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INTERNATIONAL CONFERENCE ON RADIATION APPLICATIONS

In Physics, Chemistry, Biology, Medical Sciences, Engineering and Environmental Sciences

BOOK OF ABSTRACTS

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TABLE OF CONTENTS

Click on the title of the abstract to access it

Advanced semiconductor microdosimetry for particle therapy and space

A.B. Rosenfeld[1], L.T. Tran[1], S. Guatelli[1], D. Bolst[1], S. Peracchi[1], B. James[1], V. Pan[1], J. Vohradsky[1], M. Petasecca[1], M. Lerch[1], M. Povoli[2], A. Kok[2], T. Inaniwa[3]

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Based on many years of experience in development of silicon-on-insulator (SOI) microdosimeter, the Centre for Medical Radiation Physics, University of Wollongong, has successfully developed a microdosimetric probe which is based on a SOI microdosimeter with 3D micron sized sensitive volumes (SVs) array mimicking dimensions of cells, known as the "MicroPlus-Mushroom" microdosimeters, to address the shortcomings of the large tissue equivalent proportional counter (TEPC).

A method for converting silicon microdosimetric spectra to tissue for a therapeutic proton and heavier ion beams, based on Monte Carlo simulations was developed. The MicroPlus microdosimeter provides extremely high spatial resolution and were used to evaluate the relative biological effectiveness (RBE) of ^{4}He, ^{12}C, ^{14}N, ^{16}O, ^{20}Ne, ^{56}Fe ions at Heavy Ion Medical Accelerator in Chiba (HIMAC), Japan as well as to measure the microdosimetric distributions of a proton pencil-beam scanning (PBS) and passive scattering system at different proton therapy centres. Good agreement between predicted cell survival response using MKM and measured from *in vitro* experiments in the same radiation field allow replacing time consuming cell experiments with MicroPlus microdosimeter measurements. Based on these studies new domain of quality assurance in particle therapy as dose averaged linear energy transfer (LET_D) was clinically introduced along with absorbed dose measurements.

Another application of SOI microdosimeter is for evaluation of radiation shielding and radiation protection of astronauts in radiation environment typical for SPE and GCR. We demonstrated that SOI microdosimeters are suitable for *in situ* evaluation of radiation shielding efficiency of multi-layered space craft and astronaut shelter walls in radiation fields on accelerators mimicking SPE and GCR. SOI microdosimeters supplement and bench marking Monte Carlo simulation which not always accurate due to lack of knowledge of cross sections and time consuming.

New insights from climate change studies using temporal trends of marine environment indicators

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Rapid climate change due to human activities is an urgent global problem that has far-reaching implications for the environment and human society. The oceans are recognized to play a key role in mitigating or accelerating global warming trends, largely because of their ability to rapidly exchange carbon dioxide with the atmosphere. Water column temperature, acidity, and sea level are the most studied indicators of changes in the marine environment. All three are rising at alarming rates. In this study, we will examine some of the less obvious responses of the marine environment to rising atmospheric CO_2 concentrations using case studies from the Mediterranean Sea. In particular, we highlight the impact of rapidly changing trends in salinity and sea temperature on the exchange of water masses between the upper and lower layers of the water column, affecting the oxygen content of deep-sea water, the acceleration of sedimentation rates, and the release of methane hydrates from marine sediments.

Recent observations reveal that the above-mentioned processes in the Mediterranean Sea have undergone significant changes in recent decades due to dramatic changes in temperature and salinity. The Mediterranean Sea, and especially the Adriatic Sea, are very sensitive to any small climate change. The aeration of the deep Eastern Mediterranean results from the circulation of oxygen-rich deep water, originating mainly from the Adriatic Sea. An increase in water temperature of only 0.7 °C or a small decrease in salinity of 0.2 °C could lead to stratification of the Adriatic water and prevent the formation of the oxygen-rich Adriatic Deep Water (AdDW). This stratification without complete mixing of sea layers is known as the meromictic condition. In the last two decades, we have observed an abrupt increase in the average temperature and salinity of the AdDW, from 12.6 °C to 13.9 °C in temperature and from 38.6 to 38.9 in salinity. Assuming present-day conditions, this trend will continue, and one of the consequences we are facing is the hypoxia of the lower layers of the Adriatic Sea, with implications for the entire Mediterranean Sea. As a result, marine life in the lower layers is likely to deteriorate along with an increase in the methane-hydrates release from Mediterranean sediments that might further accelerate climate change.

This study aims to determine whether the Adriatic Sea is on the path to become meromictic and how this will affect oxygen levels, sedimentation rates, and methane-hydrate release in the Mediterranean basin. The study also highlights the need for continuous monitoring of these processes in seas and oceans worldwide. These changes have significant implications for marine ecosystems, including biodiversity loss, changes in fisheries, and impacts on coastal communities. The study will close the current knowledge gap and raise awareness of yet another climate change threat.

Novel isotope labeling approaches to determine organic matter transformations in the environment

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In accordance with the European Commission's 2030 Agenda goals to constrain organic carbon transformations in aquatic habitats, we have developed a dual isotope tracer technique using $^{13/12}C$ and $^{2/1}H$ to quantify metabolic and geochemical fluxes of the microbial loop. This approach was applied during two simultaneous case studies in a sub-alpine lake that (1) investigated fungal productivity and (2) the turnover of dissolved organic matter (DOM).

Case Study 1: Predicting organic matter reactivity and thus the carbon-climate feedback in aquatic ecosystems is limited by poor understanding of the turnover of "recalcitrant" organic matter in soils. As major decomposers in both aquatic and terrestrial food webs, fungi are among the few organisms on the planet that can metabolize recalcitrant C, but are also known to symbiotically and competitively access recently produced photosynthate. Therefore, improved quantification of substrate utilization by different fungal ecotypes will help to define the rates and controls of fungal production and the cycling of different reactive components of organic matter in the environment. This study employed a dual stable isotope probing approach of fungal lipid biomarkers to determine their growth rate and metabolic mode over spatial and seasonal gradients.

Case Study 2: DOM cycling is essential to understanding energy flow in aquatic ecosystems and their role as a source or sink of CO_2 in the global carbon cycle. Quantifying DOM turnover and reactivity has been confounded by the barely detectable changes in molecular composition and ^{13}C & ^{15}N stable-isotope compositions. We hypothesized that significant spatial and seasonal changes in biological productivity might be reflected in the transfer of water-derived H to DOM, providing a novel approach to assess DOM turnover in aquatic environments. An in-situ stable isotope labeling (HDO) experiment revealed (microbial) turnover of DOM occurred on a weekly timescale, and was faster in late Autumn than in Spring. Changes in the non-exchangeable stable H isotopic composition of DOM revealed a window of DOM reactivity that could not be seen through the lens of stable C isotope signals. Further development of $^{2/1}H$-DOM analyses may improve our understanding of the provenance and processing of DOM and better constrain unknowns in the metabolic balance of aquatic ecosystems.

Developing radiopharmaceuticals for health

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The development of novel radiopharmaceuticals is a rapidly evolving field that has revolutionized the diagnosis and treatment of a wide range of diseases. Radiopharmaceuticals are unique in that they combine a biologically active molecule, such as a drug or antibody, with a radioactive isotope to create a targeted therapeutic or imaging agent. The use of these agents is growing at an unprecedented rate, driven by the increasing need for personalized medicine and the growing prevalence of chronic diseases. However, developing such important products requires a preliminary understanding of the biological targets, and, closer to the radiation field, availability of appropriate isotopes, of efficient radiolabelling methods, of automated synthesis approaches and adherence to regulations. This lecture will give an overview of the current paradigms and concepts adopted, thus providing the basis to anticipate the opportunities and challenges that lie ahead.

CALIBRA: A national research infrastructure for accelerator-based research and interdisciplinary applications

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CALIBRA is the acronym for "Cluster of Accelerator Laboratories for Ion-Beam Research and Applications" which is one of the Greek National Research Infrastructures. CALIBRA is planned to be completed in phases with the first one being implemented through the homonym project that is funded by the currently running Partnership Agreement for the Development Framework (ΕΣΠΑ 2014-2020). The CALIBRA project aims at establishing and operating an accelerator-based research infrastructure open to the national and the European scientific community to conduct research at excellence level, develop innovative applications of increased socioeconomic impact, and provide highly-specialized services, unique at the country level, to the public and private sector.

CALIBRA is implemented at the Tandem Accelerator Laboratory of NCSR "Demokritos". In CALIBRA Phase 1, the existing 5.5 MV Tandem was full-upgraded. In addition, a donated 17 MeV Cyclotron is about to be installed together a 2.5 MV Tandetron Accelerator for Accelerator Mass Spectrometry (AMS) donated by the University of Oxford, UK. The Cyclotron aims at upgrading the existing research in radiopharmaceuticals development, whereas the Tandetron AMS will focus on cultural heritage and environmental studies.

In this communication, we report in detail on the experimental setups available at CALIBRA including its neutron production target, the currently running activities and the procedures for access to beamtime for external users.

Acknowledgments: Work supported by the project "CALIBRA/EYIE" (MIS 5002799) which is implemented under the Action "Reinforcement of the Research and Innovation Infrastructure", funded by the Operational Programme "Competitiveness, Entrepreneurship and Innovation" (NSRF 2014-2020) and co-financed by Greece and the European Union (European Regional Development Fund).

A contribution to the current debate on the rationale of the Linear-No Threshold Hypothesis (LNT)

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The Linear-No Threshold Hypothesis (LNT) states that risk from ionizing radiation is linearly related to dose with no dose threshold below which there was no risk. The LNT is an important fundament in practical radioprotection and for assessment of population risk, e.g. of estimating lung cancer risk or incidence attributable to exposure to indoor radon. The popularity of the LNT stems largely from its mathematical simplicity and therefore, its practicability.

It seems that this has obscured the question of whether it is physically true, or "only" a useful practical rule. Probably one has to ask for which purpose a rule is applicable. Distribution of exposure and dose to radon through the population is strongly right-skew, with the bulk of dose low. Therefore, evidently, attribution of risk, i.e. mainly lung cancer incidence, depends strongly on the risk model for low dose.

As long as no micro-dosimetric model exists which causally relates incident radiation flux or exposure to radon progeny to a sequence of effects, starting on sub-cellular level, which results in clinical evidence, it is impossible to make statements on the effect of very low doses, since it is in principle impossible to extend empirical epidemiological inference to arbitrarily small doses. Therefore, epidemiological findings are extrapolated towards low doses.

The most quoted large-scale epidemiological radon meta-study is Darby et al. (2006), which concludes that the LNT model is statistically compatible with the findings. This has been essentially corroborated by newer studies. However, with availability or more data, there seems to be increasing evidence that the model may not be applicable to estimate risk for low doses, which represent the bulk of exposure, if the objective is assessment of population risk.

We review literature about the strongly debated question about validity of the LNT. Data are not publicly available, therefore statistical re-analysis is impossible. However, published information in the form of graphs and statistics allows some hypotheses alternative to the LNT.

The debate is so serious because of the political consequences regarding radon abatement policy. We certainly refrain from stating any "alternative truth", but investigate the possible consequences for risk assessment and what they entail for radon regulation and policy, resulting from different risk models.

Heavily-doped lead tungstate scintillators for fast detectors of ionizing radiation

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The coming high-luminosity high energy physics experiments and high-resolution medical imaging devices, in particular, time-resolved positron emission tomographs, require detectors of ionizing radiation with substantially faster scintillator response. Lead tungstate (PWO) is an intrinsic scintillator and exhibits quite fast scintillation response that probably can be further improved by appropriate doping. In this report, we present results of our study of the acceleration of luminescence decay in PWO doped by yttrium and lanthanum up to a large level. Time-resolved photoluminescence spectroscopy in the temperature range from 80 to 400 K at excitation intensities varied in a large dynamic range, transient optical absorption technique to follow the time evolution of the density of nonequilibrium electrons and light-induced transient grating (LITG) technique to study excitation diffusion were employed. All the samples under study exhibited luminescence spectra evidencing the dominance of a single emission mechanism interpreted as the recombination at oxyanionic complexes in the regular lattice. LITG measurements showed that the estimated upper limit of the diffusion length of this excitation is as low as 100 nm. This is in accordance with the assumption that the emission is caused by the radiative recombination of self-trapped excitons. The luminescence decay is strongly nonexponential, whereas the contribution of the fast decay within the first few nanoseconds increases with increasing Y and La content. This feature is interpreted by the contribution of the excitons self-trapped at the complexes inequivalently distorted due to the influence of the impurities located at different distances. The time evolution of the population of self-trapped excitons was tested by transient absorption technique in pump and probe configuration. An extremely fast decay with subnanosecond decay time was observed at high excitation intensities. Moreover, the increasing excitation intensities also resulted in the saturation of luminescence intensity. The initially fast decay in population of self-trapped excitons and the luminescence intensity saturation were satisfactorily described by taking into account nonradiative Auger-type recombination due to dipole-dipole interaction. Our study shows that the luminescence decay time in PWO single crystals can be substantially accelerated by heavy Y and La doping. However, at the acceleration occurs due to the enhanced nonradiative recombination of nonequilibrium carriers and, therefore, is achieved at the expense of emission efficiency. Nevertheless, a useful tradeoff between timing properties and efficiency might be achieved for certain applications at appropriate doping level.

Novel diamond detector development for harsh neutron flux environments

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Diamond detector systems are widely used in radiation applications, particularly in neutron induced reaction studies and neutron fluence measurements (P. Kavrigin, PhD TU Wien 2018, *J. Nucl. Eng*. 2021, 2, 422–470). A newly built diamond detector and associated electronics were developed for in-beam neutron measurements in harsh environmental conditions (high instantaneous neutron flux, high gamma-ray background etc). The diamond sensor (allotrope of carbon) is characterized by high radiation resistance, high thermal conductivity and low thermal expansion coefficient, but also high rigidity, and biological and chemical inertia. The synthetic diamond was fabricated via the CVD (Chemical Vapour Deposition) technology along with the necessary electronics, from CIVIDEC Instrumentation [https://cividec.at/]. Various tests were performed to determine the detector's response with the most prominent being those performed at the n_TOF facility at CERN, especially at the new experimental area, namely NEAR [CERN-INTC-2020-073; INTC-I-222 (2020)], an area with very high instantaneous flux and harsh environmental conditions. It was the first time an in-beam measurement is attempted at this newly build facility. The preliminary results of the tests for the development of this novel detection system will be presented and discussed.

Development of a silicon carbide radiation detection system and experimentation of the system performance

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Many studies have shown that silicon carbide (SiC) radiation detectors have excellent radiation detection capabilities for various radiation particles, including high energy resolution, fast response times, and good radiation hardness. In this work, a silicon carbide radiation detection system was developed to measure the neutron fluence rate and the gamma dose rate in high intensity radiation fields. The system was composed of two SiC radiation detectors, a temperature sensor, preamplifiers for each of the two SiC radiation detectors, a data acquisition and processing unit with two signal acquisition channels, and an application software to analyze and visualize the measurement data. The two SiC detectors were fabricated based on two kinds of 4H-SiC PN diodes with different quality, and used to respectively respond to neutron and γ-rays. Repeated experiments have shown that the two SiC detectors of the system can respond to α-particles, neutron and γ-rays. To verify the performance of the silicon carbide radiation detecting system, including the measurement accuracy and linearity of neutron fluence rate and gamma dose rate and the radiation resistance, the system was tested in four Chinese institutes, namely National Institute of Metrology, China Institute of Atomic Energy, Jiangsu Institute of Metrology, and Shanghai Institute of Applied Physics, Chinese Academy of Sciences. The tests results show that the system can measure the neutron fluence rate from 6.14×10^{2} n/cm²·s to 1.74×10^{6} n/cm²·s, and the gamma dose rate from 0.005 Gy/h to 20 Gy/h. The SiC detectors have also shown good radiation resistance. The neutron and gamma radiation field can still be measured stably after receiving neutron fluence of 1.07×10^{14} n/cm² and gamma fluence of 3.52×10^{6} rad.

Effect of the activator material in Gd_2O_2S phosphor based EPID systems: A theoretical study

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Introduction. Electronic Portal Imaging Systems (EPIDs) are used in Radiotherapy treatment as part of the patient positioning verification check. A significant part of their imaging performance is the ability to discern small objects leading to optimum spatial resolution properties. A parameter characterizing spatial resolution is the Modulation Transfer Function (MTF) expressing the image transfer characteristics as a function of spatial frequency. In this work the effect of the scintillator in EPIDs MTF is theoretically examined.

Materials and Methods. The PENELOPE based MC software package PenEasy (J. Sempau et. al., Med. Phys. 38, 5887-5895, 2011) was used. A narrow cone beam geometry with a cross section of 0.00053 cm^2 at 100 cm distance was considered. The beam was assumed to impinge on 1.8 cm Al in contact with 2 cm water equivalent phantom. At 100 cm distance a Gd_2O_2S based scintillator, as part of an EPID responsible for detecting X-rays was considered, with thickness 0.018 cm. The photon energy was 2 MeV corresponding to the average energy of a 6 MV LINAC. The energy deposition in Gd_2O_2S was determined and the corresponding MTF was calculated by an analytical formula. The formula takes into account the optical photon generation in the scintillator and the light propagation to the output. The analytical equation was employed for Tb, Eu and Pr activators within a Gd_2O_2S powder phosphor host.

Finally, the frequency dependent Contrast Transfer Function (CTF) of a Gd_2O_2S:Tb based EPID system was experimentally determined by imaging the QC3 phantom in an iViewGT™ R3.4.1 MV Portal Imaging system for 6MV, 2MU and 400 DR irradiation conditions.

Results. The statistical uncertainties of the simulations were below 1.5%. It was found that the MTF of Gd_2O_2S:Tb phosphor was superior to that of Gd_2O_2S:Eu, having a value of approximately 0.49 at 24 lp/cm spatial frequency. The corresponding values for Gd_2O_2S:Eu at 24 lp/cm spatial frequency for the 0.018 cm thickness scintillator was 0.25. Pr activator exhibited the highest MTF, but the light output results were significantly inferior to the other phosphors making the use of Gd_2O_2S:Pr an impractical choice. The Eu activator showed the highest light output per incident photon.

The error in the experimental CTF was below 5% at 7.89 lp/cm spatial frequency. The corresponding normalized CTF value at 7.89 lp/cm was close to 0.25. By considering that a normalized CTF function is close to the corresponding system's MTF, the differences between the theoretical MTF and the experimental CTF are due to the effect of pixel sampling, the effect of scatter radiation and any software algorithms imposed in the image.

Conclusion. The MTF of a scintillator based EPID has been theoretically investigated. It was found that Tb activator practically presents an optimum activator choice. A more detailed study should include the effect of scatter in MTF and the determination of the experimental MTF through CTF.

Pulsed infrared stimulated luminescence of Ce^{3+} doped YAG crystals as a dosimetric tool

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The optically stimulated luminescence (OSL) technique becomes more and more widely applied for the measurements in radiation dosimetry. Oppositely to thermoluminescence, there are so far only two materials successfully used in commercial OSL dosimetry systems: Al_2O_3:C and BeO. Because of this lack of choice of alternative detector types, there is still interest in developing new OSL materials.

The stimulation light wavelengths exploited so far for dosimetric applications of OSL are limited only to blue and green light. On the other hand, infrared-stimulated luminescence (IRSL) is quite commonly used for geochronology, mainly for the luminescence dating of feldspars. Recently, we found that Ce-doped garnets are susceptible to IR (c.a 860 nm) stimulation and exhibit strong luminescence emission [doi.org/10.1016/j.mseb.2021.115448, doi.org/10.3390/ma15238288], enabling measuring doses at the level of 0.1 mGy. The emission spectrum of Ce^{3+} ions in garnet crystals extends between 500 nm and 650 nm, it is therefore in this case impractical to use typical blue/green light for stimulation, while IR is quite suitable.

The measurements were conducted using two different readers: DA-20 (Risø) and PSLfood (RadPro & Freiberg Instruments). Both systems use photomultipliers with somewhat different spectral ranges. The measurements were performed with different setting of the reader parameters for the optimization of the system. The obtained results show that the PIRSL technique might be a very promising tool for this application. It was possible to measure as low a dose as 0.005 mGy. Other dosimetric characteristics, like reproducibility and dose-response were investigated.

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Determination of thermal neutron dosimetry using nuclear track detectors

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In this work, CR-39 and LR-115 nuclear track detectors (NTDs) were used for thermal neutron dose measurements from Am-Be neutron source. Each of CR-39 and LR-115 NTDs were covered with B_2O_3 slide converter. The exposure to thermal neutron for each CR-39 and LR-115 NTDs were occurred up to 37 hr. Four sets of pair detectors were irradiated at different thermal neutron exposure. The thermal neutron fluxes were calculated from the induced-ions track density through the means of the efficiency factor from the total track density (r). From the exposure of thermal neutron as the flux calculations from ion-track density, the equivalent doses (D) were deduced using the dose-flux relationship or flux-dose converting factor.

As ^{4}He and ^{7}Li ions were produced from the interaction of thermal neutrons with boron-covered CR-39 detector, charged particles (^{4}He, ^{7}Li) identifications were successfully obtained using the circular-track diameter analyzing method and were compared with reference alpha source. Although such method is a tedious one, results are, indeed, encouraging and certainly recommended. This tedious task was a good acceptable result that was expected. Results of this study are discussed within the frame work of nuclear track formation theories and etching mechanism in nuclear plastic detectors.

Spectral matching factor calculations between $(Gd,Y)_3(Al,Ga)_5O_{12}$ fluorescent screens of various activators and photodetectors

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Fluorescent screens are widely used in several applications where their optical properties play a crucial role in the overall imaging performance. The purpose of this study is to investigate the emission spectra of several $(Gd,Y)_3(Al,Ga)_5O_{12}$ fluorescent screens (synthesized by a spin-coating method of various Ce and Tb dopant concentrations) and to calculate their spectral compatibility with several photodetectors used in radiation detectors. The screens were produced in quartz substrates (area of 10 x10 mm^2 and 0.5 mm thickness) in ceramic form and irradiated by an UV lamp peaked at 312 nm. Powder phosphors with grain sizes from 10 up to 40 μm in diameter and elastic PDMS and Sylgard 184 binding materials were used for the development of the screens. The fluorescent screens were constructed with coating weight, ranging from 13.5 mg/cm^2 up to 28 mg/cm^2. The homogeneity achieved was approximately equal to 92% with a very high transparency. Results showed that each fluorescent screen provided different emission spectrum, with variations in peak wavelengths and intensities. The composition and the material of the activator of the screens were found to have a significant impact on the emission spectra bands and also to the emission intensities. Excellent matching factors up to 90% were calculated for the majority of the optical detectors. Comparisons with the golden standard Gd_2O_2S:Tb phosphor screen (also synthesized with spin-coating technique) were also performed. Gd_2O_2S:Tb phosphor exhibited a peak intensity of 1201 counts at 544 nm, while in the $(Gd,Y)_3(Al,Ga)_5O_{12}$: $Ce_{0.045}$ case, a peak intensity of 109 counts at 516 nm was observed.

Keywords: inorganic scintillators, fluorescent screens, spectral matching factor, $(Gd,Y)_3(Al,Ga)_5O_{12}$

LGAD sensors for application in proton CT

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The concept of proton-CT will be described with requirements of this imaging technique which offers many advantages over the conventional CT particularly for hadron therapy treatments. The p-CT using a novel Low Gain Avalanche Detectors (LGADs) will be described where three layers of LGAD timing detectors are used to measure the proton track and its energy. The measurement of proton energy which is vital for image reconstruction (density of electrons) is obtained from time of flight measurements rather than conventional scintillator based calorimeter. The first time resolution measurements with very thin (35 um) LGADs and GEANT4 simulations of the p-CT performance will be presented.

Efficiency transfer factors calculation for gamma-ray detectors using multipurpose Monte Carlo codes

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Gamma-ray detectors are a powerful tool in calibration and testing ionizing radiation laboratories, as more than 90 % of the radionuclides are gamma-ray emitters. In order to calibrate (or to measure) radioactive sources of complex geometries or matrices for which no standard sources are available, it is required a good knowledge of the efficiency transfer factors, relating the efficiency data corresponding to a standard geometry data to the efficiency data for the specific measurement geometry. A few Monte Carlo simulation codes (*FLUKA, MCNP)* were used to simulate high resolution HPGe detectors and determine the gamma-ray detectors efficiency for different incident photons energy, in order to calculate efficiency transfer factors for different matrices (soil, zeolite, gel) and different source geometries (for point-like and volumetric sources, used for radioactivity measurements and other applications). The simulations were validated with experimental data. Because of the experimental calibration's inability to handle the expanded range and measuring configurations (shape, volume, and matrices of the samples), the true coincidence-summing corrections radionuclide decay specific effects (favored by the current tendency to use high-efficiency detectors), and the desired performance parameters (very low detection limit and measuring uncertainty) met in current applications of gamma-ray spectrometry, Monte Carlo simulation is required. The target users of this technique were expanded by the availability of a wide range of Monte Carlo packages allowing the detection efficiency computation, some of them being user-friendly. The results of this work show good agreement among the selected Monte Carlo codes and also the experimental measurements. The proposed Monte Carlo approach being validated by this study, is expected to be included in the calibration services provided by the laboratory (to its own equipment, as well as to third parties).

ANET-2D Multichannel Compact Neutron Collimators for high intensity pulsed and continuous beams

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The ANET project has been dedicated to developing a 2D Compact Neutron Collimator (CNC) for Neutron Imaging applications.

In 2022, two main measuring campaigns have been performed: the first campaign took place at the FISH beamline at TU-Delft during spring. This campaign has been decisive to prove two independent methods to evaluate the achievable resolution in neutron radiography, as well as to perform a comparison of the beam divergence with or without the use of the ANET collimator.

The second campaign took place in Noboru BL-10 beamline at JPARC during December 2022. This campaign has been important to verify the performance of the collimator at different neutron beam energies and to try its use in a static configuration while, the ANET CNC is normally operated using a dynamic pattern operation mode.

The FISH and NOBORU facilities both provide high intensity beams with fluence rates greater than 10^6 n cm^{-2} s^{-1}.

This communication will present the last results obtained by the collaboration and it will demonstrate the ANET CNC radiography and tomography capability with both cold and thermal neutron facilities, with low and high beam intensities and how the ANET CNC can grant access to neutron imaging to small or medium-size facilities.

Radionuclides transfer from soil-to-tea leaves and concomitant impact assessment

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Tea has become one of the most popular stimulating beverages which is largely consumed in Malaysia. The presence of natural radionuclides in tea leaves largely depends on the presence of natural radioactivity in the associated soils. Tea leaves and the associated soils were obtained from one of the largest tea plantation areas located in Cameron Highlands, Malaysia while the marketed tea is obtained from the supermarket. The present study concerns the assessment of prevailing concentrations of long-lived radioactive materials in tea lives and soil and their transfer from soil-to-tea leaves. Activity concentrations ($Bqkg^{-1}$) of ^{226}Ra, ^{228}Ra and ^{40}K in tea soils range from 49–102, 75–124 and 80–423, respectively, while it ranged in tea leaves was 14.4-23.8, 12.7-29.5 and 297–387, respectively. Transfer of radionuclides shows typical values except for the ^{40}K. The high level of ^{40}K in tea lives might be related to the tea plantation system where potassium was sprayed directly with pesticide and foliar fertilizer. Nitrogen, phosphorus and potassium are the main components of foliar fertilizer which provide sufficient nutrients to the plant. Committed effective dose due to the consumption of tea was estimated, and found a lower value than the limiting value of 290 μSv/y reported by UNSCEAR for all sources of natural radiation. The consumption of the studied brand of locally produced tea shows negligible health risk or discard any deleterious effect on the population.

