishment. A standardization method for the final product issued from different production sites, each one situated as close as possible to the patient, is therefore necessary.

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Superficial skin cancer therapy: can Nuclear Medicine techniques be included in the therapeutic algorithm?

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https://doi.org/10.21175/rad.sum.abstr.book.2022.17.3

Introduction. Skin cancer represents the most common type of human malignancy. In 2022, about 100000 people in the United States are expected to be diagnosed with some type of the disease (basal cell carcinoma, squamous cell carcinoma or melanoma), with an expected mortality of approximately 7.5%. Mohs surgery is the current golden standard treatment, radiotherapy and brachytherapy also being applicable, either as main or as adjuvant techniques. Multidisciplinary management is of utmost importance in order to optimize the therapeutic outcome. This fact necessitates in-depth investigation of the potential therapeutic role of Nuclear Medicine.

Materials and Methods. Contemporary scientific publications on skin cancer comprehensive management were selected. Selection criteria focused specifically on skin cancer therapy feasibility studies incorporating Nuclear Medicine principles and techniques. Special emphasis was put on highlighting promising application fields and proposed effective dose schemes.

Results. Our study revealed the increasing international research efforts on fabrication and application of beta-emitters' radioactive patches, as potential non-melanoma skin cancer therapeutic agents. Such a therapeutic approach holds the advantage of a straightforward preparation stage that may be fully carried out in the hot lab of a Nuclear Medicine department, as a fully in-house procedure. The shorter range of beta particles and their steeper dose gradient -as compared to gamma radiation- make them in principle suitable for the treatment of thin superficial skin tumours located in the vicinity of healthy radiosensitive structures, such as bone, cartilage or the eye. Patients may stay in the controlled environment of a Nuclear Medicine department room during the treatment. Dosimetric estimations produced by utilization of VARSKIN programme (computer software for dosimetric assessments) showed that superficial skin tumours located in a flat area can be controlled by a single fraction of 120 MBq Y-90 microspheres' patch therapy. In such a case, application of an Y-90 patch for a 2 h period may result in the deposition of a tumour control dose of 20 Gy at a depth of 2 mm. Application of Lu-177 patches is under investigation as well, in which case the Monte Carlo estimation of surface dose rate is approximately 8.7 $Gyh^{-1}mCi^{-1}$. P-32 patches are also mentioned in literature, with an activity of 37 MBq leading to a delivered therapeutic dose of 20 Gy at 1 mm depth in about 1.8 h. Regarding melanoma treatment, benzamide-based radioligands targeting melanin (paired with I-131) are in the stage of clinical assessment, in terms of both efficacy and toxicity.

Conclusion. Beta-emitters' radioactive patches appear as a promising, easy-to-use approach in the treatment of superficial, non-melanoma skin tumours located in a flat area. Practical parameters that may result in challenging tasks include possible difficulties in Y-90 microspheres provision, as well as the corresponding financial burden. Dealing effectively with such issues, along with further scientific investigation of Y-90, Lu-177, P-32 and other beta-emitters, may lead to the technique's clinical adoption, either as a stand-alone or an adjuvant tool. As far as melanoma skin tumours are concerned, I-131 labeled benzamides may constitute a reliable therapeutic solution for melanomas resistant to other forms of therapy. Clinical adoption of the above tools is expected to substantially enhance the role and therapeutic contribution of Nuclear Medicine.

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Copper(II) complex of the polyether ionophore lasalocid: synthesis and spectral characteristics

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https://doi.org/10.21175/rad.sum.abstr.book.2022.18.1

The veterinary therapeutic lasalocid, produced by *Streptomyces lasaliensis*, is the smallest representative of the natural polyether ionophores. The antibiotic increases the permeability of biological or artificial lipid membranes to specific ions. Similarly to other ionophores, lasalocid binds metal cations as neutral complex species and transfers them through the cell membranes. Inside the cell, the liberation of the captured metal ions occurs, which disturbs the metal homeostasis, activates the energy-dependent processes and leads to the ultimate cell death.

Lasalocid was found to react with monovalent metal ions of Li, Na, Ag, Tl and divalent cations of Sr, Ba. The structural data revealed that the drug serves as a polydentate ligand, but its coordination mode differs at significant level as compared to the complexation properties of similar antibiotics such as monensin and salinomycin.

At the present we evaluated the ability of lasalocid to bind copper(II) ions. Lasalocidic acid (LasH) reacts with copper(II) ions in the presence of a weak base to form dark green precipitates. The process occurs in acetonitrile solution, at metal-to-ligand molar ratio of 1:2. The isolated complex was characterized by means of UV-VIS, IR, EPR and NMR spectroscopies. The experimental data manifest the formation of $[CuLas_2]$ coordination species.

The UV-VIS spectra of the complex in ethanol solution display a low intensive band with a maximum at 720 nm, assigned to the d-d transitions in the metal(II) center influenced by ligation with oxygen atoms. The formation of a chromophore, bearing Cu-O bonds, is confirmed also by EPR spectroscopy. The powder EPR spectra of the complex in the range from 100 K to 295 K consists of an anisotropic signal, containing parallel and perpendicular components. The parameters $g_{||} = 2.36$, $A_{||} = 135$ G, $g_{\perp} = 2.06$, the ratio $g_{||} > g_{\perp}$ and the observed superfine structure are typical for O-containing mononuclear copper(II) complex species.

Due to the limited solubility of the green copper(II) complex, we studied its NMR properties by a solid NMR technique. The observed spectrum contains very broad ^{13}C-signals and no structural information can be retrieved, but the recorded data support the inclusion of the paramagnetic metal(II) cations into the composition of the complex.

The IR spectrum of lasalocidic acid consists of several characteristic stretching vibrations, assigned to carbonyl, carboxyl, phenyl and hydroxyl functions. The broad band in the range of 3500-3300 cm^{-1} is indicative for the presence of OH-groups in the antibiotic structure. In the spectrum of the copper(II) complex, the vibration of carboxylic fragment is not observed at expense of two new bands, assigned to the asymmetric and symmetric stretching vibrations of the carboxylate anion. The position and shape of the OH-band remain intact, which suggests the absence of water ligands in the antibiotic cavity and in the complex structure, respectively. Lasalocid is the smallest representative of the polyether ionophores and the short polyether chain does not allow the folding of the drug molecule into a head-to-tail pseudocycle. Moreover, in the hitherto known structures of this antibiotic, the formation of the typical hydrophilic cavity, able to host water, is not observed.

Based on available experimental results, we suggest that lasalocid binds copper(II) ions in a polydentate coordination manner, forming a mononuclear copper(II) complex possessing a distorted octahedral inner coordination sphere. The main chromophore unit is constructed primary by Cu-O bonds, with a carboxylate function of the ligand engaged directly in the complex formation. The elucidation of the exact structure of the here reported copper(II) complex requires the isolation of single crystals, suitable for X-ray diffraction studies.

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Phytotherapy of COVID-19 – An online survey results from the Republic of Serbia and the Republic of Srpska

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https://doi.org/10.21175/rad.sum.abstr.book.2022.18.2

Introduction. Among complementary and alternative medicines, phytotherapy represents most frequently used, readily acceptable and easily performed. Since the break-out of COVID-19 pandemic, numerous therapeutic approaches have been applied in combat against this infectious disease. The aim of study was to investigate the use of phytotherapy during the COVID-19 pandemics.

Materials and Methods. This research was conducted as prospective, cross section study, in a form of online survey, specifically created for purposes for this research. The questions in survey were of open, semi-open or closed type. Filling in the survey required less than 10 minutes. The survey was written in Serbian language, and it was distributed on the territory of Republic of Serbia and Republic of Srpska, via Internet. Participation was voluntarily. Surveys were obtained from December 2020- May 2021. All the collected data were analyzed using Tibco Statistica (v13.0), and the results were presented as observed frequencies or as number of reported uses (RU) in case of multiple choices questions.

Results. A total of 1704 responses were collected. Regarding the COVID-19, 24.47% (417) of participants declared that they had been in contact with someone who had the COVID-19 and 22.12% (377) declared that they believe they already had COVID-19. In the given number of interviewed people, approximately one quarter, 23.24% (total of 396 persons) declared themselves as users of phytotherapy with the purpose of prevention or treatment of COVID-19. The most frequently used medicinal herbs were: garlic- 235 RU, ginger- 190 RU, chamomile- 161 RU, mint- 149 RU and propolis- 147 RU. The users of phytotherapy stated different reasons for its application during COVID-19 pandemic. Most of them stated positive effect on immune system (367 RU). Second most frequent reported reason was positive effect on respiratory system (135 RU), followed by presumed effect in prevention and treatment of cough (94 RU). The most frequent route of administration was peroral, as medicinal herbs were drank or eaten (394 RU). Medicinal plants were frequently used, as more than half of people responded using them on a daily basis (54.11%) and 38.65% of phytotherapy users responded using herbs two or more times in a week. The sources of phytotherapy information were various. Most frequent sources were populist thematic literature (books and magazines) (162 RU), followed by internet (152 RU). Members of the family, partners or close friends were also frequently pointed out as sources of information (151 RU). Approximately one third of phytotherapy users (30.75%) stated they have informed their doctor about use of medicinal plants. A third of users (35.25%) consulted medical professional before the start of phytotherapy. Finally, COVID-19 was not the only reason for herbal therapy – 42.50% of persons using phytotherapy against COVID-19 were also using it in prevention or treatment of other diseases and conditions.

Conclusion. The presented results suggest that phytotherapy is recognized as potential alternative and complementary regimen in fight against COVID-19. Therapy is readily accepted and frequently used. In order to avoid side effects and harmful interactions with conventional drugs, a consultation with medical professional should be advised to patients.

Keywords: Phytotherapy, herbal therapy, survey, coronavirus, COVID-19

Acknowledgments: This work was supported by Provincial Secretariat for Higher Education and Scientific Research of Autonomous Province of Vojvodina (Project: The influence of phytopreparations and dietary supplements consumption and life habits on COVID-19 clinical representation, No. 142-451-2539/2021-03).

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Development of the quantitative determination of genistein as a certified reference material (CRM)

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https://doi.org/10.21175/rad.sum.abstr.book.2022.18.3

The use of certified reference materials (CRMs) ensures metrological traceability and comparability of analysis results. Synthetic genistein was chosen as a promising substance for certification of CRM. In previous studies have shown that genistein has radioprotective properties. The radioprotective efficiency of synthetic genistein is maximal when it is administered before irradiation. The possibility of creating a medicine based on it as addition to radiation therapy of tumors has been shown.

One approach to quantify a substance as a CRM is to use an absolute method such as titrimetry. Genistein is an isoflavone, which is insoluble in water, and is a very weak acid. Based on its properties, a non-aqueous titration with potentiometric end-point was chosen.

The aim of our study is to develop a method for the quantitative determination of genistein for certification of CRM.

A 0.1 M sodium hydroxide solution in a mixture of methanol and benzene was used as a titrant, and dimethylformamide was chosen as a medium. In the course of the study, integral and differential genistein titration curves were constructed. The integral curve is not very informative for a clear definition of the titration end point. It is recommended to use a differential curve. After statistical data processing, the content of the substance was 98.77% ± 1.04. A non-aqueous titration technique with potentiometric end-point determination for the quantitation of genistein was validated and the following results were obtained: RSD of 1.25% trueness, 1.2% precision, and 1.41% intermediate precision. All set parameters in terms of relative standard deviation meet the requirements for analytical methods of 2%. Thus, this technique can be used to certify a CRM of genistein, which in turn will ensure the quality of drugs and dietary supplements containing this substance and will be more widely used in medicine.

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Thallium bromide crystals formed by the hot press mold technique for flat panel gamma-ray detectors

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https://doi.org/10.21175/rad.sum.abstr.book.2022.19.1

Thallium bromide (TlBr) is a promising compound semiconductor for use in gamma-ray detector application such as single photon emission tomography (SPECT) and gamma-ray spectrometers. In this study, plate-shaped TlBr crystals were fabricated by the hot press mold technique from purified TlBr ingots with 15 mm in diameters x 15 mm in thickness. The ingot was sandwiched between surface coted punch plates and a furnace temperature was kept at around 500 degrees C at around 1 Pa. Press pressure on to the punch plates was increased up to 50 kN while keeping the temperature. Size of press molded TlBr crystals were around 5 mm x 5 mm x 2 mm. The TlBr crystals were cut into several wafers with 5 mm x 5 mm using a diamond wire saw. X-ray diffraction and electron back scatter diffraction (EBSD) pattern shows that single orientation domains are localized in the partial area on the TlBr crystals. TlBr gamma-ray detectors were fabricated from the several wafers and detector performance was evaluated by obtaining output signal from a pre-amplifier and gamma-ray energy spectra.

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Use of MAKROCLEAR organic dosimeters for radiochromic integrating dosimetry of hadron beams

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https://doi.org/10.21175/rad.sum.abstr.book.2022.19.2

Last year, a series of experimental irradiations of radiochromic integrating MAKROCLEAR dosimeters by hadron beams accelerated on a U-120M cyclotron was performed at the Center of accelerators and nuclear analytical methods of Nuclear Physics Institute of the Czech academy of sciences.

These dosimeters have been developed in the Research centre Rez since 2016. It is a solid-state clear polymeric material that responds to irradiation by changes in its optical density. For small doses, these changes first occur in the near UV region of the spectrum, then propagate into the light region and for even higher doses pass into the infrared region of the spectrum.

Dosimeters prepared in the shape of blocks measuring 10 x 10 x 20 mm were placed in a special aluminum holder, behind a 10 mm thick aluminum collimator with a 9 mm diameter aperture so that the proton beam axis passes through the center of the sample.

During irradiation, the hadron beam was simultaneously monitored by a Farmer ionization chamber connected to a UNIDOS electrometer calibrated in the absorbed dose, so that the absorbed dose in the sample could be read in real time. The samples were successively irradiated with 15.5 MeV and 34 MeV protons at doses of 500 Gy, 2,500 Gy, 5,000 Gy, 10,000 Gy, 15,000 Gy. Next, irradiation with 17 MeV deuterons followed at doses of 5,000 Gy, 10,000 Gy, 15,000 Gy.

It was followed by scanning the irradiated dosimeters on an Epson Perfection 850-Pro transmission scanner, through a series of color filters transmitting light wavelengths 640 nm, 580 nm, 510 nm, 450 nm, and through white light with a mean wavelength of 550 nm. The scanning was performed perpendicular to the beam axis to obtain information about the beam dose profile, and along the beam axis to obtain information about the depth dose curve (Bragg curve) of the respective type of radiation.

The MAKROCLEAR dosimeters can be very easily prepared in the required shape and size. Their availability is easy, the purchase price is very low (approximately 1 eurocent per piece). Their evaluation is cheap, easy and fast, without the need for expensive or bulky laboratory equipment. In literally minutes, 3D information on the hadron beam dose profile and depth dose curve can be obtained, including the position of the Bragg peak, the dose at the Bragg peak, the dose ratio at the Bragg maximum to the plateau dose, and the maximum particles range. Because the material of dosimeter has only an 8% higher density than the average density of the human body, the method can also be applied to Bragg curves in hadron therapy of oncological diseases.

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Online dose and energy reconstruction of proton beams using a scintillator stack detector

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https://doi.org/10.21175/rad.sum.abstr.book.2022.19.3

In recent years, scintillating materials have become of great interest for dosimetry purposes, mostly for the depth-dose distribution of conventionally accelerated proton beams [1-3]. The main reason for that is the possibility to implement the signal read-out in real-time - which is a strong advantage over commonly used passive diagnostics such as Radiochromic films (RCF) [4], requiring time-demanding post-processing.

Here,we would like to present a new compact, online, and cost-effective device made of a number of thin plastic scintillators arranged in a stack. The detector has been tested for the first time at the ŘEŽ cyclotron accelerator located in Prague, Czech Republic, which provides protons up to the energy of 35 MeV. The device has proved not only to reconstruct the depth-dose distribution of the incoming proton beam but also to unfold the beam energy using a previously developed technique [5], which makes the scintillator stack a useful "two-purposes" tool in beam characterization and a promising substitute for passive RCFs. The concept of such a device is applicable for both conventional and laser-plasma accelerated protons.

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Dosimetric characterization of $BaSO_4$ phosphors activated by Eu for proton, gamma and X-ray beams

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https://doi.org/10.21175/rad.sum.abstr.book.2022.19.4

Purpose/Objective. Thermoluminescence (TL) is a significant technique used for detecting and measuring the ionizing radiations and in the diagnosis, treatment, and monitoring of patients exposed to radiation. The present work focuses to establish the TL characteristics of $BaSO_4$: Eu phosphors after exposure to low-energy protons, gamma rays and X-rays.

Materials/Methods. $BaSO_4$ phosphors activated with various concentrations of Eu were prepared by co-precipitation method. The highest sensitivity was obtained for an Eu concentration of 0.5 mol%. For studying the dependence of TL output on radiation quality, powder samples of about 10 mg were irradiated with Co-60 γ- rays (reference quality), 15.2 MeV protons, and medium (100 to 225 kV) and high energy (6 MV and 15 MV) X-rays. Absolute dosimetry was ensured with ion chambers. The TL dose response, glow curve structure and shape, reusability, fading and the radiation quality dependence were consequently studied.

Results. TL glow curve of optimized $BaSO_4$: Eu irradiated with doses up to 1 Gy display a major peak at ≈ 225 °C, which can be attributed to a simple distribution of the luminescence traps. Dose-response analysis over the dose range 0.2-1 Gy showed that the response of γ-irradiated samples was 1.7 times higher than following proton irradiation. Irradiation with 100, 160 and 225 kV X-rays gave approximately 40 times higher response compared to γ-irradiation. The TL response of high-energy X-rays (6 MV and 15 MV) appears to have about the same sensitivity as that of γ-irradiation. The reusability test for was performed for ten consecutive reading and annealing cycles of the same samples irradiated with X-rays in each cycle. The TL intensity showed a slight decrease after the first cycle and then stabilized. The TL signal fading measurement was performed for γ-irradiated samples over 50 days storage in dark atmosphere. During this period 7 % of TL signal loss was observed.