Investigation on Pixel-to-Pixel isolation by Trench and p-stop technologies under high charge density injection: Case study of segmented LGAD

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To cope with different requirements in HEP and for medical research, different isolation structures are developed to be applied in the interpixel/interstrip regions (IP) of segmented sensors based on LGAD technology. LGAD technology and isolation structure for isolation of pixels are adjusted to Minimum Ionizing Particles (MIP). However, interpixel region can be also exposed to high charge density injection due to passage of Highly Ionizing Particles (HIP) that may affect the resistance of interpixel region. In this paper we present the results from comprehensive and systematic study on different isolation structures such as: a) 2 p-stops + bias ring, b) 2 trenches, c) 1 trench. Some isolation structures are also studied before and after irradiation so we can systematically investigate the effect of radiation by neutrons on interpad behavior. Cooling effect on observed behavior in IP region was additionally studied and results are reported and discussed in this presentation. We also report the enhanced Charge Multiplication (CM) in IP region that was observed under certain conditions and in a certain type of isolation structures. As an experimental technique we used a femtosecond laser based TCT-SPA. The results for some isolation structures are compared to the results measured by standard TCT (ps-laser based). The experiments presented here are performed at the EU laser infrastructure ELI ERIC, ELI Beamlines in Prague.

Angular correlation of gamma-gamma coincidence measurements for neutron activation analysis

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The angular correlation of coincident gamma-rays emitted from Europium-152 (^{152}Eu) was determined by measuring coincident gamma-rays at multiple distances and detector orientations. Due to the nature of ^{152}Eu, it is possible to look at coincident gamma-rays produced during beta minus (β-) decay and electron capture. By looking at the 344 keV and 778 keV coincident gamma-rays which result from β- decay, and the 121 keV and 244 keV coincident gamma-rays from electron capture, an angular correlation coefficient (W) was calculated. The W for gamma-gamma coincidence produced by electron capture was higher when the detectors were at or close to parallel (180^{o}). The W for gamma-gamma coincidence for β- decay was higher as the angle between detectors approached perpendicular (90^{o}). The methods will be used to maximize counting statistics for specific radionuclides in neutron activation analysis.

Characterization of the neutron flux through the RMC SLOWPOKE-2 pool via neutron activation analysis and MCNP modelling

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The SLOWPOKE-2 reactor at the RMC has been used in the past for a variety of research projects requiring a controlled neutron flux. The SLOWPOKE-2 has two sets of sites within the reactor into which material can be inserted manually or pneumatically for exposure to neutron fluxes. These sites have physical constraints that limit the volume and dimensions of irradiated samples. In addition to these irradiation sites, the SLOWPOKE-2 includes an elevator system within the reactor pool that allows bulkier objects to be irradiated. Neutron flux within the inner irradiation sites is measured by a self-powered neutron detector, which is used to regulate the position of the single control rod and, thus in turn, the reactor flux. However, a similar system is not available within the pool, either as a control element or as a passive measurement tool. As such, neutron activation measurements are required to characterize the flux within the pool of the reactor to describe the overall neutron flux and provide a description of the neutron energy distribution. Several key studies have been conducted in the past to characterize the neutron flux through various locations of the reactor using a combination of neutron activation analysis and model simulations. An MCNP model of the SLOWPOKE-2 capable of simulating the neutron flux as a function of reactor power and position has been developed through these studies. All prior studies have been conducted at half power and prior to the refuelling of the reactor in August of 2021.

To account for the reactor refuelling and to facilitate future projects, a new characterization of the neutron flux within the pool of the reactor over a range of reactor power settings is required. The present study performs this characterization using MCNP simulations validated with neutron activation measurements. Three replicates of solutions of Co, Au, and Cd-shielded Au were placed 7.5 ± 0.1 cm from the reactor vessel at five proportions of reactor full power; specifically, 1 %, 3 %, 10 %, 50 %, and 100 %. An MCNP simulation of the SLOWPOKE-2 was used to calculate the neutron flux, the consequent neutron activation, and subsequent gamma-ray activity from the radionuclide decay generated by neutron activation at the pool location and for each respective reactor power. The simulated gamma-ray activities were compared to the measured activities from the physical samples. Initial measurements at 3 %, 50 %, and 100 % reactor power have shown that whilst the experimental and simulated activity values were comparable, the simulated cobalt activities were consistently 10 ± 1% lower than the experimental values, with a much greater difference for gold activities. Supported by further replicate measurements, the MCNP model has been revisited using increased granularity in the discrete neutron energy ranges employed to increase the accuracy of the model.

Measurements of Th/U ratio using different techniques: A comparative study

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The present work was conducted to determine Th/U ratios in different types of rock samples (sedimentary, conglomerate, igneous and sediments) using high pure germanium detector (HPGe), solid state nuclear track detectors (SSNTDs) and inductive coupled plasma mass (ICP-MS) spectrometers. A thin source approach method for alpha tracks measurements has been used. A new approach has been introduced for forming a thin layer of the rock sample. The track densities were obtained by optical microscope coupled to a digital camera and by using spark counter. Even though the measurements were carried out using very different techniques, they all give essentially comparable values of Th/U ratio for most of the rock samples.

Keywords: Th/U ratio, CR-39, LR-115, gamma spectrometer

Comparing dosimetric and spectroscopic capabilities of handheld Na(Tl)I γ-spectrometers

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The handheld or portable detectors of γ-emitters, also known as Radioisotope Identifying Devices (RIIDs), offer versatile applications as they can be used in situations where Radiation Portal Monitors (RPMs) are not installed, such as on merchant trains, vessels, or during emergency mishaps. They can also be used to closely examine suspected parts of cargo that trigger an alarm in an RPM installation. Scientists are still investigating the ability of RIIDs to identify shielded radioactive sources or nuclear materials.

The present study is based on measurements performed in simple geometries with shielded or unshielded sources located at distances of 0.5 to 4 meters from the tested RIIDs. The aim of the study is to preliminarily calculate the detection thresholds of hidden sources. Two Thermo RiidEye M-G3 3′′X3′′ detectors and one Target Identifinder ∅ 1.4′′ × 2′′ NaI(Tl) detectors were tested. Two radioactive sources were used, Cs-137 with an activity of 6.17 MBq and Eu-152 with an activity of 1.28 MBq.

In the present study, twenty measurements of 5 minutes each were taken while changing the distance of the sources from 4m to 25cm. Although the two NaI(Tl) 3′′X3′′ detectors were identical, a difference of 1.5% was observed between them. There was also a 3.5% difference in the measurements of dose rate between the first 3′′X3′′ detector and the 1.4′′X2′′ and 1.85% difference between the second 3′′X3′′ detector and the 1.4′′X2′′.

Experiments were performed in order to eliminate the influence of different geometries, which were either identical or symmetrical. Estimating the unscattered dose rate from the Cs-137 source, it varied 10% to 40% from dose rate measured by the detectors depending on the distance of the source. In the above-mentioned measurements, the background's contribution was subtracted. The closer the radioactive source was to the detector, the smaller the scattered contribution.

Moreover, the detectors could not identify the radionuclides of Cs-137 or Eu-152 when the shielding distance was such that a) the dose rate was less than twice the background, or b) the count rate was high. In the second case, there was a shift of the spectrum leading to incorrect identification of radionuclides when using automatic identification without human interference.

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Evaluation of proficiency test results of gamma ray spectrometry in determination of anthropogenic and natural radionuclides

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The aim of this paper is to evaluate the performance of gamma ray spectrometry in the Institute of Applied Nuclear Physics (IANP), Albania using Proficiency Tests (PTs). Participation in different proficiency tests is an essential tool for improvement and testing of High Purity Germanium detector (HPGe) performance. The gamma ray spectrometry laboratory in the last years has participated in different world-wide open proficiency tests organized by International Atomic Energy Agency (IAEA) with satisfactory results. For this paper, we selected the proficiency test organized by IAEA in 2020 due to the analytical challenge to recognize radioactive disequilibrium and apply appropriate decay corrections, especially for ingrowing radionuclides of broken natural decay series. The PTs of gamma-ray spectrometry measurements is carried out to improve the laboratory's ability to measure the radioactivity in the environment and foodstuffs at typical routine levels. The activity concentration of the test samples and the evaluation of the associated uncertainties are the main requirements of the test results. This PT was focused on the determination of anthropogenic and natural radionuclides in water, fish, and simulated aerosol filter samples. For this proficiency test the Laboratory Sourceless Calibration Software (LabSOCS) is used for simulating the absolute efficiency curve. In this paper are presented the results and discussed the quality of the gamma spectrometry measurements performed in the IANP. The overall performance evaluation showed that 100 % of all reported results have been acceptable. Thus, the gamma ray spectrometry using HPGe detector showed high performance in determination of anthropogenic and natural radionuclides in water, fish and simulated aerosol filter samples.

Keywords: proficiency test, gamma ray spectrometry laboratory, HPGe detector

Evaluation of the primary quality control parameters on diagnostic radiographic equipment in governmental and private healthcare institutions in Albania

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During the last decade many European countries have applied and regulated through state legislation quality control (QC) program in diagnostic radiology. Such a program forms an essential part of dose effective radiological practice and should be implemented in every x-ray medical equipment. Implementation of QC tests on diagnostic radiographic equipment can ensure the optimal status of imaging systems, providing in this way, high-quality images. QC of radiological medical devices in Albania is applicated since 2015, every three years. QC techniques used to test the components of the radiological system and verify that the equipment is operating satisfactorily are performed from the Institute of Applied Nuclear Physics and all the instruments used for performing these measurements are sponsored by the International Atomic Energy Agency. The aim of this study was to investigate the status of 8 randomly selected X-ray generators installed in radiology centers of 6 different cities in Albania during the 2021-2022 period. In this study are presented only the primary QC parameters: kilovoltage (kVp) accuracy and reproducibility, kVp variation with change of mA, exposure time accuracy and reproducibility, tube output and reproducibility, tube output variation with change in indicated tube current - exposure time product (mAs) and filtration (half value layer). All measurements were performed, using Radcal (AGMS-DM+) solid-state multisensor plugged into its appropriate (Accu-Gold+) digitizer module. This detector was placed on the radiographic tabletop along with the central axis of the X-ray beam at the focus to detector distance of 100 cm. Based on the findings, this study showed clearly that all the radiographic devices, subject of routine quality control tests were in a very good compliance with the acceptable criteria. Specifically, for the primary QC parameters tests, kVp accuracy was between 1.4 - 5%, kVp reproducibility was between 1-3.1%, kVp variation with change of mA was between 1.4 - 5.4 %, time accuracy and reproducibility was between 0 - 6.6%, tube output value with a total filtration 2.5 mm Al at 100 cm for true 80 kV operation was between 26.1 - 60μGy/mAs, tube output reproducibility was between 0 – 2.5%, tube output variation with change of mAs product was between 1 - 18% and filtration at 70 kV was between 2.6 – 3.9 mm Al. Results of this study showed that, even though radiological devices in Albania are relatively old with high workload, especially during the last years, all the devices met the standard criteria.

Non-destructive determination of ^{90}Sr, ^{241}Am and ^{137}Cs activity in Chernobyl fuel particles using gamma-beta-spectroscopy coupled with autoradiography method

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Specific feature of the Chernobyl accident was the abundance in fallout the dispersed fuel particles (FPs) comprising the debris of irradiated nuclear fuel in various degrees of Uranium oxidation, mixed with other materials. Contamination of the territory with ^{90}Sr, ^{241}Am and isotopes of plutonium occurred mainly due to the FPs. Further behavior of radionuclides initially encapsulated in the FPs was determined by rate of weathering and leaching of FPs into the environment. Even now, 36 years since the accident, a significant part of the radionuclides in soil and water bodies of the Chernobyl Exclusion Zone is in the form of micron sized FPs, which accounts for up to 70% of the total activity in the bottom sediments of the Cooling Pond of the Chernobyl Nuclear Power Plant, for example. FPs are considered as a long-term depot of radionuclides entering the environment, and due to their high specific activity, pose a potential threat when inhaled and injected. Presence of FPs should also be taken into account when assessing the transfer of radionuclides from soil to vegetation, since radionuclides bound to the FPs matrix are not biologically available, and therefore distort determination of the true transfer factor in the soil-plant system. Some specific forms of FPs are very resistant, in particular with a uranium-zirconium matrix, and require strong chemical treatment with concentrated acids for complete dissolution. Therefore, the development of non-destructive methods for the detection and characterization of FPs in post-Chernobyl radioecological studies is of crucial importance. We propose a reliable technique based on initial counting the sample by gamma and beta spectroscopy using a plastic scintillator and an aluminum adsorber followed by classical autoradiography (ARG) method, which involves exposing X-ray film by spreading on dry solid material. Calibration of “radioactive dose (mainly due to the ^{90}Y daughter of ^{90}Sr) - area of the photospot on the X-ray film” were obtained from 35 FPs selected from soil samples, which were subsequently individually counted by gamma and beta spectroscopy followed by measurement of 90Sr activity using standard radiochemical method. The activity of 90Sr in particles used for calibration ranged from 20 to 1500 Bq per particle. Digitized images of the FPs radiographic spots were processed by the ImageJ software using a special algorithm with preset pixel brightness threshold. Obtained calibration dependencies make it possible to calculate the activity of ^{90}Sr for each individual FPs by determining the areas of radiographic spots from ARG developed during known exposure time. The sensitivity of this method allows it to reliably detect FPs in a sample with ^{90}Sr activity as low as 0.02 Bq per sample when the sample is exposed for 15 days. Proposed methodology can also be used in estimation of the “equivalent” size of FPs, dispersion and distribution of activity of ^{90}Sr within the FPs of different size fractions. This also facilitates identification and picking up single FPs for further extended individual characteristic analysis, EDXRF, SEMs, etc.

Assessment of radiation exposure in area of holiday cottages in Šumadija region, Serbia

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Activity concentrations determination of radionuclides in soils is very important in order to assess the radiological impact on human health. The coronavirus pandemic has led to increased interest in cottages and country houses. After the quarantine and the state of emergency, a large number of people wanted to secure a piece of land and a house where they could continue living or at least temporarily escape from the city. Due to that, we chose Šumadija region, popular area of holiday cottages, as a study area of this work.

In this work the radionuclides' activity concentrations in soil samples were determined using gamma spectrometry. The aim was to do screening and to estimate the health risk due to external irradiation from terrestrial radionuclides. The radiological and health risk assessments were done based on the activity concentration of gamma – emitting radionuclides in soil samples. The determination of the human radiation dose is a very important task, mean values of absorbed gamma dose rate was 68 $nGyh^{-1}$, while annual gonadal dose was 485 μSv for investigated area. In conclusion, the results obtained in this study fall within the range of values in rural areas worldwide and are below the values which can cause a significant radiation hazard to population.

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Activity determination of a ^{137}Cs radioactive source used in oil-welling company in Albania

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Institute of Applied Nuclear Physics (IANP) is responsible for the safe and secure management of radioactive waste and DSRS at the national level. IANP collaborates with different institutions and private companies for the safe storage and transport of radioactive materials. In this study is described the procedure followed to evaluate the total activity of two radioactive sources of unknown activity.

During 2018, IANP received in the National Radioactive Waste Storage Facility 5 DSRS from Geophysical Service Center in Fier, Albania due to the closure of their temporary storage facility.

Based on the data of radioactive sources from their certificates that IANP possesses and the measurements carried out on site of these sources, it turned out that the sources were two ^{241}Am-Be of 5 Ci initial activity each and one ^{137}Cs of initial activity 300mCi in separate containers each and two ^{137}Cs of initial activity 52mCi and 51mCi each, into one container.

The two ^{137}Cs sources of activity 52mCi and 51mCi each (reference date July 1978), were supposed to be together in one container, and we needed to verify that they were both into one capsule.

We estimated the activity of the source using the geometry of a point source. By making a comparison with the actual activity calculated on the basis of the certificate of these sources it resulted that the activity calculated on the basis of the measurements performed was 1.418 GBq, which was approximate to that calculated on the basis of the certificate 1.528 GBq in March 2018 and, finally, we confirmed that the last two ^{137}Cs sources were in the same capsule.

Subsequently, the transfer of all sources was done to the National Radioactive Waste Storage Facility in Tirana.

Chemical decontamination technique used to minimize the radioactive waste from IFIN-HH

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The process to reduce, remove, or neutralize radiological contamination is a concern from many points of view. The chemical and/or mechanical process must be carried out under protective conditions for all participants in the process, being a progressive operation.

The process of chemical decontamination with chemical gels by spraying or brushing is an effective method in situations where it is necessary to minimize radioactive waste. Also, the use of chemical decontamination can partially or totally eliminate the detergents present in the residual water resulting from the large-scale use of decontamination through washing, reducing soil and water pollution with these substances.

This study continues the activities started a few years ago (*Rom. Journ. Phys.*, Vol. 59, Nos. 9–10, P. 912–919, 2014) when a program was developed to test and evaluate the radioactive decontamination factor of electrical components and ventilation systems within the decommissioning project of the VVR-S nuclear research reactor from Magurele-Bucharest, Romania. Back then, the studies were carried out for eight types of artificially contaminated surface with radionuclides ^{137}Cs and ^{60}Co.

Since the chemical decontamination gel presents numerous advantages such as: it does not need to be prepared, it can be applied easily, decontamination is simple, the decontamination factor is high, it minimizes the contamination of radioactive materials, etc., this study presents the results obtained for the evaluation of the degree of decontamination for couple of frequently materials presented in the radioactive waste treatment process within Radioactive Waste Management Department from IFIN-HH. For this study, the materials were artificially contaminated with ^{241}Am, ^{137}Cs, ^{133}Ba and ^{60}Co.

Traceability of solid state detectors used for Half Value Layer measurements in diagnostic radiology

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Quality Control (QC) measurements in diagnostic radiology are performed on a wide range of X-ray machines, used for different modalities such as radiography, fluoroscopy, mammography etc. Diagnostic radiology multimeters are in wide use in QC measurements [IAEA TRS 457, IAEA, 2007]. Many of these devices are based on several solid-state detectors positioned behind different filters, and values of different quantities can be calculated based on the signal from these detectors. Besides air kerma and X-ray tube high voltage, multimeters can often measure other special quantities, such as Half Value Layer (HVL), total filtration, irradiation time, product of current and time etc. Calibrations for these special quantities are very rarely available in Secondary Standards Dosimetry Laboratories (SSDL) or other calibration laboratories, so many end-users have problems to establish traceability.

Research is currently being undertaken in Vinca Institute SSDL with the aim to establish traceability for HVL calibrations. HVL is a quantity that is commonly measured in SSDLs during internal QA/QC procedures, but there is no consensus on how to establish the traceability in SSDLs. Furthermore, measurement uncertainty for HVL is rarely estimated. In this research, HVL measurement procedure will be updated and detailed evaluation of measurement uncertainty will be undertaken. Sources of uncertainty that will be considered are: energy dependence of ionization chamber, thickness of aluminum filters, statistics of current measurements (reference chamber and monitor chamber), temperature, pressure etc. Traceable results of HVL measurements will further be used to calibrate and test multimeters in reference fields. In this paper, first results are presented.

Keywords: Half Value Layer, diagnostic radiology, traceability, measurement uncertainty

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Solid state detector energy response in W/Al mammography radiation quality series

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Ionization chambers and solid state detectors incorporated into multimeters are often used for quality control in different modalities of medical imaging and diagnostic radiology. The equipment to be used in the routine QC procedures needs to be calibrated under well-known radiation conditions (known as radiation qualities) defined by the international standards. International standards IEC 61267:2005 [IEC 62167, IEC 2005] and IAEA TRS 457:2007 [IAEA TRS 457, IAEA 2007] cover general radiography and fluoroscopy radiation qualities (abbreviated as RQR and RQA series, in the voltage range from 40 kV to 150 kV), and computerized tomography radiation qualities (abbreviated as RQT series, in the voltage range from 100 kV to 150 kV), among other. In the field of mammography reference radiation fields are defined for molybdenum anode/filtration combination (Mo/Mo, abbreviated as RQR-M series, in the voltage range from 25 kV to 35 kV). Since Mo/Mo mammography units are widespread and available at hospitals they have been included in the standard [IEC 62167, IEC 2005]. Even so, Secondary Standard Dosimetry Laboratories (SSDLs) that are performing calibrations of QC dosimeters for end-users, rarely have availability of such anode/filtration combination under reference laboratory conditions. SSDLs most often employ X-ray generators with W/Al combinations. Additionally, nowadays many different combinations of anode/filtration are present in mammography units of different manufacturers that are commonly used in the hospitals. Multimeters are often sensitive to spectral changes caused by different anode/filter combination, so it is doubtful that the traceability established for one anode/filter combination can be used to measure doses for another combination. Measurements with different solid state detectors were performed under laboratory conditions with W/Al radiation qualities established in the SSDL. In the future, research will be expanded to clinical conditions in radiation fields produced by mammography units which employ Mo/Mo, Mo/Rh, Rh/Rh, W/Rh and W/Ag. Dosimeter response will be evaluated based on the dependency of 1st HVL which is correlated to radiation output of the X-ray generator (the incident photon spectra).

Keywords: diagnostic radiology, mammography, solid-state detector, energy response, anode/filtration combination

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A Time Series Forest Method for automatic classification of anomalous glow curves of LiF:Mg,Ti based thermoluminescent dosemeters

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Thermoluminescent dosimetry is a widely used passive dosimetry method for estimating protection quantities i.e. the effective or equivalent dose. When the thermoluminescent dosemeters (TLD) are irradiated, they store the dose information through the processes of ionisation and subsequent trapping of charge carriers. The charge carriers in TLD crystalline material move from the ground state to the higher energy states (trapping centres) that are partially stable at room temperature. By heating the material, charge carriers leave the metastable energy states and recombine at recombination centres, emitting light (glow). The heating procedure gives rise to a glow curve (GC) – the light intensity as a function of temperature and time. By calibrating the TLD reader, the area under the GC is converted to a dose value (e.g., personal dose equivalent, $H_p(10)$). The shape of the GC depends on the time-temperature profile (TTP) defined for each TLD material separately and may be regular or possess some anomalies. Inspecting the GC shape, as one of quality control measures, is usually conducted qualitatively and performed by trained TLD service staff. Hence, this paper presents the implementation of the machine learning Time Series Forest (TSF) method for the classification of anomalous GCs of LiF:Mg,Ti based TLD.

TSF is a tree – ensemble method that combines entropy gain and distance measure for evaluating splits. This method shows significant computational efficiency compared to the well – known one – nearest – neighbour classifier. The dataset used for the TSF method consists of 201 normalized GCs exported by the software supplied with Harshaw 6600 Plus Automated Reader – WinREMS. The dataset is labelled into five different classes: (1) regular shape, (2) spikes at random positions, (3) TLD signal in the low – temperature region, (4) TLD signal in the high – temperature region, and (5) shift of the entire GC to higher temperatures. A random split of the dataset into training and testing in a 70/30 training/test ratio was performed, while the 10 – fold cross – validation was used for the hyperparameter tuning.

The results showed that the TSF method can classify four different anomalies for GC with an accuracy of 96% and a macro average F1 score of 96%. According to the obtained results, it is possible to conclude that the TSF is a promising candidate method that could be implemented as a new software package for automated GC quality control within the TLD service.

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Quality control of NaI scintillation detector for gamma spectrometric determination of radon concentration

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Measurement of radon (^{222}Rn) concentration using charcoal filters according to the EPA 520/5-87-005 method is performed in Radiation and Environment Protection Department of Vinča Institute for Nuclear Sciences on NaI scintillation detectors. Concentration of radon adsorbed on active charcoal is determined indirectly, by gamma spectrometry of its daughter products via their gamma peaks at 295 keV, 352 keV (^{214}Pb) and 609 keV (^{214}Bi).

In order to assure the reliability of the measurement results, and in accordance with Standard ISO 17025/17 quality control and quality assurance (QA/QC) procedures needs to be applied. Related activities ought to be planned, described in the quality control documentation, performed in a systematic manner, recorded and reviewed.

First, the energy and efficiency calibration of the detection system needs to be performed in a proper manner. The NaI scintillation spectrometer is internally calibrated using the certified radioactive ^{226}Ra standard in charcoal matrix and in the geometry identical to the measurement geometry, produced by Czech Metrology Institute and traceable to Bureau International des Poids et Mesures (BIPM).

As defined in laboratory's procedures a regular quality control of the NaI scintillation detector is performed once a week. Quality control activities include the background measurement and measurement of adequate reference material. Gross background count rate in the energy region of interest is used to verify that the detector and shield have not been contaminated and that there is no significant variation of the background. Reference material used is the soil sample with known content of ^{226}Ra. Gross count rate in the reference material spectrum is used to check the energy and efficiency calibration. These values are recorded and verified if they are within the acceptance limits. Obtained results, together with acceptance limits, for a certain period (one year usually) is graphically presented in the control charts.

The acceptance limits for background count rate and reference material gross count rate in the energy region of interest are defined according to the statistical analysis of the data from previous QC period. The mean and standard deviation is calculated and the acceptance limits are set to be $\pm 2\sigma$ and $\pm 3\sigma$.

QC measurement results falling between $\pm 2\sigma$ are considered to be satisfactory, while those falling inside $\pm 3\sigma$ are warning. QC measurement results exceeding $\pm 3\sigma$ indicate that there is a problem with the measurement system and that analysis of causes and design and application of corrective measures are needed.

Analysing the control charts for the previous QC period (year 2022) showed that the controlled parameters were within the defined limits of acceptance. Occasional discrepancies, mainly due to background variation, were minor and were addressed immediately. Background variation was treated simply by repeated measurements after additional ventilation of the measurement laboratory.

Impact of high gamma doses on structure, optical behavior and track parameters of polymeric NTD for γ-dosimetry

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In this study, the effects of high γ-radiation on the structure, optical properties and track parameters were investigated in plastic nuclear track detector (NTD). CR-39™ samples were irradiated at 50 to 500 kGy γ-doses and then exposed to fission fragments (F.F) fluence from ^{252}CF source. The track diameter (D), bulk etch rate (V_B), etch induction time (EIT), cut-off saturated time ($t_{cut\text{-}off}$) of saturated diameters and projected track length (L_o) of normally and inclined incident fission tracks were estimated for different removal layers (h). A linear relationship between the D and γ-doses (D_γ) up to 500 kGy was obtained. V_B was determined at different Dγ, and a linear relationship was obtained up to 300 kGy. EIT was about 50-55 min for pristine sample and reach to 1-5 min at 300 kGy and $t_{cut\text{-}off}$ was about of 125-140 min for pristine and reach to nearly 8 min at 500 kGy. From UV-Vis spectrophotometric study, an inversely linear relation of the band gap energies (E_{gap}) as a function of Dγ was obtained and found to decrease from 3.73 to 3.44 eV and 3.93 to 3.82 eV for indirect and direct transitions, respectively. In addition, a systematic increase of Urbach energy (E_U) from 0.47 to 0.71 eV was recorded with increasing Dγ. Moreover, a linear behavior of the refractive index (n) with gamma-ray doses of irradiated CR-39™ detectors, for direct and indirect methods, was recorded. The results reflected a potential possibility of using γ-irradiated CR-39™ in dosimetric measurements through the different studied parameters.

Measurement of radiation exposure dose using emergency detectors and OSL Helios reader

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The application of ionizing radiation in different domains such as medicine, science, and industry, and the potential use of nuclear weapons, carry the risk of undesirable nuclear or radiological incidents. In places where there is no access to standard dosimeters, common materials that can act as a passive detector are sought. The dose from such a detector can be read using, for example, the optically stimulated luminescence (OSL) method. The aim of this study is to investigate the potential of selected phosphors for emergency dosimetry and comparison of dose recovery test results using various commonplace materials. The studies compared dose results obtained with potassium chloride dietary supplements, protective glass for mobile phones, table salt, aluminum oxide substrates and a standard OSL detector based on beryllium oxide (BeO, Thermalox 995). The protective glass for the camera lenses were round shape tempered glass for iPhone 12with a thickness of 0.3 mm and a diameter of 9.5 mm. Dietary supplements under study were in the form of tablets (Potas Apteo) or granules (Potazek). The tablets were irradiated whole, but sliced were used for measurement, so that each type of sample has a repeatable sample size and weight. The granules were measured in a specific amount (30 granules) and glued to the tape that facilitated the measurements (the tape did not give an OSL signal). Table salt in the form of powder was irradiated in small paper bags, and for measurements it was divided into samples of similar weight (10 mg) using a measuring cup. The samples were irradiated using 137-Cs gamma source with activity of 370 MBq. Irradiation was carried out for two unknown doses, and the reference dose was determined using BeO detectors. In the event of an unexpected radiation event, it is not possible to measure the OSL signal immediately. Therefore, in this experiment after irradiation the samples were stored two days in a light-tight package until the OSL readout. The OSL measurements were performed using a Helios OSL reader (manufactured by Zero-Rad) with green light stimulation. The measurements were carried out in a continuous wave OSL mode collecting OSL decay in time of 60 s. The unknown dose was determined from a calibration curve measured for each material separately when irradiated with a 90-Sr/Y beta source. The dose from materials that exhibited fading was further corrected for the signal loss factor. The dose recovery test for most materials tested showed promising results. The recovered doses were well-classified under the triage category (radiation dose triage levels: <1 Gy low, 1–2 Gy medium, and >2 Gy high). The worst result was obtained for the protective glass on the phone, where the OSL signal was very small compared to other materials. The other detectors, especially table salt and dietary supplements with potassium, had a high OSL signal, which indicates their high usefulness in emergency determination of the dose by the OSL method.

Progress in high resolution gamma-ray spectrometry of environmental samples at the Marine Environmental Radioactivity Laboratory, HCMR

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Gamma-ray spectrometry via high purity germanium (HPGe) detector is widely applied for low activity concentration measurements of environmental samples since it is a non-destructive technique and may provide high precision data. However, several implications concerning the accurate efficiency calculation of different extended geometries and spectrometric analysis corrections must be addressed. The progress for implementing radioactivity measurements using extended geometries and high resolution gamma-ray spectrometry at the Marine Environmental Radioactivity Laboratory (MERL) of Hellenic Center for Marine Research (HCMR) will be demonstrated for sediment and water samples. In order to optimize the quantification method a combination of various reference sources measurements with semi-empirical numerical methods for the efficiency calibration of the detection system, along with Monte Carlo simulation technique is applied. The analysis results are further validated via inter-comparison exercises with different laboratories. The experimental procedure, the calculation steps and the quality control applied at MERL are presented through the determination of natural and anthropogenic radionuclides in water and soil standard samples in the frame of a world-wide proficiency test of ALMERA network.

Investigation of several new ionic liquids' behavior during $^{210}Pb/^{210}Bi$ Cherenkov counting in waters

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The detection of ^{210}Pb levels in aquatic environments evokes interest in various scientific studies. Its precise determination is important not only for the radiological assessment of drinking waters but also, ^{210}Pb and ^{210}Po distribution in the marine environment are significant for the assessment of the removal rates of particles from the ocean and particle fluxes during transport along the coast, as well as particulate organic carbon export in the upper ocean.

Measurement techniques for ^{210}Pb determination, gamma spectrometry, alpha spectrometry, or liquid scintillation counting (LSC), are either time-consuming or demand expensive equipment or complicated chemical pre-treatments. However, one other possibility is to measure ^{210}Pb on an LS counter if it is in equilibrium with its progeny ^{210}Bi - through the Cherenkov counting method. It is unaffected by the chemical quenching and assumes easy sample preparation but has the drawback of lower counting efficiencies than standard LSC methods, typically from 10% up to 20%. The aim of the presented research in this paper is to investigate the possible increment of detection efficiency of Cherenkov counting during $^{210}Pb/^{210}Bi$ detection on an LS counter Quantulus 1220. Recent reports have demonstrated that certain ionic liquids can act as wavelength shifters, thus the performance of several newly synthesized ionic liquids was tested during Cherenkov counting. Considering naturally low levels of ^{210}Pb in aqueous samples, the addition of ionic liquids to the counting vials with the analyzed samples has the benefit of detection limit's decrement during ^{210}Pb quantification.

Our results demonstrated that ionic liquid, 1-butyl-3-methylimidazolium salicylate, is more efficient in Cherenkov counting efficiency increment than the previously explored 2-hydroxypropyl ammonium salicylate. Consequently, the impact of a few other ionic liquids that were synthesized with the same cation group (1-butyl-3-methylimidazolium benzoate, 1-butyl-3-methylimidazolium 3-hydroxybenzoate, and 1-butyl-3-methylimidazolium 4-hydroxybenzoate) was explored in order to test their potential influence on Cherenkov counting efficiency. It was confirmed that, among the explored ones, only ionic liquids in the form of salicylates exhibit wavelength-shifting effects. Namely, the addition of small amounts (around 0.8 g) of 1-butyl-3-methylimidazolium salicylate increases the detection efficiency from 16% to >70%, consequently reducing the detection threshold more than four times. Moreover, the addition of ionic liquids could find application in the quantification of other radionuclides besides $^{210}Pb/^{210}Bi$ via the Cherenkov counting method.

On site calibration of Ionization Chamber for ^{166}Ho at Gemelli Hospital in Rome by using portable ENEA TDCR detector

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^{166}Ho is a beta-gamma emitting radionuclide with interesting theranostic applications, due to its 80 keV gamma-ray emission and short half-life ($T_{1/2}$ 26.8 h). In fact, ^{166}Ho can be used in radioembolization procedures as an alternative of commonly used ^{90}Y [*European Journal of Nuclear Medicine and Molecular Imaging* 47 (4) (2020) 798–806.]. To be able to quantitatively evaluate the optimal and selective distribution of microspheres to the liver tumors, both accurate activity determination and post-treatment imaging using diagnostic instruments, as SPECT and/or MR Imaging are indispensable [*Journal of Nuclear Medicine* 54 (12) (2013) 2093–2100]. For these reasons, a direct measurement of the activity of a ^{166}Ho solution (50 MBq/g roughly) was performed, with an uncertainty lower or equal to 1%, at the Gemelli Hospital in Rome by the Triple-to-Double-Coincidence (TDCR) method using the ENEA portable TDCR instrument [*Appl. Radiat. Isot.* 93 (2014) 45-51]. This allowed to calibrate the Ionization Chamber (IC) of Gemelli Hospital, with low uncertainty (≤2%), which is used for routinely applications in radiopharmaceutical dispensing to the patients. This work opens interesting perspectives in the field of Nuclear Medicine for calibrating, on site, instruments devices used in medical fields, such as ICs, gamma-cameras and also PET imaging systems.

Development of a method for characterization and segregation of metallic waste after decommissioning

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Adequate radiological characterization is important for the optimization of metallic waste management.

For decommissioning planning, the objective is to obtain a radiological understanding of the involved installation. The characterization at this stage could be carried out by means of:

1) neutron activation calculations based on reactor design and neutron flux;

2) dose rate measurements;

3) in-situ gamma spectrometry;

4) sampling for determination of the scaling factors in activated and contaminated components.

In-situ characterization is carried out during dismantling to classify and package the generated waste. This is usually achieved by using portable devices to measure dose rates or total counts. Then, the packages are monitored for activity assessment and determination of the management route.

The radiological characterization of activated components, which appeared with surface contamination, is essential for the decision-making process during decommissioning. The selection of cutting and decontamination techniques should be based on the accurate determination of the radionuclides inside the material and/ or in the surface contamination. Also, after dismantling, the metallic waste may be activated and/or contaminated with radionuclides which are products of neutron activation or fission. It is important to decide in which cases the decontamination will be efficient as well as to select the appropriate decontamination techniques based on whether the waste is slightly activated or contaminated or both.

A semi-empirical technique for optimization of determination of contamination and activation of components and metallic waste, is under development based on a combination of gamma spectrometry measurements and MCNPX Monte Carlo simulations. Firstly, the technique aims at reduction of the uncertainties related to the density and activity distribution. The specific activities inside and on the surface of the materials could be determined by using the measurement results of the proposed non-destructive technique in combination with the use of the scaling factors for activation and/or contamination.

Radiological characterization of metallic waste on decommissioning by comparing real and simulated spectrum

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The main objective of a decommissioning plan is to obtain a radiological understanding of the involved installation. The radiological characterization of activated and/ or contaminated components is essential for the decision-making process during decommissioning. The cutting techniques to be followed in order to reduce the production of secondary radioactive waste and limit the doses to personnel and the selection of decontamination techniques should be based on accurate determination of the radionuclides inside the material and/ or in the surface contamination. In addition, the effective management of radioactive waste is based on an adequate characterization.

The radiological characterization methods used in decommissioning are:

(a) neutron activation calculations based on reactor design and neutron flux;

(b) dose rate measurements;

(c) in-situ gamma spectrometry;

(d) sampling for determination of the scaling factors in activated and contaminated components.

Neutron activation calculations contains several uncertainties based on the input data - such as material data (composition and impurities), neutron flux and energy, nuclear data libraries - and on the methodology of the process and the simulation codes. Moreover, sampling methods are also challenging considering the uncertainties based on the representativeness of the samples and the deviation of the activities. Taking into consideration the neutron calculation uncertainties as well as the difficulties in sampling, this work is focused on the development of a non-destructive gamma spectrometry technique by using MCNP6.1 simulations for interpretation of the resulting gamma-ray spectra of the radionuclides in activated and/ or contaminated components. In particular, a gamma-spectrum will be produced, based on the activities of the detected radionuclides in the activated or contaminated component and the results of MCNP6.1 simulations. This spectrum will be compared with the experimental spectrum. The proposed technique will be useful on determining the activities inside and on the surface of a metallic component.

Analysis of DPRK's trade and prohibited items of UN sanction transactions

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The DPRK has conducted six nuclear tests since 2006, and the possibility of a seventh test in 2022 has increased, posing a threat to international peace and the nonproliferation regime. In response to these threats, the UN Security Council has imposed sanctions on the DPRK by adopting sanctions resolutions. Under these circumstances, this study analyzes the trends and causes of DPRK's trade with China over the past decade since the 2010s, when Kim Jong-un took power, and identifies DPRK's main trading partners and trade items by examining its primary export industries and main export items. As DPRK does not disclose its trade statistics, we analyzed DPRK's statistical data using the mirror statistics method using publicly available data from the International Trade Center (ITC) Trade Map, UN Comtrade, Korean Statistical Information Service (KOSIS), and Korea International Trade Association (KITA). In this research, the DPRK's trade trends analysis showed that the UN sanctions replaced the main trade items. So, we investigate UN-sanctioned prohibited items in the import and export sectors that significantly impacted DPRK's trade. Also, we analyzed the HS codes of the UN-sanctioned items to identify possible nuclear items. Finally, we analyzed the states that have recently traded sanctioned items with DPRK through the UN Panel of Experts report and those traded, including nuclear items. Despite the limitations of DPRK's characteristics and the data reported by DPRK's trading partners, this study is significant in that it analyzes the central states and trends of DPRK's trade through open data and identifies states that may trade nuclear items in the future through the analysis of UN-sanctioned prohibited items and HS codes. Specifically, we found that China, which accounts for more than 90% of DPRKs trade, and 15 other countries, which account for less than 10%, have a history of trading HS code 84, which is an UN-sanctioned item against DPRK. The study results will be used to develop scenarios in which nuclear items are illegally transferred into DPRK to assess the risk of importing and exporting through DPRK.

Role of the International Nuclear Security Educational Network (INSEN) in strengthening Nuclear Security Globally

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The International Nuclear Security Educational Network (INSEN) is a partnership through which the IAEA, educational and research institutions, as well as other stakeholders cooperate to promote sustainable nuclear security education (https://www.iaea.org/services/networks/insen).

INSEN Mission is to enhance global nuclear security by developing, sharing and promoting excellence in nuclear security education. This nuclear security education contributes in preparing the next generation of professionals with knowledge, expertise, and understanding of the importance of nuclear security.

INSEN membership is open to any educational and research institution already involved or, that plans to be involved in nuclear security education in the future. Membership to INSEN is through educational or research institutions, and it connects professors and researchers working on nuclear security.

The network has three working groups focused on

- development and maintenance of educational materials, tools and methodologies
- programme, curriculum and faculty development
- knowledge management and promotion of nuclear security education and INSEN

The culmination of activities by all INSEN Working Groups has led to the development of European Master Programs in Nuclear Security.

Through INSEN are implemented and developed new (online) teaching and assessment methodologies and tools. INSEN members use the available educational material for the development of courses and teaching curricula, while they collaborate together in co-organizing workshops, in co-designing curricula, for developing proposals for additional funding. Most of the INSEN members are engaged in capacity building and promoting knowledge, courses, workshops, while other INSEN members are involved in organizing, conducting, facilitating and coordinating Professional Development Courses (PDCs) in nuclear security.

INSEN is significant not only because it helps states at the national level, but also, it has a multiplier effect for the international level with its ability to bring together academics and researchers from around the world, help them to cooperate in curriculum development, provide opportunities for faculty exchange, and organize PDCs to multiply the knowledge that is created.

Experimental evaluation of different wireless sensor modules under Gamma radiation

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Wireless technologies have been used in many areas, such as monitoring, control of nuclear power plants and nuclear waste management facilities on Earth and communications and telemetry in space-bound vehicles. They can provide a convenient way to transfer data without jeopardizing human safety. However, the critical components in these wireless technologies are semiconductor chips. Many studies have been done to understand the effects of radiation on electronic components, both from theoretical and practical aspects. Knowing the vulnerabilities of different semiconductor materials and their sensitivities to radiation can help wireless system designers to mitigate the radiation effects.

This paper will report some experimental results of exposing different wireless sensor modules to Gamma radiation. The radiation tests were carried out when the wireless devices were powered on and in transmitting and receiving modes of operation. The experiments were carried out at the Ohio State University, USA.

The focus of the work will be on (1) radiation-induced degradations in characteristic/performance of these electronic devices; and (2) mitigation techniques of using redundant/dissimilar technologies to enhance the survivability of the overall system.

It is concluded that, when selecting electronic components, one should consider the characteristics and performance of individual electronic components and the semiconductor materials used in constructing them. Most notably, one can choose between devices with similar functionalities but fabricated with different technologies, i.e. TTL (Transistor–Transistor Logic) based on bipolar junction vs. CMOS (Complementary metal–oxide–semiconductor).

Monitoring of ^{210}Po and uranium in vegetables and fruits for Kuwaiti adults

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^{210}Po and uranium were monitored in most consumed vegetables and fruits. The highest ^{210}Po was in Dates and Bananas (110 ± 30 and 110 ± 10 mBq/kg), while the lowest was monitored in green pepper (12 ± 2 mBq/kg), whereas uranium was below minimal detectable activity (MDA). Thus, such a study is highly necessary nowadays to be implemented because most Kuwaitis are vegetarians. The importance of the study can also be linked to the probable nuclear releases of the currently operating nuclear power plants in the region and in addition, to the high local consumption of imported fruits and vegetables from different countries with different nuclear histories. Conclusively, radiological data for natural alpha emitters have been established for fruits and vegetables in Kuwait, and they were found to be in agreement with international similar data confirming their radiological safety. Future studies will be done determining gamma emitters ^{210}Pb, ^{226}Ra, and ^{228}Ra in fruits and vegetables, in addition to the seafood analysis because it is the 1st source of ^{210}Po incorporation.

Present problems of radiation protection quantities: Too many inconsistent quantities

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The present system of radiation protection quantities and units is rather complicated and difficult to use for the adequate interpretation of monitoring results required for the radiation risk assessment.

First, there are too many quantities currently in use in radiation protection. Most of them cannot be directly measured because of their too complicated definitions, which are causing a problem even for radiation protection officers responsible for routine monitoring of persons and the environment. As a result, they may only rarely be able to express the results of the measurement using various dosimeters or sensors into such quantities as personal equivalent dose, ambient dose equivalent, and directional dose equivalent or air kerma.

Second, most of the nowadays radiation protection quantities are related to the quantification of radiation risk due to external radiation, and only stochastic effects are considered. The risk assessment of internal exposure in terms of the effective dose is confusing.

Third, the assessment of deterministic effects is completely unclear and neglected. The RBE-dose with the unit Gy-Eq is rather confusing since it does not specify the organ, and this results in difficulties in the evaluation of the consequences of inhomogeneous whole-body exposure to high radiation doses where deterministic effects are expected. Moreover, radiation workers usually do not see any difference between equivalent dose and dose equivalent or quality and radiation weighting factors.

Fourth, the unit of Sv, which is supposed to use only for the risk at relatively low exposures (stochastic effects), is often used for quantifying high-exposure levels characterizing deterministic effects (tissue reactions). Even some commercial monitors claim that they can measure radiation up to several Sv. Similar inconsistencies appeared in some national radiation protection regulations.

Therefore, it is suggested: a) *to reduce* the number of quantities for routine monitoring to a very minimum; b) *to develop* a system of quantities for assessing whole-body deterministic effects using a unit complementary to Sv; c) *to continue* using the present complicated system of quantities limited only for their applications in specific fields of science and research or for a specific need in medicine by specialists. In any case, the definition of the effective dose has to be modified: a) to assume *only organs* giving explicitly their volumes (e.g., to avoid bone surface and to define clearly the skin), b) to make the *difference* between the stochastic effects inducing cancer and hereditary disorder.

Conceptual shielding design of sandwich walls for a particle therapy centre using Monte-Carlo simulations with FLUKA

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Particle therapy, such as proton and carbon ion therapy, has become increasingly popular in radiation therapy, especially for cancer treatment. These therapies offer highly precise treatment with reduced damage to healthy tissue and fewer associated side effects. However, the unique properties of primary and secondary particles and radiation products pose significant challenges for radiation shielding in particle therapy centers.

This publication focuses on the conceptual shielding design of sandwich walls (SW) for radiation protection, which was introduced for the first time at MedAustron particle therapy center, near Vienna, Austria. The SW design was recently proposed for the shielding design of the new particle therapy center for the countries of Southeast Europe (SEEIIST).

Using the FLUKA Monte-Carlo transport code, we provide a comparative analysis of the fluence and its double differential of both the ionizing particles (protons, neutrons, alpha particles) and gamma radiation for a spherical model of the shielding with sandwich walls versus full concrete walls. We examine the effects from irradiation of an average human body (AHUBO) model head phantom with primary protons of 100 MeV and C-Ions of 190 MeV (within the therapeutical range), both of which produce Bragg-peaks in the center of the AHUBO head phantom.

Our findings demonstrate the effectiveness of the sandwich wall design for radiation shielding in particle therapy centers. The comparative analysis provides valuable insights into the possibilities of SW shielding design that provides radiation safety for patients and staff while saving concrete and producing less excavated soil to be transported and dumped, thereby reducing the carbon footprint of the design. This work will have significant implications for the introduction of the green agenda in the particle therapy facility design and is applicable to future particle therapy centers, including SEEIIST.

Keywords: particle therapy, shielding, Monte-Carlo simulation, FLUKA, sandwich walls, soil

Study of shielding properties of zinc borate doped polypropylene matrix

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Neutrons are used very effectively in many critical areas such as materials science, space exploration, medical applications and the energy sector. Understanding the interaction between neutrons and matter is especially important in terms of security measures such as in shielding studies. Neutrons mostly lose energy through elastic and inelastic collisions. Lighter elements such as paraffin, water and polymers with high hydrogen content are more effective at slowing down neutrons in the case of elastic collisions. Generally speaking, light elements such as lithium and boron are used to capture neutrons. In inelastic collisions, incoming neutrons excite atoms by transferring some of its energy to the target atom, which then becomes unstable. The excited target atom returns to a more stable state by emitting gamma rays. As a result, this mechanism requires that the selected shielding material should also provide effective absorption towards gamma and X-rays emitted by the shielding material. At the same time, the shielding material is also expected to be flexible, transparent, light, resistant to high temperature and pressure, economical, easy to produce, abundant in raw materials and environmentally friendly. For this purpose, intensive studies are carried out by many academic circles. In this study, neutron and gamma shielding properties of zincborate (ZnB) doped polypropylene (PP), one of the three polymer types with the largest production volume in the world, at rates of 5.6%, 8% and 17%. Boron was preferred due to its relatively high abundancy in Türkiye. Zinc was preferred due to its relatively lower toxicity compared to lead. Theoretical and experimental mass absorption coefficients were calculated using gamma rays at 10 different energy values in the range of 31-1332 keV. Gamma ray absorption studies revealed that the produced ZnB-doped PP composites were effective shielding materials with increasing ZnB percentage against electromagnetic radiation at low energies (31, 59.5 and 81 keV). It was observed that the absorption decreased as the energy increased. Macroscopic neutron cross section values were calculated as 0.304, 0.207, 0.586, 0.450 cm^{-1} for, respectively, 0%, 5.6%, 8% and 17% ZnB-doped PP composites. It was concluded that the produced PP composites were more effective in terms of neutron absorption than other polymer types mentioned in literature. However, anomalies were observed with increasing ZnB addition. It was concluded from SEM images that the fluctuating behavior in the macroscopic cross-section values with increasing ZnB percentages was the result of polymer-particle interactions. In addition to mechanical tests, combustion analyses of the produced PP composites were also carried out due to the effect of ZnB to the combustion resistance of PP composites.

Keywords: radiation shielding, polypropylene, zincborate, neutrons, gamma rays, mechanical behaviors, combustion analysis

Prospective prussian blue - cellulose hybrid materials for the environmental and human protection from exposure to radioactive fallouts

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Since the occupation of Ukraine territories on 24 February 2022, the Russia has exalted in nuclear threats to Ukraine and other European countries. These circumstances have reinforced the activities of the European Union to enhance the radiation protection against nuclear and chemical hazards. There tremendous experience of the terroristic attacks on September 11, 2001 in the United States of America (U.S)., when many people got affected by internal contamination with radioactive or nonradioactive thallium (Tl) or radioactive cesium (Cs) remains us concerns of preparedness to chemical, biological, radiological and nuclear hazards including "dirty" bomb attacks, nuclear incidents and the rising risk level of nuclear war circumstances and cross-border contamination of Latvian and other neighbor populations of Ukraine and Belarus.

The research activities of the University of Latvia (UoL) team aim are the development of decorporating and decontamination agents for Tl, Cs and other radionuclides based on the modified cellulose and its derivative hybrid micro-nano materials incorporated with Prussian Blue (PB) particles. Radiogardase® the commercial PB is the only antidote that is currently approved by the U.S. and European Medicines Agency for the decorporation of internal Cs, Tl. Meanwhile, there are needs for easily accessible PB-polymer materials that could be used also for external protection measures.

That has affected the growing rate of 2D and 3D materials based on PB particle incorporated on textile materials based on cellulose and its modifications for prevention of external exposure (e.g. inhalation, ingestion of radionuclide dust aerosols the case of environmental pollution and human exposure to nuclear particles, which may raise at different concentrations depending on the climate, wind, contamination rate in radioactive zones and may affect the transfer of particles through radioactive fallouts raising risks to humans and animals [Lee et al. (2018). Scientific reports, 8(1), 4540.].

In this work, we have focused on the synthesis of PB by the green mechanochemical synthesis method. We have compared the synthesized PB to particles, we have obtained previously by conventional solution-synthesis reported in the works of Faustino et al. and other authors [*Int. J. Pharm.*, 569, 118600. 2019]. One of important aspects relates to fractionation and solvent free green synthesis allowing more easily to develop composites or incorporate particles on the surfaces of cellulose materials related to control of particle size and efficiency for Cs and Tl adsorption.

The incorporation of PB on cellulose and cellulose acetate materials was tested by several cellulose base materials such as nano and micro cellulose, cellulose diacetate and triacetate, which were functionalized to increase the immobilization efficiency of PB for Cs and Tl sorption, especially this is attributable to model experiments in different pH environments testing both PB cellulose and cellulose acetate hybrid 3D forms (aerogels). Innovative aspect included development of PB- cellulose acetate aerogel based on fibers similar to those used in cigarette filters. Cigarette filters are a significant problem due to their poor biodegradability, the possibilities of utilization of such materials were evaluated based on the previous experience of the team members on testing anaerobic digestion methods [*Key Engineering Materials*, 885, 103-108. 2021].

It was concluded that the PB synthesized by green, solvent-free mechanochemical method provided good Cs and especially Tl sorption capacity from different systems modeling drinking water, stomach and intestinal fluids and in most cases these results were comparable or even over exceeding in the case of the adsorption capacity of Radiogardase® used for control studies. For example, the Tl sorption efficiency of synthesized PB reached up to 190 mg/g in the case of intestinal fluid compared to 109 mg/L for commercial PB. It can be concluded that PB -cellulose hybrid materials could be used for the development of air filters such as face masks, water filtration systems and other radiation protective materials, which should be also tested for their safety and environmental degradation.

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Identification of biomarkers for acute radiation syndrome using various omic platforms and nonhuman primate model

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Threats of radiological or nuclear disasters are of serious concern and are a top priority for government agencies involved in domestic security and public health preparedness. There is a need for radiation medical countermeasures (MCMs) and sensitive bioassays for assessments of radiation exposures originating from unanticipated nuclear/radiological events. The United States Food and Drug Administration (US FDA) Animal Rule approval pathway for MCMs requires an in-depth understanding of the mechanisms of radiation injury, drug efficacy, and biomarkers for approval. Biomarkers can be helpful for extrapolating the efficacious MCM dose in animals to humans. Nonhuman primates (NHPs) are considered the animal model that reproduces the most appropriate representation of human disease. The NHP model is also considered the gold standard of animal models for drug development and approval by the FDA, and has a high degree of resemblance in terms of pathways of physiological responses and targets that are relevant to human disease. We have investigated few MCMs using an NHP model with promising efficacy outcomes. We have also identified candidate biomarkers for MCMs and the acute radiation injury using various omic platforms and NHP model. Multi-omic platforms appear to be highly useful in assessing radiation exposure levels and for identifying biomarkers of radiation injury, which can expedite the regulatory approval of MCMs.

In brief, there are a few promising MCMs under advanced development and a large number of metabolomes, lipidomes, proteomes, transcriptomes, miRNAs, and microbiomes have been identified as potential biomarkers for radiation injury and also for determining the efficacy of MCMs. Admittedly, these biomarkers are at early stages of development and will require further investigation and validation using animal models and human samples. Improvements in omics identification databases has facilitated the development of multi-omic panels for clinical use. The application of the multi-omics approach appears to be informative in evaluating relative degrees of radiation exposure levels, identifying and validating novel biomarkers of induced injuries, as well as testing the efficacy of given MCMs.

Disclaimer: The opinions or assertions contained herein are the private views of the authors and are not necessarily those of the Uniformed Services University of the Health Sciences or the Department of Defense, USA. Authors declare no conflict of interest.

Indication of the magnetic fields influence by bioluminescent analysis

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The influence of magnetic fields on biological objects is an actively studied scientific problem with of the potentially high hazard level on living organisms and humans. Great attention is paid to the sensitivity of organs both to electromagnetic fields of technical origin and to the effects of geomagnetic events caused by cosmophysical phenomena. 25 solar cycles with large flare activity that began in 2019 and resulting in frequent magnetic storms of various types. The question of the influence of magnetic and electromagnetic fields generated in the ionosphere and magnetosphere on living organisms in space is topical. The biological effects of terrestrial magnetic anomalies, which are currently being actively studied using satellite remote sensing methods, have not been explored. These tasks cannot be solved without a standardized biological test systems and of course microorganisms in particular, as highly sensitive objects, can be promising bioindicators of magnetic and electromagnetic effects.