Conclusion. The radiation quality dependence study shows that the TL output per dose to water of the $BaSO_4$: Eu nanophosphor is dependent on radiation type (γ-rays vs protons) and photon energy (γ-rays vs X-rays). The strong X-ray energy dependence may be explained by the high mass energy absorption coefficient of the $BaSO_4$ compound. However, the simple glow curve structure, excellent reusability and low fading indicate favorable properties for dose determination in radiotherapy, as long as the samples are calibrated in the user beam.

Acknowledgments: This work was supported by the Research Council of Norway (Project ID: 299181).

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Raman piezospectroscopic analysis of mechanical stress in silicon nitride and alumina nitride ceramics irradiated with fast bismuth ions

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https://doi.org/10.21175/rad.sum.abstr.book.2022.20.1

This work presents the results of a comparative analysis of residual mechanical stress profiles in AlN and the previously obtained data on Si_3N_4 [1] – nitride ceramics with different structural responses to the high-energy heavy ion impact.

Depth-resolved Raman piezospectroscopy was used to study residual mechanical stress profiles in polycrystalline silicon and aluminum nitrides irradiated with 710 MeV bismuth ions to fluences of 1×10^{12}, 2×10^{12}, and 1×10^{13} cm^{-2}. It was found that stress fields of opposite signs are formed in the irradiated Si_3N_4 layer, separated by a buffer zone located at a depth coinciding with the thickness of the sample layer, amorphized at high ion fluences due to multiple overlapping of track regions. At great depths, tensile stresses witch magnitude reaches their maximum value in the region of the end of the ion range are detected. In contrast to Si_3N_4, radiation-stimulated changes in mechanical stresses in AlN were within the measurement error throughout the entire thickness of the irradiated layer, except of the near-surface region. The observed effect is associated with the different structural sensitivity of silicon and aluminum nitrides to high-density ionization - the formation of amorphous latent tracks in Si_3N_4 and their absence in AlN.

In the irradiated silicon nitride layer, stress fields of different signs are formed, separated by a buffer zone located at a depth coinciding with the thickness of the sample layer, amorphized at high ion fluences due to multiple overlapping of track regions. Deeper, tensile stresses are registered and reach its maximum in ion end of range. Compared to Si_3N_4, mechanical stresses in AlN are found to be out of experimental inaccuracy only at a Bi ion fluence of 1×10^{13} cm^{-2}.

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Acknowledgments: The work was carried out under the grant of the Ministry of Education and Science of the Republic of Kazakhstan AP 08856368 “Radiation resistance of ceramics based on nitrides and carbides in relation to the impact of heavy ions with energies of fission fragments”.

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Self-oscillations of particle yield from methane films irradiated with an electron beam: experiment and simulation

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https://doi.org/10.21175/rad.sum.abstr.book.2022.20.2

The ongoing interest in research of radiation effects in solid CH_4 is driven by its significant role in astrophysics, technology of cryogenic moderators, radiation physics and chemistry. The phenomenon of delayed desorption was observed during irradiation with neutron flux [1, 2], ions [3, 4] and electrons [5]. In our experiments [5], unlike the previous ones, two types of self-oscillations in the yield of particles from solid CH_4 were detected. The first theoretical model of the self-oscillations with short and long periods was suggested [6]. Here we present an outgrowth of this research.

Samples of solid CH_4 with a thickness of 100 μm were grown by a condensation of gaseous CH_4 onto a Cu substrate cooled to a liquid-helium (LHe) temperature T=4.2 K. The substrate was placed in a vacuum chamber with a base pressure P of 10^{-7} torr. The open surface of the samples allows the simultaneous registration of several relaxation emissions: electrons, photons and desorbing particles. The irradiation was performed in dc regime with electrons of subthreshold energy (1 keV) to avoid the knock-on sputtering. The total yield of particles from the surface of solid CH_4 was characterized by an increase in P in the vacuum chamber. The measurements were carried out in the dynamic pumping mode. After a long exposure (about an hour) to an electron beam at LHe T, we observed an explosive emission of particles from an irradiated CH_4 film. This "explosion" resulted in a drop in the chamber vacuum by two orders of magnitude. The central peak of explosive particle emission was preceded by oscillations in the yield of particles with increasing amplitude. The oscillation period τ appeared to be dependent on the irradiation current density j and decreased with increasing j of the electron beam. The ejection of particles was accompanied by a sharp increase in T of the CH_4 film, followed by a slow decrease.

The calculations performed showed that, along with the previously detected temperature self-oscillations in irradiated solid CH_4 that manifested themselves in a sharp and large temperature increase, there are oscillations with smaller temperature fluctuations and a shorter period. Self-oscillations are defined by the activation nature of diffusion and radical recombination processes. Two types of oscillations are a periodic change of temperature and concentration with time of some decay products of a CH_4 molecule upon irradiation: hydrogen atoms and the CH_3 radicals. The two processes of self-oscillations are interconnected: instability in the system of CH_3 radicals affects the fluctuations in the concentration of hydrogen atoms. The effect of decreasing the concentration of CH_4 over time (due to various fragmentation reactions during irradiation) on the temporal dynamics was taken into account. It has been shown that the temporal dynamics of particle desorption repeats the dynamics of self-oscillations.

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Experimental measurements of secondary neutrons on particle accelerators

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https://doi.org/10.21175/rad.sum.abstr.book.2022.21.1

Fast digital spectrometer for neutron spectroscopy is presented. A pulse shape discrimination (PSD) performance of the spectrometer has been evaluated within two experiments with different neutron energies. A modular design of the spectrometer allows a variety of measurements in mixed radiation fields. The detector signal output is connected to an analog input amplifier and split into two channels with a different gain. Each signal channel is digitized by a fast analog digital converter. The digital channels are merged into one composite channel with a higher digital resolution in a wide dynamic range of energies.

The experimental measurements of secondary neutrons were carried out in the laboratory of Van de Graaff accelerator and at the Proton Therapy Center in Prague. A detector with liquid scintillator NE-213 was employed in both experiments. Secondary neutrons with maximum kinetic energy of 17 MeV were produced. In a workplace of the Proton Therapy Center, secondary neutrons were generated during the interaction of the primary proton beam of energies in the range of 100 to 200 MeV with a plastic phantom.

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Comparison of the Monte Carlo simulations for modeling a well-type HPGe detector

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https://doi.org/10.21175/rad.sum.abstr.book.2022.21.2

Monte Carlo (MC) is a method that provides great convenience to users both in the validation of experimental results and in conducting research that cannot be done experimentally. Parallel to the developing technology in nuclear instrumentation, the use of the MC simulation method with proven accuracy and reliability in gamma spectrometry is increasing day by day. MC-based simulation techniques have been successfully used to evaluate HPGe detector response for wide energy range gamma-rays and different geometries. Since MC programs have advantages/deficiencies relative to each other, making a comparative evaluation using several MC software at the same time for selected situations leads the user to the most accurate result. In this study, a well-type HPGe detector was modeled using PHITS, a general-purpose MC program, which has been shown in our previous studies to be used reliably in modeling coaxial HPGe detectors. In addition, both method validation and MC programs were compared by using GESPECOR, which is a specific-purpose MC program. Well-type HPGe detectors are preferred in gamma-ray spectroscopy laboratories, especially in radioactivity analyzes of samples with low amount and activity, because of their high counting statistics, since 4π counting geometry is provided in the well. In both MC simulation programs, the detector was modeled by defining all the geometric parameters of the detector given by the manufacturer, such as the dimensions of the crystal, the dimensions of the well, the dimensions of the end cap, and the thickness of the dead layer. Well-type detector modeling in GESPECOR is done by entering the information given by the manufacturer since it is available in the program; In PHITS, after the detector is modeled using cylinder, sphere, and torus geometric shapes, the size information given by the manufacturer is entered. For comparison, full energy peak efficiency values of 63.3 keV at low energy and 1460 keV at high energy of a sample in SiO_2 composition in small tube geometry placed inside the well were used in both programs. When the full energy peak efficiency values obtained were examined, a difference of <7% was found between PHITS and GESPECOR, showing that the PHITS MC program could be used in well-type detector modeling.

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Correction of the contribution of scattered photon radiation to the ionization chamber readings during the X-ray radiation quality assessment

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https://doi.org/10.21175/rad.sum.abstr.book.2022.21.3

The study devoted to the investigation of the possibility of the scattered photon radiation contribution mitigation to the ionization chamber readings during quality characteristics assessment of X-ray facility radiation by the means of HVL1 and HVL2 for the (N, H, L) quality series according to the ISO 4037-1:2019. Compensation of the scattered radiation contribution to these quantities was done by means of the correction coefficients. The calculation of the coefficients was carried out by zero aperture approximation method implemented in the Fluka Monte Carlo code. Unlike other similar methods, the proposed method utilizes air kerma as a main calculation value. Using air kerma instead of deposited energy enables the calculation time reducing in several times.

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Development of a standard dosimetric facility with protection against external radiation background for the metrological support of highly sensitive radiation monitoring devices in accordance with the requirements of international standards

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https://doi.org/10.21175/rad.sum.abstr.book.2022.21.4

An important task in radiation monitoring is the correct measurement of dose rate at the level of natural radiation background. For this purpose it is necessary to use measuring instruments with high sensitivity, low level of own background and high temporal stability. In this case, an important problem to be solved during calibration of dosimetric measuring instruments is to provide the lower limit of the measuring range at the level of the ambient background radiation. International technical standards IEC 61017:2016 and IEC 60846-1:2009 recommend the lower limit of dose rate measurement range for ambient radiation monitoring at 0.03 ÷ 0.05 μSv/h. For metrological support of dose rate values at the 0.03 - 0.1 μSv/h (μGy/h) level for calibration or verification of measuring instruments, it is necessary to create standard gamma radiation fields of near background levels with minimal influence of natural radiation background using standard measuring instruments.

Research on this topic has been discussed as part of the work of the WG15 working group of the International Electrotechnical Commission (IEC) subcommittee 45B “Radiation Protection Instruments”. As of 2019, a group of experts is developing a new international technical standard ISO/AWI 20956 “Low dose rate calibration of instruments for environmental and area monitoring”. The new verification scheme of the Russian Federation 2020 contains requirements for working standards having protection against external radiation background for metrological support of gamma radiation fields of near background levels for dose rate of 0.03-0.3 μGy/h (μSv/h).

Besides questions of metrological assurance of dose rate values at 0.03 - 0.3 μSv/h at standard dosimetric facility with protection against external radiation background, it is required to solve a number of problems related to the presence of scattered radiation, work in the radiation field of point gamma radiation sources and accuracy of positioning of measuring instruments due to the limited working space of such facility.

In the report the problems of metrological support of dose rate values at the level of 0.03 - 0.3 μSv/h are discussed; the results of model calculations of the developed facility parameters by Monte Carlo method are presented, and solutions proposed for creating the standard dosimetric facility with protection against external radiation background are proposed.

Implementation of this reference dosimetric facility at “ATOMTEX” enterprise will allow calibration and verification of serially produced dosimetry instruments in the range of dose rates from 0.03 to 0.3 μSv/h in accordance with the requirements of international technical standards.

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Experience in creating a calibration laboratory in accordance with the requirements of ISO/IEC 17025 for the calibration of environmental dosimeters

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https://doi.org/10.21175/rad.sum.abstr.book.2022.21.5

Ensuring the reliability of dosimetric equipment is an important task for both manufacturers and consumers. The development of accurate calibration methods plays an important role, regardless of whether the laboratory develops its own methods or includes existing ones. There are many factors to take into account when calibrating environmental dosimeters. In addition to the general risks of using improper equipment or failures in processes requiring strict control, calibration procedures and tools can potentially vary from laboratory to laboratory.

The ISO/IEC 17025-2019 “General competency requirements for testing and calibration laboratories” accreditation of calibration laboratories allows laboratories to demonstrate their competently perform their work and provide reliable results, thereby increasing the confidence in their work both at the national and global levels. The standard also promotes cooperation between laboratories and other bodies by ensuring wider recognition of the results of activities between countries. Calibration certificates can be accepted in different countries with no additional testing required, which in turn promotes international cooperation.

The report presents the experience of creating a calibration laboratory in the field of ionizing radiation measurements and confirmation of compliance of its activities with the basic requirements of the international standard ISO/IEC 17025-2019.

Dosimetric radiation monitoring devices: dosimeters, dosimeters-radiometers, dosimeters-spectrometers, spectrometers, dose rate meters, detection units, multichannel systems with detection units designed to determine the air kerma rate, ambient and directional dose equivalents rate of gamma radiation are calibrated using reference dosimetric facilities. The report examines technical characteristics of reference facilities, specific features of ensuring their metrological traceability to the International System of Units (SI), as well as contribution to uncertainty in determining the calibration factor.

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Case report of a patient with compressive ureteral obstruction due to cervical cancer pelvic mass

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https://doi.org/10.21175/rad.sum.abstr.book.2022.22.1

Introduction. Cervical cancer is one of the leading female malignant diseases worldwide. Due to the introduction of cervical screening many countries witnessed a drop in advanced and inoperable stages. However, besides the regular screening, there are still cases of an advanced inoperable disease that rapidly expand and compress and/or infiltrate surrounding tissues and organs in the pelvis. Beside the introduction of new target therapy, the external beam concurrent radiotherapy followed by brachytherapy is the mainstay of cervical cancer treatment.

Such is the case of 45 years old female patient with diagnosed inoperable HPV associated cervical cancer with loco-regional spread in pelvis (clinical stage IIIB) with consecutive bilateral ureteral compression which resulted in acute renal failure. Initially patient was with unilateral nephrostomy and on chronic hemodialysis. Laboratory results had an elevated leucocytes ($22x10^9$/l), increased levels of degradation products (urea, creatinine), as well as an increased levels of Gamma-glutamyl transferase (GGT) enzyme and other transaminases.

Objective. Since there were no options for surgical treatment or systemic oncological treatment, it was decided to irradiate the patient as the only possible curative method with an aim for eventual ureteral decompression and restoring the kidney function. An intra-venous antibiotic therapy was applied with modulated dose and an external beam radiation therapy was started. It was decided not to give Cisplatin concomitantly with the ongoing radiation treatment, because of bilateral renal failure and because of patient decreased performance status. Standard fractionation radiotherapy was administered in 28-daily fractions till reaching 50.4Gy with added consecutive boost of 10Gy (total 60.4Gy).

Results/Clinical Outcome. Tumor infiltrated the whole of the uterus and initially at the start of the treatment and its volume measured 640.3ccm. At the 17^{th} radiotherapy fraction it reduced to 548.5ccm. At the 27^{th} fraction it measured 342.4ccm, but despite the almost 50% tumor reduction, there was no visible ureteral decompression and no conditions for performing an intracavitary brachytherapy. Therefore, a 5-fraction consecutive boost (TTD=10Gy) was added. There was still no spontaneous urination function, however neprostomy urinary elimination increased, patient condition during the treatment stabilized and patient had a reduction in hemodialysis days.

Laboratory results showed a normalization of leucocyte levels (5.54×10^9/l), creatinine levels decreased in normal range (83μmol), Potassium reduced to (4.6mmol/l) and GGT normalized (46U/l).

On the first post-treatment checkup, patient was still with neprostomy catheter, but not on hemodialysis, wheelchair free. Vaginal smear result with no malignant tissue detected, however vaginal swab test showed presence of bacteria. Because of present necrosis a second smear was taken.

On the second checkup, patient started to urinate spontaneously and second vaginal smear result showed no malignant cells present.

Conclusion. It can be concluded that in cases of HPV associated cervical cancer tumors with bilateral ureteral obstruction, radiotherapy can be an effective desopstructive treatment.

Keywords: Cervical cancer, ureteral obstruction, hemodialysis, radiotherapy

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Improved treatment with bevacizumab in advanced cervical cancer – Case report

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https://doi.org/10.21175/rad.sum.abstr.book.2022.22.2

Metastatic cervical cancer is still a significant health problem, especially in developing countries where approximately 70% of cases at first diagnosis are with advanced disease. Platinum resistance after chemoradiotherapy, as well as the lack of sufficiently effective chemotherapy, makes metastatic disease with limited therapeutic options and the worst clinical outcome, according to the 5-year survival rate.

Cervical cancer is an aggressive, angiogenically controlled disease in which vascular endothelial growth factor (VEGF) is a key mediator of angiogenesis, a process that directly correlates with disease development and progression. Bevacizumab is a human VEGF - a neutralizing monoclonal antibody that blocks this mediator. Paclitaxel-cisplatin in combination with bevacizumab has a strong recommendation (I, A) for first-line treatment of metastatic or recurrent cervical cancer, balanced between efficacy and toxic profile.

The University Clinic for Radiotherapy and Oncology - Skopje has a positive treatment experience for metastatic cervical cancer with bevacizumab. Patient MT, 34 years old, in 2019 with a biopsy received a histopathological finding for adenosquamous cervical cancer, inoperable, clinical IIB stage. With definitive chemoradiotherapy treatment (50.4Gy competing with 5 cycles of weekly cisplatin) and brachytherapy (21Gy), implemented until January 2020, partial regression was achieved, with a residual cervical lesion (9x7mm). In March 2021, computed tomography (CT) verified multiple metastatic changes: bone (vertebrae C2, osteolysis of the right clavicle), retroperitoneal lymphadenopathy, focal lesion of the right adrenal gland. In April 2021, bisphosphonate therapy (zoledronic acid) and chemotherapy (paclitaxel-carboplatin) were started in combination with target therapy (bevacizumab - 15mg / kg). Palliative radiotherapy (20Gy) was performed in the cervical spine (C2-3) and right clavicle. In July 2021, after six cycles of combined treatment, complete remission of metastatic changes was verified with control CT. Bisphosphonate and target therapy with bevacizumab have been continued as maintenance therapy. A total of 14 cycles of bevacizumab were performed until January 2022. During the whole period of therapy, the general condition of the patient is ECOG PS = 0, without the occurrence of any side effects. The patient is still without disease progression, in good general condition.