The important fact is that the molecular mechanism of bacterial bioluminescence is based on free-radical oxidation of reduced forms of flavins by the enzyme luciferase [https://doi.org/10.1016/j.csbj.2018.11.003]. Therefore, elucidation the properties of the effect of magnetic fields on bacterial bioluminescence will allow us to better understand the fundamental problems of modern biology and also to develop new technologies based on biological biosensors in the future. We previously established the influence of electromagnetic radiation (15 W, 2.45 GHz) for 5 and 15 min on morphological and transcriptional activity of luciferase encoding luxb gene expression of Photobacterium phosphoreum [https://doi.org/10.2478/s11535-014-0347-5].

We used a system of continuous cultivation of luminescent bacteria *P. phosphoreum* IMV B-7071 to monitor the state of the Earth's magnetic field in real time. The results have been used to create a database of changes in the luminescence of bacteria under the influence of the geomagnetic fields (GMF). Profiles of geomagnetic field fluctuations monitored by the Institute of Geophysics of the NASU, Kyiv were used. Their processing has revealed some indications of the correlation relationship between these data series. We believe that quantitative assessment of the bacterial luminescence and a real-time analysis of the magnetic situation will allow to classify the biological effect of magnetic storms with different characteristics and to determine the sensitivity of the system in terms of a possible early response to a change in the magnetic situation recorded by physical instruments.

The obtained results provide an additional contribution to the understanding of biomagnetosensing mechanisms based on enzymatically controlled free radical processes in microorganisms.

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Improved measurement of potassium levels in rats using a *in vivo* neutron activation analysis system

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Abnormal levels of potassium have been linked to several health conditions, including High blood pressure, cardiac dysfunction, kidney damage, and osteoporosis. Given the limited availability of in vivo measurement techniques, there is a need for novel methods to measure potassium in vivo to enhance the diagnosis and management of potassium metabolism related diseases. This study aimed to evaluate the feasibility of compact neutron generator based in vivo measurement system for quantification of potassium using rat carcasses. A cohort of thirty-nine rats (n= 20 males and 19 females, average weight 255±15 and 163±7 gram), which were part of another manganese exposure study were sacrificed and inserted in the polyethylene bottles. These rats were then placed and irradiated in a carefully designed irradiation cave built on the side of the neutron generator with an optimized thermal neutron flux and radiation dose ratio. The irradiation time was 10 minutes, followed by a 10-minute decay and 2-hour measurement using a high efficiency high purity germanium detector (HPGe).

Results. The average K concentration in male and female rats was significantly different (3546+/-473 vs. 2258+/-281). There was a significant correlation between potassium concentration and weight in both male and female groups (for male r(20) =.48, P=0.03, for female r(19)=.59, P=.007). We assessed the influence of manganese toxicity on potassium levels and observed no significant impact.

Conclusion. This study suggests that in vivo neutron activation analysis could serve as a promising method to quantify potassium and to investigate the storage and metabolism of potassium in human and in animals.

Application of the combined method of radiation sterilization for the effective processing and preservation of bone material of ancient animals

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A new method of processing and sterilization of biological samples of mammoth and other ancient animals using ozone and radiation exposure of high-energy electrons for long-term storage and research is proposed. The obtained results will make it possible to create a new promising method of processing biological samples of ancient animals with the minimum possible changes in their structure, properties and characteristics, to establish optimal parameters of the sterilization process of samples. This technique can be used in the future to work with various samples of fossil biological objects.

To effectively inactivate bacteria and other pathogens, ancient animal fossils must be treated. The most common microorganisms, Bacillus anthracis, may be present in soil and in the remains of dead animals. The bactericidal effect of radiation makes it possible to inactivate microbes, limiting the natural soft tissue decay mechanisms that are triggered during thawing. In addition to safety issues, this treatment greatly improves preservation of the specimen. The main purpose of preserving an exhibit is to prevent further destruction.

Today the Laboratory “Mammoth Museum of NEFU” has the world’s largest collection of frozen remains of extinct animals of mammoth fauna. One of the urgent tasks for the Mammoth Museum is the development of techniques to ensure the long-term preservation of fossil material for the purpose of its scientific study and then possible exhibition.

To date, the Museums mainly use chemical methods of sterilization. Researchers have repeatedly noted the high toxicity of ethylene oxide, its carcinogenic properties and the possibility of mutagenic effects on plants, bacteria and laboratory animals. The most effective method of sterilization is radiation treatment. Due to its penetration ability, gamma radiation quickly became the only method that was used throughout the sample volume. However, gamma radiation (20-40 kGy) causes damage to DNA, which can significantly reduce the quality of analysis and lead to the loss of necessary information.

The authors applied a new combined method of treatment and sterilization of biological samples of mammoth and other ancient animals using radiation exposure for long-term storage. Combined radiation sterilization has the ability to break down the DNA of harmful microorganisms as well as their spores, increasing the shelf life. This method also allows you to replace or drastically reduce the use of chemicals. The results of studies of mammoth biological specimens under the influence of ionizing radiation and the analysis of changes in mechanical properties before and after radiation exposure became the basis for the development of the storage method. Studies of tissue samples of the Maloliakhov mammoth using complex biophysical methods with the use of scanning electron and atomic force microscopy, infrared spectroscopy and Raman spectrometer have been conducted. The results of the study are new data on cell morphology, elemental analysis, chemical composition and chemical compounds of fossil fragments.

In the future, there are plans to develop general regulations for the preservation of found bones of extinct animals and the conservation of fossil ancient remains from the Pleistocene Epoch, as well as archaeological bone findings.

The measurement of the dielectric parameters of blood erythrocytes in cancer patients

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The possibility of using the method of microwave dielectrometry to study the hydration of substances is determined by the fact that the molecules of bound water and the dissolved substance in the centimeter wavelength range are less mobile than the molecules of free water [Development trends in medical science and practice: the experience of countries of Eastern Europe and prospects of Ukraine: monograph/ed.by authors. 2018; 18-37]. Analysis of the dielectric parameters of blood erythrocytes in cancer patients will provide additional information about the state of water directly in the membranes of erythrocytes during a tumor process, which is of interest in connection with the development of physicochemical methods for diagnosing malignant diseases [*AS Cancer Biology*. 2018; 2(10):55-60.]. This paper presents the results of a study of the temperature dependence of the frequency of dielectric relaxation and the degree of hydration of a suspension of erythrocytes and the ghosts of erythrocytes of blood in normal conditions and in malignant tumors in the temperature range of 2-45^{0}C.

The experiments were carried out on the erythrocytes of the blood of donors and oncological patients before the use of antitumor methods of treatment. The group of patients with malignant neoplasms included patients with stage II-III tumors of the following localizations: stomach cancer (n=30), lung cancer (n=30). The control group consisted of 25 healthy donors. The sample preparation procedure was described in detail earlier [*ScienceRise: Medical Science*, 2015; 7/4(12):11-17]. The study of the dielectric characteristics of a suspension of erythrocytes and the ghosts of erythrocytes in the temperature range from 2 to 45 ^{0}C was carried out on a microwave resonator-type dielectrometer at a frequency of 9.2 GHz. The linear form of the dependences of the real (ε′) and imaginary (ε′′) parts of the complex permittivity on the concentration of erythrocytes indicates that the dielectric properties of the solvent do not depend on the concentration of cells. The transition from the quantities (ε') and (ε") directly measured in the experiment to the quantities (ε_s) and (f_d), the static permittivity and the dielectric relaxation frequency of water in solution, was carried out using the Debye equations. Assessment of the hydration was estimated using the formula $\Delta\varepsilon_s = \varepsilon_{sw} - \varepsilon_{ss}$, where $\Delta\varepsilon_s$ is the decrement of the static permittivity of the solution relative to the solvent, and quantities (ε_{sw}) and (ε_{ss}) are the static permittivity's of the solvent and solution, respectively. The results obtained were processed statistically using the software package statistics/w for mathematics.

Temperature-dependent changes in dielectric parameters (f_d) and ($\Delta\varepsilon_s$) of erythrocyte suspension and the ghosts of erythrocytes of blood of cancer patients were found. On the Arrhenius curve which are described of the frequency of dielectric relaxation of the suspension of erythrocytes of blood of patients with malignant tumors in the temperature range of 80 ^{0}C, a break is observed, with an increase in the activation energy from 15.4 kJ/mol to 22.3 kJ/mol. The degree of hydration of the erythrocyte membranes of blood of cancer patients decreases in the temperature range from 2 to 15 ^{0}C and increases in the temperature range of 18-32 ^{0}C.

The observed temperature-dependent changes in the dielectric parameters ($\Delta\varepsilon_s$) and (f_d) of the ghosts of erythrocytes and suspensions of erythrocytes of the blood of patients, together with the related changes in the structural and functional properties of erythrocyte membranes, can be considered as one of the important aspects of the relationship between the organism and the tumor.

Effects of ionizing radiation on the concentration of volatile organic compounds in beef, turkey and salmon

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Radiation technologies are widely used in many fields of science and technology, including the food industry. Food irradiation is increasingly used to ensure the microbiological safety of foods and increase their shelf life.

In addition to the inhibition of biological microflora, molecules in foodstuff, such as lipids, undergo oxidation as a result of radical processes. As a result of their radical peroxidation, volatile organic compounds, hydrocarbons, carbon monoxide, esters, and other compounds can be produced, some of which may be toxic to the body in certain amounts. As a result of the formation of these compounds, organoleptic parameters change, particularly, volatile compounds, that are in charge of altering the smell, occur. Therefore, it is important to study the changes in chemical parameters occurring in the irradiated foods.

The aim of this research was to assess how an accelerated electron beam influenced the concentrations of volatile compounds in beef, turkey, and salmon.

The samples were irradiated on a continuous 1 MeV electron accelerator UELR-1-25-T-001 (SINP MSU, Russia) at dosages of 0.25, 0.5, 1, 2 and 5 kGy an average dose rate of 5.9 Gy/s.

The concentrations of volatile compounds were determined using a gas chromatography-mass spectrometer Shimadzu GCMS-QP2010 Ultra (Shimadzu, Japan).

The samples contained the following types of compounds:

1. in beef: *alcohols* – ethanol, pentanol-1, hexanol-1, *aldehydes* – acetaldehyde, pentanal, hexanal, heptanal, nonanal, octanal, *ketones* – acetone, pentanone-2, 2,3-butanedione, 2-butanone;

2. in turkey: *alcohols* – hexanol-1, isopropanol, 2,3-butanediol, 2-ethylhexanol, *aldehydes* – hexanal, pentanal, octanal, *ketones* – acetone, 2,3-butanedione, 3-hydroxybutanone-2, 6-methylbutanone -3;

3. in salmon: *alcohols* – 1-pentanol, 1-penten-3-ol, *aldehydes* – acetaldehyde, propanal, 2-methylpropanal, pentanal, hexanal, heptanal, octanal, nonanal, 3-methylbutanal, *ketones* – acetone, 2.3 -butanedione.

The dependences of the concentrations of identified compounds on the radiation dose followed some general trends. At doses of 0.25-0.5 kGy, an increase in the concentrations of compounds was observed due to the decay of "primary molecules", the destruction of which occurred within doses up to 0.5 kGy. When a dose of 1 kGy was reached, the process of decomposition of the volatile compounds became predominant due to their decomposition and recombination with other molecules. The decay of "secondary molecules," whose destruction necessitates doses above 0.5 kGy, resulted in a rise in compound concentration at doses between 1 kGy and 5 kGy.

Thus, the change in volatile compound concentrations with radiation dose occurs due to the decay of the volatile compounds themselves according to an exponential law (decrease in concentration), due to the decay of "primary molecules" and "secondary molecules" (increase in concentration).

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Improvement of hydrogen fuel cells seen by positron annihilation spectroscopy

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The aim of the present study is to improve Proton Exchange Membranes (PEM), in particular PFSA (perfluorosulfonic acid) such as Nafion® by ion beam implantation. A paramount application of PEM membranes is being represented by the hydrogen fuel cells with a great potential in the alternative energy field. Au and Pt ion implantation may enhance PEMs catalytic characteristics and electrical contact that improve charge collection and makes the chemical adhesion more efficient [https://doi.org/10.3390/ijms21155517]. Several ion implantation tests were performed at different energies, using the facilities within IFIN-HH, the 3 MV TandetronTM accelerator provided a beam in the 1-3 MeV range, Au^{2+} ions with a fluence up to $1.5*10^{14}$ ions/cm^2 [https://doi.org/10.1016/j.nimb.2015.07.011].

Four PEMs of different thicknesses, two of them with a slightly different chemical structure, were implanted. Three irradiation steps were chosen for each membrane, in the range 10^{13} - $1.5*10^{14}$ ions/cm2, with two repetitions for 1 MeV, respectively 3 MeV.

The preliminary testing of the fuel cells was carried out with a home-made test-bench where, at a constant flow of H_2, the maximum electrical power output and the cathode electrode temperature were measured. Fuel cells have been tested in pairs, one of thems used as a reference. The data was taken automatically with a sampling rate of 1 Hz, and t stored to an HDD, where it can be accessed in real time and displayed as I-V characteristic.

At the microscopic level certain defects that may occur in PEM can be studied by positron annihilation spectroscopy (PAS) [Jean et al., "Principles and applications of positron and positronium chemistry"] technique revealed information about particle agglomerations, defects and free volume properties induced by the implanted ions.

Lifetime Spectroscopy (PALS). To determine the size of Elementary Free Volume (EFV), the PALS experiment is run. A traditional fast-slow spectrometer, which is based on two collinear plastic scintillation detectors, is used to measure the positron lifetime. Prior to beginning the experiments, the coincidence gamma lines of 60Co (1173 and 1332 keV) are used to test the spectrometer timing resolution by 210 ps. The spectrum's channel width is calibrated to be 6.2 ps. A 48V source was utilized with low activity to minimize background (500 kBq). Each sample's positron lifetime spectrum is divided into three discrete exponentials using the LT-10 program, with a lifetime of i(ns) and an associated intensity of Ii(%). The pick-off process in the EFV regions of the polymer, which modifies O-Ps annihilation, is responsible for the longest-lasting component, which has a lifetime of a few ns. The EFV may be thought of as a spherical potential well and its radius can be calculated using a semi-empirical equation, according to a quantum mechanical model created by Tao [https://doi.org/10.1063/1.1677067].

Coincidence Doppler Broadening Spectroscopy (CDBS). To determine the chemical environment of EFV locations, the CDBS experiment is carried out [https://doi.org/10.1016/j.radphyschem.2019.108461]. A digital spectrometric chain that additionally includes an analog component on the fast track for ultrafast amplification and the temporal window is used for coincidence measurement. The 16 Channel Multievent Peak Sensing ADC, 12 bit resolution CAEN VME 1718 is the foundation on which the digital spectrometer is built. The two HPGe detectors pre-amplifier output signals are directly sampled by the digitizer, and the acquired data are then examined by a home-made code from which the coincidence parameters can be established.

The membranes with the best response obtained after testing in the fuel cell are studied by PALS and CDBS, where an estimate of the defects and voids in the sample is made [https://doi.org/10.1016/j.matchar.2021.110952]. Experimental results obtained from these measurements are presented. Also, the PAS measurement technique is described in detail. The data obtained in the end represent a correlation between the defects induced by irradiation with Au ions and the electrical efficiency of the membrane in a fuel cell.

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Algorithm for calculation of depth dose distributions in materials when processing objects with electron beam

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The method of processing with ionizing radiation has become widespread in the industry and has now replaced chemical and thermal methods of processing for some categories of objects. Processing products with accelerated electrons is one of the most efficient methods of processing.

According to ISO/TC 198 and ISO/TC 34 the upper absorbed dose limits for irradiation of food and medical devices should not exceed 10 kGy and 30 kGy, respectively. At the same time, the ranges of effective doses for each irradiated object are not specified by the international standards and must be determined experimentally so that irradiation at doses not exceeding the upper limit would not change the physical and chemical properties of the object, bearing in mind that the goal of irradiation is achieved at doses above the lower limit of the range that ensures the microbiological safety of objects. Since the uniformity of dose distribution for a number of objects, such as transplantation items, blood for transfusion, meat and fish, must be at least 85%, it is necessary to determine the optimal processing parameters, such as the effective energy of electrons in the beam, the irradiation method, the beam sweep width, the duration of current pulse, pulse frequency, sweep frequency, as well as the speed of the conveyor belt on which the objects are placed.

The aim of the study is to develop an algorithm that allows one to reconstruct the absorbed dose distribution in a target material, such as water, from a set of calculated depth dose distributions in aluminum, graphite, or any other material. This choice of materials is due to the fact that water acts as a model substance in the study of biological objects, and the verification of industrial accelerators includes measuring the absorbed dose distribution in aluminum or graphite.

The algorithm proposed in this research makes it possible to reconstruct the dose depth distributions in the target materials from distributions in the reference materials. It has been established that the distribution accuracy increases with an increase in the effective energy of electrons in the beam and a decrease in the density of the reference material. It is also clear that the use of several materials can significantly improve the accuracy of reconstructing the dose distributions.

The proposed algorithm can also be used to validate absorbed dose distributions measured in a target material when used as a reference.

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Boron content determination in ore samples using Geant4-simulated PGNAA and MCLLS algorithm

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In this study, a new method was developed for the determination of Boron concentration in ore samples using the Monte Carlo-Library Least Squares (MCLLS) algorithm with the neutron inelastic-scattering and thermal-capture analysis (NITA) technique. To simulate the Prompt Gamma-ray Neutron Activation Analysis (PGNAA) system, the Geant4 toolkit was utilized to model the interactions between 14 MeV neutrons and ore samples. The histograms generated with Geant4 toolkit, were broadened using the energy resolution function of the Bismuth Germanate (BGO) scintillation detector. These energy-dependent spectra were used into the MCLLS algorithm. A single element library was created using broadened histograms from nine ore samples, which were used to compare and estimate the boron content of an unknown sample. The boron content was then validated by comparing the estimated results to those obtained through laboratory analysis.

The MCLLS method provided a statistically sound approach to estimating the boron content in the unknown sample, with the reference library allowing for precise comparison and estimation. The simulation of the PGNAA system using Geant4 allowed for detailed modelling of the neutron-gamma interactions in the ore samples, and the broadening of histograms enabled the correction of energy resolution effects from the BGO scintillation detector. The proposed method provides an accurate and efficient means of boron content determination in ore samples, with potential applications in industrial settings where accurate elemental analysis is required.

In conclusion, the Monte Carlo-Library Least Squares (MCLLS) method coupled with the neutron inelastic-scattering and thermal-capture analysis (NITA) technique was developed for the determination of boron concentration in ore samples. The simulation of the PGNAA system using Geant4 allowed for detailed modelling of the neutron-gamma interactions in the ore samples, and the broadening of histograms enabled the correction of energy resolution effects from the BGO scintillation detector. The MCLLS method provided a statistically sound approach to estimating the boron content in the unknown sample, with the reference library allowing for precise comparison and estimation. Overall, the proposed method provides an accurate and efficient means of boron content determination in ore samples, with potential applications in industrial settings where accurate elemental analysis is required.

Research activities at the Police Academy in Prague aimed at the detection and elimination of the CBRN threat

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Chemical, Biological, Radiological and Nuclear (CBRN) agents present a potential danger if they are misused by terrorists for malevolent action. It is, therefore, essential to adopt appropriate preventive measures to avoid such attempts by criminals. First, all CBRN materials should be kept secured and strictly controlled so that any access to them is maximally averted. The presence, even a tiny amount or traces of CBRN components, should be detected, and appropriate methods should be applied to identify the material involved. For this purpose, an instrumental neutron activation analysis (INAA) proved to be a reliable and sensitive method used for assessing the CBRN components and evaluating other dangerous substances, including illegal drugs and narcotics seized by law enforcement authorities.

During the last two years, the Police Academy of the Czech Republic (PA CR) was with other cooperating partners engaged in research oriented towards developing appropriate methods based on the INAA to identify individual components of CBRN as well as use such a method for its applications in selective detection of drugs and other dangerous materials. The PA CR cooperated in this research with three other Czech universities and some international organizations, including United Nations Office for Drugs and Crime. The cooperation in this field will also continue with the NATO CBRN Center of Excellence, where attention will be paid to developing and maintaining the necessary CBRN defence capabilities, including intelligence, personnel, equipment, policies, plans, exercises and training. As of the beginning of this year, PA CR participates in a multinational CHIMERA project (coordinated by a Polish consortium iTTi) concentrated on specific problems related to ensuring CBRN safety and security.

The paper presents some results achieved under the recent projects carried out at the PA CR related to CBRN and other dangerous substances. At the same time, the current PA CR involvement in new projects and its evolving international collaboration addressing various specific aspects of controlling and eliminating CBRN risks and threats will also be outlined.

Challenges in the use of handheld radiation detection equipment and radioisotopes identification from front line officers (FLOs)

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The use of portable handheld radiation detection instruments from the front-line officers in all countries has challenges that impact the process for detecting and combating the illicit trafficking of radioactive materials. At border crossing points or seaports where there is a high number of import and export commodities, the primary and secondary inspections are made by front line officers (FLOs) with non-technical backgrounds and the expectation that high confidence and rapid alarm assessment must be done.

Because many alarms are simply the result of naturally occurring radioactive materials (NORM) moving through commerce, separating alarms possibly caused by nuclear and other radioactive materials from the alarm pool of mostly NORM can be quite difficult.

Response and inspection time become a challenge that requires responsibility and coordination. International Atomic Energy Agency (IAEA) has supported all Member States (MS) to improve the ability of responsible employees to control persons and vehicles for radioactive materials that are out of regulatory control, to prevent illegal movement and trafficking of these goods through different research coordinated projects as CRP J02012 “Advancing Radiation Detection Equipment for Detecting Nuclear and Other Radioactive Material out of Regulatory Control”. In the frame of this project was prepared a survey with five sections and 28 questions in total that participated 42 different MS.

This paper provides information about the personal information and experience of different FLOs, the equipment used during inspections, notifications of PRDs and RIDs, display and interfaces of RIDs, and features for radiation detection equipment in general. The purpose of this survey was to identify the problems related to the measurement and identification of different radionuclides using equipment like PRDs, RIDs, etc., especially for NORM alarms assessment which compose more than 99% of Alarms at Border Crossing Points Survey result on PRDs screen notification unit based on FLOs job function, asked to 33 FLOs was in μSv/h.

Radiological risk assessment of food crops grown in Rustenburg, South Africa

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Due to the increasing world population, the global challenge of food security has led to the extensive use of agrochemicals to increase productivity. However, agrochemicals, mining and industrial activities have been reported to increase environmental radioactivity, and this poses a significant threat to human health. The presence of radionuclides in environmental media and their migration to food crops through soil and irrigation water has contributed significantly to human ingestion dose. Consumption of food crops with high radioactivity levels is associated with various health risks in humans. In this study, the level of natural radionuclides in food crops grown in Rustenburg, one of the mining cities in South Africa, is measured using inductively coupled plasma - mass spectrometry (ICP-MS). The activity concentration of natural radionuclides in food crops ranges from 0.13 Bq/kg in parsley to 25.28 Bq/kg in maize, 0.02 Bq/kg in maize to 0.60 Bq/kg in beetroot, and 8.78 Bq/kg in wheat to 45.11 Bq/kg in parsley for ^{238}U, ^{232}Th and ^{40}K, respectively. The average activity concentration of ^{238}U, ^{232}Th, and ^{40}K in onion, beetroot, leeks, mints, parsley, maize and wheat are (0.51, 0.17 and 25.52) Bq/kg, (1.43, 0.60 and 37.35) Bq/kg, (0.25, 0.18, 36.01) Bq/kg, (0.26, 0.07 and 36.01) Bq/kg, (0.26, 0.07 and 38.36) Bq/kg, (0.13, 0.14, and 45.11) Bq/kg, (25.28, 0.02 and 10.60) Bq/kg, and (0.54, 0.04 and 8.78) Bq/kg, respectively. The total ingestion dose from the consumption of natural radionuclides onion, parsley, mint, maize, leek, wheat and beetroot samples were also estimated and found to be 94.13 µSv/yr, 162.98 µSv/yr, 138.94 µSv/yr, 290.42 µSv/yr, 130.86 µSv/yr, 75.80 µSv/yr and 141.39 µSv/yr respectively. The average committed effective dose in all investigated food crops is below the international recommended level of 120 µSv/yr for ^{238}U and ^{232}Th, 170 µSv/yr for ^{40}K, and a total dose of 290 µSv/yr reported by the United Nations Scientific Committee on the Effects of Atomic Radiation, except in maize and wheat. The estimated lifetime cancer risk from ingesting food crops is less than the threshold level of 2.90×10^{-4}, thus, indicating that sampled food crops are safe for consumption and commercial purposes except for maize and wheat.

LiF:Mg,Ti TLD angular dependence evaluation at low energy incident radiation

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Accuracy of measurement in individual dosimetry monitoring service is achieved by performing calibration of dosemeters, ensuring that the measured values are traceable to the primary standard for the quantity of interest. Even though a dosemeter can exhibit remarkable performance in the reference calibration radiation field (e.g. ^{137}Cs), its performance can greatly differ under certain conditions. Effects of different influence quantities need to be examined to ensure that the dosemeters are reliable for use in a specific ionizing radiation practice. The most significant radiation characteristic influence quantities are the radiation energy, angle of incidence and dose (rate). International standards issued by IEC and ISO define radiation conditions and procedures for dosemeter type testing under effects of different radiation, environmental and mechanical influence quantities. Dosemeter performance is expressed in terms of relative response and is evaluated by comparing with defined limits of variation, taking into account the measurement uncertainty, according to [IEC 62387:2020, IEC, 2020].

A passive dosimetry system based on LiF:Mg,Ti thermoluminescent dosemeters (TLD) was tested for the effects of photon energy and angle of incidence in two dosemeter orientations, horizontal (up/down) and vertical (left/right), for the measurement of personal dose equivalent ($H_p(10)$ and $H_p(0.07)$). The dosemeters were read out on the Harshaw TLD™ Model 6600 Plus Automated Reader (Thermo Fisher Scientific, USA), calibrated in ^{137}Cs reference field. Low-energy X-ray reference field N-40, established according to ISO 4037-1:2019 [ISO 4037, ISO, 2019] and ±45°, ±60° angles of incidence were used to examine the passive dosimetry system performance. Limits of variation from -29 % to +67 %, defined in [IEC 62387:2020, IEC, 2020] for energy and angular relative response, were used for performance evaluation.

The overresponses for $H_p(10)$ for 45° and 60° were (51 – 62) % and (76 – 88) %, respectively. The results for $H_p(0.07)$ for 45° and 60° were (66 – 69) % and (79 – 95) %, respectively. Thus, for both quantities it was observed that the criteria are met for the angle of ±45°, while for ±60° neither comply with the standard, for both dosemeter orientations, when uncertainties are taken into account.

This shows that tested TLD system has high overresponse in low energy photon fields when larger angle of incidence values is encountered. The response could be improved if dosemeters are calibrated using appropriate reference calibration field or if different dosemeter holder is employed.

Keywords: individual monitoring, $H_p(10)$, $H_p(0.07)$, external radiation dosimetry

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Status of radiation safety management for workers in KOMAC

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Korea Multi-Purpose Accelerator complex (KOMAC) has operated proton accelerator with 100 MeV energy and 20 mA beam current, which is developed by Korea's own technology since 2015. It has ten target rooms, and now it uses six target rooms for research. KOMAC Radiation Safety Team has managed about one hundred thirty radiation workers.

This year, own-workplace education is conducted to improve understanding about radiation safety in proton accelerator field.

To minimize external exposure, KOMAC operates entrance control system that is linked with permission to enter and that provides electronic personal dosimeter. After working, operators return their dosimeters to system and we can monitor dose-rate in real time.

Personal Safety Interlock System (PSIS) is also operated to forbid workers to approach to high radiation field by three operation modes. Each mode is determined by accelerator condition.

In this poster, other similar facilities can refer the contents of our education and the structure(configuration) of the safety system for radiation protection.

Space radiation quality factor for Galactic Cosmic Rays and typical space mission scenarios using a microdosimetric approach

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Space radiation exposure from omni-present Galactic Cosmic Rays (GCRs) in interplanetary space poses a serious carcinogenic risk to astronauts due to the -limited or absent - protective effect of the earth's magnetosphere and, in particular, the terrestrial atmosphere. The radiation risk is directly influenced by the quality of the radiation, i.e., its pattern of energy deposition at the molecular scale. For stochastic biological effects radiation quality is described by the quality factor, Q, which can be defined as a function of Linear Energy Transfer (LET) or the microdosimetric lineal energy (y). In the present work, the average Q of GCR for different mission scenarios is calculated using a modified version of the microdosimetric Theory of Dual Radiation Action (TDRA). NASA's OLTARIS platform is utilized to generate the radiation environment behind different aluminium shielding (0-30 g/cm^2) for a typical mission scenario in low-earth orbit (LEO) and in deep space. The microdosimetric lineal energy spectra of ions ($Z \geq 1$) in 1 μm liquid water spheres are calculated by a generalised analytical model which considers energy-loss fluctuations and δ-ray transport inside the irradiated medium. The present TDRA-based Q-values for the LEO and deep space missions were found to differ by up to 10% and 14% from the corresponding ICRP-based Q-values and up to 3% and 6% from NASA's Q-model. In addition, they are in good agreement with the Q-values measured in the International Space Station (ISS) and by the Mars Science Laboratory (MSL) Radiation Assessment Detector (RAD) which represent, respectively, a LEO and deep space orbit.

Doses in contrast-enhanced mammography dual-energy digital mammography versus doses in full-field digital detector mammography

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Introduction. Contrast-enhanced mammography (CESM) is a method that combines digital mammography with intravenous administration of a contrast agent. The main indication for this examination is inconclusive findings in 2D mammography (FFDM) and USG. During the CESM, double the number of exposures is performed compared to the routine examination in FFDM. It was assessed how this affects the dose of X-rays received by women.

Material and Methods. Dose comparisons were performed for the GE Pristina Senographe mammography unit. In the period from 2019 to 2022, data on 44,908 examinations were collected, which constitutes 151,052 exposures (142,588 exposures were digital mammography, 8,467 exposures were performed in the CESM mode). AGD values were retrieved from the DoseWatch software. The acceptable values of AGD presented in the "European guidelines for quality assurance in breast cancer screening and diagnosis Fourth edition" (2006) were used as the criterion for assessing the degree of women's exposure to X-rays.

Results. The median value of AGD from CESM examination was about 1.8 times higher than in FFDM. However, for a single CESM exposure (i.e., the sum of low-energy and high-energy exposures for a given projection) the acceptable dose level was exceeded in subsequent years for 26%, 18%, 16% and 23% of exposures. The acceptable level of AGD was exceeded by at least 20% mainly for breasts with a thickness after compression less than or equal to 3.5 cm (87% of all cases).

The median of the effective dose for the entire examination performed in FFDM for individual years ranged from 0.52 to 0.56 mSv. Whereas, for study performed in CESM, it ranged from 0.92 mSv to 1.01 mSv.

Conclusion. The AGD and the total effective doses received by women for the CESM were higher than in the FFDM. However, the values of AGD for CESM exposures meet the acceptable limit in most cases.

Comparison of gamma and X radiation attenuation characteristics for ordinary concrete, concrete with barite and concrete with limonite and steel

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During the implementation of procedures for designing building barriers for protection against gamma and X radiation, the unavoidable question of choosing construction materials with appropriate mechanical and radiation characteristics for protective barriers arises. Based on engineering practice, it is necessary to compare different types of concrete used for the construction of facilities where there are sources of gamma and X radiation, such as in cases where radiation sources appear in medical facilities with linear accelerators, cyclotron installations for accelerating nuclear particles, in the environment of nuclear reactors, in radioactive waste storages, or in radiation sterilization units. In the cost-benefit analysis, several criteria are used to evaluate the characteristics of the concrete, so that in addition to the mechanical characteristics, the radiation characteristics of the construction material are also considered. One of the most important characteristics of concrete for radiation protection is its total mass attenuation coefficient. In this paper, computer code XCOM was used for the calculation of the total mass attenuation coefficients in energy range from 0.01 MeV to 100 MeV for three types of concrete: ordinary concrete, concrete with barite and concrete with limonite and steel. Based on the comparison of calculation results, it was concluded that concrete with limonite and steel has greater protective power than other two concrete types for the gamma and X radiation energy less than 30 keV. The second important conclusion is that the concrete with barite has greater protective power than other two concrete types in the range of photon energy from 30 keV to 300 keV, and for photon energy greater than 6 MeV. A detailed analysis of the calculation results found that in the energy range of 400 keV to 6 MeV values for the total mass attenuation coefficients are approximately the same for three different types of concrete.

Development of the safety indicator for Korea Multi-purpose Accelerator Complex

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Because the safety status of nuclear relevant facilities that operate the huge radiation generator is a combination of various systems and factors, it is necessary to develop an indicator that can intuitively understand its safety status. It is required systematic function of various devices and instruments on the operation of an accelerator, even if it is a single system. In order to perform its inherent original function, various devices and sensors must be connected.

And, the soundness of these devices can be one of the indicators of the safety status of the facility. In addition, the safety culture consciousness level of the members should also be an axis of the index that indicates the safety status of the facility.

We will introduce the detailed configuration of the safety index under development under the name of facility safety indicators. In this paper, we will introduce the detailed configuration of items under developing as facility safety indicator. The indicator is consisted of accelerator operation stability, radiation safety index, and the safety culture consciousness level.

Applications of radioactive ^{197}Hg as a highly specific tracer for atmospheric mercury sampling and calibration studies

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Measurements of atmospheric mercury (Hg) conducted in the recent decades have been a subject of bias due to lack of metrological traceability and measurement uncertainty. Traceability for gaseous elemental mercury (GEM) has been recently set, but this is not the case for gaseous oxidized mercury (GOM) and particulate-bound mercury (PBM). Gaseous Hg(II) species are very reactive, while their ambient concentrations are very low, thus causing difficulties in proper sampling and calibration. In here, we present the summary of our work conducted using radioactive ^{197}Hg as a highly specific tracer for atmospheric mercury sampling and calibration.

GOM and PBM sampling is the most problematic step in the atmospheric mercury speciation. GOM sampling with speciation traps composed of KCl sorbent materials and KCl trapping solutions are commonly used sampling methods. The specificity tests using ^{197}Hg demonstrated that the KCl sorbent traps are highly specific when using fresh traps, while their specificity drops when they are reused. The results of the trap stability tests indicated that the highest relative Hg(II) losses occur when low Hg(II) content is loaded, due to the reduction of Hg(II) to Hg(0).

Evaporative calibration units, commonly used for GOM calibrations, are based on evaporation of $HgCl_2$ solution. Using ^{197}Hg, we also evaluated its performance. The average recoveries ranged from 39.4–88.5% at 5.90 and 1178 ng m^{-3} $HgCl_2$ gas concentration, respectively. The losses were due to the adsorption of Hg(II) on the inner walls of the calibrator and tubing. The calibration unit seems to be suitable for $HgCl_2$ concentrations higher than 1 µg m^{-3}. Calibrator performance was also evaluated for $HgBr_2$ gas calibration, but the average recoveries were much lower than for $HgCl_2$ gas.

A calibration method for Hg(II) species based on nonthermal plasma oxidation of Hg(0) to Hg(II) was also developed. $^{197}Hg(0)$ was produced by quantitative reduction of Hg(II) from aqueous solution. The generated Hg(0) in a stream of He and traces of reaction gasses (oxygen, chlorine, bromine) was quantitative oxidized to corresponding Hg(II) species by nonthermal plasma. The presence of produced HgO, $HgCl_2$, and $HgBr_2$ was confirmed using quadrupole mass spectrometry. This work demonstrates the potential of nonthermal plasma calibration approach for the production of traceable amounts of Hg(II) compounds.

Nuclear and related analytical techniques used to study atmospheric deposition of trace elements and radionuclides in Europe, Asia and the Pacific Region based on moss analysis

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The application of mosses as biomonitors of trace elements and radionuclides in selected rural and urban areas affected by intense anthropogenic activity is reviewed. This technique is widely used in many countries in Europe (https://icpvegetation.ceh.ac.uk/), whereas it is scarcely used in Asia. The aim of the UNECE International Cooperative Program (ICP) Vegetation in the framework of the United Nations Convention on Long-Range Transboundary Air Pollution (CLRTAP) is to identify the main polluted areas of Europe, produce regional maps and further develop the understanding of the long-range transboundary pollution [Chapter in a book Biomonitoring of Air Pollution Using Mosses and Lichens: Passive and Active Approach – State of the Art and Perspectives, Nova Science Publishers, New-York, USA, 2016, pp. 246., http://www1.jinr.ru/Books/Books_rus.html]. The idea of transferring this technology to the countries of Asia and the Pacific region is being discussed. Examples of its application are given in the northern part of Vietnam, the most heavily industrialized areas on the periphery of Hanoi and the districts of Tainguyen. In addition to terrestrial passive moss biomonitoring, potentialities of applying active moss biomonitoring (moss bags technique) are demonstrated. The results obtained at a local scale in the areas experiencing environmental stress can be used to establish levels of pollutant emissions and provide information to public health authorities.

Keywords: moss biomonitoring, trace elements, radionuclides, anthropogenic impact

Radiocarbon dating of planktonic foraminifera in sediment cores from the NE Mediterranean Sea: paleoceanographic and paleoclimatic reconstructions during the last 20 kyrs

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Hereby, we present a multidisciplinary/multi-proxy high resolution study of paleoceanographic-paleoclimatic conditions and climate mechanisms during the last 20 kyr in several northeastern (NE) Mediterranean sites. For a reliable reconstruction of past climate changes and their effects on the physical dynamics and the biogeochemical and ecosystem functioning, a very detailed age control has been performed as the result of a series of reliable radiocarbon datings. This task includes: planktonic foraminiferal picking for accelerator mass spectroscopy (AMS) datings, evaluation/calibration of AMS datings, age model and detailed tight time framework construction for all gravity and multi cores. In particular, at least two grams of dried sample are disaggregated using hydrogen peroxide, and then wet sieved through a 125 μm mesh in order to extract the foraminiferal specimens. The chronology is based on AMS ^{14}C datings performed on clean handpicked mixed planktonic foraminiferal assemblages. A total of at least 10 mg of planktonic foraminifera, preferably surface-water dwellers (*Globigerina bulloides*, *Globigerinoides ruber*) is needed for each dating. The provided conventional ^{14}C ages are calibrated using the program CALIB 8.0 (Stuiver et al., 1998; Stuiver and Reimer, 1993) and the MARINE20 dataset with a regional reservoir age correction (DR) of 149 ± 30 years for sapropel interval (Facorellis et al., 1998) and 58 ± 85 outside the sapropel (Reimer and McCormac, 2002).

Detailed study of selected time intervals during the last 20kyr, revealed various paleoceanographic and paleoclimatic events: distinctive cooling events at ~18 and 13 kyr BP, the so-called Last Glacial Maximum and Younger Dryas followed by a rather mild climatic period (Holocene Climate Optimum), between 10 and 6 kyr BP, which is reflected by the deposition of the most recent sapropel layer S1. The deposition of S1 occurred during the early Holocene in two phases, S1a (10.8 – 8.8 cal ka BP) and S1b (7.8 – 6.1 cal ka BP) interrupted by a cold event around 8.2 ka BP. The termination of S1 formation is accompanied by a rapid re-ventilation of deep waters in the Aegean Sea associated with the decline of stratified conditions in the water column, concomitant to the decline in sea surface temperatures.

A rather unknown climatic fluctuation is a warm and humid period within the Middle Holocene, which ended because of an abrupt climatic deterioration at 4.2 ka BP, being a widespread cold event for the northern hemisphere. The paleoclimatic study for the last 1500 years in the northern Aegean, based on multi-proxy reconstructions and detailed radiocarbon dating of a high-resolution multi-core record, revealed various warm (Medieval Warm Period, Industrial warming period) and cold intervals (Dark Ages, Little Ice Age, Tambora volcanic eruption), linked to the northern hemisphere and the global scale variability. In respect to our findings, the current warming in the reconstructed SSTs has been unprecedented in the context of the past 1500 years.

Bioaccumulation of trace elements in keystone bivalve and fish species in the Bulgarian Black Sea ecosystem

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The aim of this study was to assess the elemental concentrations and bioaccumulation in common bivalve and fish species in the Bulgarian Black Sea part with both ecological and commercial importance species including Mediterranean mussel (Mytilus galloprovincialis Lamarck, 1819), wedge clam (Donax trunculus Linnaeus, 1758), round goby (Neogobius melanostomu Pallas, 1814), red mullet (Mullus barbatus Linnaeus, 1758), whiting (Merlangius merlangus Linnaeus, 1758) and horse mackerel (Trachurus mediterraneus Steindachner, 1868). The samples were taken from sites in the larger Varna Bay to the north and in the larger Burgas Bay to the south. The bivalve samples were collected from the sublittoral manually by scuba diving or were obtained from commercial providers. The fish specimens were randomly picked from several trawl selectivity experimental catches by pelagic Midwater ottertrawl (7 × 7 mm mesh size of the codend). A total of 22 chemical elements concentrations were measured in the total soft tissues of the studied species by Particle Induced X-Ray Emission (PIXE) at the 3 MV Tandetron™ accelerator from IFIN-HH, in Romania. In particular, only the concentration of metal elements (Mn, Fe, Ni, Cu, Zn, Cd, Pb) in the samples of Mediterranean mussels was determined by Inductively Coupled Plasma – Optical Emission Spectrometry (ICP-OES). Metallic elements have been found (Na, Mg, Al, K, Ca, Ti, Mn, Fe, Co, Ni, Cu, Zn, Cd, Hg, Pb), next to metalloids (Si and As) and nonmetallic (Br, P, S, Cl). The analyses indicated that the trace element concentrations showed variations depending on the region and species. The highest accumulation of light metal elements in the studied species in Varna Bay were Na (4155.2±217.2 ppm) and Mg in wedge clams (1117.3±44.5 ppm), K in goby (10149.3±243.6 ppm). The highest accumulation of heavy metals was Fe in red mullets (94.2±21.7 ppm), Cu in wedge clams (92.7±21.8 ppm), and Zn in Mediterranean mussels (253.5±64.7 ppm). The accumulation of the heavy metal pollutants Cd, Hg and Pb both in bivalves and fish species from Varna Bay was below the detectable limits with the exception of Mediterranean mussels where slightly higher concentrations of Pb were found at one site (2.18±0.82 ppm). The highest accumulation of light metal elements in the studied species in larger Burgas Bay were the following: Na (4283.7± 77.3 ppm) and Mg in wedge clams (1150.9± 35.9 ppm), K in goby (8885.2±622.7 ppm). The highest accumulation of heavy metals was Fe in Mediterranean mussels (381.1± 48.9 ppm), Cu in wedge clams (40.6±18.9 ppm), and Zn in Mediterranean mussels (253.5±64.7 ppm). Heavy metals pollutants Cd, Hg, and Pb in all the studied species kep below the detectable limits also for the southern region. In conclusion, the difference between the bioaccumulation capacity of the biota actually seems to reflect the real presence of the trace elements in the marine environment. Hence, the studied bivalve and fish species are confirmed to be good indicators for the long-term monitoring of metal concentrations in the marine environment.

Keywords: Bulgarian Black Sea, elements, bivalves, fish, PIXE, ion beam analysis

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Heavy metal pollution history in marine sediments from Bosphorus and İstanbul's Black Sea coastal area by ^{210}Pb and ^{137}Cs chronology

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Turkey is surrounded by the seas around three sides; and there is busy cargo ship traffic crossing along. The Black Sea, where most of the fishery activities of Turkey occur, is an important resource not only for Turkey but also for other countries along the sea's coast. Therefore, there is much interest and research of the economic importance, biological richness, and strategic location of the sea. In addition to its historical significance as part of the Silk Road, its importance has recently increased because of petroleum production and transportation.

The Çanakkale and Istanbul Straits, the way the only route connecting the Black Sea to other seas by, carry heavy ship traffic and involves intensive risk for environmental pollution (ship accidents, especially ships carrying oil). Istanbul is the most heavily populated and industrialized metropolitan area of Turkey. In addition to industrial and domestic load from Istanbul Metropolitan, dissolved and particulate pollution loads from the Danube River are transported towards Bosphorus by alongshore currents. Additionally, this region receives pollution not only from various local land-based, sources, but also from the heavily populated and industrialized Istanbul Metropolitan and from maritime transportation over the last few centuries. They all cause significant environmental impact on the marine environment. There is almost no detailed study on the history of heavy metal pollution, its sources and deposition in the bottom sediments from Bosphorus and İstanbul's Black Sea coastal area. Furthermoreб a survey of the literature indicates that very limited results with regard to dating of only three sediment cores from the Bosphorus outlet area of the Black Sea, north of Istanbul have been published. In this study, we attempt to close this gap by presenting data on the geochemistry, sedimentology, and radionuclide chronology of ten bottom sediment cores from the Istanbul Strait (Bosphorus) and İstanbul's Black Sea coastal area.

The sampling via a gravity corer were performed by R/V Alemdar II research vessel from to İstanbul University, Institute of Marine Sciences and Management during 24-26 November, 2021. The sediment cores were collected systematically at least 10 stations in Bosphorus and İstanbul's Black Sea coastal area. In the present study, CRS and CIC Model were applied to date the sediment cores and the validity of the proposed Pb-210 chronology is confirmed by records of ^{137}Cs distribution in the sediment sequence. In the ongoing study, sedimentation rates were appeared in the range of 0.343 – 1.33 cmy^{-1} for dated two cores. Furthermore, heavy metal analysis will be performed. Sedimentation rate and historical trends in heavy metal input and also sediment quality parameters will be established in detail, taking into consideration all the collected data.

Gamma spectrometric measurement of radioactivity in soils profile samples of the Hadžići area, B&H

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Soil represents the trophic base for the survival of numerous biological species. Therefore, soil is an essential component of the environment, contributing directly (or indirectly) to the general quality of life. Soil pollution and soil recovery measures require knowledge of the processes that govern the retention, degradation, and removal of pollutants in the context of soil-pollutant interactions and the particular behaviour of specific pollutants with respect to distribution, transformation, degradation, and transport in soil. Behaviour and fate of the natural essential and nonessential elements as well as harmful substances, which might be found in soil, are related to their mobility, and their ability to make reversible or irreversible connections in the soil environment. Among varieties of pollutants which reach the soil, most often by human activity, soil contamination with radionuclides represents a special challenge in terms of their removal from the soil and monitoring their migration through the soil. Correlations between mobility (and bioavailability) of radionuclides in soil and soil characteristics (pH, clay content, organic matter content, soil particle diameter, etc.), chemical and physical properties of radionuclides and speciation of radionuclides that could be simply understood as chemical and physical interactions of radionuclides with soil environment. Regarding previously mentioned, analyzing the radionuclides content in the soil is of great importance. During the last war in Bosnia and Herzegovina, depleted uranium, in the form of ammunition, was used on several locations, including the area of Hadžići. The estimated amount of used ammunition is close to three tons. The largest proportion of ammunition, whole penetrator and fragment could only be found deeper in the ground. Only a fraction of depleted uranium penetrator, detected in the surface ground layer was removed. Thus, the aim of this study was to assess the vertical distribution of radionuclides (^{232}Th, ^{40}K, ^{238}U and ^{226}Ra) through soil depths (0–10,10–20, 20–30, 40–50, 50–60 cm) at three sampling sites in the vicinity of Hadžići, to evaluate possible depleted uranium (DU) presence. Depleted uranium was assessed by activity ratio of ^{238}U/^{226}Ra using an approximate method. In addition, the vertical distribution of ^{137}Cs along 3 site profiles were used for the distinction between cultivated and uncultivated soil. To determine activity concentrations of mentioned radionuclide gamma spectrometry measurements were performed by using two detectors. Vertical coaxial HPGe detector (ORTEC) with a relative efficiency of 25% and a resolution of 1.95 keV was used for detection of higher energy radionuclides. Radionuclides with lower energy were detected on the LEGe detector (CANBERRA) with a relative efficiency of 32% and a resolution of 1.82 keV. It was found that the vertical distribution of the radionuclides ^{232}Th, ^{40}K and ^{226}Ra exhibits very similar trend across the three sampling sites. At site 1, the activity concentrations of ^{232}Th, ^{40}K and ^{226}Ra increased linearly with increasing the soil depth from 0 to 60 cm. The minimum obtained values for ^{232}Th, ^{40}K and ^{226}Ra were found in the 0–10 cm soil layer and maximum values were recorded in the 50–60 cm soil layer. Nevertheless, the maximum activity concentrations for ^{232}Th and ^{40}K were found in the 30–40 cm soil layer and for ^{226}Ra in the 50–60 cm soil layer. Minimum values of activity concentration for ^{232}Th, ^{40}K and ^{226}Ra were found in the 50–60, 40–50 and 0–10 cm soil layers, respectively. The trend for ^{226}Ra is the same as for site 1; the activity concentration is increasing with the depth of soil layer, but opposite for ^{40}K and ^{232}Th. The maximum obtained activity concentration for 238U was in the 50–60 cm soil layer, and minimum activity concentration was found in the 20–30 cm soil layer. Minimum/maximum activity concentrations at site 1 were as follows; for 40K were814.42 Bq/kg/1039.48 Bq/kg, for ^{232}Th 53.98 Bq/kg/74.12 Bq/kg and for ^{226}Ra 50.32 Bq/kg/65.73 Bq/ kg. Sites 2 and 3 did not show linearity in activity concentrations of radionuclides and their vertical distributions. Using the activity ratio of 238U/226Ra and 235U/238U, the presence of depleted uranium (DU) was established at the site 3. The potential migration/relocation of radionuclides in the downhill area gives rise to keep up environmental monitoring because even a slow migration of these elements in the soil profile may lead to the pollution of the surrounding area and groundwater.

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Assessment of trace metals contamination of port sediments on the Montenegrin Coast

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Harbours are known as confined ecosystems that are considered among the most affected coastal areas faced with a wide range of environmental problems including the discharge of sewage waste and ballast water, petroleum and its derivatives, and antifouling paints, together with dredging activities, which may affect both the dredged and the disposal sites. Harbours are specifically characterized by their limited water exchange with the open sea. Many harbours are classified as harmfully polluted environments, due to the persistence of high contents of contaminants in the sediments and their toxicity and ability to be absorbed in the trophic chain. During 2019 and 2020, monitoring of trace metals (Zn, Cu, Cr, Ni, Pb, As, Cd, and Hg) in sediment was carried out at 12 locations, of which 9 locations represent "hot spot" locations (Shipyard of Bijela, Porto Montenegro, Port of Bar, Port of Kotor, Port of Risan, Port of Tivat, Port of Herceg Novi, Port of Budva, Port Milena), 2 locations represent sensitive transitional (Dobrota, Ada Bojana) an area as well as at one location representing the reference area (Dobra Luka). Given that Montenegro has not established criteria for evaluating the quality of marine sediments, the assessment is made by referring to the legal framework of the European Union and the standards for sediments of developed countries (Canada, the Netherlands, the UK and others). Here, for the sole purpose of comparison, the UNEP/MAP guide (UNEP(DEPI)/MED 439/15 - Pollution Assessment Criteria and Thresholds) as well as the OSPAR guide "The Convention for the Protection of the Marine Environment of the North-East Atlantic" (OSPAR) on levels and trends of contaminants in the sea and their biological effects. Based on the obtained results and their comparison with the BAC and ERL values, it can be concluded that the content of most elements in the sediment at investigated locations exceeds the BAC value and/or BAC and the ERL value. Exceptions are the locations Port of Bar (for Cd), Ada Bojana, Port Milena, Port of Budva and Dobra Luka (for Hg, Pb, Zn) and Port of Herceg Novi and Port of Risan (for Zn). The content of Cu, Cr and Ni in the sediment exceeds both the BAC and ERL values at all locations, with the exception of the Port of Tivat, Port of Budva and Dobra Luka, whose content is below the BAC and ERL values, respectively. According to OSPAR, the results for arsenic show that its content is above the BAC value only at the Porto Montenegro location. Comparing the results obtained for selected trace metals in 24 sediment samples collected from the Montenegrin coast, it can be concluded that the anthropogenic impact and geographical location are probably the main factors contributing to the differences observed for these samples.

Conchix (shell organic matrix) – an innovative medium for the assessment of trace metals in marine environment

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Trace metals content in the four media: soft tissues, shells and in the shell demineralization products (organic matrix - *conchix* and extract) of the Mediterranean mussel *Mytilus galloprovicilais* L. at three sites in the Boka Kotorska Bay, Montenegro were determined. Beside the allometric parameters (size, weight, *conchix* % in the shell, etc.), mussel's condition index (CI) and metal/shell weight index, the main aim was to investigate the accumulation patterns of trace metals in *conchix* and possible relationship with other media tested. *Conchix* weight within a group of mussels from Sv. Nedjelja was significantly higher in comparison with Cogi; on the other hand, CI of mussels from Sv. Nedjelja was significantly lower in comparison with Cogi and IMB. *Conchix* % in the shell showed negative correlation (r = - 0.316) with dry shell weight; despite the increase of dry shell weight, conchix % in the shell decreased but remained within the narrow range of 2-3%. PCA analysis showed similarities in trace metals accumulation in all media except *conchix*. According to CCA analysis, *conchixes* are grouped around Cu, Fe and Hg while Cd and Zn are in correlation with soft tissues. Moreover, the shells are in correlation with Mn, while the shell extracts are grouped close to Pb. As far as we know, this was the first application of *conchixes* as intact organic matrices obtained by a gentle EDTA-based demineralization in determination of trace metals content. Simple and low-cost synthesis, close contact with marine environment, susceptibility to possible pollution sources due to significant correlation in accumulation pattern of specific trace metals are the main reasons for consideration of Mediterranean mussel's *conchixes* as information sources on controlling changes in the aquatic ecosystem due to anthropogenic impact and/or climate change.

Distribution of heavy metals in bottom sediment samples at the Azerbaijan sector of the Caspian Sea

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The Caspian Sea is a unique natural reservoir on our planet. It is a land locked water body located on the border of two large parts of the continent of Eurasia. The area of the sea is 392,600 km² and the sea level lies 27 m below sea level. The Caspian basin hosts a unique ecological system as a result of isolation for over two million years. It is approximately 1200 km long with a maximum breadth of 466 km, contains 79,000 km3 of water, and has a total coastline of more than 7000 km. The Caspian is fed by five major rivers or river groups: in the north the Volga (80% of total inflow) and the Ural (5%); in the west the Terek, Sulak and Samur (4-5%) and the Kura (7-8%); and, in the south, the short mountain rivers from the Iranian Alborz range (4-5%) [*Journal of Radiation Researches* 5: 442-448 2018]. Azerbaijan has more than 800km of coastline along the Caspian Sea. The sources of Caspian Sea pollution are industrial, agricultural and accidental discharges and sewage. The main sources of pollution to the Caspian Sea have generally been considered to be offshore oil production and land-based sources, notably the Volga River.