Bevacizumab is the first targeted therapy in cervical cancer, achieving a 26% reduction in the risk of death (HR = 0.74) and a 33% reduction in the risk of disease progression (HR = 0.67). Prolonged overall survival and progression-free survival are a major step forward in the treatment of persistent, recurrent, or metastatic cervical disease that has had limited treatment options for decades.

Keywords: Bevacizumab, cervical cancer, metastatic, persistent, recurrent disease

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Evaluation of induced radioactivity over time for medical linear accelerators

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https://doi.org/10.21175/rad.sum.abstr.book.2022.23.1

Purpose. In recent years, along with demand, the number of replaced and discarded linear accelerator has increased in Korea. As for linear accelerators using a high energy of 8MV or higher, concentration of radionuclides owing to radiation should be considered because of photonuclear reaction radiate the components of the accelerator and materials. In Korea, in order to reduce the risk of activation from radioactive materials, disposal/decommissioning must be carried out when clearance level for activity is less than that specified in the regulation. However, it is difficult to measure the concentration of radionuclides induced by parts, and it is very difficult to assess the change in radioactive concentration over time. Therefore, in this study, medical linear accelerator equipment was simulated with Monte Carlo codes, and the storage period and disposal/ decommissioning period were confirmed by analyzing the radionuclides and concentrations of each part immediately after the beam was shut down.

Materials and Methods. Radionuclides and concentration of radionuclides over time were identified using PHITS(ver 3.25) code and DCHAIN code. The equipment used in this study are Varian Clinac iX, Elekta Agility™, and Siemens Oncor Expression, and major parts such as target, primary collimator, flattening filter, ion chamber, bending magnet, jaw and lead block were simulated in consideration of 15MV and 10MV energy in which photonuclear reactions occur well. It was assumed that medical linear accelerator was operated for 10 years with an intensity of 80Gy/day and 40Gy/day to check the activity levels, and changes in the concentration of radionuclides and radionuclides for each parts were confirmed after shutdown of the equipment over time, and it was checked whether it complied with the standard value of 10^3 bq/g for the clearance level for activity.

Results. The concentration of radionuclides over time was confirmed by adding the concentration values of all nuclides generated by each part. 30 minutes after shutdown, the ion chamber, bending magnet, and lead block among the equipment using 15MV/10MV energy were confirmed to be less than the permissible concentration value. It was confirmed that the concentration of radionuclides in all three components of equipment using 10MV energy fell below the clearance level for activity after 2 months, but with 15MV energy, target, primary collimator, and flattening filter remained higher than the permissible concentration of self-disposal after 6 months. In particular, it was confirmed that the radioactive concentration of target of the three-equipment using 15MV energy was $1.60*10^3$ to $2.28*10^4$ bq/g even after one year, exceeding the permissible concentration for self-disposal. Typical radionuclides that remain above 1bq/g after 6 months were identified as ^{51}Cr, ^{54}Mn, ^{55}Fe, ^{57}Co, ^{58}Co, ^{179}Ta, ^{181}W, and ^{185}W.

Conclusion. Considering the clearance level for activity specified in the regulation in Korea, the target of the 15MV Varian, Elekta, and Siemens equipment had to be stored for at least 6 months to be disposal, while the same parts of 10MV equipment could be disposed of after 2 months. If the radioactive concentration can be predicted in consideration of the energy and workload used for each medical linear accelerator as described above, it is considered that guidelines for workers to work safely so as not be exposed to radioactive material during decommissioning /disposal can be presented.

Keywords: PHITS Monte Carlo code, DCHAIN, radioactivity, radionuclide, clearance level

Acknowledgments: This research was supported by the Nuclear Safety Research Program through the Korea Foundation of Nuclear Safety (KoFONS) using the financial resource granted by the Nuclear Safety and Security Commission (NSSC) of the Republic of Korea(No. 2003013) & Korea Institute of Radiological & Medical Sciences(KIRAMS) grant funded by the Korea government(Ministry of Sciences and ICT)(No. 50572-2022).

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Design and development of an irradiation facility for X-ray radiography and tomography at Politecnico di Milano

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https://doi.org/10.21175/rad.sum.abstr.book.2022.23.2

In the last two decades, lab-based X-ray Computed Tomography (XCT) has established itself as a powerful and polyvalent tool to perform non-destructive testing (NDT) and is now employed in many fields of both academia and industry. Since it allows to visualize the 3D internal morphology of a sample at various spatial scales and through time, XCT has proved to be very useful in the morphological characterization of electrochemical devices, such as fuel cells and batteries.

As part of the *Energy for Motion* project, the Nuclear Measurements Laboratory of Politecnico di Milano is designing and developing an XCT facility, to support the research activities in the field of electrochemical device engineering, and to analyse objects of different density, atomic number, and size (from few cm up to 20 cm).

The facility will be based on a custom XCT scanner, which is currently under development. It will consist of an X-ray source, a positioning system with a rotating stage, an X-ray camera, and a computer for control and data processing. In this preliminary phase, both theoretical modelling and experimental activities have been performed, in order to assist the design of the facility and predict the performance of a given setup.

The X-ray source of the scanner is a high-power medical X-ray tube (RTC1000HS by IAE). A theoretical model of the source was realized, using the general purpose Monte Carlo (MC) code FLUKA. Both the X-ray fluence energy spectrum and the 2D spatial distribution of the source were calculated for various high-voltages (40-150 kV) at a fixed distance from the focal spot. Moreover, measurements of the unfiltered X-ray spectra were performed using a collimated HPGe detector. A first comparison between the theoretical and measured data gave a good agreement in the shape of the normalized energy spectrum.

Furthermore, a MC code was written in MATLAB® to investigate the limits in the inherent spatial resolution of the source. Indeed, the relatively large focal spot diameter (0.6 mm) of the X-ray tube can blur the image due to geometrical magnification ("penumbra" effect). This is especially critical in high-resolution applications, i.e., for small field-of-views (FOV). The code simulates the irradiation of a sharp edge cylinder (totally opaque to X-ray radiation) a few cm in diameter (depending on the desired size of the investigated object) and calculates only the contribution of the geometrical magnification to the Modulation Transfer Function (MTF) of the system. Results show that resolutions of 30 μm could be achieved with sufficiently small objects.

Regarding the X-ray camera, the chosen configuration is based on a GADOX (Gd_2O_2S) scintillator screen coupled to a CCD sensor via a 90° mirror and a photographic lens, a common choice in X-ray imaging. A model of such type of detector was developed, with a particular attention to the response of the scintillator, which is the most critical stage for the signal and resolution properties of an X-ray camera. The model can calculate the light-output and the MTF of a GADOX scintillator of given thickness and for a given X-ray energy, considering both the direct contribution of the impinging beam, and that of the K-fluorescence X-rays generated during the irradiation. The novelty of the presented model is that it is able to calculate the aforementioned quantities with a fast numerical computation, without the need of MC simulations. Regardless of the simplifying assumptions, the results of the theoretical model showed excellent agreement with numerical calculations carried out with FLUKA for energies up to 100 keV. Future experimental results are foreseen to validate the model.

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Training capabilities for the first responders at a CBRNe event at the Centre for Energy Research (EK)

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https://doi.org/10.21175/rad.sum.abstr.book.2022.24.1

The article presents the training and practice opportunities of the FOSTER (**F**irst resp**O**nder**S** cen**T**er at the Center for **E**nergy **R**esearch) courses at the Centre for Energy Research (EK) for the first interveners.

At a CBRNe (Chemical, Biological, Radiological, Nuclear, explosive) event several organizations have to work together to handle properly the event. This is a difficult task, the first responders are from different organisations have to practice together based on a common procedure. The Nuclear Security Department (SBL) of EK established an indoor and outdoor training site (FOSTER) at the Centre for Energy Research. After the establishment several training events were held at the FOSTER sites.

The international exploration joint actions organized by the Including EU project were examined. The outdoor site was the place where the "train the trainer" event and the Hungarian Joint Action of the Including was held. The Police and EK made a demonstration from the common procedure for exploration.

One of the main tasks of the Nuclear Security Department (SBL) of EK is to explore, collect, identify and store the lost orphan nuclear sources, materials in Hungary as delegated in the 490/2015 (XII.30.) governmental decree to EK. Also, this decree requires the relevant intervention procedures and the steps of the intervention (which organization, when) in such cases.

EK is the Technical Support Organization of the Hungarian Atomic Energy Agency (HAEA) and has got also cooperation programs with the:

- Police
- Disaster Management Directorate (DMD)
- Counter Terrorism Center (CTC)
- Military of Hungary (MH)
- MH Görgei Artúr Chemical Protection Information Center (GACPIC)
- National Bureau of Investigation, Hungarian Police
- National Tax and Customs Administration (NTCA)

The Including project: INCLUDING is seek to provide a full-fledged and comprehensive training in the RN security sector at European level. Starting from the existing training resources of the Partners in the Consortium, in most cases developed in the framework of EC projects, INCLUDING aims to enhance practical know-how and to boost a European sustainable training and development framework for practitioners in the RN Security sector. Far from being a simple aggregation of entities separated geographically and with complementary expertise, INCLUDING is intended to be a cluster of facilities and resources pursuing a Federated Model in which individual components will cooperate together to provide a common framework for optimizing the exploitation of all the potentialities available in the Cluster.

The Centre for Energy Research established an indoor and an outdoor training field at the EK for the training and harmonizing the different organization's procedures of exploring orphan radioactive sources/nuclear materials.

Several scenarios can be performed at these training fields utilizing the available natural and technical conditions like the "C" level isotope laboratory, a hangar with normal background and enhanced background supplemented with neutron field.

For outdoor scenarios the EK created an outdoor site at the KFKI campus. It is placed inside a forest clearing. A hot zone can be designated, and an observer station is placed at the site. At the indoor site several scenarios can be done like parking lot, BCP (border control point), highway accident etc.

At the training sites UGV and UAS, testing is also available. The EK also made UGV tests.

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Synthesis of nanocomposites for radionuclide binding

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https://doi.org/10.21175/rad.sum.abstr.book.2022.24.2

Radioactive cesium (Cs-137) and strontium (Sr-90) are hazardous environmental pollutants with half-life periods 30.07 and 28.79 years and long biological half-lives. These radionuclides may be disseminated in the environment during nuclear incidents such as nuclear power plant failures, dirty bomb, radioactive waste disposal and accidents of radiopharmacy facilities. The adverse human health issues include irreversible genetic effects and oncological diseases. There are known Cs-137 antidotes available such as Radiogardase®-Cs produced for the Western European countries and the Ferrocin® produced and disseminated in the Russian Federation and the satellite countries. It is crucial to emphasize that antidotes are effective only when taken before or shortly after exposure to Cs-137.

Several researchers have reported of attempts to improve the sorption of Cs-137 using nano-size iron (III) hexacyanoferrate(II) (Prusian Blue (PB) solid form) combined with activated charcoal [1]. Some recent studies indicated immobilization of PB nanoparticles directly in the pores of activated charcoal stabilized by creating a hybrid sorbent with pectin [2]. A recent prominent study included synthesis of PB and cross-linked pectin tested for the elimination of Cs-137 [2].

Recently, Komkova [3] reported of hydrogen peroxide as the reducing agent for the improvement of the stability and size control of PB nanoparticle formation.

In our study, nanoparticles of hexacyanoferrate were immobilized on self-made activated charcoal (by pyrolysis first and then activation at 980 °C), soaked in deionized water and dried in an oven at 105 °C. The PB-charcoal was immobilized on pectin resulting in a ternary hybrid composite. The efficiency of the resulting composite sorption capacity was compared with that of the Radiogardase®-Cs antidote and the commercial PB solid all tested for the adsorption of cesium and strontium ions.

Results were observed using an inductively coupled plasma mass spectrometry (ICP-MS), X-ray diffraction, atomic absorption spectrometry, ICP-AES techniques. The procedure allows to create a suitable adsorbent for Cs-137 and Sr-90 that can be produced in any pharmacy without additional use of expensive technological industrial techniques.

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Acknowledgments: Funded by the MikroTik Ltd. and the University of Latvia Foundation. Project “Development of an extemporaneous antidote for highly toxic and radioactive cesium, thallium and rubidium compounds”.

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Determination of neutron absorption rates of 5% colemanite, ulexite, B_2O_3 doped HDPE materials

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https://doi.org/10.21175/rad.sum.abstr.book.2022.24.3

Free neutrons are used in various applications like material activation analysis, non-destructive radiography, neutron tomography, medical radiotherapy, and more. However, neutron-induced radioactivation can disrupt a cells' functionality and replication ability, making them hazardous to work with. Therefore, reliable neutron shielding for radiation protection of the operating staff is essential for these facilities.

For neutrons with energies up to 10 MeV, a good shield consists of hydrogen-based materials for neutron moderation and high thermal neutron absorption cross-section having elements for neutron capture. In this study, shielding composites containing high density polyethylene (HDPE) and 5% by weight colemanite, ulexite, or B_2O_3 minerals are fabricated. The macroscopic cross-section of these mixtures at different sample thicknesses is determined using a 239Pu-Be (α,n) neutron source. For 2 cm thickness, HDPE/B2O3 has 86%, HDPE /Colemanite 84.4% and HDPE/Ulexite 83.3% absorption rate. These mixtures were compared to pure HDPE, which absorbs only 78% of the incident neutrons for the same thickness. Moreover, to determine each compound's physical and mechanical characteristics, material characterization studies were carried out.

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Solution for the semi-automatic positioning of the ceiling-suspended screen for radiation protection in interventional radiology

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https://doi.org/10.21175/rad.sum.abstr.book.2022.24.4

The correct positioning of the ceiling suspended screen is crucial for proper occupational radiation protection in interventional radiology. In relevant patent of the author of the paper, semiautomatic control of screen positioning was presented, based on an X-ray device and a screen merging into one system. The essence of the solution is that after the initial manual positioning, automatic repositioning of the screen is executed, by curving the screen laterally, clockwise or counterclockwise, and then with the upper or lower edge forward. All potential clinical situations had been analyzed, considering the need to correct the position of the screen during clinical work for optimal protection, while continuously providing general safety conditions.

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WebNir: Web-based tools for assessing occupational exposure to Non-Ionizing Radiation

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https://doi.org/10.21175/rad.sum.abstr.book.2022.24.5

A project aimed at developing and collecting in a web platform (https://webnir.eu) a set of operational tools designed to give support to prevention practitioners has been launched in June 2017. This was part of a collaborative research, initially entrusted by INAIL (Italian Workers' Compensation Authority - Department of Occupational and Environmental Medicine, Epidemiology and Hygiene, Physical Agents Laboratory) to CNR-IFAC ("Nello Carrara" Institute for Applied Physics of the Italian National Research Council).

The project is constantly evolving and currently involves other public institutions:
- "Scientific Hospitalization and Care Institute" Policlinico San Matteo;
- Italian National Institute of Health;
- Environmental Protection Agency of Lazio;
- Local Health Authority of Tuscany.

The WebNir tools are dedicated to the activity of assessing and reducing risk from exposure to electromagnetic fields (EMF) and artificial optical radiation (ROA), with particular reference to workers with active implantable medical devices (AIMD). Currently, available tools allow to:

- display standardised intervention procedures for certain classes of occupational EMF sources;
- analyse EMF regulations, visualise the trend of their limit values as a function of frequency and time, and calculate exact values at specified frequencies and/or time intervals;
- plot and compare the frequency-dependent trends of two or more regulatory limits;
- determine the respect distance from an EMF source by interpolation of measured data along a straight line, at progressively increasing distances;
- evaluate and compare exposure to the electric field and magnetic flux density near power lines;
- evaluate the magnetic flux density generated by any configuration of conductors, choosing from a wide variety of geometries;
- process a sequence of measurements of the perceived magnetic field in the case of movement of a subject in a magnetostatic field and determine relevant radiation protection indices;
- analyse in the time domain a properly sampled waveform in the low or intermediate frequency range and calculate weighted peak indices relevant to applicable regulations;
- load, recognise, and process data files of measurements in the time or frequency domain originating from any type of instrumental chain;
- calculate the shielding effectiveness of an ideal screen;
- estimate the induced voltage at the input of a pacemaker exposed to EMF;
- generate interactive graphs to dynamically display compliance with EMF-related operating procedures.

While the interface of these tools is a web page, the computational load is divided between the user's computer and the server platform that deploys the applications. Therefore, for applications not requiring particularly sophisticated mathematical tools, the computational part is developed in JavaScript (fully resident on the user's machine) or in PHP. Conversely, when the use of advanced scientific libraries was necessary (like for digital filtering or Fourier transform), the computational program was implemented in Python, using the WSGI (WebService Gateway Interface) protocol to enable communication between the user interface and the Python code. It turned out to be very convenient to use the JSON (Java Script Object Notation) exchange format both to send and receive data in client-server communication and to import and export data to the various user interfaces.

The portal is still under development. In addition to refining existing programs and implementing new ones, also based on the needs of the other co-involved units of the project, a program is being developed that will allow for an evolution of the current state. This will make it possible to produce a multilingual responsive website that, in addition to supporting all the libraries already employed within WebNir, performs keyword-based searches on the site and related documents. Meanwhile, upcoming applications will already be developed in both Italian and English.

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Development of nuclear security training programme – PC NFS experience

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https://doi.org/10.21175/rad.sum.abstr.book.2022.24.6

Public Company "Nuclear Facilities of Serbia" (hereinafter PC NFS) is the only nuclear operator in the Republic of Serbia. Continuous upgrade of nuclear security systems is part of PC NFS strategic objectives. People are the most important part of every nuclear security system. PC NFS is always trying to follow world practices in this field, and not only to fulfill regulatory requirements. This paper shows PC NFS efforts and experience in strengthening nuclear security system through development training programme for our employees.

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Application of the INAA methods for the detection of seized illegally transported drugs: Relevant radiation protection aspects

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https://doi.org/10.21175/rad.sum.abstr.book.2022.24.7

Various physical methods are preferably used for the non-destructive detection of drugs or other narcotics. In some applications, instrumental neutron activation analysis (INAA) proves particularly suitable for its high sensitivity and reliability. This method of analysis uses the interaction of neutrons with the substance, where photons, charged particles, and secondary neutrons are emitted, the properties of which uniquely reflect the elemental composition of the examined sample. Relevant information on the representation of individual elements is obtained from the spectrometry of these particles. The method is non-destructive and requires virtually no specific sample preparation.

One of the following neutron sources can serve as a neutron source for INAA: a radionuclide neutron source, a nuclear reactor, or a neutron generator. Each of these sources has specific properties, especially in terms of neutron emission (number of neutrons per unit time) and the energy spectrum, which is crucial in terms of interaction processes and parameters of the radiation produced. Nuclear reactors produce the highest neutron output from these sources but are very limited by their availability, size, and high logistical overhead. Radionuclide sources include such sources as AmBe and PubMed, where neutrons are produced by the interaction of alpha particles with beryllium nuclei. Another radionuclide source, Californium 252 (Cf-252), produces neutrons as a result of spontaneous fission. For all radionuclide sources, their continuous neutron production must be taken into account, and the half-life must also be taken into account, leading to a constant decrease in emissions. Fusion neutron sources produce neutrons by merging deuterium-deuterium or deuterium-tritium nuclei. For some purposes, this type of source is very advantageous due to its small size and still reasonable emission.

Due to the fact that the work takes place near strong neutron sources, which also emit gamma radiation, it is necessary to ensure adequate protection of personnel and other persons who could experience unwanted radiation, especially in the event of an emergency radiation situation. The paper discusses the optimal possibilities of radiation protection in these specific conditions, where it is necessary to use particular approaches to measure the mixed field of n-gamma radiation.

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Parallels and commonalities between the protection against COVID-19 and radioactive ionizing radiation sources

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https://doi.org/10.21175/rad.sum.abstr.book.2022.24.8

The COVID-19 pandemic has heavily affected our daily life and many other spheres of society, including industry, medicine, travel, tourism, education, science and many other areas. A considerable effort has been spent worldwide to stop and reduce the spread of these deadly viruses and thus protect the population against the potential impact of COVID-19 through vaccination and the introduction of some personal protective equipment as well as an efficient method aimed at the reducing the spread of this dreadful disease.

Although the COVID-19 was first reported Wuhan, China, in December 2019, it took some time to recognize some commonalities between the protection against this coronavirus and the well-elaborated methods and equipment developed during several decades of the Cold War. At the beginning of the COVID-19, there was a lot of improvisation, especially as to the equipment for personal protection. Only after some months, it was recognized that there are some striking similarities when it comes to the protection against COVID-19 and the protection against exposure caused by ionizing radiation emitted by sealed or unsealed radioactive material. There is a wealth of data and extensive experience in the protection against CBRN (Chemical, Biological, Radiological and Nuclear) threats. One of the key principles of radiological protection is to keep doses As Low As Reasonably Achievable (ALARA). This is achieved by various combinations and variations of three basic parameters: time of exposure, distance from the source of radiation, and shielding to reduce the radiation. Moreover, inhalation of coronavirus from the contaminated air reminds us of internal contamination of persons by airborne radioactive substances. Knowledge acquired from the protection against CBRN and especially against radioactive contamination can be very helpful in fighting and taking efficient measures against COVID-19. In the ongoing COVID-19 pandemic, the probability of an individual being infected is dependent on the viral load that an individual is exposed to in public spaces over a period of time. All prevention and control measures are based on preventing any such exposure to the virus using restrictions and measures we learned from CBRN.

The paper presents an overview of the problems experienced in this field and illustrates some experience of the Police Academy of the Czech Republic in Prague trying to minimize the effect of the pandemic in the research projects and educational process.

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Work organization of the upgraded Center for Nuclear Medicine and PET, within the University Clinical Center of Serbia, in accordance with the IAEA/EANM radiation protection recommendations

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https://doi.org/10.21175/rad.sum.abstr.book.2022.24.9

Within the project of reconstruction of the Republic of Serbia Clinical Centers, in spite of construction and infrastructure constraints, an extremely functional nuclear medicine technical and technological solutions were implemented for: administration and quality control of radiopharmaceuticals, radionuclide therapy unit, two new PET / CT devices (which were bounded to the previously established radiopharmaceuticals preparation system), a modern CZT general purpose gamma camera, a cardiological unit with ergospirometry, department for hematological nuclear medical examinations, as well as units for nuclear medicine nephrourology and endocrinology with dedicated gamma cameras. The initial set of working procedures (which have passed the national accreditation drill) has been supplemented with new ones, in line with the expansion of the scope of health services. The joint perseverance of experts in various specialties, employed at the Center, demonstrated in a practical way the importance of an interdisciplinary approach in nuclear medicine. The result is a nuclear medicine center of excellence, built without compromises, with the radiation protection system fully compliant with the IAEA/EANM guidelines.

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Dose-effects models for space radiobiology: An overview on dose-effect relationships

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https://doi.org/10.21175/rad.sum.abstr.book.2022.25.1

Space radiobiology is an interdisciplinary science that examines the biological effects of ionising radiation on humans involved in aerospace missions. The dose-effect models are one of the relevant topics of space radiobiology. Their knowledge is crucial for optimising radioprotection strategies (e.g., spaceship and lunar space station-shielding and lunar/Mars village design), the risk assessment of the health hazard related to human space exploration, and reducing damages induced to astronauts from galactic cosmic radiation. Dose-effect relationships describe the observed damages to normal tissues or cancer induction during and after space flights. They are developed for the various dose ranges and radiation qualities characterising the actual and the forecast space missions (International Space Station (ISS) and solar system exploration). Based on a Pubmed search including 53 papers reporting the collected dose-effect relationships after space missions or in-ground simulations, we identified seven significant dose-effect relationships (e.g., eye flashes, cataract, central nervous systems, cardiovascular disease, cancer, chromosomal aberrations, and biomarkers). For each considered effect, the absorbed dose thresholds and the uncertainties/limitations of the developed relationships are summarised and discussed. The current knowledge on this topic can benefit from further in vitro and in vivo radiobiological studies, an accurate characterisation of the quality of space radiation, and the numerous experimental dose-effects data derived from the experience in the clinical use of ionising radiation for diagnostic or treatments with doses similar to those foreseen for the future space missions. The growing number of pooled studies could improve the prediction ability of dose-effect relationships for space exposure and reduce their uncertainty level. Novel research in the field is of paramount importance to minimise damages to astronauts from cosmic radiation before Beyond Low Earth Orbit exploration in the next future. In this talk, we will present the state of the art of knowledge in the fields and some possible hints and examples of potential synergies between different research areas to improve it.

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The effect of ultra-high dose rate (FLASH) electron beam on the development of zebrafish embryos

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https://doi.org/10.21175/rad.sum.abstr.book.2022.25.2

Objective. Ultra-high dose rate (FLASH) radiotherapy (dose rate: >40 Gy/s) combines the miracle effect of reducing toxicity (sparing) of normal tissue but maintaining the tumour cell killing power as conventional dose rate. The understanding of FLASH model is still limited and more in vivo biological model is needed to confirm the hypothesis. The aim of this zebrafish embryo study is to investigate the presence of FLASH effect at different dose and dose rate of electron irradiation.

Methods. 5 hours post-fertilization (hpf) zebrafish embryos and a research linear accelerator were used in this study. The embryos were irradiated by single fraction of 6 – 30 Gy (2 Gy interval stepwise) by 10 MeV electron beam at A: FLASH dose rate (280 Gy/s); B: FLASH dose rate (120 Gy/s); C: 30 Gy/s and D: conventional dose rate (0.1 Gy/s). A group of embryos without irradiation was acted as control. Survival, morphological details and malformations were assessed daily up to after 4 days of irradiation.

Results. Similar results were paired up in FLASH group (Group A & B). There was no significant difference between Group A & B in all assessments. The survival rate of the group C & D dropped more rapidly after 22 Gy. There was a significant difference between FLASH groups and the other two groups in the rate of impaired embryo development. Embryos with curved spine was started to observed after 8 Gy (30%) and reached maximum at 30 Gy (100%) in Group D, compared with ~60% at 30 Gy to that of FLASH groups. Similar trend was also noted in the rate of abdominal enlargement.

Conclusion. FLASH sparing (protection) effect of zebrafish embryo (5 hpf) was presented in ultra-high dose rate electron beam in all given dose from 6 to 30 Gy. Further investigations including others type of radiation and different stage (hpf) of embryos are recommend to confirm the requirement of FLASH effect.

Human decontamination

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https://doi.org/10.21175/rad.sum.abstr.book.2022.25.3

Public company "Nuclear Facilities of Serbia" is a licensed company for the process of human decontamination. Regardless of the protection measures taken, professional contact and work with the source of ionizing radiation carries, to a certain extent, the risk of contamination. It most often occurs when working with radioactive materials (RM) in nuclear medicine, in RIA laboratories, in medicine during radiotherapy and radiodiagnostic procedures, as well as in nuclear facilities during the disposure of radioactive waste. Contamination can be both external (skin, hair, and eyes) and internal (intake of RM into the body).

Decontamination is the process of removing RM from the surface or from inside the body of a contaminated person. This prevents the onset of radiation sickness of a contaminated person, and also the potential contamination of others and the environment. Before starting the decontamination process, it is necessary to have information about the type of RM, the dose read by the detector, and the insight into the health condition of the contaminated person. The manner and order of decontamination depends on this information. After each phase of the external decontamination process of the contaminated part of the body, the measurement is performed with a detector and the decontamination procedures are repeated until the three consecutive measurements are the same. Internal decontamination implies the procedure of applying a chemical agent to prevent both the absorption and the deposition of RM inside the body, and also applying agents for their accelerated elimination from the body.

Personnel who perform the decontamination procedure must protect all parts of their body and clothing worn with protective equipment (gloves, masks, booties, tights, protective caps). Upon the completion of decontamination, all clothing of the contaminated person and medical staff who performed the procedure, as well as all materials used in the decontamination process is collected, packaged and stored as radioactive waste.

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Functioning of antioxidant defense systems of *Zea mays*, the seeds of which were subjected to pre-sowing γ-irradiation in conditions of salt stress

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https://doi.org/10.21175/rad.sum.abstr.book.2022.25.4

It is known that seeds at the time of their germination are very susceptible to the action of various agents. For this reason, plant seeds are treated with various physical and chemical agents before sowing. It is assumed that ionizing radiation activates intracellular defense systems, which leads to the stimulation of physiological processes through a complex chain of signaling pathways. Irradiation of seeds in stimulating doses before sowing leads not only to the acceleration of seed germination, but also to an increase in yield and improvement in its quality. It is proposed to use pre-sowing irradiation not only as an agricultural method to increase the yield and its qualitative characteristics, but also as a tool for searching for genes associated with stimulation of plant development under stressful conditions. To date, many varieties of cultivated plants have been introduced that have not only increased productivity, but also high resistance to damaging agents.

The response of the plant to this was assessed by determining changes, both in biometric parameters and in activity of antioxidant enzymes. The results of our studies showed that pre-sowing γ-irradiation of seeds in certain doses could stimulate the growth and development of maize under conditions of salt stress. It was found that irradiation of seeds at a dose of 50 Gy stimulates the development of this plant in relatively low (5 - 50 mM) salt concentrations.

As you know, when deactivating reactive oxygen species that form under adverse stress conditions and are a real source of danger to cells, the antioxidant system plays a significant role. The results show that pre-sowing γ-irradiation of seeds at a dose of 50 Gy at certain salt concentrations promotes a change in the activity of antioxidant enzymes, such as superoxide dismutase (SOD), catalase (CAT) and ascorbate peroxidase (APX), which constitute the “fore front” of plant protection from adverse conditions.

The results on the activity of SOD, which plays the role of dismutation of superoxide anion radicals that are formed under unfavorable conditions for plant development, show that at relatively low concentrations (1 - 10 mM) of NaCl in the case of irradiated and unirradiated seeds, there are no significant differences between the activities of this enzyme. At high salt concentrations, seed irradiation leads to a significant increase in SOD activity.

The change in the activity of APX and CAT depending on the salt concentration differs from the change in the activity of SOD.

In other words, in the case of a salt concentration of 1 mM in both plants growing from irradiated and unirradiated seeds, the activity of CAT and APX is almost the same. In addition, an increase in the salt concentration in the ranges of (1–10) mM and (5–50) mM (for CAT and APX, respectively) leads to a large-scale increase in the activity of these enzymes. Moreover, small changes in their activities accompany a further increase in salt concentration for both enzymes.

It is known that both CAT and APX play the role of catalysts in the decomposition of H_2O_2 into water and molecular oxygen. H_2O_2 is one of the more active and more “aggressive” (from the point of view of cell damage) forms of oxygen. In addition, it is known that if CAT performs this function at high concentrations of H_2O_2, then at low concentrations APX goes to the “leading front”.

A decrease in the activity of APX and CAT against the background of an increase in the activity of SOD at relatively high (50 - 100 mM) salt concentrations can be considered the result of the interconnected and coordinated functioning of antioxidant enzymes under conditions of salt stress.

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Clonal heterogeneity and its relevance to the radiosensitivity of tumours

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https://doi.org/10.21175/rad.sum.abstr.book.2022.25.5

Cancer is a leading cause of death worldwide and radiation therapy remains a common option in cancer treatment for a large majority of patients. Previous research has shown that successfully treating tumours with radiation may often prove difficult due to the complexities and variety that comes with each individual tumour microenvironment. It is understood that changes in signalling molecules have a great impact on the evolution of a tumour. However, understanding the possible heterogeneity of a tumour is a major challenge in prescribing a successful overall radiation treatment. In the work presented here, clonal cell populations within a heterogeneous HCT116 cell population were isolated and analyzed for variation in radiosensitivities which may be a result of genetic instability and the clonal distribution of cells. Further we investigated these clonal populations for the radiation-induced bystander effect (RIBE) in which the directly irradiated population gives off non-targeted effects which can influence the behaviour of cells not directly exposed to ionizing radiation. Notably we see variation in radiosensitivity across clonal lines as modeled by the existing linear-quadratic (LQ) and multi-target (MT) models for ionizing radiation induced cell death. Through use of the MT model, we see clonal populations which exhibit variant values for the size of their curve shoulder. Here we identify an apparent link between radiosensitivity and the size of the curve shoulder and find clonal line A to be most radioresistant (shoulder size = 5.5) and therefore unable to produce RIBE in a healthy cell population. In contrast we see clonal line G (shoulder size = 0.88) is able to produce RIBE and cause a significant reduction in cell survival following the RIBE medium-transfer assay. Due to this apparent heterogeneity in cell or tissue populations, there exists a need for a better understanding of the interactions of ionizing radiation with clonal cell populations to allow radiologists to confidently develop radiation therapy plans for even the most complex and resistant tumours.

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Evaluation of the genotoxic effects of the combined effect of a pulsed magnetic field and gamma radiation in plant cells

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https://doi.org/10.21175/rad.sum.abstr.book.2022.25.6

Pulsed magnetic fields (PMFs) are used in scientific research, materials science, and medicine. The mechanisms of the biological effect of PMFs remain far from being fully understood. One way to study the biological effects of PMFs may be to study their combined effects with factors with the well-understood biological effects, such as gamma radiation. The key step in the biological action of ionizing radiation is the process of nuclear DNA damage and repair. The Allium test is one of the widely used tools for assessing genotoxic effects. The aim of this study was to evaluate the combined effects of PMFs and gamma radiation on the induction of chromosome aberrations in ana-telophase in meristem cells of onion (*Allium cepa* L.) seed seedlings.

The combined effect of PMFs (pulse repetition rate at the location of the biological object was 28.6 kHz; magnetic field induction in a pulse was 16.0 mT) for 60 s and gamma radiation at a dose of 3 Gy (IGUR-1M unit with 4 sources of ^{137}Cs with dose rate of 0.7 Gy/min in the working space). The following groups were formed: exposure to PMFs 15 minutes before gamma irradiation, exposure to PMFs 15 minutes after gamma irradiation.

In the control group, the frequency of cells with chromosome aberrations was 2.8±0.7%. PMFs led to a statistically significant increase in chromosome aberrations (CA) up to 6.6±1.1% (χ^2=10.82; p=0.001). Gamma irradiation at a dose of 3 Gy resulted in a statistically significant increase in CA up to 33.1±2.1% (χ^2=172.69; p<0.001).

Under combined exposure, a statistically significant difference from the group with exposure to gamma irradiation alone was recorded in both versions of the experiment (PMFs exposure before and after gamma-irradiation). Exposure to PMF 15 minutes before gamma irradiation led to a decrease in the frequency of aberrant cells compared to the effect of gamma irradiation alone to 26.1 ± 2, 0% (χ^2=5.98; p=0.02). The use of PMF 15 minutes after gamma irradiation of seedlings brought about a more pronounced decrease in the frequency of CA to 19.1±1.7% (χ^2=26.48; p<0.001).