Sediment samples from the stations were collected by Van Veen Grab fitted with stainless steel jaws. Main objectives of this study are to evaluate trace metals and major elements in 20 sediments collected from the Azerbaijan sector of Caspian Sea and to assess relationships between the elemental concentration levels, total organic carbon, total carbonate and particle size. An Agilent 7700x ICP-MS system was used to analyze each sample for element content.

Grain size helps to determine the textural and depositional characteristics of the environment. Particle size distribution in sediments is a function of availability of different sizes of particles in the parent material and the processes operating, where the particles were deposited.

Sediment types in the studied areas vary from coarse silt to very fine sand. The carbonate content ranged between 58.46% and 95.02 %. Total organic carbon content in studied stations ranges between 1.86% and 3.86%. The chemical contamination in the sediments was evaluated by comparison with the sediment quality guideline proposed by USEPA [EPA: Summary of Guidelines for Contaminated Freshwater Sediments, (1995)]. Concentration of As in all sites is higher than 8mg/kg which indicates that all sites are heavily polluted with arsenic. Cd, Pb, Zn and Hg concentrations in all stations under investigation belong to unpolluted category. Concentration of Cr is below than 25mg/kg in 20 sites which indicates that they were not polluted with Cr. However, all the other sites were considered as polluted. Results of the measured Cu concentrations showed that sites 8-10, 12 and 15 were moderately polluted and all the other sites were not polluted. Concentration of Ni in sediment samples were less than 20mg/kg in 12 sites (not polluted) and were greater than 20mg/kg (<50mg/kg) in 11 sites (moderately polluted). Concentration of Ba in all sediment samples taken from investigated area was higher than 60mg/kg. All sites were considered as heavily polluted with Ba and contamination is probably related to the oil production in Caspian Sea [*Marine Pollution Bulletin*, 48 (2004) 61-77].

Assessment of the vertical distribution of natural and anthropogenic radionuclides in sediments of the Aral Sea

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The Aral Sea is located in Central Asia, on the border of Kazakhstan and Uzbekistan. The Aral Sea was the fourth largest lake in the world occupying over 60 thousand square kilometers. Water of Syrdarya and Amudarya riv., which were recharging Aral, was used for irrigating crops (predominantly, rice and cotton). An irrational use of water lead to perishment of Aral. In the early sixties, the runoff of river water decreased. Hence, the sea level was sharply reduced.

In 1989, Aral split into two water bodies: the Northern Aral Sea (the territory of Kazakhstan) and the Southern Aral Sea (the territory of Uzbekistan).

In 2021, within the framework of the IAEA TC project RER7015, the research was carried out of the vertical distribution of natural and anthropogenic radionuclides in the sediments of the Aral Sea. Sampling of sediments was taken at 2 sites in the form of undisturbed cores from the coastal part of the sea. The height of cores was 30 cm. The divide of sediments cores into layers was carried out immediately at the sampling sites. The thickness of one layer was 10-12 mm, weight 0.15-0.25 kg.

According to the obtained data, the natural radionuclides content in sediments was: ^{40}K – from 90 to 550 Bq/kg; ^{232}Th – from 5.2 to 23 Bq/kg; ^{238}U – from 9 to 38 Bq/kg. The content of total and excess ^{210}Pb was also determined.

The anthropogenic radionuclides ^{241}Am and $^{239+240}$Pu content in sediments was below the detection limit (<1 and <0.23 Bq/kg, respectively). The ^{137}Cs content was recorded at a level of up to 1.7 Bq/kg.

In both sediment cores the vertical distribution of ^{137}Cs radioactivity displayed peaks, which correspond to global fallout from nuclear weapons testing. Using these peaks and the ^{210}Pb dating method, the sedimentation rates were calculated for the coastal zone of the Aral Sea.

The means sedimentation rate determined using excess ^{210}Pb was 0.290 cm/year and using the ^{137}Cs peak was 0.314 cm/year (0.302 ± 0.012 cm/year on average). The obtained data are consistent with the data obtained for the coastal zone of the Black Sea (0.25 - 0.41 cm/year, according to (*Oceanology* 61: 572-584 2021), but slightly higher than the sedimentation rates obtained for the coastal zones of the Aegean Sea (0.20 ± 0.03 cm/year, according to (https://doi.org/10.1007/s12665-012-1530-5).

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The research of the radionuclide contamination distribution in various types of water bodies at the Semipalatinsk test site territory

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At the territory of the Semipalatinsk test site there are various types of water bodies: static and dynamic. Natural lakes are classified as static water bodies. The radioactive contamination of lakes is formed due to radioactive fallout during testing of nuclear weapons, as well as due to wash-off from contaminated catchments. The streams of the "Degelen" site are classified as dynamic water bodies. The radioactive contamination of streams is formed due to the washing out of radionuclides by water from the cavities of tunnels. For research, the content of anthropogenic radionuclides ^{137}Cs, ^{90}Sr and $^{239+240}$Pu was determined in the ecosystem components "water - sediments – plants" these water bodies.

The main parameters for the distribution of radionuclides in aquatic ecosystems are: distribution coefficients (K_d, L/kg) for sediments and water and the concentration ratio (F_V) for aquatic plants and sediments.

In STS water bodies, the K_d varies for ^{137}Cs from n×10^1 to n×10^3, for ^{90}Sr – from n×10^0 to n×10^2, for $^{239+240}$Pu – from n×10^2 to n×10^4. The K_d decreases in the series $^{239+240}$Pu > ^{137}Cs > ^{90}Sr, and the radionuclide ability to accumulate in sediments decreases. It follows from this ^{90}Sr is contained in comparable amounts both in water and in sediments, in cases where the K_d is n×10^0, and ^{137}Cs and $^{239+240}$Pu are predominantly concentrated in sediments. At the same time, the K_d for ^{137}Cs and ^{90}Sr for lakes are an order of magnitude lower than those for streams. This is due to the level of water bodies contamination with these radionuclides. Since the streams of the "Degelen" site are more contaminated than the lakes, sediments are also capable of accumulating a greater amount ^{137}Cs and ^{90}Sr. For $^{239+240}$Pu, the K_d for lakes is 1–2 orders of magnitude higher than for streams. $^{239+240}$Pu is washed out from tunnels with waters in smaller quantities than ^{137}Cs and ^{90}Sr due to its chemical properties. At the same time, $^{239+240}$Pu that got into lakes is completely accumulated in sediments.

For the studied water bodies, based on the obtained F_V, it was found that the highest accumulation by plants is characteristic of the radionuclide ^{90}Sr (0.018 - 37), relatively less for ^{137}Cs (0.038 - 1.9) and $^{239+240}$Pu (0.02 - 0.7), accordingly, the series of decreasing radionuclides in terms of their ability to accumulate by plants as a whole has the following form: ^{90}Sr > ^{137}Cs > $^{239+240}$Pu. At the same time, the F_V of ^{90}Sr and ^{137}Cs for streams is an order of magnitude higher than for lakes, and the F_V of $^{239+240}$Pu for lakes and streams is at the same level. In a number of cases, in streams with F_V > 1, plants contain ^{90}Sr and ^{137}Cs in amounts exceeding their specific activity in sediments. This is typical for the "Degelen" test site and is associated with the removal of these radionuclides with the water of the tunnel watercourses, and thus, the radionuclides enter the plants not only from sediments, but also from the water.

The ^{129}I AMS measurements for determining the nuclear pollution of the environment

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^{129}I is a major anthropogenic radionuclide product which, together with other long-lived isotopes, is analyzed by AMS. It can provide important information regarding the spread of nuclear contamination, especially at a time when technologies of this type have become particularly important.

In the environment, significant amounts of ^{129}I exist as a result of nuclear weapon tests carried out in the last century and releases of spent fuel from nuclear reprocessing plants, which has led to an increase in concentration of up to 4-5 orders of magnitude compared to pre-nuclear era levels in some areas.

Iodine is transported from sources of nuclear pollution both hydrologically and atmospherically. Through AMS measurements, the spread of nuclear contamination in the environment can be tracked even before it becomes dangerous, with the best sensitivity of 10^{-13} for the isotopic ratio of $^{129}I/^{127}I$.

After commissioning the AMS facility at IFIN-HH, Romania, a nuclear pollution measurement program was initiated to determine trace-level concentrations of ^{129}I in water samples taken from rivers, seas, and oceans. We measured iodine concentrations on the American Coast after the Fukushima accident, in the Indian and Chinese Seas.

We analyzed water samples collected from various locations along the Danube River, the Danube Delta, the Black Sea coast of Romania and Bulgaria, and a few from the Aegean Sea, to determine the current level of ^{129}I concentration in these areas. We will continue to determine the current iodine levels in the entire Romanian area.

In the context of the war in Ukraine, knowing this current level of ^{129}I, can show us whether nuclear weapons will be used at a given moment, by determining increases in concentrations.

^{238,239,240}Pu in the Antarctic ecosystems

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Antarctic is probably the least polluted place in the World. Additionally, harsh weather conditions in the Antarctic have resulted in the development of specific, little differentiated ecosystems. Thus, the Antarctic is unique study area to analyze transport and sources of artificial radionuclides in the environment.

Our previous analysis suggested some differences between terrestrial and marine ecosystem regarding plutonium isotopic ratios. The present work is the verification of the hypothesis concerning the diversification of plutonium sources in the environment of Antarctica.

Plutonium activity and atom ratios were analyzed in two groups of biological samples: terrestrial (mosses and lichens) and marine (algae, birds, mammals and fish). 100 samples were analyzed in terms of radioisotopes content, ^{238,239,240}Pu, among others. In general, ^{238}Pu/$^{239+240}$Pu and ^{240}Pu/^{239}Pu ratios in the terrestrial set indicate the global radioactive fallout and accident of spacecraft with radioisotopic thermo generator SNAP-9A to be the sources of Pu in the Antarctic. Similarly, the same sources of Pu may be recognized in the marine environment. Although, ^{240}Pu/^{239}Pu values turned out to be surprisingly varied in this group of samples. The attempt to explain this issue along with statistical analysis of the results obtained will be presented.

Soil activity levels assessment for VVR-S nuclear Research Reactor Decommissioning area

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A comparative analysis of the activity levels for natural and artificial radionuclides from soil around the VVR-S Nuclear Research Reactor from IFIN-HH, Romania was performed both at the end of reactor operation and reactor decommissioning. The purpose of the study was to demonstrate that free release criteria under Regulatory Body regime for soil are met at the end of reactor decommissioning. The potential soil pollution sources were gaseous effluents evacuated into atmosphere by reactor stack as well as the accidentally discharging liquid effluents or uncontrolled landfill of waste. To obtain information about soil contamination caused by recent radioactive airborne dust or from past unknown "accidents" as well as natural background, gamma spectrometry indirect measurements of samples taken from soil surface and depth were performed. Thus, both natural radionuclides from uranium and thorium family and artificial radionuclides were detected. The ^{226}Ra and ^{232}Th activity concentrations were less than 100 Bq/kg at the end of reactor decommissioning in 2020. At the end of operation period in 2005 some values higher than the background were registered ^{226}Ra. The activity concentration mean value of ^{226}Ra were comparable for both period and corresponds to equilibrium with 3.3 ppm U_{nat}., soil background characteristic value. Also, the activity concentration mean values of ^{232}Th were comparable and corresponds to equilibrium with a content of 8.75 ppm Th_{nat}. It was noticed that the activity levels of the ^{226}Ra and ^{232}Th for soil at the end of reactor decommissioning, do not exceed the exclusion level of 1000 Bq/kg provided by National Safety Requirements, in force. The ^{137}Cs exclusion level of 100 Bq/kg was also not exceeded. It can be stated that the decommissioning activity did not generate soil contamination.

Can we see differences between the ^{14}C activities of urban (Zagreb) and rural (Cvetković) sites (central Croatia)?

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Radiocarbon (^{14}C) is both the cosmogenic and anthropogenic isotope. Anthropogenic ^{14}C is produced in atmospheric nuclear bomb tests, and in various nuclear facilities. The bomb-produced ^{14}C has been globally distributed across the planet. Furthermore, combustion of fossil fuels that do not contain ^{14}C causes an increase of atmospheric CO_2 concentration and consequently depletion of local ^{14}C levels. Naturally produced CO_2 and that formed by fossil fuel combustion are characterized by different stable isotopic composition of carbon ($d^{13}C_{CO2}$). The $D^{14}C$ (‰) is fractionation and age-corrected deviation from the standard pre-industrial content of ^{14}C ($D^{14}C$ = 0 ‰). The $d^{13}C$ is defined as the relative difference of $^{13}C/^{12}C$ ratio in sample and reference material and is expressed in ‰.

^{14}C activity in the atmospheric CO_2 in Zagreb, Croatia, has been monitored since 1985. Recently (2019 ongoing), we started monitoring ^{14}C at the location of Cvetković village (near Jastrebarsko, Zagreb County). Zagreb is considered to be a location with heavy fossil fuel combustion as compared to the Cvetković. Additionally, we took samples for $d^{13}C_{CO2}$ analyses in atmosphere during period 2021–2022. Here we compare the data from period 2019 – 2022.

A static sampling method has been used for monitoring ^{14}C activity – concentrated NaOH is exposed in a tray for 4 weeks and it gives an average ^{14}C activity over the sampling period. The method is simple and requires neither electric power nor any control, so it can be used at remote sites. However, the method introduces large isotope fractionation in ^{13}C due to high alkalinity of NaOH and it cannot be applied for monitoring of $d^{13}C_{CO2}$. Therefore, grab (instant) samples of CO_2 for $d^{13}C_{CO2}$ have been collected and measured at the Jožef Stefan Institute, Ljubljana, Slovenia. Both ^{14}C activity and $d^{13}C_{CO2}$ data will be used to differentiate carbon of global origin and carbon from local fossil fuel combustion.

Monthly ^{14}C activity at Zagreb is constantly below the ^{14}C activity at Cvetković. These data (both $D^{14}C$ at Zagreb and Cvetković) are comparable to the data of [*Radiocarbon* 64, 2022, 723]. Mean ^{14}C activity at Zagreb ($D^{14}C$ = -6.7 ‰) is lower than that in Cvetković ($D^{14}C$ = +6.2 ‰) due to fossil fuel combustion in the city of Zagreb. This is especially pronounced during winter when in Zagreb the mean value is $D^{14}C$ = -12.7 ‰ and in Cvetković $D^{14}C$ = +2.5 ‰.

No such difference is observed on $d^{13}C_{CO2}$; in Zagreb mean $d^{13}C_{CO2}$ is -11.0 ± 1.3 ‰, and in Cvetković -11.4 ± 1.4 ‰. These values are lower than at Mauna Loa (-8.8 to -8.5 ‰) and in the most of the stations [gaw.kishou.go.jp], but are comparable to sites in Velenje (Slovenia) region near Šoštanj power plant [*Geologija* 58, 2015, 35]. More negative $d^{13}C_{CO2}$ values are observed in winter (Zagreb -11.9 ‰, -12.2 ‰ Cvetković) then in summer (-10.1 ‰ vs. -10.4 ‰) at both locations.

Keywords: atmospheric CO_2, Central Croatia, $D^{14}C$, $d^{13}C_{CO2}$, origin of carbon

Levels of natural and artificial radioactivity in infant powdered milk consumed in Albania and estimation of the annual effective dose

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The aim of this study is to determine the levels of radioactivity in some different samples of powdered infant milk consumed in Albania and to estimate their effective dose. Infant powdered milk is the basic foodstuff for their growth and development in many countries around the world. Powdered milk is source of nutrients with amino acids, proteins, minerals and the others, thus, for health of infants, it is important to measure levels of radioactivity and effective dose. The activity concentration of natural and artificial radionuclides of 40K, 226Ra, 232Th and 137Cs were measured in fourteen types of powdered milk. Gamma spectrometry and a high-resolution HPGe detector was used to perform the measurements of all samples collected. The results indicated that natural radionuclides of 40K, 226Ra and 232Th were detected in all selected samples, whereas the presence of artificial radionuclide of 137Cs was not detected in most of them. The activity concentration of 40K, 226Ra and 232Th varies from 92.83 ± 4.32 to 400.53 ± 17.00 Bq kg-1, 0.80 ± 0.15 to 4.91 ± 0.28 Bq kg-1 and 0.19 ± 0.02 to 1.89 ± 0.14 Bq kg-1, respectively. The highest value of activity concentration of 137Cs was found 0.36 ± 0.03 Bq kg-1. The average values of Annual Effective Dose (AED) due to consumption of powdered milk for two ages group were found to be 664.54 μSv y-1 for first group ≤ 1 year and 138.53 μSv y-1 for second group 1-2 years. The results of activity concentrations and doses were compared with international reference values for powdered milk infants. The values of annual effective dose in this study were lower than recommended limit of 1 mSv y-1 by WHO and ICRP for all ages. Therefore, all powdered milk samples are safe for consumption with acceptable radiological risk and none of them pose any significant radiological impact to the infants. The data reported in this paper provide us the baseline levels of natural and artificial radioactivity in milk and help for future researches on foodstuff for radiological protection for the relevant population.

Keywords: powdered milk, activity concentration, gamma spectrometry, annual effective dose

Impact of rapid warming on the mobile forms of uranium and thorium in soils – a model experiment

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The study of the mobile forms of natural radionuclides in the soil has been an object of interest for a long time, due to the danger of their distribution through food chains and their entry into the human body. The contribution of natural radionuclides, such as uranium and thorium, to the dose burden of the population is determined both by their radioactivity and the radioactivity of their daughter products, and by their fixation in the surface soil layer, which largely depends on their mobility and geochemical forms. The chemical forms of binding of radionuclides in the soil depend to a significant extent on its characteristics, such as pH, cation exchange capacity (CEC), morphological and mineralogical composition, humus content, etc. At the same time, sudden changes in ambient temperature, soon after pollution, can have an impact on the mobility of pollutants in the soil, due to a change in the adsorption-desorption processes, complexation reactions, pH of the soil solution, etc.

This work presents the results of a model experiment conducted with soils taken from the surface 0 – 10 cm soil layer from 9 different regions in Bulgaria. The soils were characterized in terms of pH, CEC, humus content, morphological and mineralogical composition. Aliquots of each soil were contaminated in the laboratory with an aqueous solution of $UO_2(NO_3)_2$ containing ^{238}U, ^{235}U and ^{234}Th and conditioned for a period of 1 to 4 weeks at two temperature regimes: 15 ^{o}C and 40 ^{o}C. Afterwards, a sequential extraction procedure was used and the following geochemical forms of uranium and thorium were determined: (1) water-soluble and exchangeable; (2) bound to humic and fulvic acids and (3) carbonate-bound forms. Measurements of the radionuclides extracted in each fraction were carried out using gamma-spectrometer with HPGe detector, using the gamma lines of ^{234}Th at 63.29 keV and ^{235}U at 185.72 keV. The % fractions of the extracted mobile forms of the radionuclides stored at the two temperature regimes were compared, taking into account soil characteristics and chemical properties of uranium and thorium.

The results showed that a sudden increase in ambient temperature from 15 ^{o}C to 40 ^{o}C over a period of 2 weeks, soon after contamination of the soil with uranium and thorium, caused a decrease of the water-soluble and exchangeable fraction and of the carbonate-bound forms of the radionuclides and an increase in the fraction of nuclides associated with humic and fulvic acids in most of the studied soils.

A study of the mobility of uranium and thorium in soils after freezing

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The mobility of uranium and thorium in soils and their transfer through food chain has been the subject of long-term studies aimed at assessing the dose load and the radiological risk to the population in case of contamination. Sufficient data are lacking, however, regarding the influence of abrupt changes in climatic parameters on the mobility and geochemical forms of natural radionuclides. The study of the sharp decrease in ambient temperature on the mobile fractions of uranium and thorium in different types of soil, especially in the first weeks after contamination, would contribute to a more adequate modeling of the geochemical fate of these radionuclides and a risk assessment of radiation exposure in case of an accident. The present work is an investigation of the effect of soil freezing for a period of 3 weeks, shortly after contamination, on the water-soluble and exchangeable forms and the carbonate-bound forms of uranium and thorium. A model experiment was conducted with 6 soil types: Haplic chernozem, Chromic cambisol, Haplic luvisol, Calcaric chernozem, Gleyic fluvisol, Vertisol. Soils were contaminated with a solution containing ^{238}U, ^{235}U and ^{234}Th and were stored at 18°C for one week. Each of the soil samples was then divided into 2 aliquots, which were stored at 18 °C and -18 °C for a period of 3 weeks. The geochemical binding forms of uranium and thorium were investigated using a sequential extraction procedure.

The obtained results showed that the effect of freezing affects the mobile forms of radionuclides in a different way and depends on the acidity of the soils, the clay content and the cation-exchange capacity. Radionuclides from soil characterized by neutral pH, very low cation exchange capacity (CEC) and low clay content increase their mobility the most after freezing. At the same time, in soil with alkaline pH, very low CEC and low clay content, uranium and thorium do not change their mobility after freezing. The sharp decrease in temperature led to a decrease in the mobility of radonuclide in the soil, which is characterized by high CEC, high clay content and slightly acidic pH.

Study of the effect of Sr-90 on plant variability

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Ionizing radiation, as an environmental factor, leads to adaptive processes that affect the survival, growth, and development of plants. In this aspect, the leaf plate is a promising organ indicator of morpho-anatomical changes due to the accumulation of radioactive substances. In this regard, the purpose of this work was to study the influence of the radiation factor on the morpho-anatomical parameters of the Phaseolus vulgaris leaves of 2 generations under the model experiment conditions with the root intake of the radionuclide Sr-90. Beans were grown on soils selected in the territory where military radioactive substances were tested. The control group was grown on background soil with identical physicochemical properties. As the main morpho-anatomical parameters of the leaf, the thickness of the mesophyll and the thickness of the upper and lower epidermis were used. The selection of plant leaves was carried out at the end of the growing season after their complete formation, followed by fixation in the Copenhagen mixture. Micropreparations were prepared using an MZP-01 sled microtome (Tekhnom). Morpho-anatomical studies were performed using an MC 300 microscope (Micros) and BioWizad 4.2 software.

Thus, the maximum variation was noted for the thickness of the mesophyll (22%), and the minimum for the thickness of the upper epidermis (13%). For bean leaves grown on radioactively contaminated soil, significant changes in the studied morpho-anatomical parameters were established (at $p<0.05$). The greatest values of the thickness of all tissues were noted in the leaves of the 1st generation (the thickness of the upper epidermis is 13 μm, the thickness of the lower epidermis is 15 μm, the mesophyll thickness is 202 μm), the smaller values are for the 2nd generation (the thickness of the upper epidermis is 12 μm, lower epidermis - 13 μm, mesophyll thickness - 194 μm), and the minimum - for the control group (upper epidermis thickness - 10 μm, lower epidermis thickness - 12 μm, mesophyll thickness - 125 μm). The thickness of the mesophyll in the experimental group of the 1st and 2nd generation is greater than in the control group by an average of 38 and 36%, the thickness of the upper epidermis is by 23 and 17%, and the lower one is by 20 and 8%, respectively.

Thus, a high level of specific activity of Sr-90 in the soil cover has a significant effect on the morpho-anatomical structure of Phaseolus vulgaris leaves. The action of this radiation factor causes a change in the thickness of the mesophyll and the upper and lower epidermis. The established patterns can be applied in monitoring radioactively contaminated territories as a method of passive bioindication.

Radiation dose rate and morphological changes in leaves of *Betula Pendula* Roth. and *Phragmites australis* (Cav.) Trin. ex Steud in some water ecosystems of the Chernobyl Exclusion Zone

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The purpose of the observations was to establish the relationship between the biological concentration factor (BCF) of ^{90}Sr and ^{137}Cs with the corresponding dose rate and some morphological effects of the leaves of hanging birch (Betula pendula Roth.) and common reed (Phragmites australis (Cav.) Trin. ex Steud).

During 2011-2020, we conducted observations in six water ecosystems of the Chernobyl Exclusion Zone. 192 soil samples at the edge of the water, 620 samples of birch leaves and 1330 samples of reed leaves were taken, in which the concentration of ^{90}Sr and ^{137}Cs was measured, and the power of the external and internal radiation dose was calculated. The external radiation dose of the reservoir water was calculated according to the data of the National report on the state of the natural environment in Ukraine. The morphometry of plant samples was carried out according to the cross-sectional area of petioles of birch tree leaves (LS_s), the cross-sectional area of reed leaves (L_s), the ratio of the area of the upper half of the leaves to the lower half (K_{tb}), the ratio of the area of the leaves to the area of a circle with a diameter corresponding to the length of the leaves (K_{sl}). The given values of data samples are summarized by their medians.

Statistical analysis was carried out using the Monte Carlo method. The Spearman correlation coefficient (rS) and the Kolmogorov-Smirnov test (KS) were calculated.

Based on the results of observations, the value of BCF relative to the soil for ^{90}Sr in birch tree and common reed was determined to be 1.13 (V%=43) and 0.21 (V%=32), respectively. BCF ^{137}Cs – 1.17 (V%=51) and 0.32 (V%=40), respectively. Regarding the water of reservoirs, BCF was calculated only for common reed: for ^{90}Sr 3.0 (V%=43), for ^{137}Cs – 0.38 (V%=41).

The internal and external dose of plants from the soil is for birch tree for ^{90}Sr – 0.11 uGr/h and 0.23 uGr/h, respectively; for ^{137}Cs – 0.5 uGr/h; 1.6 uGr/h, respectively.

For common reed from water for ^{90}Sr – 0.11 uGr/h; and 0.47 uGr/h, respectively; for ^{137}Cs – 13 uGr/h and 0.21 uGr/h, respectively.

Values were set: K_{tb} of leaves for birch tree and reed - 0.86 (V=11%) and 0.30 (V=43%), respectively; K_{sl} – 0.77 (V=9%) and 0.15 (V=41%), respectively. The value of LS_s for birch tree is 0.26 mm (V=21%), and L_s common reed is 1.3 mm (V=31%). Statistical analysis showed close relationships between morphometric parameters and external and internal dose rates for ^{90}Sr and ^{137}Cs with Rs values greater than 0.75, which is mostly described by linear regressions. Only the K_{tb} values of reed leaves have dose rate feedbacks. Each of the analyzed pairs of samples according to the KS test has a common law of statistical distribution. The parameters of the statistical relationship between the concentration of radionuclides in plant leaves and biotopes enable their use for bioindication of radionuclide pollution of the environment.

Relationship between Safecast ambient dose rate and indoor radon data

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Large amounts of data on natural environmental radiation have been collected in Europe during the last decades. Radiation sources can be divided into cosmic and terrestrial or geogenic radiation, where the latter include atmospheric radiation from indoor and outdoor radon and progeny. Quantities routinely surveyed in Europe and available in data bases include ambient dose rate, geochemical concentrations of uranium, thorium (and progeny) and potassium in the ground and radon concentration in indoor air. Increasingly, other quantities are studied for various purposes, including outdoor radon, flux from the ground, radon in ground water and thoron. It can be assumed that the quantities are statistically related for physical reasons, since the common source is uranium and thorium in the ground, related to them by various pathways.

A relatively new dataset is ambient dose rate measured by the Citizen Science project Safecast. By early 2023, 200 million data have been collected worldwide, publicly available as data tables and as map. Surveying density is regionally very different. In Europe, most densely covered countries are the Czech Republic and the Netherlands. This immense dataset has hardly been used in environmental modelling, so far.

In this contribution, we study possible statistical associations between these datasets. In particular, we are interested in whether Safecast data may serve as predictors of indoor radon concentration or of the status of a geographical unit as radon priority area.