The types of aberrations were studied in the experimental groups. In the control group, there were bridges in the proportion of 73.3±1.9% and fragments in 26.7±1.9%. Gamma irradiation led to the formation of bridges, fragments and lagging chromosomes (LC). The proportion of bridges in the group with gamma irradiation was 47.7±2.2%, fragments 42.0±2.2%, LC - 10.5±1.4%. When exposed to PMFs, chromosome aberrations are mainly represented by bridges 88.2±1.4% (χ^2=4.77; p=0.03), frequency of fragments was 8.82±1.23% (χ^2=7.52; p=0, 01), LC - 2.9±0.7%. Such differences in the frequency of different types of chromosome aberrations allow assuming that the mechanisms of the genotoxic effect of ionizing radiation and PMF are different.

The use of PMFs 15 minutes before gamma irradiation did not lead to a change in the spectrum of chromosome aberrations as compared to the effect of single gamma irradiation: the frequency of bridges was 52.6±2.2%, fragments - 41.6±2.2%, LC - 5.8±1.0%.

The ratio of different types of aberrations under the exposure to PMFs 15 minutes after gamma irradiation became more similar to the effect of the PMFs only. The proportion of bridges increased to 74.8±2.0% (χ2=4.8; p=0.03), frequency of fragments and LC reduced relative to the effect of gamma irradiation alone and amounted to 23.2±1.9% (χ2 =4.8; p=0.03), 2.0±0.6% (χ2=5.8; p=0.02) respectively.

Thus, the analysis of the results showed that PMFs in combination with gamma irradiation leads to a decrease in the effectiveness of ionizing gamma radiation. Differences in the spectra of chromosome aberrations have been revealed. It is indicative of the difference in the mechanisms of the genotoxic effect of PMFs and of the biological effect of gamma irradiation. When exposed to PMFs after 15 minutes, the predominance of bridges in the spectrum of chromosome aberrations indicates the activation of DNA repair systems.

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Selective yttrium recovery from carbonate media with a new mixture of quaternary ammonium carbonate and different polyphenolic ligands

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https://doi.org/10.21175/rad.sum.abstr.book.2022.26.1

The radionuclides monitoring during nuclear processes is very important part of nuclear technology, and one of the most significant radionuclides is ^{90}Sr, a fission product, normally existing in equilibrium with its daughter radionuclide ^{90}Y. The last is of special interest not only in radioecology (for ^{90}Sr determination), but also in nuclear medicine (for $^{90}Y/^{90}Sr$ generators).

The most part of yttrium extraction methods are developed for acid media with several classes of extractants (dioctylphosphoric acid, β-diketones, D_2EHPA and crown ethers). And this is understandable, because the main processes of spent nuclear fuel processing are carried out in nitric acid media. At the same time, it is obvious that the transition to carbonate media can significantly increase the safety of processing.

Solvent extraction and $^{90}Y/^{90}Sr$ separation in carbonate media (0.5 mol/L K_2CO_3) is studied using a mixture of methyl trioctyl ammonium carbonate (0.015 mol/L MTOAK) and different polyphenolic ligands in organic diluents (BuAc, 2-nitrotoluene and toluene). Among 10 ligands only several compounds appeared to be interesting for further experiments – 2,3-dihydroxynaphtaline, alizarin, catechol. It was stated that the change of a diluent plays important role in extraction ability of some ligands. Butyl acetate and toluene were finally chosen for yttrium extraction and separation. It is assumed that MTOAK possessed a dual function in extraction process, beside its ability to extract yttrium, it facilitated the ML complex transfer into the organic phase by increasing hydrophobicity of new ML complex, notably in toluene. Yttrium distribution ratio D_Y up to 85 was obtained for 2,3-dihydroxynaphtaline and alizarin in BuAc, whereas in toluene the same values of yttrium distribution ratio were obtain for catechol. The value lg $SF_{Y/Sr}$ for the process of yttrium-strontium separation was about 5.5 in BuAc and toluene. Yttrium stripping was carried out with 0.05 mol/L solution of nitric acid. The experiment showed that the stripping proceeded practically completely with the first contact.

The extraction system possessed a good feasibility for reuse. Organic phase undergone five cycles of yttrium extraction and it had a steady D_Y.

Acknowledgments: The study was supported by the Russian Science Foundation (project No 20-63-46006).

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BOOK OF ABSTRACTS

The resistance of tritium (HTO) in the water determination method to salinity of the samples and interfering radionuclides

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https://doi.org/10.21175/rad.sum.abstr.book.2022.26.2

Tritium (^3H) is a radioactive isotope of hydrogen of natural and anthropogenic origin. Natural tritium is constantly formed in upper layers of the atmosphere as a product of nuclear reactions of atmospheric gases and cosmic radiation. The sources of anthropogenic tritium are some types of nuclear reactors, nuclear facilities and thermonuclear testing in the atmosphere [1]. As tritium is one of the hydrogen isotopes it represents all of its physical properties including extremely high mobility in all ecosystems. Despite the origin, environmental tritium can be found in three main forms: tritiated water (HTO - the most abundant form of tritium in the environment), organically bound tritium (OBT) and gaseous tritium (HT or CH_3T) [2].

The increasing awareness in the field of occupational radiation protection found reflection in current European legislation. Even in countries not operating nuclear reactors, drinking water suppliers are obligated to measure tritium activity concentration in water periodically. For nuclear facilities and operators of nuclear reactors the list of samples where tritium activity has to be monitored includes i.a. sewage, rainwater, ground waters, drinking waters.

In this study, a method for tritium determination in fresh and saline water as well as sewage and rain waters was described. The method has been introduced as standard procedure for monitoring the Świerk Nuclear Centre (Poland) as an adaptation of the existing monitoring system to new regulations concerning nuclear reactor operator. The method was found to be cheap, rapid and reliable for all of the abovementioned matrices in a wide range of tritium activity concentrations.

The method consisted of the following steps: decolourisation, matrix masking, distillation and liquid scintillation counting (LSC). The sample preparation procedure allowed to obtain unquenched sample, what is important as the maximum energy of β particles emitted by tritium is fairly low (18.6 keV) and therefore counting efficiency strongly depends on quenching intensity. Decolourisation is obtained by mixing sample with activated carbon followed by filtration. This is also the initial step of matrix removal. Further, the sample is filtrated and mixed with sodium carbonate and sodium thiosulfate in order to trap volatiles (e.g. iodine) and distilled. Aliquot of the distillate is mixed with scintillation cocktail and measured in low background liquid scintillation counter. The performance of the preparation procedure was tested by measuring two sets of samples: one was deionized water spiked with interfering radioisotopes (namely $^{90}Sr/^{90}Y$ and ^{14}C), and the other was composed of different dilutions of sea water. The procedure proved to be resistant to interfering radionuclides and salinity of water reaching up to 7380 ± 390 ppm. With standard counting time up to 13 hours it was suitable for determination of tritium activity concentration between 4 and 10^7 Bq · dm^{-3}. Accuracy of the method was verified in an international intercomparison organized by PROCORAD Association.

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Synthesis of *N*-acetamido-4-deoxy-4-[F-18]fluoroglucosamine

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https://doi.org/10.21175/rad.sum.abstr.book.2022.26.3

Objectives. Alzheimers disease (AD) is a protein misfolding disease caused by accumulation of abnormally folded amyloid b (Ab) proteins in the brain. It is well known that agents that inhibit binding between heparin sulfate proteoglycan and amyloid precursor are effective anti-amyloid compounds both *in vitro* and *in vivo*. 2-Acetamido-4-deoxyglucosamine analogues have shown amyloid inhibitory properties *in vivo*. We wish to report two [F-18] PET tracers 2 and 3 as potential imaging agents for detecting amyloid plaques.

Methods. The triflate precursor 1 for use in the radiofluorination was obtained from the commercially available 2-acetamido-2-deoxy-a-D-glucopyranose in four steps. The radiofluorination by nucleophilic displacement of triflate 1 with K[^{18}F]F-kryptofix (K_{222}) was accomplished by allowing the reagents to flow through a microreactor (2 m x 100 m) in a NanoTek LF Microfluidic Synthesis System.

Results. The reaction conditions for radiolabeling were optimized in the Discovery Mode using the NanoTek LF 1.4 Software. The radiofluorinations of precursors 1a and 1b (4 mg in 0.5 mL of acetonitrile) using krypotofix-[^{18}F]fluoride (49 mCi) were carried out at 90 ^{o}C with a flow rate of 100 mL/min to obtain 29 % and 94 % fluoride incorporation respectively. The products 2 and 3 were purified by HPLC and uncorrected isolated radiochemical yields were observed to be 10 % and 48 % respectively. The radiochemical purity in each case was 98 %.

Conclusions. The preparation of radiofluorinated galactosamine analogues 2 and 3 was unsuccessful by a conventional vial chemistry. However, these tracers were conveniently synthesized using microfluidics. The biological evaluation of compounds 2 and 3 is currently underway.

Research Support: Molecular Imaging and Translational Research Program and the Robert H. Cole Research Foundation.

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An improved synthesis of 2',3',5,'6'-tetrafluorophenyl-6-[F-18]fluoronicotinate, an amine reactive bifunctional agent

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https://doi.org/10.21175/rad.sum.abstr.book.2022.26.4

Introduction. Bioactive peptides and proteins are very important key regulators of cell growth and cellular functions in living organisms. Radiolabeling of these sensitive biomolecules including nucleotides, antibodies and antibody fragments has been used in nuclear medicine for imaging tumors and inflammatory processes. A very few direct radiofluorination reactions of these biomolecules are known as it involves drastic reaction conditions that would entail the denaturing of the proteins and antibodies. Radiochemists have circumvented this problem by using F-18 prosthetic groups to label these molecules. An example of such an reactive prosthetic group is [F-18]SFB. Its radiosynthesis requires two to three steps and HPLC purification prior to conjugation with peptide. Furthermore, following conjugation with [^{18}F]SFB an additional purification step is often required to obtain the [F-18]peptide with sufficient specific activity and purity for in vivo studies. Olberg and co-workers have reported the synthesis of 6-[F-18]fluoronicotinic acid 2,3,5,6-tetrafluorophenyl ester using trimethylammonium triflate precursor that was prepared in two steps and trimethylamine gas was continuously bubbled through the reaction mixture in the first step. We wish to report one step synthesis of DMAP precursor 2 that does not involve any use of gas, followed by radiofluorination to obtain the title compound.

Methods. Precursor 2 was prepared from 2,3,5,6-tetrafluorophenyl-6-chloronicotinate (1) and diaminomethyl pyridine by heating them together in THF at 60 ^{o}C overnight in a quantitative yield as a while solid. Radiofluorination was performed on Sofie Elyxis Pureform using $^{18}F^{-}/K_{222}/K_2CO_3$ in dimethyl acetamide at 90 ^{o}C.

Results. Cyclotron produced fluoride (50 mci) was trapped on QMA cartridge, eluted with a mixture of K22/K2CO3 and azeotropically dried using drying sequence in Sofie Elixys Synthetic Platform. Precursor 2 (5 mg) was dissolved in dimethyl acetamide (1 mL) and added to anhydrous fluoride, heated at 90 ^{o}C for 15 min. The reaction mixture was diluted with water (30 mL) and passed it through C_{18} Sep-Pak to remove unreacted isotope. Fluorinated product was released from the cartridge using ethyl acetate to obtain 18 mCi of the desired product.

Conclusion. The convenient synthesis of the tile compound was achieved from dimethlamino pyridonium salt in 74 % radiochemical yield and 97 % radiochemical purity.

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Kinetic study of the oxidative dissolution of uranium dioxide and triuranium octaoxide in carbonate media

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https://doi.org/10.21175/rad.sum.abstr.book.2022.26.5

Kinetic study of the oxidative dissolution of uranium oxides in carbonate media under oxidative conditions is critical for the development and improvement of a key stage in new alternative approaches for reprocessing spent nuclear fuel.

In this research, with applying of some kinetic models, in particular, Kolmogorov-Erofeev, Prout-Tompkins, first order, Yander, anti-Yander, Ginstling-Brownstein, anti-Ginstling, shrinking core model, exponential law model, Kroger-Ziegler, Zhuravlev, shrinking cylinder model, shrinking cube model and Valenci, the mathematical processing of experimental data on the oxidative dissolution of the UO_2 and U_3O_8 powders in aqueous solutions of $NaHCO_3$, Na_2CO_3, and $(NH_4)_2CO_3$ in the presence of H_2O_2 at various temperatures and concentration of reagents was carried out. The most adequate kinetic models describing the process of UO_2 and U_3O_8 oxidative dissolution in carbonate media were selected. The values of reaction rate constant and apparent activation energy for oxidative carbonate systems were calculated. A correlation between the reaction rate constant value and the conditions of the UO_2 and U_3O_8 oxide powders oxidative dissolution process was established.

The obtained kinetic data can be useful in the development of a new process for dissolving spent nuclear fuel in carbonate media.

Keywords: Uranium dioxide, triuranium octaoxide, carbonate media, hydrogen peroxide, oxidative dissolution, kinetic methods, reaction rate constant, apparent activation energy

Acknowledgments: The work was carried out with the financial support of the Russian Science Foundation. Grant number 20-63-46006.

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Oxidative dissolution of triuranium octaoxide in hydroxide-peroxide media

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https://doi.org/10.21175/rad.sum.abstr.book.2022.26.6

Introduction. The main direction of spent nuclear fuel reprocessing in carbonate media is related to its dissolution in carbonate or carbonate-alkaline solutions and is considered as an alternative to hydro-chemical reprocessing in various options of the PUREX process.

An oxidizing agent is required to dissolution UO_2 and U_3O_8 in carbonate and carbonate-alkaline media. The applying of H_2O_2 in dissolution process allows the rapidly and quantitatively dissolution of UO_2 and U_3O_8 in aqueous solutions of alkali metal or ammonium carbonates. Addition of the peroxide ion to the U(VI) carbonate solution results in highly soluble mixed peroxo-carbonate complexes [1-3]. Soluble mixed peroxo-hydroxide complexes are formed in aqueous alkaline solutions [4]. However, at the moment, the processes of uranium oxides dissolution in the NaOH - H_2O_2 systems have not been studied.

Aims. Study of the kinetic of U_3O_8 powder oxidative dissolution in NaOH solutions and determine the conditions for complete dissolution of U_3O_8 in alkaline media containing hydrogen peroxide.

Results. The article presents the results of kinetic study of oxidative dissolution of U_3O_8 powder samples calcined at 480°C, 600°C, 800°C, 1000°C, and 1200°C in NaOH - H_2O_2 solutions in the temperature range 25-75°C. The possibility of complete dissolution of U_3O_8 (480°C) and U_3O_8 (600°C) powder samples in 1.0M NaOH – 0.1M H_2O_2 solutions at 75°C and H_2O_2 fractional feeding due to the formation of soluble mixed peroxo-hydroxide complexes of uranium(VI) is shown. It has been found that stopping the H_2O_2 feed leads to the decomposition of soluble peroxo-hydroxide complexes of uranium(VI) and the quantitative distribution of uranium(VI) from the alkaline solution to the precipitate.

Conclusion. Obtained data makes it possible to develop approaches to the processes of selective leaching of uranium from voloxidized spent nuclear fuel and its hydrolytic reagent-free precipitation from alkaline solutions in the form of a preliminary concentrate purified from the bulk of highly radioactive fission products. Such an approach may be one alternative to replacing the first solvent extraction cycle of uranium(VI) from carbonate solutions after oxidative dissolution of spent nuclear fuel in the CARBEX (CARBonate EXtraction) process.

Keywords: triuranium octaoxide, oxidative dissolution, hydrogen peroxide, sodium hydroxide

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Acknowledgments: The work was carried out with the financial support of the Russian Science Foundation. Grant number 20-63-46006.

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Radioecology of mountain beginnings of the Tisza River: Ukrainian part

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https://doi.org/10.21175/rad.sum.abstr.book.2022.27.1

The Carpathian mountain ranges have a particular isotopic and microelement composition of soils and water resources, which significantly affects the ecological performance of large adjacent areas and is where the largest rivers in Europe originate.

The main part of Transcarpathian water resources is river runoff, which plays an important role in the accumulation and movement of chemical components and isotopic composition of the surface layers of mountain slopes. The study of the characteristics of the natural radioactivity of silt is essential for monitoring the ecological status of water basins assessing the well-being of their population. The radionuclide analysis makes it possible to build a map of the spatial distribution of isotopes of natural and man-made origin along the riverbed.

Such research is vital for the water basin of the Tisza River, which is one of the largest rivers in Eastern and Central Europe. The territory of Ukraine contains the upper, primarily right-bank part of the Tisza basin, which lies on the southwestern slopes of the Ukrainian Carpathians and the Transcarpathian lowlands.

The source of the Tisza River is considered to be the source of its longest tributary - the Black Tisza River.

The beginning of the river is located on the southwestern slope of the mountain Bratkivska Vododilno-Verkhovynsky ridge. Downstream 4 km Downstream 4 km above the city of Rakhiv, the Tisza riverbed is formed by the confluence of the Black Tisza and White Tisza. The total water resources of the Tisza basin within Ukraine are 13.3 km^3.

The report presents the results of radioecological studies of the silts of the Tisza River (Transcarpathia), obtained as a result of the summer 2021 expedition at 22 points along its course.

The sampling scheme included both mountainous and lowland areas of Transcarpathia, which had different anthropogenic loads. We chose the scheme with the beginning of sampling in the river's upper reaches (above the village of Yasinya). Man's impact on the ecosystem is the smallest; other points are selected downstream, where the anthropogenic load increases. The extreme point of study for the Tisza River is a point in Dilove village.