In open country, the terrestrial component of ambient dose rate depends mainly on the geochemical background, roughly classified by geology. In built environment, on the other hand, it is to different degree also controlled by construction materials of buildings and streets. One can therefore assume different dependency between radon (indoor and geogenic) and ambient dose rate, than in open country. This was investigated by repeating the correlation analysis between dose rate and indoor radon for different estimated degrees of urbanization of measurement location.

Anomalous radon emission as pre-signal of moderate to strong earthquakes in Vrancea geotectonic active region in Romania

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Due to the subcrustal earthquakes located at the sharp bend of the Southeast Carpathians, Vrancea area in Romania, placed at conjunction of four tectonic plates is considered one of the most seismically active areas in Europe with a high potential of seismic hazard for the neighboring countries. Rock micro fracturing in the Earth's crust preceding a seismic rupture may cause local surface deformation fields, rock dislocations, charged particle generation and motion, electrical conductivity changes, gas emission (radon, carbon dioxide, methane etc.), in environmental radioactivity, fluid diffusion, electrokinetic, piezomagnetic and piezoelectric effects as well as climate fluctuations. Space-time anomalies of radon gas emitted in soil and near the ground air, as well as underground water weeks to days in the epicentral areas can be associated with the strain stress changes that occurred before the occurrence of medium and strong earthquakes. This study aims to investigate temporal variations of radon concentration levels in air near or in the ground by the use of solid-state nuclear track detectors (SSNTD) CR-39 and LR-115 in relation with some important seismic events recorded in Vrancea region, Romania. The experimental observations reveal a strong correlation between the recorded radon emission peaks associated with some moderate and the major earthquakes in Vrancea region. Was analyzed the temporal pattern of radon in air near the ground in Vrancea zone, the higher ^{222}Rn concentrations have been related with seismic events of moment magnitude Mw ≥ 5.0 recorded during 2012-2022 period. The standard deviation of the radon measurements (s) was about 10% of the average radon concentration. For some of the recorded earthquakes that occurred during the observation period, was measured radon in air concentration increase with one month - two weeks before the quakes, followed by post-quake reduction of ^{222}Rn. The recorded radon anomalies pre-signals of earthquakes during eleven years monitoring period performed with solid state nuclear track detectors CR-39 (short term-10 days exposure time) suggest that earthquake precursors registered before moderate or strong seismic events are associated with some physical processes in or near the Vrancea earthquake fault zones or its neighbouring. This paper considered also the effects of meteorological parameters (air temperature, pressure, relative humidity, wind intensity and rainfall) on radon in air near the ground concentrations. The present results show existence of coupling between lithosphere-surfacesphere-atmosphere-ionosphere associated with preparation and seismic event occurring. Continuously monitoring of radon concentration anomalies in air near the ground in relation with Vrancea seismicity is an important issue and a surveillance tool in the field of earthquake hazard for Romania.

Soil gas radon measurement in urban area: A case study of Yerevan, Armenia

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Radon radioactive gas (^{222}Rn) produces in the soil as a result of the uranium (^{238}U) decay process in uranium-bearing bedrocks and overburden. Thereafter, moving up through the soil to the surface it can enter residential areas posing a source of risk to the population.

This first assessment of soil gas ^{222}Rn in Yerevan was carried out considering the geological structure of the area, where natural radionuclides containing igneous rocks dominate. Overall, in 34 randomly selected locations, where the geological structure has different types, soil gas radon in-situ measurements were implemented. RAD7 radon solid-state detector with in-ground radon detection accessories (DURRIDGE) was used for measurements. Soil gas radon was measured at a depth of up to 0.8 m with stainless steel soil gas probe and RAD7 Grab Protocol. DURRIDGE's CAPTURE software was used for data humidity automatic corrections. Obtained experimental data were analyzed and summarized using descriptive statistics and graphs (R Studio), and interpolation maps of soil gas radon activity concentration were developed (ArcMap software).

Soil gas ^{222}Rn activity concentration ranges from 483.4 (at 0.3 m depth) to 38375 Bq/m^3 (at 0.7 m depth), averaging at 5347.7 Bq/m^3. IDW interpolation maps revealed the spatial distribution of radon, dividing the city into two parts: low radon activity in the north (<10000 Bq/m^3) and high activity levels in the southern part (>10000 Bq/m^3). Soils with high radon activity are mainly located in two types of geological zones, with compositions rich in sandy, clay, and sandstone formations.

Citizen Science in radiation protection: A necessary approach to radon action plans

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Effective involvement of the public in Radiation Sciences is a goal not yet achieved in the field. The lack of a multidisciplinary approach and consideration to societal aspects of radiation protection of the public compromises large scale initiatives, which fail to reach their full potential. This is especially true for radon actions plans designed for national coverage. Projects to control public exposure to indoor radon in dwellings have regularly faced low response rates when targeting populations – despite running on high infrastructure and availability of resources (such as free distribution of detectors and simple procedures). Lack of public interest on the theme of natural radiation; the historically rooted negative perception of nuclear sciences; and mistrust in governmental actions are constraints to voluntary social involvement in efforts radon monitoring in high frequency environments. The paper presents the first Brazilian experience on seeking active participation of the public in a pilot project of indoor radon measurements in dwellings. Two census sectors of 200 homes were the target of this study conducted in the municipality of Poços de Caldas (260 km north to São Paulo). The city, located region known worldwide for its high levels of natural radioactivity and for being home to the country's first uranium mining facility, holds a history of poor local stakeholder engagement and a high level of disinformation and mistrust on local institutions from the sector (operator and regulator). The study aimed to involve the target population by attracting its interest to the issues of natural radioactivity and prompting the voluntary participation of individuals in a 3-month indoor monitoring campaign. The strategy was based on the: i) design of a communication campaign with its own visual identity; ii) creation of a logical sequence of educational content using friendly visuals and delivering messages inspired by the Extended Parallel Process Model (EPPM), which seeks to motivate engagement by balancing perceptions of threat (health concerns in case of ionizing radiation) and self-efficacy (the ability to respond to the concerns in active ways); iii) encouragement of community-like efforts in a way to stimulate voluntary group participation and local cooperation. The efforts resulted in a 20% response rate from the local population – similar to rates observed in well-established radon monitoring programmes around the world. Considering the pilot study was conducted: i) with low infrastructure (scarce resources for investment on social media engagement and production of materials, low availability of team members to engage consistently with the public); ii) in a region historically suspicious of such activities; and iii) without a tested protocol of communication – the results may point to the importance of applying citizen science approaches in public engagement, where society may be actively included in exposure control efforts.

Climate effects of aerosols and ^{222}Rn on COVID-19 pandemic in Bucharest metropolitan area

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In frame of predicted climate change due to the increasing trend of extreme events frequency, the ozone layer depletion and global warming in South-Eastern part of Europe, urban air pollution is an important issue in scientific research. Air pollution represents one of the most important drivers affecting the Earth's energy balance and hydrological cycle, climate and human health. This paper investigated the influences of urban aerosols and radon (^{222}Rn) together climate parameters variability at both local and regional scales in relationship with COVID-19 pandemic incidence and mortality in Bucharest metropolitan area of Romania, considered one of the European's most polluted hotspots cities. Is well known that outdoor air pollutants, especially particulate matter in different size fractions, serve as important carriers of viral infections and play a critical role in the transmission of SARS-CoV-2 virions. This study considered also contribution of natural radioactive gas radon- ^{222}Rn and its α- and β progeny in the lower atmosphere. Is well known that most of its long-lived progeny attach to aerosol particles (0.1-2.5 μm), which can be inhaled and deposited on lung, continuing to decay and produce high α-radiation exposure to the respiratory system, and associated lung inflammation or neuroinflammation. In synergy with SARS-COV-2 pathogens attached to aerosols without or with attached radon progeny as source of exposure to ionizing radiation, these may contribute to additional adverse effects to the human respiratory system, and may contribute to increased COVID-19 severity and lethality. A spatio-temporal analysis of the daily particulate matter in two size fractions PM10 and PM2.5 in relation with daily radon concentrations and meteorological parameters was done through synergy of in-situ monitoring data as well as MODIS Terra/Aqua time-series satellite data for 2020-2022 time period. In order to prevent COVID-19 pandemic spreading is very important to assess the environmental drivers related to the epidemiological behavior of the viral outbreaks. The rapid spread of the COVID-19 viral infections in large urban areas, characterized by high urbanization and dynamic land-change systems, people's mobility and economic development considers air pollution and climate variability among the determinants of SARS-CoV-2 pathogens transmission at the local and regional level and associated risk factors. Besides aerosols and radon this study analyzed the Total Aerosol Optical Depth at 550 nm (AOD), a marker of air pollution in conjunction with meteorological variables (air temperature, relative humidity, pressure, wind speed intensity and direction, surface solar irradiation, planetary boundary layer height and synoptical circulation conditions) and season of the year. For the investigation of the temporal pattern of AOD linked of SARS-CoV-2 virulence and propagation have been used C005 (version 5.1) Level 2 and Level 3 Terra MODIS AOD550 monthly time-series satellite data for period 01/01/2020- 31/12/2022. As one of the multi risk exposure factors in COVID-19 transmission in large urban areas like as Bucharest metropolitan area, outdoor short-term and long-term exposure to air pollutants and radon under specific climate conditions may play a significant role in spatiotemporal spreading of SARS-CoV-2 pathogens and COVID-19 disease severity. This study investigated the COVID-19 waves patterns under different air quality and meteorological conditions, highlighting the role of synoptic anticyclonic stagnant conditions during each COVID-19 wave for SARS-CoV-2 virus spreading. These results contribute to a better understanding of urban decision makers and epidemiologists through considering the specific characteristics of different urban sectors for air quality improvement.

Introducing a regional database of radioactivity in the air – GRAMON

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Ground Air Radioactivity Monitoring (GRAMON) database is a recently established collection containing activity concentrations of gamma emitters in aerosol samples. The measurements come from Serbia (sampling site Belgrade), Slovenia (sampling sites Ljubljana and Krško), Bosnia and Herzegovina (sampling site Sarajevo), Montenegro (sampling site Podgorica), and North Macedonia (sampling sites Skopje and Bitola), thus covering the northern and central parts of the Balkan Peninsula.

As a database arising from the monitoring programmes in several countries, GRAMON is not fully homogeneous in terms of the radionuclides and time periods studied. For example, the beryllium-7 records are available for all sampling sites, while the lead-210 records only in Serbia, Slovenia, and Bosnia and Herzegovina. The time series for Serbia and Slovenia began in 1991, for Montenegro and North Macedonia in 2008, and for Bosnia and Herzegovina in 2010.

However, sampling, sample preparation, and measurement procedures across the sites and laboratories are similar. In brief, aerosol samples are collected on filter papers using air samplers. Activity concentrations of radionuclides are determined by standard gamma spectrometry using high-purity germanium detectors. The time series contain monthly mean activity concentrations.

Since only some of the GRAMON records have been previously published, this database provides a source for radioactivity research in the region that has been underrepresented in large-scale studies. We further hope to expand the number of contributing laboratories and cover a wider region of Europe, especially its southern and eastern parts.

Revealing relationships between meteorological elements and airborne radioactive particles in ambient air of Kuwait

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Airborne natural and man-made radioactive particles (RAP) spread over long distances and in different directions. Both the physical and chemical properties of aerosols control this movement. This study aims to evaluate the particle size distribution of radionuclides and the effect of meteorological elements on their concentration in two residential areas that differ in the surrounding environment in Kuwait.

Air samples were collected using high-volume air samplers connected to a five-stage cascade impactor. The samples were collected from two residential areas in Kuwait: the Ahmadi area, which is near the refineries and petrochemical industries, and an open urban area called Al-Jahra, located northwest of Kuwait City. Low background gamma spectrometry and chemical separation methods were used to determine the radionuclide concentrations of ^{7}Be,^{40}K, ^{210}Pb, and ^{210}Po defined in three particle sizes (10.2, 2.4, and less than 0.73 μm). Meteorological elements were obtained from the Kuwait Meteorological Authority for the same two regions, coinciding with the times of airborne sampling.

Results showed that most of the radioactivity concentrated on the fine particle size fractions, except for ^{40}K, which reflects the effects of the local dust sources. The radioactivity concentration value of ^{210}Pb, ^{7}Be, and ^{40}K were closed for both cities with geometric mean values of 1.03, 6.80, and 2.34 mBq/m^{3}, respectively. While the activity concentration of ^{210}Po is lower in Al-Jahra, where the geometric mean is 0.634 mBq/m^{3} and is equal to 0.898 mBq/m^{3} in Ahmadi. Also, the ratio of ^{210}Po/^{210}Pb estimated is different between the two cities in Ahmadi is more significant than the calculated ratio based on the latitude and longitude of Kuwait City 0.712 and close to unity while in Al-Jahra is lower. This provided that ^{210}Po is likely enriched by anthropogenic sources in the Ahmadi area.

The study also showed that ^{7}Be, ^{210}Pb, and ^{210}Po related negatively with air humidity and positively with air temperature in both cities. However, the correlation coefficient of ^{210}Po and humidity showed significance (R2; 0.60) in the Al-Jahra area, while it showed insignificant (R2; 0.30) in Ahmadi. The concentration of ^{210}Pb is not affected by the wind direction in both cities, but ^{210}Po is affected by the wind direction in Al-Jahra more than Ahmadi area. In addition, the concentration of ^{7}Be is increased by wind direction NWN in both cities. In contrast, wind direction SSE affects the ^{40}K concentration in Al-Jahra, but there is no significant effect of the wind direction on the ^{40}K concentration in the Al-Ahmadi area.

Concentration levels of gross αlpha and βeta and annual effective dose in drinking waters of Albania

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According to Albanian legislation, the gross alpha/beta radioactivity concentration, should be below the level of 0.5 Bq/L and 1 Bq/L respectively for human consumption.

For this reason, gross α and gross β activities of 16 different water samples from different companies that sell bottled water in Albania were determined. The instrumentation used to count the gross α and gross β activities was an α/β counter of the Ultra Low Level α/β Counter, MPC 9604, Protean Instrument Corporation, multiple detector type with 4 sample.

The activity concentrations vary in the interval 11 mBq/l to 71 mBq/l for gross α and 90 mBq/l to 750 mBq/l for gross β in tap water. The obtained results showed that, natural activity concentrations of α and β emitting radionuclides in drinking water samples did not exceed WHO recommendations. For all samples the gross β activity is always higher than the gross α activity. The results obtained in this study indicate that the annual effective doses are below the WHO recommended reference level of 0.1 mSv/y for all water samples.

Keywords: water samples, gross alpha-beta radioactivity, gas proportional counters

Assessment of lignite-fired power plants impact on radon activity concentrations

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Coal generally contains trace amount of radionuclides with a typical range of activity concentrations of 30–100 Bq kg^{-1}, 10–600 Bq kg^{-1} and 10–200 Bq kg^{-1} respectively, for 40K, 238U and 232Th.

Moreover, when coal is burned in coal-fired power plants, the remains, such as coal slag and fly ash, become more enriched in naturally occurring radionuclides than the unburned coal.

From some studies in Kosovo's coal-fired power plants activity of radionuclides in coal, ash and slag were found to be lower compared with several available studies.

However, some types of coal contain considerably higher amounts of 226Ra, which for lignite is not necessary in equilibrium, radon activity investigation is important.

Radon has been surveyed in 51 dwellings in the vicinity of an open-cast lignite mine and two lignite-fired power plants in the Pristina region, Kosovo. CR-39 solid-state nuclear track detectors were exposed for more than three months. Radon activity concentration ranged from 41 Bq m^{-3} to 327 Bq m^{-3}, and the resulted annual effective doses was, from 0.74 mSv y^{-1} to 5.83 mSv y^{-1}.

The impact of lignite-fired power plants on indoor radon concentration has not been observed.

^{210}Pb and trace elements concentrations in Helsinki urban air, Finland

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This study examines the atmospheric concentrations of radioactive isotopes and trace elements in ~600 air filter samples collected from the Helsinki metropolitan area from 1962 to 2005. Finland is characterized by a continental and cold climate, with the city of Helsinki and its surrounding area situated on a coastal region by the Baltic Sea. The concentrations of trace elements Pb, Si, Zn, as well as the radioactive isotope ^{210}Pb, were studied to evaluate the influence of different pollutants with anthropogenic origin on the atmosphere and environment. The extent to which information concerning the specific activity of lead (^{210}Pb/Pb) can help in understanding the sources, dispersion and accumulation of lead in the environment was also examined

An aerosols' sampling system was operated on the roof of the Finnish Meteorological Institute (FMI) main building and air filters were analyzed by a high-resolution energy dispersive X-Ray fluorescence spectrometer at the Institute of Nuclear and Radiological Sciences and Technology, Energy and Safety, N.C.S.R. Demokritos.

All these elements present a declining trend over the years. On a percentage basis, trace elements and ^{210}Pb concentrations have been greatly decreased (Si: 87%, Zn: 61%, Pb: 95% and ^{210}Pb: 51%). Trace elements show lower concentrations after 1980, a year which coincides with the application of the first regulations for controlling and reducing air pollution.

The principal natural sources of trace elements are wind-borne soil particles, volcanoes, biogenic sources wild forest fires and sea salt spray from long-range transport of air pollutants to Finland. Si, Zn and Pb are tightly connected with the soil-derived dust and their distribution is favored by the dry conditions during the warm season. Their origin can be due to both natural and anthropogenic sources of pollution.

Pb was studied simultaneously with the ^{210}Pb concentrations to identify the effects of anthropogenic activities. Most of the stable lead in the human environment is of technological origin, with Pb extracted from mines having very low ^{210}Pb content. Pb concentrations have decreased since 1970s and are strongly correlated with lead smelters north of Helsinki, on-site incinerators, lead gasoline and fuel combustion. The ratio ^{210}Pb/Pb, which shows the amount of radioactive isotope in elemental lead, has been steeply increasing since 1980.

Seasonal differences can cause significant changes in elemental concentrations, with the highest values occurring in cold season. ^{210}Pb concentrations showed greater fluctuations over the years, with the maximum values also appearing in the cold season. In winter, the lower troposphere becomes stratified, allowing emitted air pollutants to stay close to the ground and not be diluted upwards.

Vertical distribution of radionuclides in a marine sediment core from the deep basin Northern of Skyros Isl., Aegean Sea

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In this work, the level of natural and artificial radioactivity in a marine sediment core obtained from the Northern basin of Skyros (Sporades region - Aegean Sea, Greece) was measured through gamma-ray spectrometry using a high-purity germanium detector. More specifically, the massive activity concentration was determined for the radionuclides of ^{226}Ra, ^{214}Pb, ^{214}Bi and ^{210}Pb belonging to the ^{238}U series, ^{208}Tl and ^{228}Ac of the ^{232}Th series, the natural potassium radioisotope ^{40}K and the anthropogenic caesium radionuclide ^{137}Cs and their vertical distribution in the sediment core was obtained. Also, based on the radio dating method of ^{210}Pb, the sediment accumulation rate was estimated at (0.17 ± 0.02) cm y^{-1} which in the specific core is equivalent to sediment deposition of 1cm per (6 ± 1) years. Thus, a temporal reconstruction of the radionuclide deposition was realised and a significant increase of both ^{238}U (200% increase) and ^{232}Th (almost 100 % increase) was revealed in the period 1950-1960. The causes for the increment are still under investigation, however, in that period, several severe seismic events occurred in the Sporades region potentially resulting in sediment gravity flows which increase the sedimentation rate. The results highlight the use of radiotracers in the investigation of deep-sea geophysical phenomena.

Towards the implementation of a phantom for the low contrast evaluation of Electronic Portal Imaging Detectors (EPID): A theoretical study

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Introduction. Electronic Portal Imaging Systems (EPIDs) are used in Radiotherapy treatment as part of the patient positioning verification check and for portal dosimetry purposes. The quality control of the imaging performance of an EPIS is performed with dedicated phantoms. In this work, an examination through Monte Carlo (MC) simulation is presented in order to determine an appropriate step wedge phantom configuration for measuring low contrast differences in EPIDs.

Materials and Methods. The PENELOPE based MC software package PenEasy (*Med. Phys.* 38, 5887-5895, 2011) was used. A simple geometry of a narrow cone beam with a cross section of 0.00053 cm2 at 100 cm distance was assumed. The beam was considered to impinge on a 4 cm water equivalent phantom in conjunction with a metal sheet of Pb, Al, Fe or W positioned at 80 cm distance. At 100 cm distance a Gd2O2S:Tb scintillator, as part of an EPID responsible for detecting X-rays was assumed. The Gd2O2S:Tb thicknesses considered were 0.02cm and 0.03 cm. The photon energy was considered to be 2 MeV, a value corresponding to the average energy of a 6 MV LINAC. All the metal thicknesses were allowed to range from 0.1 cm to 1.5 cm per 0.1 cm step. For each case the energy deposition in Gd2O2S:Tb was determined. The optical photons escaping to the Gd2O2S:Tb output were calculated by an analytical formula. The signal calculated this way corresponded to a specific metallic sheet thickness. Hence, if a wedge metallic pattern from 0.1 cm to 1.5 cm is assumed to be constructed, then the optical photon output originating from each step would be known. Subsequently, the contrast per one step, two steps and three steps were calculated. In order to account for the effect of the electronic part of the portal imaging detector and the software algorithms, the image of a commercially available phantom was experimentally obtained in an iViewGT™ R3.4.1 MV Portal Imaging system incorporated in the Infinity™ Linac (Elekta AB, Stockholm, Sweden) for 2MU and 400 DR irradiation conditions. The pixel value was compared to the corresponding optical photon values, determined for irradiation condition delivering 1cGy maximum depth dose at a water phantom at 100 cm distance.

Results. The statistical uncertainties of the simulations were below 1%. It was found that the use of Pb and W materials demonstrate an average contrast of 3% and 5% per step respectively. The use of Fe allows the calculation of a 2-step contrast as low as 1.5% Finally, it was determined that the pixel value per optical photon can be expressed by a descending power equation.

Conclusion. An initial theoretical study was performed to determine possible materials for fashioning a step wedge phantom for EPID quality control procedures. It was found that Pb, W and Fe could be utilized and create contrast as low as 1.5%.

Radiobiologic evaluation of anatomical changes during weight loss in head and neck cancer

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Anatomical change in head and neck cancer is widespread case which can occur due to weight loss, tumor shrinkage, inflammation. Nonetheless, many radiotherapy centers do not make a cone beam computed tomography (CBCT), relying to the mask fixation, and keep carrying out the treatment from initial to its completion without revision of the original plan.

The aim of this study was to investigate radiobiologic impact of weight loss during treatment of the head and neck cancer.

The study was accompanied with data of 13 patients with locally advanced head and neck cancer. As a treatment technique was taken VMAT, 25 fraction to lymph nodes plus tumor and 10 fractions to the local tumor, 2 Gy per fraction. After 3-4 weeks from commence of treatment there was new CT with anatomical changes and current treatment plans were replanned according to new anatomic data as an adaptive treatment.

Radiobiologic evaluation was carried out using the Niemierko's tumor control probability (TCP) and normal tissue complication probability (NTCP) models based on equivalent uniform dose.

Tumor control dose 50 % (TCD_{50}) was taken value of 70.26 Gy and normalized slope parameter (γ_{50}) was equal to 10.7 Gy for tumors and 2.2 for parotid glands.

The results reveal that shrinking of the head and neck region during weight loss can have a significant effect on a treatment. Despite that head and neck region is known as low TCP region, anatomical shrinkage can more decrease that value so treatment can turn into ineffective treatment. The mean TCP of the original plans was estimated to be 80.5%. After 3-4 weeks during CBCT were notable weight loss and due to these anatomical changes were seen. Study showed that TCP after 3-4 weeks could be decreased till 27.3 % (27.3 % – 58.6 %, min – max in different plans), which can lead to the ineffective treatment.

Moreover, weight loss can highly increase NTCP, more than twice in average, the highest range was from 12.3% to 87.6%. Such a high spread of values in NTCP can be explained by significant shrinkage of muscles from cheeks' sides of head and neck region.

The study showed that weight loss is serious problem in radiotherapy during treatment of head and neck cancer. Shrinkage of head and neck region during weight loss can significantly decrease TCP and at the same time significant increase NTCP, what could lead the low efficiency treatment.

The implementation of a 3D verification system to analyze the effect of limiting the dynamic parameters of a multileaf collimator on the dose distribution

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Introduction. The goal of radiation therapy is to deliver the required dose to the target volume and limit the dose to normal tissues as much as possible. Consequently, one of the important parameters in radiation therapy with a linear accelerator is the accuracy of irradiation, in particular the precise formation of the field or field segment by a multi-lead collimator ("MLC") during a radiotherapy session. As the total operating time of the linear accelerator increases, the elements responsible for accurate field shaping may wear out.

Purpose. To evaluate the effect of changes in the maximum limiting values of movement of the field-forming elements of the multileaf collimator on the verification result using the system of three-dimensional verification of plans of dosimetric distribution of absorbed dose.

Materials and methods. The Elekta Synergy accelerator (Elekta AB, Sweden) has an MLK Agility for the formation of irregularly shaped fields. Structurally, this collimator consists of dynamic leaf guides (DLG), leaf pairs and transverse diaphragms. In the study in TPS MONACO v5.51 (Elekta AB, Sweden) in the properties of the beam model the dynamic parameters of maximal speed of leaves ("L"), guide of leaves ("PJaw") and diaphragms ("TJaw") in the range from 10 to 30 mm/s with step of 10 mm were changed. Four case types were selected for this study: TG-244 - "Prostate_Bed", TG-244 - "Abdomen", TG-244 - "Headandneck", and TG-244 - "Thorax". Radiation therapy plans were created using VMAT dose delivery techniques with one or two arcs. The dose constraint settings for the calculation algorithm remained the same for all plans within the same localization. A total of 6 plans were created for each of the localizations with different variation in dynamic characteristics. Plan verification was performed using the ArcCHECK cylindrical phantom with 3DVH software (both Sun Nuclear corp, USA). The analysis was performed by the gamma-index method with γ(3%,2mm, global normalization) criteria. Verification of the created plans was performed with simulated course of radiotherapy, i.e. daily for 20 days.

Results. The application of a three-dimensional verification system showed that decreasing the maximum leaf speed does not increase the convergence of the dose-response plans. Reducing the maximum velocity of the diaphragms and guide blades block to 20 mm/sec leads to an increase in the convergence of the gamma index criteria.

Conclusion. Reducing the maximum displacement speed of the "PJaw" and "TJaw" parameters of the multileaf collimator can improve the accuracy of the therapeutic plans on the linear accelerator and, if the drive systems are worn, reduce their effect on treatment quality.

Comparison of various types of ionization chambers in terms of calibration coefficients

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The use of calibrated radiotherapy electrometers with ionization chambers, traceably to primary standards directly or through secondary standards, is necessary and required by law for the accurate evaluation of patient radiation dose delivery in radiotherapy. In Poland, these measuring instruments are calibrated at the Secondary Standards Dosimetry Laboratory which is now the integral part of the Maria Sklodowska-Curie National Research Institute of Oncology in Warsaw.

The aim of this study was comparison of various pieces of the most frequently used ionization chambers in Poland in terms of calibration coefficients. The most commonly used chambers are: PTW 30013, PTW 23343, PTW 34001, PTW 30001, Scanditronix-Wellhofer FC65-G and Scanditronix-Wellhofer PPC05.

In this study, we compared at least 13 calibration coefficients values for ionization chambers with different serial numbers for each of the six types of ionization chambers mentioned earlier. The calibration coefficients were measured at the Polish SSDL over a period of four consecutive years to minimize the aging effects of the ionization chambers. Some of the ionization chambers were calibrated with more than one electrometer during the analyzed period. The calibration coefficients based on standards of absorbed dose to water $N_{D,w}$ were established in ^{60}Co beam by comparing the readings of the calibrated dosimeter with the readings of the reference dosimeter in reference conditions defined in the Technical Reports Series No. 398 (IAEA, 2000).