The distance between the sampling points does not exceed 5–15 km, which allows establishing the sources and ways of radionuclides entering the bottom sediments of the studied river. The position of the sampling points was determined using GPS navigation. An essential task of radioecological monitoring is the choice of isotopes - labels that reflect both geochemical features and man-made factors of the studied region.

The optimal set of isotopes of natural and anthropogenic origin for determining the distribution of radionuclides of siltstones of the Tisza riverbed, particularly the natural U / Th series, ^{40}K, is discussed. Furthermore, the intensity of man-made factors can be analyzed by studying the content of ^{137}Cs isotopes.

The obtained results are systematized using multidimensional statistical analysis methods to establish the spatial regularities of accumulation and statistical clustering of an isotope set for the sediments samples of mountain and lowland areas of the Tisza River. Finally, the sustainability of radiological indicators are discussed, and the impact of migration processes and global factors.

The latter may be due to precipitation and air movement from large surrounding areas. The results obtained in this study allowed one to get databases of natural and man-made radionuclides of the Tisza River riverbed, which are the identifying features of the object of research, and let certification of its isotopic composition, in turn, radiation mapping of the studied mountainous areas.

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Interrelation between the beryllium-7 specific activity in the surface air and North Atlantic Oscillation based on their wavelet coherence

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https://doi.org/10.21175/rad.sum.abstr.book.2022.27.2

The natural radionuclide beryllium-7 (Be-7) is produced in the upper levels of the atmosphere and is transported to the surface on carrier aerosols. Therefore, among other factors, the abundance of Be-7 in the surface air is governed by the rate of its production and large-scale air transport. The North Atlantic Oscillation (NAO) index, which quantifies the surface sea-level pressure difference between the Subtropical (Azores) High and Subpolar low, exerts large effects on precipitation and circulation patterns in Europe. With an aim to look closely into the interrelations between the Be-7 specific activity in the surface air, sunspot number (as a proxy for the production signal), and NAO index, this paper investigates their long-term time series over 28 years, between February 1987 and December 2014.

The Be-7 specific activity was recorded in Vienna (48.22 °N; 16.35 °E; 193 m a.s.l.), Austria, and stored in the Radioactivity Environmental Monitoring databank (REMdb) that is created and supported by the European Commission-Joint Research Centre in Ispra, Italy. The sunspot number (SN) data were downloaded from SILSO (Royal Observatory of Belgium, Brussels, Belgium), while the NAO records were retrieved from the Climate Prediction Centre of the National Oceanic and Atmospheric Administration, USA. Since the temporal resolution of the Be-7 measurements varied between six and eight days, they were first linearly interpolated into an array of weekly data, and then, the daily SN and NAO data were averaged into weekly records to match the Be-7 data. Next, Pearson's correlation analysis and wavelet transform were used to analyse the time series.

The low Pearson's correlation coefficients between the Be-7 specific activity in the surface air and SN (-0.15207) on one hand, and the NAO index and SN (0.13512) on the other hand, imply a lack of direct linear interrelations between these variables. The Pearson's correlation coefficient between the Be-7 specific activity in the surface air and NAO index is even lower (-0.05904). However, the Be-7 specific activity wavelet spectrum shows a pronounced annual period, and looking further into the link between the Be-7 specific activity and NAO index at this characteristic periodicity, reveals a prominent pattern. Specifically, the wavelet coherence levels between these two parameters show variations that seem to be in agreement with the 11-year solar cycle: the coherence increases as the sunspot number transitions between its extremes, and it decreases around the maxima and minima in sunspot number. Further, phase difference shows that at the one-year periodicity, the Be-7 specific activity always lags behind the NAO index. The phase difference ranges between 2 and 6 months; it reaches the minimum around the solar activity extremes, and the maximum in-between.

These findings imply that, although weak, the signature of sunspot number can be seen in the wavelet coherence level between the Be-7 specific activity and NAO index.

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The influence of phosphate fertilizers on the radiological situation of cultivated lands: ^{210}Po, ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs concentrations in soil

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https://doi.org/10.21175/rad.sum.abstr.book.2022.27.3

In 1996 the European Council Directive 96/29/EURATOM pointed phosphate fertilizers to have potentially negative influence on environment from the radiation protection point of view. Fertilizers along with irrigation and crop rotation were the milestones that allowed to increase agricultural productivity. Firstly, based on natural materials such as compost, manure, fish processing waste etc., and since 19th century created synthetically, fertilizers caused a boom in crop yield and helped to propel the global food production, especially after World War II.

In this work the concentrations of ^{210}Po, ^{226}Ra, ^{232}Th, ^{40}K, and ^{137}Cs in selected fertilizers and soil samples were determined. The results were used to calculate the annual addition of natural radionuclides and increment of the external radiation exposure caused by use of studied fertilizers.

Soils intended for different types of crops were sampled in early spring, when no vegetation has occurred yet. Analysed fertilizers were those with which the soil was previously fertilized. All samples were oven dried in 40°C in order to prevent the loss of polonium. Further preparation consisted of grinding, sieving through 200 μm mesh sieve and homogenization. For gamma radionuclides determination samples were packed in 450 cm^3 Marinelli beakers, gastight closed in order to prevent radon gas from escaping and stored for about 30 days. During this time equilibrium between both ^{226}Ra and its progenies (^{214}Pb and ^{214}Bi) was reached. The samples were measured by means of high purity germanium detector GX3520 from Canberra. The polonium concentration was determined by radiochemical separation including: microwave digestion, co-precipitation with manganese dioxide and spontaneous deposition on copper disc. The spectrometer used in this study was equipped with 450 cm^2 PIPS detector from Canberra. Obtained results showed significant differences in radionuclide composition between phosphate and nitrogenous fertilizers. The activity concentration of ^{226}Ra was over 20 times higher in phosphate fertilizer (111.9 ± 9.8 Bq/kg) in comparison to nitrogenous fertilizer (5.37 ± 0.57 Bq/kg), for ^{210}Po the ratio was higher, and reached 32. The radium equivalent activity for phosphate fertilizer was 207.7 Bq/kg in comparison to less than 5.6 Bq/kg for nitrogenous fertilizer. The calculated increase of external radiation exposure due to use of phosphate fertilizer ranged between 3.4 and 5.4 nG/h, what represents up to 10% of the polish average outdoor exposure due to terrestrial gamma radiation (45 nGy/h). In all studied fertilizers ^{137}Cs was below minimum detectable activity (0.15 – 0.80 Bq/kg), however in soil samples concentrations of this isotope ranged from 3.79 ± 0.43 to 5.53 ± 0.62 Bq/kg.

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Level of ^{90}Sr in sediments of the Danube River at the border profile Serbia-Hungary

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https://doi.org/10.21175/rad.sum.abstr.book.2022.27.4

The radioactive fission product ^{90}Sr has a sufficient half-life time (28.8 y) to be detected for a long time after it appeared in the environment. This radionuclide emits a β-particle of 546 keV, giving progeny to ^{90}Y, also a β-emitter ($T_{1/2}$ = 64.2 h, 2.28 MeV), with which it reaches secular activity equilibrium for a 14 days. Due to properties, radiostrontium may be considered as a highly hazardous anthropogenic radionuclide. The worldwide presence of ^{90}Sr has been caused intentionally or accidentally in the period between 1950 and 1970, as a consequence of various human nuclear activities. The ^{90}Sr determination is an important part of the annual plan of the radioactivity survey in environmental samples such as soil, sediment, grass, milk, wheat, foodstuff (especially vegetables).

A potential contaminant of the Danube River ecosystem (in a radioactive sense) is the Paks Nuclear Power Plant, located in Hungary, 85 km from the Serbian-Hungarian border. Hence, this paper has been given insight to the results of investigation of ^{90}Sr content in sediment of the Danube River at border profile between Serbia and Hungary. Sediment samples were collected a few times of year at Serbian side of the Danube River (left coast) in Bezdan. Within the mentioned ecosystem sampling was classified into four zones (sampling points), the first at 1425.5 km river flow, the second at 1426.3 km river flow, the third at 1427.2 km river flow and the fourth at 1428 km river flow. In the each zone one sample is collected. The preparation and analysis of collected samples were performed in Laboratory for Radiation Measurements of the Vinča Institute for Nuclear Sciences. The study covered a period of six years from 2016 to 2021. The level of activity of radionuclide of interest was determined by the radiochemical analytical method of ^{90}Sr determination via its short-lived daughter ^{90}Y. The samples after applied radiochemical procedure were counted by low-level gas proportional counter Thermo Eberline FHT 770T (ESM Eberline Instruments GmbH, Erlangen, Germany). The counting time was 5400 s. The counting efficiency of this counter was 35 % for the β-particle of ^{90}Y.

The measured values of ^{90}Sr activity concentration in sediment samples of the Danube River were ranged between 0.18 Bq/kg and 0.79 Bq/kg for dry matter, depending on the sampling season or sampling point. The values of ^{90}Sr activity concentration in investigated samples were far below level before starting work of the Paks Nuclear Power Plant (7.1 Bq/kg of dry matter). Evaluation of the accuracy of the applied method was confirmed using reference material and interlaboratory comparison samples. The results of this study were compared to the values available from the literature and the comparison confirmed that no significant contamination of investigated ecosystem in terms of the content of anthropogenic radionuclide ^{90}Sr. The conducted study points out the importance of systematic testing of the content of anthropogenic radionuclide ^{90}Sr in sediments as an important element in the system of control and testing of environmental safety.

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Determination of radionuclide concentrations in soil and black walnut leaves and fruit using gamma-ray spectrometry

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https://doi.org/10.21175/rad.sum.abstr.book.2022.27.5

The Juglandaceae are a plant family known as the walnut family and Juglans L. is one of the eight living genera in that family. It contains about 20 species and among them, Juglans regia L. is most commonly studied. Juglans nigra, the eastern American black walnut, is a species of deciduous tree in the walnut family, native to North America, but today it is spread all over the world. All walnut trees (Juglans species) produce edible seeds (known commonly as nuts), but those of black walnut are notoriously difficult to extract from their husks. It's well known all kind of walnuts due to the chemical composition has multiple biological significance. Some studies have shown that Juglans nigra nuts protect low-density lipoprotein against oxidation in vitro and there is relationship between nuts consumption and reduced risks for heart disease due to its effect on blood lipids. Tinctures of black nuts and leafs produced in the traditional way contain tannin and quinine, iodine, vitamin C in the form of ascorbic acid, alkaloids and minerals. Nowadays, as interest in functional food and herbal products is increasing tinctures of black nuts are used as primarily to cleanse the body of parasites, fungi and toxins.

Most research on black walnut is related to chemical research of its fruit or leaf, while there is no research related to the radiological characteristics of black walnut. In this research, a radiological analysis of the black walnut leaf and fruit, prepared tinctures, as well as nearby soil sample are presented. Concentrations of natural radionuclides (^{210}Pb, ^{235}U, ^{238}U, ^{228}Ac and ^{40}K), as well as concentrations of ^{137}Cs as an artificial radionuclide, were analysed in all samples. All samples were measured in close to detector geometry by means of two coaxial HPGe spectrometers: AMETEK-ORTEC GEM 30-70, with 37 % relative efficiency and 1.7 keV resolution for ^{60}Co at the 1332.5 keV, and Canberra GX5019, with 55 % relative efficiency and 1.9 keV resolution for ^{60}Co at the 1332.5 keV. Measured samples of soil and black walnut leaf and fruit were prepared by drying and crushing. All samples were packed in the appropriate cylindrical geometry equal to efficiency calibration standards.

For soil sample obtained radionuclides concentrations are:(69 ± 5) Bq/kg for^{210}Pb, (2.0 ± 0.4) Bq/kg for^{235}U, (41 ± 5) Bq/kg for^{238}U, (52 ± 3) Bq/kg for^{228}Ac, (532 ± 27) Bq/kg for^{40}K and (6.1 ± 0.4) Bq/kg for^{137}Cs.

For leaves sample obtained radionuclides concentrations are:(28 ± 3) Bq/kg for^{210}Pb, < 1.3 Bq/kg for^{235}U, < 35 Bq/kg for^{238}U, (2.0 ± 0.7) Bq/kg for^{228}Ac, (462 ± 25) Bq/kg for^{40}K and < 0.6 Bq/kg for^{137}Cs.

For fruit sample obtained radionuclides concentrations are:(7.5 ± 1.7) Bq/kg for^{210}Pb, (0.6 ± 0.1) Bq/kg for^{235}U, (24 ± 4) Bq/kg for^{238}U, (1.8 ± 0.3) Bq/kg for^{228}Ac, (808 ± 42) Bq/kg for^{40}K and < 0.5 Bq/kg for^{137}Cs.

For leaves tincture obtained radionuclides concentrations are: < 4 Bq/kg for^{210}Pb, (0.9 ± 0.2) Bq/kg for^{235}U, (25 ± 3)Bq/kg for^{238}U, (0.8 ± 0.1) Bq/kg for^{228}Ac, (53 ± 3) Bq/kg for^{40}K and < 0.3 Bq/kg for^{137}Cs.

For fruit tincture obtained radionuclides concentrations are: (29 ± 4) Bq/kg for^{210}Pb, (0.7 ± 0.2) Bq/kg for^{235}U, (10.7 ± 2.9) Bq/kg for^{238}U, < 1.6 Bq/kg for^{228}Ac, (45 ± 3) Bq/kg for^{40}K and< 0.3 Bq/kg for^{137}Cs.

This study showed that ^{137}Cs concentrations in black walnut leaf and fruit, as well as in tinctures were below the detection limits. Concentrations of other radionuclides are lower than their concentrations in the soil, except for concentration of ^{40}K in black walnut fruit, which objectively have more potassium due to the structure of the fruit. It indicates that the consumption of leaf and nut tinctureis absolutely safe, especially in relation to artificial radionuclides.

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The study of gross beta-radioactivity of *Eleutherococcus senticosus* and of some several medicinal plants in hydroponics and soil of Ararat Valley and Dilijan forest zone

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https://doi.org/10.21175/rad.sum.abstr.book.2022.27.6

It is known that natural and technogenic radionuclides (RN) along the biogeochemical chains of agrocenoses may enter into human body through irrigation water – soil – plants likwise in hydroponic system through nutrient solution – substrate – plants, leading to the development of dangerous diseases.

Thus, control of herbal raw material's gross β-radioactivity and obtaining radioactively safe medicinal raw material are priority issues. Since 1996 we have carried out radio monitoring researches in water-soil-plant ecosystems in Ararat Valley (city Yerevan area of IHP, zone with 30 km radius from the Armenian NPP (ANPP)) and in Dilijan's forest experimental station (DFES) (zone with 100 km radius from the ANPP). These investigations being practically important can lead to developing protective, which can be used in polluted anthropogenic zones. Furthermore, those measures will give an opportunity to obtain ecologically safer agricultural products.

The studies were carried out during 2018-2021. The Ararat Valley is located at about 850-900 m from the sea level, with the average monthly temperature of 25-26°C during Summer, and with the yearly average sum of precipitations reaching up to 200-300 mm. DFES is located at about 1400-1500 m above sea level, where the average annual temperature is 8.1°C, and the average annual precipitation is 660-750 mm.

The radio-chemical studies showed that the medicinal raw material from the following medicinal plants: Siberian ginseng-*Eleutherococcus senticosus* (Rupr.& Maxim), Ashwagandha-*Withania somnifera* (L.) Dunal, Rosemary-*Rosmarinus officinalis* L., English lavender-*Lavandula angustifolia* L. and Common chicory - *Cichorium intybus* L., cultivated in open-air hydroponics and soil sites of Ararat Valley and DFES, is radioecologically safe, since its gross β-radioactivity doesn't exceed threshold of 1.0 Bq/g. The research demonstrates that Siberian ginseng grown in conditions of biogeocenosis of DFES accumulated 2 times less RN in leaves than in hydroponic vegetative vessels located in Ararat Valley. Medicinal plants grown in hydroponics and soil, with a slight deviation, show the same gross β-radioactivity decreasing pattern as follows: Ashwagandha > English lavender > Common chicory > Rosemary > Siberian ginseng.

In natural waters, soils and medicinal plants of Ararat Valley and DFES the content of controlled technogenic RN (^{90}Sr - $T_{1/2}$ =28.6 years; ^{137}Cs - $T_{1/2}$ =30.1 years) didn't exceed MAC.

Acknowledgments: The work was supported by the Science Committee of MESCS RA, in the frames of the research project № 21T-4D205.

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Radioactivity of fungi in schist-type soil in the Stara Planina mountain ecosystem

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https://doi.org/10.21175/rad.sum.abstr.book.2022.27.7

Mountain ecosystems are going through changes due to numerous physical-chemical processes in the environment rather than the anthropogenic activities. Primordial radioactivity of rock and soil material migrates and fractionates in other environmental sections like waters, air and biota. Having a feature to accumulate different minerals and trace element present in soil and three substrates, fungi indicates their composition and related processes. The aim of this study is uptake of radionuclides by fungi in the schist soil of the Stara Planina, mountain famous for biodiversity as well as for enhanced natural radioactivity areas. Samples of various fungi species (stipes and cups) and their soil substrates have been collected in summer season 2019. Collected soil samples are pedologically characterized and analysed by gamma-spectrometry (HP Ge) after the secular radioactive equilibrium had been reached. Soil characterization has shown the share of coarse fragments, sand, silt and clay in the schist (shale) structure while pH value was 4.80-5.33 and organic carbon content 3.10%. The content of significant natural radionuclides ^{40}K, ^{226}Ra, ^{232}Th, ^{238}U and manmade ^{137}Cs was (in Bq/kg) was 500±30, 27±2, 26±2, 32±4, 1.6±0.2 respectively. Dried fungi samples were analysed by gamma spectrometry showing the natural radionuclide content in wide range of values. Obtained results indicate dependence of the radionuclides uptake from the substrate on their abundance in schist soil type as well as the fungus specie physiology. Slight difference was observed in results between content in species with different types of nutrient uptake (mycorrhizal and saprobic). The ^{137}Cs content varied from 2-20 Bq/kg. Further knowledge on the local population habits in use of edible fungi species would enable dose assessment for the representatives of the public and contribute to a further research on the Stara Planina mountain ecosystem.

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Assessment of radionuclide input into the Curonian Lagoon by suspended matter

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https://doi.org/10.21175/rad.sum.abstr.book.2022.27.8

The Curonian Lagoon is a semi closed area (1584 km²) in the south-eastern part of the Baltic Sea. The main sources of radionuclides in this area are global fallout from nuclear explosions and fallout of radionuclides from the Chernobyl accident. Even after decades, particle-bound radionuclides still enter the Curonian Lagoon from contaminated catchments. The aim of this study was to estimate the input of anthropogenic radionuclides (^{137}Cs, ^{239,240}Pu) through the suspended solids of the Neman River.

During the sampling campaign, suspended sediment samples were collected *in situ* by filtering a large volume of water (~1000 L) through 0.2 µm, 1 µm, 25 µm sediment filter cartridges (US Filter Plymouth Products). After sampling, the filters were dried at 25°C for one week. Gamma-emitting radionuclides were measured using an ORTEC gamma-ray spectrometer with an ORTEC gamma-ray spectrometer with an HPGe GWL-120-15-LB-AWT detector (resolution 2.25 keV at 1.33 MeV). After the gamma measurements, the ash samples were dissolved in strong acids (HNO3, HCl, HF, and HClO4). TOPO/cyclohexane extraction and radiochemical purification with TEVA resins (100–150 µm) were used to separate Pu isotopes. Pu isotopes were electroplated on stainless steel discs and measured using an alpha-spectrometry system with passivated implanted planar silicon (PIPS) detectors with an active area of 450 mm2 (AMETEK, Oak Ridge, Tennessee, USA) (Lujaniene et al., 2022) [1].

The activities of radionuclides in the suspended sediment were estimated to be 1.2 Bq/m³, (^{7}Be), 1.9Bq/m³ (^{40}K), 0.1 Bq/m³ (^{137}Cs), 0.4 Bq/m³ (^{210}Pb), 17.6 Bq/m³ (^{239,240}Pu).

The contribution of radionuclides to the Curonian Lagoon was estimated from measured activities in suspended sediment, assuming a suspended matter concentration of 12 mg/L and an average annual sediments input of $4.844 \times 10^8 \pm 3.790 \times 10^8$ kg/years, reported by Mežine et al. (2019) [2].The calculated average annual contribution of radionuclides with riverine suspended matter is 76 GBq ^{40}K, 4 GBq ^{137}Cs, 16 GBq ^{210}Pb, 0.1 GBq ^{239,240}Pu.

The average plutonium input was also estimated using a different approach that considers the plutonium input from the 100 458 km² catchment (Gasiūnaitė et al., 2008) [3] due to soil erosion. Taking into account the published data for the conservative assessment, it was assumed that the average plutonium deposition in the catchment is uniform and does not exceed 39 Bq/m². Plutonium enters the water flow gradually through soil erosion with an average residence time in the catchment of 3000 years according to the approach described by Wang, (2021). The average annual contribution of the river to the plutonium budget of the Curonian Lagoon was estimated to be 0.9 GBq/year. The calculated values differ significantly by a factor of 9, which may be related to the fluctuations of the plutonium concentration in the suspended sediments during a year.

According to estimates of Mežine et al. (2019) [2], the average amount of sediment trapped in the Curonian Lagoon is about 62%. Therefore, the radioactivity of the Curonian Lagoon is expected to increase annually by 96 Gb due to gamma emitters (^{137}Cs, ^{40}K, ^{210}Pb) and 0.9 GBq due to plutonium (^{239,240}Pu).

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Radiological status of drinking water from the Eastern Rhodopes region, Bulgaria

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https://doi.org/10.21175/rad.sum.abstr.book.2022.28.1

The quality of drinking water in Bulgaria is controlled by the Ministry of Environment and Water. However unregulated sources are often used for drinking purposes too. In addition to the impaired chemical, biological and physicochemical parameters, there is a risk of natural radionuclides concentration above the permissible levels. Higher content of natural uranium in the bedrock can be dissolved by groundwater or surface water and lead to high activity concentrations in drinking waters. The long term use of water containing high content of uranium can cause kidney problems and pose cancer risk.

50 unregulated water sources from the region of the Eastern Rhodopes were studied. Natural uranium was measured spectrophotometrically. Gross alpha and beta activity were determined by low-background alpha-beta counter. Uranium content was between < 0.002 and 0.012±0.003 mg/l, alpha activity - ≤0.001÷1.54±0.3 Bq/l, beta activity - ≤0.02÷0.9±0.2 Bq/l. Water samples containing uranium and gross alpha activity over permissible levels were tested for Po-210.

The study of such unregulated water sources expands the monitoring of drinking waters in the country and makes it possible in case of hazard to inform the relevant authorities and population in order to protect human health.

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The effect of *Juglans nigra* L. green husk extracts on the biodistribution of radiopharmaceutical sodium pertechnetate in mice

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https://doi.org/10.21175/rad.sum.abstr.book.2022.29.1

Juglans nigra L. (Black walnut) green husk contains a variety of useful chemical compounds with numerous health benefits. However, the biological effects of these compounds are not fully known. The aim of this research was to evaluate the effect of the extracts from *J. nigra* green husks on the biodistribution of the sodium pertechenetate ($Na^{99m}TcO_4$). The extract was orally administered to the healthy Wistar rats (male, 1-month-old, weighing 89.4±3.4g) at single doses of 13.7 mg/kg/day by gavage for 10 days. On the eleventh day, 0.1 ml (approximately 148 kBq) of the $Na^{99m}TcO_4$ was injected into the tail vein. Rats were sacrificed at different time intervals and the radioactivity in the organs of interest was measured in a gamma counter with a NaI (Tl) detector. The percentage of radioactivity per organ (%ID/organ) was calculated. The organ uptake of the $Na^{99m}TcO_4$ in an additional control group of animals was also studied. The results obtained showed an alteration in the organ uptake of $Na^{99m}TcO_4$ in rats treated with extract. The radiopharmaceutical $Na^{99m}TcO_4$ is generally distributed throughout the vasculature and interstitial fluid and is concentrated in the stomach, intestinal tract, thyroid and salivary glands. After treatment of rats with the extract, there was a statistically significant decrease ($p<0.05$) in the uptake of $Na^{99m}TcO_4$ (%ID/organ) in the thyroid, heart, kidneys, liver and colon, and an increase in intestinal uptake compared to controls. These results are associated with properties of the chemical compounds present in the *J. nigra* extract. We assume that the compounds from the extract *J. nigra* could promote physiological modifications in these organs and alter the biodistribution of $Na^{99m}TcO_4$ in the treated animals. Although these research studies were performed in animals, the findings suggest that caution should be exercised while interpreting the results of $Na^{99m}TcO_4$ based nuclear medicine examinations in patients using *J. nigra* extract from green husk.

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Dose uncertainties in case of insufficient body coverage during the radiotherapy CT simulation

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https://doi.org/10.21175/rad.sum.abstr.book.2022.30.1

Introduction. In radiotherapy CT simulation, the simulated part of the body can be insufficient on the craniocaudal axis and there may be a lack of scattering material on the end of the PTV. This is a rare but possible situation and may be the result of a misunderstanding, a CT machine malfunction, etc. Usually, the solution to this problem is resimulation, which delays the start of the treatment and adds a dose to the patient. This work examines the difference between the relevant doses for this problem and makes an assessment of the uncertainties of those doses by artificially adding slices through DICOM modifications of CT files, using MATLAB.

Materials and Methods. In this work, 35 patients with normal CT simulations in the pelvic region (gynecological, rectum) were processed and 3D-CRT plans were made in Monaco 5.11.03. Using the MATLAB program, the CT axial slices were deleted to the last slice on which the PTV was contoured in a superior direction for Head First positions, which simulates a situation in which the CT series has insufficient slices. This CT series were then artificially extended by 2.5 cm either as a copy of the last slice or as a copy of the last Body contour filled with HU for water. Intestine were taken into account as an organ at risk and were contoured up to 2 cm above the last slice of the PTV. To get the contour in the missing part of the CT simulation, the contour of the intestine from the last slice was copied to the next 2 cm. The plan from the normal CT series was then transferred to the other 3 modified CT series and the doses of PTV, CTV and intestine were compared. The volumes $V_{95\%}$, $V_{98\%}$, and Conformity index(CI) as defined in Monaco were compared for the PTV and CTV. Volume V_{45Gy} in absolute value and the total volume V_{tot} were compared for intestine as an OAR and the differences were defined as percentages of V_{45Gy} and V_{tot} of the original CT series.

Results. The results showed that there was up to 3% difference in $V_{95\%}$, and $V_{98\%}$ for PTV and CTV between normal and shortened CT series. Between the artificially extended CT series and normal CT series the differences in these parameters were negligible. For OAR the mean difference in V_{45Gy} was 0.1% with SD of 1.7% which is not significantly different from zero for p=0.05 significance. Total intestine volume was smaller for artificially extended CT series for most of the cases and the mean difference was -2.6% with SD of 1.5%, which is significantly lower than zero for p=0.05 significance.

Conclusion. This method of artificially adding missing slices provides only a scattering medium for the dose to the target and because of that the differences in respect to the original CT are negligible, so, regarding the target, it can be used if the shape of the body contour doesn't change substantially. For intestine the results showed that there isn't a significant difference in V_{45Gy}, but there is a significant difference in V_{tot}, so all relative mode calculations will be affected by this difference.

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Results of national pilot study of the IAEA-supported national end-to-end audit of the IMRT technique

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https://doi.org/10.21175/rad.sum.abstr.book.2022.30.2

Introduction. Each Polish hospital must undergo an independent dosimetry audit which is in concordance with regulations of the Ministry of Health. In 1991, the TLD based postal dose audit service was launched and has been operating since then. It offers audits to all radiotherapy hospitals in Poland. Audits in reference conditions for photon and electron beams are offered regularly on a yearly basis to all 42 radiotherapy hospitals in Poland. In 2021, an IAEA on-site end-to-end audit methodology for IMRT/VMAT treatments (https://dosimetry-audit-networks.iaea.org/) was tested within a national pilot study.

Materials and Methods. Seven hospitals took part in this study. Each participant had to successfully complete pre-visit activities to take part in an on-site visit, including:

- verification of small MLC fields output factors,
- verification of profiles for the 2x2 cm2 field,
- a MLC positioning test,
- treatment plan preparation following given constraints and priorities on provided CT scan of SHANE phantom,
- local QA verification of prepared plan,
- filling in datasheet including all relevant information.

At the beginning of each on-site visit, local staff CT scanned the SHANE phantom according to their protocol for head and neck IMRT treatments. CT images were transferred to TPS and HU values of different phantom densities were used to verify the HU conversion curve defined in the TPS. The plan generated during the pre-visit exercise was re-calculated and the doses obtained for PTVs and OAR were verified. This plan was verified using a local QA method. The beam output was measured.

The calibration films (range: 1-9 Gy) were irradiated in a solid water phantom. The 2x2 cm2 MLC shaped field and MLC positioning test, which were prepared during pre-visit phase, were also irradiated on films in solid water phantom.

The SHANE phantom was next set-up for the measurements with a PTW 31010 Semiflex 0.125 cm3 ionization chamber and with gafchromic EBT3 films (Ashland Inc.). The position of the phantom was verified using the onboard imaging method used for patients and corrected if shifts were detected. The percentage dose differences between the calculated and measured doses were reported.

Results. Audit plans were created for a 6 MV beam, 5 different linear accelerator models and 2 different TPS algorithms.

Pre-visit results proved that all hospitals generally met the criteria for all the TPS related parameters which were verified, except the deviations obtained for output factors for small fields (2 hospitals). Also all the hospitals were able to prepare plans in accordance to the constraints provided.

On-site results showed that the criteria for the CTtoRED conversion curve were not met by any participant. There is, however, concordance between TPS calculated and measured 2x2 cm2 profiles for 50% isodose (avg. 0.1 mm SD=0.3%), with larger differences obtained at 80% (0.8 mm SD = 0.8%) and 20% (0.3 mm SD = 0.9%) isodoses. The test of the MLC performance showed very good positioning accuracy of all the MLCs tested.

The ionisation chamber dose measurements in PTV were all within the 5% tolerance limit (max 4.5%) and in OAR within 7% (max 5.3%). The global gamma results acceptance limit were 90% of points passing 3%, 3 mm and all the participants were within those limits (avg. 97.4% ± 2.6%).

Conclusions. The exercise proved to be successful and the adoption of IAEA methodology to national circumstances was carried out without problems. The acceptance criteria established by the IAEA proved to be adequate except for the CT conversion curve. The new limits were established nationally, taking into account extensive studies performed locally. The results of the dose measurements for six hospitals indicate that the acceptance limits could be more rigorous. The audit proved to be difficult in its implementation, due to its labor intensiveness (the long time required at the audited hospital and extensive analysis of the collected data).

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Variations in lung volume between sets of 4DCT images acquired on the same group of patients

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https://doi.org/10.21175/rad.sum.abstr.book.2022.30.3

Goal. Four-dimensional computed tomography (4DCT) is a method of imaging that provides visualization of respiratory induced tissue and tumor movement. It allows capture of CT images over a breathing cycle and dividing them into a series of phases, relative to the degree of breath inhalation.

4DCT is used in lung radiotherapy to account for respiratory induced tumor motion by defining CTV to ITV margins. However, this method is not without limitations, since breathing patterns can change over time in both amplitude and frequency.

Our goal was to illustrate the variability of breathing by comparing differences in volume of lungs delineated on a pair of 4DCTs of the same patient, taken on different days.

Methods. We have selected ten patients that have undergone stereotactic ablative radiation therapy for lung metastasis in our institution twice within a period of 1 to 9 months (median 5).

A new 4DCT was acquired for each treatment; therefore, every patient had a pair of 4DCTs.

The structure of the lungs has been delineated on all of the phases using the Varian Eclipse deformable registration. A minimum, maximum and an average of the ten volumes have been determined for each of the pairs of 4DCTs.

Differences between the minimum, maximum and average volumes have been calculated and normalized to the average lung volumes.

Results. Out of ten patients, relative differences in average lung volumes was less than 5% for four patients, between 5% and 10% for five patients, while one patient had differences that exceeded 15%.

Mean differences between normalized average, maximum and minimum volumes of pairs of 4DCTs were 5.8%, 5.9% and 5.9% respectively, but varied widely from a minimum of below 1% (0.7%, 0.8% and 0.8% for the patient with the most stable breathing) to a maximum of over 13% (13.7%, 17.4% and 15.8% respectively for the patient with the greatest breathing inconsistencies).

Discussion. Our 4DCTs were taken months apart - based on our measurements, it is not clear whether the same inconsistencies would occur between 4DCTs taken hours, days or weeks apart, but literature suggests that such variations are to be expected.

Although 4DCT provides invaluable information regarding the motion of tumor and organs at risk, its reproducibility can be significantly affected by respiratory variation. As a measure of that reproducibility we have chosen to take the lung volume - it is a simple tool for this purpose, but could be misleading one - a 15% change in average lung volume does not imply the same change in ITV volume - especially for tumors in lower lobes.

It is important to take this variability into consideration when using 4DCT to determine ITV margins. Possibilities include individualized approach to each patient using 4DCT in combination with surface guided radiotherapy for motion management and possible margin adjustment.

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Comparison of dosimetric characteristics between Varian EDGE™ and CyberKnife® systems depending on tumor target volume

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https://doi.org/10.21175/rad.sum.abstr.book.2022.30.4

Goals. The goal of this study was to evaluate conformality and dose falloff depending on target volume between two systems for stereotactic radiosurgery: conus based CyberKnife® (CK) and MLC based Varian EDGE™ (EDGE).

Materials and Methods. We retrospectively examined 13 patients with peripheral brain meningiomas treated on Varian EDGE™. Additional treatment plans were made on the CK system using VOLO™ optimizer to evaluate differences between two systems. Brain - Planning target volume (PTV) ranged from 0.8-40 ccm with a mean volume of 15 ccm and had circular shape. Dose of 14Gy was delivered in one fraction.

EDGE treatments were delivered using RapidArc® non-coplanar arcs with multileaf collimator (MLC), while CK treatments were delivered using fixed circular collimators. Plan quality metrics used for evaluation were conformity index (CI), and dose gradient index (DGI).

In order to determine critical target volume whereupon one of the systems becomes more optimal, we examined linear correlations between dose characteristics and volume, to evaluate the corresponding curve interception.

Results. Both CI and DGI show no significant difference between EDGE and CK, with CI being (1.18±0.15) and (1.22±0.15) for respective system (p=0.14), and DGI being (79±11) versus (76±13), respectively (p=0.13). Conformity index shows negligible linear dependance on target volume for CK system (r=-0.05) while on EDGE there is low negative correlation (r=-0.43). The curves are intersecting on a value of 6.1ccm; volumes under 6.1 ccm had better conformality on CK.

Dose gradient index had negative correlation on both systems so dose falloff is slower with the growth of the target volume. On EDGE correlation is weaker (r=-0.63) then on CK (r=-0.89). Volumes under 2.7 ccm had better dose falloff on CK.

Discussion. All the results showed that DGI and CI are both inversely proportional to target volume. Conformity index on CK had very weak negative dependence on target volume, probably due to round collimator which is suitable for lesions which are roughly spherical. Further research of CI variation with shape is needed. Results indicate that irradiation of small volumes on CK and larger ones on EDGE would be optimal for sparing healthy tissue.

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Seasonal measurements of radon concentration level in the period of spring at the Technical College of Applied Sciences in Zrenjanin

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https://doi.org/10.21175/rad.sum.abstr.book.2022.31.1

This paper presents the results of the indoor radon level measurements at Technical College of Applied Sciences in Zrenjanin (Serbia) during spring 2022, in order to check safety levels. These studies were part of the project "Radon level measurements" which was financed by the Provincial Secretariat for Higher Education and Scientific Research. The project was created at the Technical College of Applied Sciences in Zrenjanin in 2022 and is still in the process of realization. Indoor radon concentration measurements were performed at the basement and groundfloor levels on a surface of approximately 4000m^2. Labs, offices, storage spaces, classrooms, a printing press office and a heating system room are situated there. Airthings Correntium Home Radon Detector was used for this purpose, which is capable of performing long-term measurements and it is based on alpha spectrometry with passive diffusion chamber and precision of about 10% (for short-term measurements). We did short-term two-day-long (48h) measurements in rooms with no ventilation and the doors and windows were closed all the time (worst case scenario). Rooms were sealed for at least 12h before the start of the measurement and the heating system was not used. Radon concentrations ranged from 13± 1 to 42±4 Bq·m^{-3} and were within safe level according to our National Reference Level (i.e. 200 Bq·m^{-3} for new homes and 400 Bq·m^{-3} for old and existing homes) limits and World Health Organization action reference level of 100 Bq·m^{-3}.

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Radon-222 concentration levels in soil and water in different regions of Georgia - radon mapping

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https://doi.org/10.21175/rad.sum.abstr.book.2022.31.2

According to GNSF project FR-19-22022, “Radon mapping and radon risk assessment in Georgia”, the authors carried out fieldwork to quantify the radon (222Rn) distribution in water and soil gas as well as to ascertain geological factors influencing the radon concentration levels in some geographical areas of Georgia.

On-site 222Rn concentration has been measured in soil gas (more than 300 sampling points) and in various water sources (boreholes, wells, deep thermal wells and springs, over 500 samples) using AlphaGUARD PQ2000 PRO (Saphymo, Germany) radon monitor. The radon concentration ranged from 0.1 to 221 Bq/l in water and in soil gas up to 80000 Bq/m3. All observation sites were marked by GPS position.

The Radon mapping, representing the key method for fulfilling the project requirement, is based on application of geochemical methods. After processing, the field data were digitized and transferred into the GIS System, the application technology of which revealed the connection of radon anomalies to geological and hydro-geological structures, including the tectonic faults.

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Studies on Early Middle Ages metal artifacts from Dobruja using X-ray fluorescence

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https://doi.org/10.21175/rad.sum.abstr.book.2022.32.1

Modern archaeometry offers a wide range of physico-chemical analytical methods for analyzing the elemental composition of archaeological metallic artifacts. One of these methods is X-Ray Fluorescence used with the portable Bruker Tracer 5^{i} spectrometer. In this paper there were analyzed pieces of adornment and clothing which represent important landmarks for dating the archaeological researched complexes on the territory of Dobruja (Hârşova, Adamclisi, Tufani, Oltina, Dinogetia-Garvăn, Cochirleni, Valu lui Traian).The metal from which such pieces were made represent an important aspect regarding the chronological value of ornaments and garments. The garments with a strictly utilitarian role were generally made of bronze and iron. They have a simple morphology and have been used for longer periods of time. Analyses of different objects consisting of ornaments and wear pieces (sconces, belt ends, earrings, rings, crosses) determine the chemical composition of the copper alloy and prove whether the objects were casted or not. Bronzes are alloys of copper with tin, more resistant than copper but with variable compositions, depending on the object. Evaluating the preliminary results, we concluded that there are several different bronze alloys, compositions with different Cu- (Sn-Zn-Pb-Ag). Most belt ornaments are cast from tin-lead bronze (Cu-Sn-Pb) with a high percentage of copper and a variable tin and lead content. In many artifacts, the alloy also contains a significant amount of zinc (Zn). Another alloy is the one composed of Cu-Zn with additions of Sn and Pb, and the third alloy encountered is Cu-Pb with additions of Sn and Zn. Historical “bronzes” have an extremely variable composition, as most metalworkers probably used whatever scraps they had at hand. Another way to obtain the raw materials needed to make bronze products was to remelt artifacts made of this metal, a process known widely in prehistoric times. Tin is added to improve the castability of the alloy by lowering the melting point, also strengthening the bronze. A bronze with 10% tin can be easily polished and chiseled, and offers a beautiful patina, while a bronze with 12% tin is harder to work after casting. The addition of lead also improves turnability by lowering the melting point and making the alloy more ductile, but without exceeding 5% lead as the alloy weakens. Metals and their alloys (in this case bronze) are sensitive to the action of moisture, impurities carried by air currents, soils, and gases in the atmosphere. The corrosive degradations differ from one metal to another, presenting various shapes and intensities, corresponding to the nature of the corrosive agent or the attacked material, the duration of the agent’s action or the overlap of several corrosive actions of different types. Sometimes these effects are interesting, ennobling the appearance of the object (well-formed patinas), and other times they are harmful (badly formed patinas, massive loss of material in the form of wounds, pinches, cracks, passage to metastable forms etc.).

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Transesophageal echocardiographic control at the stages of performing endoscopically assisted coronary bypass graphing

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https://doi.org/10.21175/rad.sum.abstr.book.2022.32.2

Introduction. Recently, a new direction – minimally invasive coronary surgery – has been increasingly entering the clinical practice of cardiac surgery. It is based on performing an operation on a beating heart (in case of damage to only the anterior descending artery) without the use of cardiopulmonary bypass, or using the so-called MECC perfusion (in case of a multivessel lesion) and the use of anterior-lateral mini-thoracotomy. In this case, the isolation of one or both internal mammary arteries is performed completely endoscopically. The rehabilitation period with minimally invasive intervention is much shorter than with traditional coronary artery bypass grafting, there is less blood loss, and the risk of postoperative infectious and other complications is significantly lower. The ability to perform complete myocardial revascularization without sternotomy allows for coronary bypass grafting in patients with an extremely high comorbid background, for whom the use of traditional approaches is associated with an extremely high risk of postoperative mortality. Given that in 100% of cases this technique involves the use of two ITAs (internal mammary arteries), it can be assumed that in the long term it will show good results in terms of graft patency, the absence of adverse cardiovascular events (MACCE) and quality of life indicators. Transesophageal echocardiography (TEEC) is a prerequisite at all stages of endoscopically assisted coronary artery bypass grafting (CSB).

Purpose of the study was to evaluate the possibilities of intraoperative TEE at the stages of performing endoscopically assisted CABG.

Materials and Methods. At the National Medical Research Center for Surgery named after A.V. Vishnevsky in 2017-2018 35 endoscopically assisted CABGs were performed. The surgical procedures were performed under the control of intraoperative TEE.

Results. All surgical interventions were successful. There were no bleeding and other surgical complications, as well as deaths in the postoperative period. Postoperative bed-day was 5.2 days. Evaluation of the use of intraoperative TEE allowed to develop a technique for its implementation and an algorithm for TEE-control of cardiosurgical manipulations.

Stages of TEE in endoscopically assisted CABG:

1. Vein cannulation (avoids damage to the hepatic and other visceral veins, damage to the right and left atrium).

2. Control of cardioplegia (presence of regurgitation flow through the aortic valve from the aortic root).

3. The end of cardiopulmonary bypass (since direct visualization of the heart during cardiopulmonary bypass is practically impossible, the data of TEE are the basis for assessing the adequacy of the restoration of cardiac activity and the main criterion in the selection of cardiotonic therapy in the postperfusion period).

Conclusion. TEE is important when performing endoscopically assisted CABG, allowing to avoid complications at the stages of the intervention, as well as to assess the adequacy of its implementation.

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High harmonic generation in crystalline silicon and zinc oxide irradiated by an intense ultrashort infrared laser pulses

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https://doi.org/10.21175/rad.sum.abstr.book.2022.32.3

Photoionization, energy deposition and high harmonic generation (HHG) in bulk crystalline silicon and zinc oxide irradiated by intense near infrared laser pulses with varying pulse duration < 100 fs were theoretically studied. Depending on the laser intensity perturbative and breakdown regimes of generation of XUV irradiation can be distinguished. In the perturbative regime, the dielectric response of Si is dominant and high harmonics are generated during each half-cycle of the pulse via re-collision of electron-hole pairs. The resultant high harmonic spectrum consists of isolated peaks at odd harmonic orders. HHG is characterized by low conversion efficiency of near-infrared to ultraviolet irradiation. In the dielectric breakdown regime, temporal coherence of the transmitted laser pulse deteriorates and a quasi-continuous spectrum emerges. Depending on the pulse duration of the applied laser, a non-linear optical rectification of the transmitted pulse in Si is observed, which produces intense even order harmonics in bulk silicon. Depending on the polarization of the laser field odd or even harmonics are observed in bulk zinc oxide.

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Forensics in the Field: An exploratory journey from 'search and rescue' to identifying human remains using diagnostic imaging procedures

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https://doi.org/10.21175/rad.sum.abstr.book.2022.32.4

This presentation will focus on the forensic journey from looking for a missing person, search and rescue procedures to identifying human remains.

A missing person scenario can be a traumatic event for family members and the importance of recovery of the individual is paramount. The missing person may be located safe and well or occasionally partial remains may be found. It is vital that such remains are correctly identified and closure can be given to the family and an identity can be given to the recovered individual. The correct identification is a vital component of any police and or forensic investigation. This process relies on a variety of skilled professionals all with their expertise working together to build a picture of the recovered individual or their remains. This may involve the identification of specific body parts with identifying features such as piercings or tattoos, or bony remnants, teeth, individual bones or soft tissue remains.

A variety of professionals are involved in this process from search and recue team personnel to radiographers, forensic pathologists and the police. All of these professionals work in a different yet symbiotic nature to build a picture of the individual and work towards a positive identification of the victim.

The presentation will initially explore the basic principles of mantrailing and the key concepts of search and rescue including the interaction between the handler and the dog. The importance of this will be highlighted and its relevance to the forensic examination as this is one of the initial steps in the process. The accuracy of this step can influence the forensic process and impact on victim identification. The importance of the avoidance of cross contamination and pitfalls that can occur will be explored as well as their relevance for the forensic investigation. The use of identification techniques on human remains found will be explored including Diagnostic Radiography, human anthropology and the information it can provide. The value of Diagnostic Imaging will be explored as well as its limitations.

The presentation will conclude with take home points on good practice.

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Cryodestruction in local advanced pancreatic cancer: indications, performance and effectiveness evaluation

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https://doi.org/10.21175/rad.sum.abstr.book.2022.32.5

The purpose was to determine the indications and evaluate the cryodestruction (CD) of locally advanced pancreatic cancer (LAPC) results.

Materials and Methods. Since January 2012, CD was performed in 69 LAPC patients (mean age 54±7.2 years). Preoperative examination: US, MSCT and/or MRI. Pancreatic lesions size: 2.5-7.0 cm. Local destruction was supplemented by the bypass anastomoses in 14 (20.3%) cases, bile duct stenting - in 18 (26.1%). Russian devices "KRIO-MT" and "KRIO-01" and porous-spongy applicators made of titanium nickelide were used. Cryoapplicators diameter: 2-5 cm. The target temperature: -186°C. Exposure time: 3-5 min. Sessions number: depended on the tumor size (1-5, average 2.4). Postoperative examination: US (1, 3, 5 days or on demand), MSCT and/or MRI.

Results. Preoperative examination made it possible to determine the possibility of CD performing. CD indications: unresectable pancreatic tumor, involvement of unpaired main visceral arteries in the tumor, severe pain syndrome, general contraindications for open operation. CD contraindications: germination of a hollow organ over a considerable extent; distant metastases. The NCCN Guidelines Ver. 1.2016 Pancreatic Adenocarcinoma was used in determining of LAPC.

We consider it mandatory to use intraoperative US (IOUS) during CD. The tumor center was determined at IOUS and a cryogenic applicator was placed directly in its projection. Before pancreatic neoplasms CD, a mandatory study of the liver was performed to detect metastases. IOUS made it possible to avoid possible injuries to healthy organs and vessels and to correctly assess the completeness of the destruction of pathologically altered tissues. IOUS performed from different points makes it possible to immediately determine whether the zone of the iceball overlaps the tumor. Thus, IOUS, with a certain researcher experience, makes it possible to judge with a high probability of CD effectiveness. US-control allows intraoperative assessment of changes in bloodflow in large vessels. The cessation of bloodflow occurred mainly in vessels of small diameter (up to 3 mm), which were thrombosed as a result of freezing. The large vessels walls are resistant to low temperatures and blood flow in the vessels of large diameter after cryotherapy is completely restored.

US-emphasis in postoperative period: examination of post-destructive changes zone to determine the completeness of the tumor treatment: free fluid in the abdominal cavity; accumulations of bile, pancreatic secretion, blood; free fluid in the pleural cavities. MSCT was performed in patients in unclear situations and/or when bleeding was suspected.

Intra-abdominal bleeding was in 3 (4.3%) cases (due to cracks on the border of pancreatic tissue and "iceball" (1); damaged of the artery during the biopsy after CD (1); from the mesenteric artery basin vessel (1), was endovascular stopped. Acute pancreatitis was in 5 (7.2%) cases; suppuration in the manipulation area - 2 (2.9%), eventration - 1 (1.5%). Ascites was detected in 10 (14.5%) cases (stopped conservatively within 5–8 days).

MSCT and MRI are much more informative and effective. MRI makes it possible to differentiate viable pancreatic tissue from devitalized areas. The early criteria of CD effectiveness were the complete overlap of tumor tissue necrosis zone, the absence of residual fragments along the periphery. If they are detected on MRI and adequate US, it is possible to perform an additional CD session in a few days.

There were no lethal outcomes during CD and in immediate postoperative period. The complete disappearance of the pain syndrome after CD was in 39.6%, a significant decrease in its intensity - in 41.8%.

Conclusion. Cryodestruction of LAPC in unresectable patients is an intervention that significantly improves the quality of life of cancer patients, primarily by reducing pain. US, MSCT and/or MRI allow to determine the indications, conduct a CD and evaluate the results at the stages of implementation.

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Comprehensive examination and treatment of kidney cancer patients with combined surgical diseases

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https://doi.org/10.21175/rad.sum.abstr.book.2022.32.6

Kidney cancer is one of the most common urological tumors, accounting for 2% of all malignant neoplasms. The average age of its detection is 60 years. Therefore, often, by this age, patients also have other pathological changes that require surgical treatment.

Purpose was to evaluate the results of a comprehensive examination and treatment of kidney cancer patients with concomitant surgical diseases.

Materials and Methods. At A.V. Vishnevsky NMRC of Surgery accumulated experience in diagnosing and treating 24 patients with kidney cancer and combined surgical diseases (men predominated - 21 (87.5%), average age - 61.1 years (38 - 82).

Results. A possible combination of surgical pathologies made it necessary to develop a comprehensive program for examining patients, aimed at identifying all possible pathological changes in human organs and systems. This program is possible and works effectively only in a multidisciplinary hospital.

Identified concomitant surgical pathologies can be divided into three groups: I group - cardiovascular diseases (CVD); II group - cancer of the chest and abdominal cavity and small pelvis; III group - benign disease. Group I (n = 13 (54.2%): critical stenosis of the coronary arteries - 10; aortic aneurysm - 1; arteriovenous fistulas of the external iliac artery and vein - 1; cardiac arrhythmias - 2 (the total number of patients is higher, because of one patient had coronary artery stenosis in combination with arrhythmia). Group II (n = 7 (29.2%): lung cancer - 1; esophageal cancer - 1; stomach cancer - 2; neuroendocrine and hepatocellular liver cancer - 1 case each; prostate cancer - 1. In patients with kidney cancer, intraluminal thrombosis of various levels was also detected in 9 (37.5%) cases. In 1 case, mts was also simultaneously detected in the lung. Group III (n = 4 (16.6%): choledocholithiasis - 1; choledochal stricture - 1; inguinal hernia - 1; spleen hemangioma - 1. Further, a personal consultation was held for each patient with the definition of treatment tactics: first of all, surgical correction of pathological changes that had a more significant threat to life (more often these were CVD) was performed.

In the presence of kidney cancer and CVD, the following interventions were performed: simultaneous interventions were performed in 1 case (arteriovenous fistulas of the external iliac artery and vein); in 7 cases with combined stenoses of the coronary arteries both open and endovascular interventions were performed as the first stage; also, the first stage was resection of an aneurysm of the infrarenal aorta with aorto-bifemoral prosthesis and coronary bypass grafting with RFA modification of the Cox-Maze operation; endovascular interventions were performed as the second stage in 2 cases in the presence of kidney cancer with inferior vena cava thrombus.

In the presence of kidney cancer and cancer of another organ of the thoracic and abdominal cavity and small pelvis, it is presented: simultaneously performed hemihepatectomy (neuroendocrine liver cancer) and resection of the stomach (2 cases of gastric cancer); as the first stage, resection and plastic surgery of the esophagus (esophageal cancer) and prostatectomy (prostate cancer) were performed; as the first stage, a kidney operation was performed, and as a second stage, a lung resection (lung cancer and mts in this lung).

In the presence of combined benign diseases, the first stage in choledocholithiasis was lithoextraction; in case of choledochal stricture, the stricture was eliminated; hernia repair was performed in the second stage; spleen hemangioma is under observation.

Conclusion. The developed system for examining patients who come to the surgical hospital for kidney cancer allows timely identification and elimination of life-threatening pathological conditions and, thus, improving the results of treatment of patients with this pathology, which is possible only in a multidisciplinary surgical hospital.