The arithmetic mean value, median value and standard deviation value, expressed as a percentage of the arithmetic mean value of calibration coefficients for each chamber type and the ratio of the largest and the smallest calibration coefficients in each group of chambers will be presented in this study. Moreover, the results will be analyzed using an appropriate statistical test at a predetermined significance level. The choice of the statistical test will be justified providing evidence that the assumptions regarding the choice of the given statistical test are met.

The obtained results indicate that the maximum differences in the calibration coefficients of the analyzed cylindrical ionization chambers do not exceed 4%. For the analyzed plane parallel ionization chambers, the calibration factors may differ by more than 10%. Therefore, it should be remembered that the use of an ionization chamber in clinical work must always be preceded by its calibration in a competent calibration laboratory. This will enable measurements of the dose delivered to the patient in teleradiotherapy with the expected accuracy.

The effect of body mass index on patient radiation dose during lumbar discectomy and fusion utilising VirtualDose-IR software

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In this study, Monte Carlo software was utilised to study the effect of body mass index (BMI) on the organs' dose (OD), peak-skin dose (PSD) and effective dose (ED) received by patients undergoing lumbar discectomy and fusion (LDF) operations. Patient-related (age, sex, weight, height, and BMI) and procedure-related data (x-ray projection, field-of-view, tube voltage, additional copper filtration, source-to-detector distance, and source-to-skin distance) were obtained from 102 LDF operations conducted at the University Hospital of Patras. Fluoroscopy time (FT), kerma-area product (KAP) and cumulative air-kerma (K_{air}) (at interventional reference point) were also recorded from the dosimetric report of the fluoroscopy system (Philips BV Endura). Additionally, the incident K_{air} was calculated. The intra-operative data were inserted into the VirtualDose-IR software to calculate OD, PSD and ED utilising sex-specific and BMI-adjustable anthropomorphic phantoms. For normal-weight patients, the mean FT, KAP, cumulative K_{air}, incident K_{air}, PSD, and ED were 13.4 s, 0.71 Gycm^2, 3.22 mGy, 9.25 mGy, 62.00 mGy, and 0.27 mSv, respectively. For overweight patients, the mean FT, KAP, cumulative K_{air}, incident K_{air}, PSD, and ED were 21.2 s, 0.90 Gycm^2, 4.08 mGy, 14.98 mGy, 116.00 mGy, and 0.30 mSv, respectively. For obese patients, the mean FT, KAP, cumulative K_{air}, incident K_{air}, PSD, and ED were 52.6 s, 2.80 Gycm^2, 13.90 mGy, 60.86 mGy, 475.00 mGy, and 1.18 mSv, respectively. A 58% and 293% increase was found in FT, 27% and 294% in KAP, 27% and 332% in cumulative K_{air}, 62% and 558% in incident K_{air}, 87% and 666% in PSD and 11% and 337% in ED of overweight and obese compared to normal-weight patients, respectively. The threshold for transient erythema is exceeded for one overweight patient (PSD 2383 mGy) and two obese patients (PSD 2828 mGy, 2669 mGy) without skin erythema observed in the subsequent follow-ups. The PSD values significantly differ among the three BMI groups (Kruskal-Wallis test, p=0.026), while incident K_{air} between normal-weight and obese patients (Mann-Whitney test, p=0.015). In all BMI groups, the spleen (normal-weight 2.34 mGy, overweight 1.68 mGy, and obese 17.10 mGy), kidneys (normal-weight 0.90 mGy, overweight 1.00 mGy, and obese 7.34 mGy) and colon (normal-weight 1.00 mGy, overweight 0.90 mGy, and obese 3.83 mGy) received the highest doses. However, the doses received by the kidneys (Mann-Whitney test, p=0.043), pancreas (Mann-Whitney test, p=0.026), and spleen (Mann-Whitney test, p=0.009) increased significantly only in obese compared to overweight patients, whilst the urinary bladder doses showed a significant increase in overweight compared to normal-weight patients (Mann-Whitney test, p=0.044). The mean ODs were lower in comparison to previously published studies. The reported dosimetric data could contribute to optimising LDF procedures and establishing a radiation protection culture at the Neurosurgery operating theatre.

Relationship between patient radiation dose and procedural factors in anterior cervical discectomy and fusion utilising VirtualDose-IR software

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In this study, Monte Carlo software was utilised to study the effect of procedure's type (single-level, multi-level) and cervical levels (C3/C4, C4/C5, C5/C6, C6/C7) on the organs' dose (OD), peak-skin dose (PSD) and effective dose (ED) received by patients undergoing anterior cervical discectomy and fusion (ACDF) procedures. Patient-related (age, sex, weight, height, and body mass index) and procedure-related data (x-ray projection, field-of-view, tube voltage, copper filtration, source-to-detector distance, and source-to-skin distance) were obtained from 50 ACDF procedures conducted at the University Hospital of Patras. Fluoroscopy time (FT), kerma-area product (KAP) and cumulative air-kerma (K_{air}) were also recorded from the dosimetric report of the C-arm system. Additionally, the incident K_{air} was calculated. The intra-operative data were inserted into the VirtualDose-IR software to calculate OD, PSD and ED. For single-level procedures, the mean FT, KAP, cumulative K_{air}, incident K_{air}, PSD and ED were 6.5 s, 0.14 Gycm^2, 0.62 mGy, 0.95 mGy, 2.30 mGy, and 0.016 mSv, respectively. For multi-level procedures, the mean FT, KAP, cumulative K_{air}, incident K_{air}, PSD and ED were 7.1 s, 0.18 Gycm^2, 0.81 mGy, 1.24 mGy, 5.29 mGy, and 0.037 mSv, respectively. The mean FT values were 4.5, 5.1, 6.9, and 12.5 s, the mean KAP 0.05, 0.05, 0.22, and 0.33 Gycm^2, the mean cumulative K_{air} 0.24, 0.22, 0.96, and 1.47 mGy, the mean incident K_{air} 0.38, 0.33, 1.48, and 2.26 mGy, the mean PSD 0.91, 0.92, 3.52, and 5.21 mGy, and the mean ED 0.005, 0.005, 0.028, and 0.038 mSv for C3/C4, C4/C5, C5/C6, and C6/C7 procedures, respectively. An increase of 9% was found in FT, 29% in KAP, 31% in cumulative K_{air}, 31% in incident K_{air}, 130% in PSD and 131% in ED of multi-level compared to single-level procedures. The PSD values are significantly different among the cervical levels. The ED values significantly differed regarding the procedure type and cervical levels. The procedures in C5/C6 resulted in significantly higher KAP, incident K_{air}, and ED than C4/C5 levels, while those performed in C6/C7 resulted in significantly higher ED and PSD than in C4/C5 levels. The thyroid (0.290 mGy), oesophagus (0.140 mGy) and salivary glands (0.120 mGy) received the highest mean doses. The salivary glands absorbed significantly higher doses in males (0.170 mGy) than females (0.014 mGy), while the extrathoracic region's dose significantly increased for multi-level (0.036 mGy) than single-level (0.016 mGy) procedures. The procedures in C6/C7 resulted in significantly higher oesophagus (0.210 mGy) and thyroid (0.450 mGy) doses than C3/C4 (thyroid 0.088 mGy, oesophagus 0.042 mGy) and C4/C5 (thyroid 0.081 mGy, oesophagus 0.037 mGy) levels, as well as procedures in C5/C6 (thyroid 0.360 mGy, oesophagus 0.170 mGy) compared to C4/C5 levels. These dosimetric data could be used in optimising patient radiation protection during ACDF procedures by keeping the ODs and ED as low as reasonably practicable.

Local diagnostic reference level for computed tomography of chest and abdomen in two Saudi cities

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Background and Aim. Spiral computed tomography (CT) scans, which are regarded as a high-contrast resolution, quick, and cross-sectional imaging technique, have become increasingly popular as a result of technological advancements. The main aim of the current study was to assess CT radiation dose and propose local diagnostic references level LDRL for the adult trunk [chest and abdomen) using CT dose parameters such as CT dose index volume $CTDI_{vol}$ and dose length product DLP as well as to compare practice for a fore mentioned examinations between hospitals and consequently literature published.

Methods and Materials. 428 patients were examined in King Abdul Aziz Specialist hospital (KAASH) in Taif city and Aseer Central Hospital (ACH) in Abha city in Saudi Arabia (216 for abdomen and 212 for chest) from December 2022 yo Narch 2023. The parameter of exposure and slice thickness were recorded in special designed data sheet as well as gender, age and patients morphometric. The LDRL was achieved from third quartile of CTDIvol and DLP for each hospital and examination, Microsoft Excel version 2010 was used to analyze results and plot the figures.

Results. The average DLP (mGy) and CTDIvol (mGy.cm) for chest and abdomen were 243mGy.cm, 5.8mGy and 549mGy.cm, 9.6mGy respectively. The proposed LDRL for chest and abdomen were 354mGy.cm, 7.3mGy and 615 mGy.cm, 9.2mGy respectively.

Conclusion. KAASH in Taif irradiated patients with a higher dose for the abdomen than ACH in Abha, but both hospitals agreed on the amount of radiation received by patients for chest imaging. The proposed LDRL for two examinations is less than the DRL obtained from the literature.

Evaluation of the effectiveness of Monte Carlo simulations to describe the excitation features of a Macro-XRF imaging spectrometer

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Macroscopic X-Ray Fluorescence (MA-XRF) systems constitute an invaluable non-invasive analysis tool of the materials elemental composition and their development is progressively increasing. A novel portable MA-XRF imaging system was recently developed at the X-Ray Laboratory of NCSR "Demokritos" in Athens (Greece). The system consists of 12 W (60kV, 200μA) transmission tube with a Rh anode and a silicon drift detector (SSD) of a 95 mm² active area. The spectrometer operates with variable beam focusing within the range from 0.1 mm to 4 mm achieved by means of either different apertures or a polycapillary X-ray lens. For quantitative XRF analysis, thorough evaluation of the system components is crucial. To this end, the tube excitation spectra for different applied voltage were reproduced using the code PenRed (*Comput. Phys. Commun.* 267, 108065, 2021) which is based on the general-purpose Monte Carlo PENELOPE. The spectral response was deduced by introducing in the simulation the thin anode thickness and material along the beam path towards the sample position. The PenRed results were compared with the semi-empirical model proposed by Ebel (*X-Ray Spectrom.* 28, 1999).

The use of a polycapillary X-ray lens to focus the exciting X-ray beam at the micrometer scale (<0.1 mm), acts as an intermediate energy pass filter, thus significantly modifying the energy distribution of the tube generated spectrum. The characteristics of the polycapillary lens were evaluated using the Monte Carlo based polycapillary X-ray ray tracing code polycap1.1 (*Spectrochim. Acta B* 173, 105974, 2020). The polycap code requires a detailed description of the lens geometrical and physical characteristics allowing user defined polycapillary shapes and beam profiles and provides the estimation of the lens transmission efficiency taking into account capillary wall transmission (internal, external leakage), wall surface roughness and beam polarization effects. The lens transmission efficiency, gain and the beam size on focus and in various optic-to-sample distances were evaluated and compared with available corresponding experimental results.

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3 MV Tandetron beamline upgrade for ultra-high dose rate irradiation

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The clinical usage of FLASH radiotherapy (FLASH-RT) consists in the irradiation of tumour at ultra-high dose rate (>40 Gy/s), after which it was observed an improvement of the healthy tissue response to radiation [*Nature*, 183 (4673), 1959, *Radiother. Oncol.*, 139:18-22, 2019, *Oncol.*; 11: 644400, 2021]. Despite the great potential envisaged by FLASH-RT a clear understanding of the biological phenomena is still out of reach due to the limited number of facilities compatible to work in the ultra-high dose rate regime.

We present in this study an upgrade, consisting of a new beamline attached to a 3 MV Tandetron™ from IFIN-HH, Romania [*NIM B*, 359:12-19, 2015, *NIM B*, 528: 45-53, 2022]. An electrostatic deflector working in the milliseconds range is pulsing the ions up to a dose rate of 250 Gy/s. A home-made setup dedicated to radiobiology studies is detailed and the dosimetric characterization of a 2 MeV proton beam is also presented within this work. Fluka simulations validated the data acquired with a Markus ionisation chamber and the lateral beam profile recorded with radiochromic film and plastic track detectors.

Mouse melanoma cells line (B-16) was used for preliminary studies. Dose effects were evaluated based on reactive oxygen species (ROS) levels as well as the induction of DNA damage. Further studies will compare the effects induced in similar conditions to normal cells.

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Comparative analysis of medical exposure to ionizing radiation – the 2021 National Report and the 2020/2021 UNSCEAR Report

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Medical exposure is the most important anthropogenic source in terms of population exposure. This was highlighted in the UNSCEAR Report published in 2008, and is even more emphasized within the 2020/2021 UNSCEAR Report, the most recent in this field.

Some of the main objectives established both at the national and international level is to improve the radiation doses from medical exposures of patients, by optimizing exposure protocols and also to decrease the ionizing radiation examination frequency, by using the non-irradiant examination procedures.

The evaluation of medical exposure to ionizing radiation consists in estimating the annual frequencies of the main examinations/procedures types, including the distribution by age and gender groups, and of the typical radiation doses received by patients, for each type of examination/procedure, as well as estimating the annual collective doses and effective doses per inhabitant. The results obtained within the annual national report based on the medical exposure data recorded in 2021 for diagnostic radiology and nuclear medicine examinations in Romania, are analyzed in comparison with the results obtained at the international level from the 2020/2021 UNSCEAR Report on medical exposure.

According to the 2020/2021 UNSCEAR Report, the effective dose per inhabitant, at international level, is 0.57 mSv, without taking into consideration the therapeutic procedures. This value is lower than 0.65 mSv mentioned in the 2008 report, as a result of the inclusion in this new report of many developing countries, where the population access to medical imaging procedures is limited. In the case of developed countries, the effective dose per inhabitant is 1.71 mSv. For Romania, the effective dose per inhabitant estimated for the year 2021 is 0.75 mSv, above the average international value, but much lower than in the case of developed countries.

The typical doses per examination, at national level, are comparable and generally lower than the international average values, but unlike the situation considered characteristic at international level, the frequency of CT examination is higher in Romania, similar to developed western countries. As a result, at national level, the contribution to the effective dose per inhabitant of computed tomography is overwhelming (88%). For this reason, it is very important to pay special attention to the justification of exposure for each individual patient, especially in case of CT procedures, and to prescribe non-irradiating imaging procedures or conventional radiology instead of computed tomography in all situations in which they are a viable choice. At the same time, the implementation at national level of an IT individual registration system, based on personal identification number, for all examination/diagnostic procedures performed and for the radiation doses received by patients, would be useful to avoid recurrent exposures.

Characteristics of the inexpensive 2D plastic scintillator detectors for radiotherapy departments

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There is no perfect detector and most of them have one thing in common – they are not inexpensive. One of the exceptions are plastic scintillation detectors (PSD). Our goal is to build a low-cost dosimetry set that can compete with conventional ionization chambers. For this study, a low-cost detector setup was built using a plastic scintillator sheet and a standard DSLR camera.

A radiation dosimeter must have a number of characteristics, starting with at least one physical property as a function of the diametric quantity measured. The following parameters were investigated: repeatability, linearity, dose rate dependence and energy dependence.

Tests were carried out on the general purpose PSD Saint Gobain BC-400 PSD. The PSDs used in this study were formed into 10 cm square plates with the thicknesses of 1 mm. They were irradiated using the Elekta Versa HD system with 6, 10 and 15 MV flat photon beams and 6 and 10 MV flattening filter-free beams. The readout system was a Pentax K-x 12.4 megapixel DSLR camera equipped with the 55-300 mm 1:4-5.8 tele lens.

Initial measurements focused on applicability such as background measurements as a function of beam parameters such as dose, energy, field size and exposure time.

A series of preliminary tests were carried out on the constructed set to define the optimum measurement conditions, and then the main dosimetric tests were performed. Preliminary tests allowed the selection of optimal parameters such as a system geometry, ISO, a focal length and a diaphragm. A series of background measurements proved that electronic and radiation noise could be effectively reduced to about one percent of the measured signal. In addition, the stability of the system was assessed by repeated measurements of the beam with the same parameters.

Finally, a comparison was made between the treatment planning system data and the measured results for each photon energy. The most important feature of the dosimeter is the dose-response relationship. Plastic scintillation detectors, even in such a simple and inexpensive system, meet this requirement and show high stability of readings.

Applications of 2D plastic scintillator detectors in radiotherapy departments

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Plastic scintillation detectors (PSD) have been used in beam quality tests in the Radiotherapy Department of the Katowice Cancer Centre. The commonly used standard for 2D small beam measurements is the Gafchromic film, which is a passive detector with an inconvenient readout. The aim of this study was to investigate whether a low-cost PSD-based system could be used as a 2D detector for small field measurements.

Beam measurements were carried out on a general purpose Saint Gobain BC-400 PSD. The PSDs used in this study were formed into 10 cm square sheets of 1 mm thickness. In front of the PSD was 2 cm PMMA build-up. An acrylic mirror was placed under the PSD to reflect the scintillating light towards the camera. Small beams from 0.5x0.5 to 70x70 mm were measured to assess the response of the system. Comparisons were made between a filed size measured with PSD and the Gafchromic EBT3 dosimetry films.

Beam profiles were measured at a half of the maximum height. The resulting pixel size was estimated to be 0.053 mm, which corresponded to approximately 19 pixels per millimeter. The standard deviation of the pixel size is approximately 0.001 mm. This translates to the uncertainty of 1 mm in the measurement of the field size for fields up to 7 cm. The average difference between the film and the scintillator was 0.27 mm. The relative average difference was 0.91%. Relative differences increased for smaller fields.

The system setup and materials used allowed a maximal theoretical resolution of about 0.1 mm. Preliminary results show that the system is capable of achieving a spatial resolution of 0.27 mm difference on average compared to the Gafchromic film. We attributed the reduction in the resolution to the uncertainty in the geometric alignment of the system. The thickness of the scintillator in which the light is generated and scattered is also related to the blurring of the edges of the observed light field. Further work will focus on building a system that gives reproducible results and minimizes the geometrical influence.

Processing heterogeneity problem in the case of two-dimensional radiotherapy

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Conventional (2D) radiotherapy with linear accelerator technique is a traditional radiotherapy technique. Treatments are planned by defining the X-ray perpendicular to the patient. It has been largely replaced by highly compatible external radiotherapy, which uses CT images to plan treatment. In conventional treatment, beam formation is limited, and simple square or rectangular beams are usually used. The amount of radiation delivered to the target tumor is generally inaccurate, resulting in less effective treatment.

By the way, two-dimensional radiation therapy still plays a role in palliative and analgesic treatments that use large margins and where the simplicity of the planning process allows for treatment on the same day. In this type of treatment, the media within the radiation field is considered homogeneous, and this is not the case, as all parts of the human body contain a high degree of heterogeneity, and this adds an error to the dose to be delivered to the area to be treated.

The present work aims to determine the percentage of error resulting from heterogeneity existence for energies 6 and 15 million volts in the cases of two-dimensional radiotherapy. Then, reach the appropriate recommendations to improve the using conventional treatment by linear accelerator technique. Standard solid phantom and ionization chambers with different materials are used to obtain the percentage of error resulting from heterogeneity existence. Results show that the type and origin of materiel have effects on the received dose in used standard phantom.

Development of a dynamic liver phantom for radiotherapy applications

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Purpose. Tumor movement reduces the dose coverage of the target and may cause irradiation of normal tissues surrounding the target, which may reduce the effectiveness of radiation therapy. In the treatment of tumors in the thorax and abdomen, the patient's breathing causes significant anatomical changes during irradiation. Accurate dose distributions can be determined on phantoms that can simulate respiratory motion and the associated organ shape changes.

This study aims to develop and produce a liver phantom that can simulate breathing with 3D printing technology and molded silicone material, taking into account these uncertainties in radiotherapy treatments and developing technology.

Materials and Methods. Our dynamic phantom to be produced consists of 2 main components. The 1st part is the liver made of silicone material. The 2nd part is the platform that can simulate breathing.

Liver Phantom Materials and Modeling. Production stages of liver fantom created with RTV2 silicone material:

Step 1. The patient image from the CT scan was used.

Step 2. Digital Imaging and Communication in Medicine (DICOM) files were imported into Mimics 21 software (Materialise, Leuven, Belgium). The liver organ was modeled in the abdominal region.

Step 3. The three-dimensional (3D) model was exported in stereolithography (STL) format and data was loaded into the 3D printer. PLA was chosen as the filament material and the liver mold printing was completed in two parts.

In Step 4, the prepared RTV2 silicone material was poured into the first mold and allowed to dry for about two days. Then the first part of the liver was removed from the mold with the help of mold release spray. The same mixture was prepared in the second mold and the part formed in the first mold was placed on top of the other and fused. Thus, a whole liver was formed.

Phantom mechanics. The silicone liver is placed between the dynamic and static plates. The dynamic plate moves in the superior-inferior direction and the gating platform moves in the anterior-posterior direction to simulate the respiratory cycle.

Reproducibility. To test the static reproducibility of the designed liver phantom, 3 fiducials each were placed into the silicone liver at the edge, middle, and apex regions. The phantom was operated and 5mm and 10 mm displacement were applied to the silicone liver with the dynamic plate. This process was repeated on three different days. The movement of the fiducials was then analyzed.

Results. A total of 9 fiducials were placed into the silicone liver at 3 different sites. The 3D coordinates of each fiducial were recorded in axial, coronal, and sagittal planes. These coordinates were used as reference points. When 5 mm displacement was applied, the difference between the reference points and the new coordinates was calculated. The differences were averaged and 4.42 mm, 4.84 mm, and 5.58 mm were calculated for the edge, middle, and apex regions of the liver, respectively. When the displacement was applied 10 mm, 7.59 mm, 8.33 mm, and 10.44 mm were found.

Conclusions. Static tests of the developed dynamic phantom resulted as expected. The phantom's respiratory motion tests and dosimetric measurements are in progress.

Evaluating VMAT delivery accuracy using end-to-end test for different types of VMAT plans

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Volumetric modulated arc therapy (VMAT) is the next logical step in the improvement of the dynamic intensity modulated radiotherapy by improving the delivery efficiency and reducing the treatment time.

In this study, we have evaluated the delivery accuracy of different types of VMAT plans by performing an end-to-end test using the CIRS IMRT Thorax 002LFC phantom. We have created 10 VMAT plans with one, two and three partial or full arcs and measured the dose in different points according to a modified IAEA CRP E24017 protocol.

For the measurement points representing the target volumes we have found that using two or three full arcs gives best results. Using only one arc or partial arcs gives suboptimal values in some of these points, although as the number of arcs increases, the accuracy of partial arc delivery improves.

For low-dose regions representing the heart and esophagus, field size has a more pronounced effect, with larger fields leading to slightly reduced accuracy. Inaccuracies are usually highest where the inhomogeneity of the body is greatest, such as the points representing the lungs and the spinal cord region, where the inaccuracy of the computational algorithm in inhomogeneous regions also has an impact.

In conclusion, the end-to-end test showed that the plans are clinically acceptable, but the recommendations for this particular machine would be not to use single arc treatments and to consider algorithm inaccuracies in regions of greater inhomogeneity during the treatment planning process.

Evaluation of dosimetric plan quality for glioblastoma treated with 3D conformal radiotherapy

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Glioblastoma is classified as grade- IV glioma of primary brain tumours, and is faced more often in adult patients. The standard approach to therapy in the newly diagnosed glioblastoma, includes surgery followed by concurrent radiotherapy with chemotherapy. The aim of this study is retrospectively to analyze dosimetric treatment plan quality for patients treated for glioblastoma in our clinic using 3D-conformal radiotherapy. Radiotherapy treatment plans are realized by combining 2 to 6 coplanar and non- coplanar fields, open or weged, achieving dose coverage, dose homogeneity to tumour within recommendations, while minimizing dose at organs at risk.

Keywords: 3D conformal radiotherapy, dose, treatment plan

Outcome prediction in radiotherapy

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Evaluation of the results of radiotherapy (RT) are extremely important for estimation the effectiveness of therapy, personalizing the approach, selecting new fractionation regimens, and assessing complications after treatment. This article analyzes the methods of predicting the results of treatment in order to classify them, evaluate the advantages and disadvantages.

RT is carried out in order to achieve a certain biological effect, when the maximum damage to the tumor is achieved while saving the function of normal tissues. In practice, to evaluate the effectiveness of treatment physician needs tools that predict a certain outcome from this type of treatment.

The fractionation regimes used in radiation therapy are largely the result of radiobiological experiments on animal sterilization, with achieving permanent sterilization without damaging normal tissues. Attempts to explain the effects of dividing the dose into fractions led to the creation of the Strandquist plot, then Ellis and colleagues introduced the concept of a nominal standard dose.

The linear-quadratic (LQ) approach is one of the key tools in radiobiology. It provides a simple relationship between cell survival and the delivered dose. Biologically Effective Dose, equivalent dose (EQD_2) are usually used to compare the effectiveness of different fractionation regimens or to assess the cumulative effect of different types of radiation therapy. At the same time, the LQ approach does not take into account the peculiarities of the target and organ coverage.

Various studies have demonstrated that even very small cold areas can significantly reduce tumor control, whereas hot areas affect control significantly only if the volume of the hot area is large. Various models of the probability of tumor control (TCP) and the probability of complications in normal tissues (NTCP) allow, based on the analysis of not only biological principles, but also statistical data, to evaluate the effectiveness of the treatment plan. TCP / NTCP allows to compare the effectiveness of different treatment plans, but do not take into account the influence of the reaction of biological tissues, the natural radiosensitivity of biological systems, the degree of oxygenation of the tumor, concomitant diseases and features of physiology.

Recently, research has been conducted on the use of machine learning in assessing patient survival and predicting toxicity. The outcomes of treatment after radiation therapy are determined by a complex interaction of clinical, biological and dosimetric factors. Such studies explore the possibilities of predicting outcomes based on large medical data for personalized medicine, understanding spatial variations in tumor radiosensitivity, assessing the toxicity and response of a tumor based on the spatial distribution of doses. Many of these studies face limitations on the number of patients, lack of external checks, complex requirements for data quality and, as a result, poor data.

$LaCl_3$:Ce crystalline scintillator thickness optimization for low radiographic X-ray tube voltages: A theoretical study

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Introduction. $LaCl_3$:Ce crystalline scintillator is a prominent material with a small decay time that has been considered for radioisotope imaging. Its density (3.86 g/cm^3) and light yield (49 photons/keV) are also making it an attractive candidate for hybrid imaging systems like SPECT/CT and PET/CT. Published experimental results of $LaCl_3$:Ce Absolute Efficiency (AE), i.e. the ratio of the emitted optical light flux over the incident exposure rate, have demonstrated that 1 cm thick crystal, excited by X-ray tube voltages above 120 kVp may be used as part of the detector of a hybrid imaging system. In this study, we examine the usability of $LaCl_3$:Ce scintillator under low radiographic X-ray exposure of 50 kVp for industrial radiography, or security applications.

Materials and Methods. A theoretical model was applied to the experimental AE data of 1 cm LaCl3:Ce crystal irradiated with a 50 kVp X-rays. The model assumes that the crystal can be divided into N elementary layers and the optical photon propagation probability is constant for each layer. The model also considers the X-ray attenuation properties in the crystal, the intrinsic conversion efficiency showing the optical photon power per absorbed X-ray power and the reflection of the optical photons at the input and output crystal surfaces. For the calculation of the intrinsic conversion efficiency the light yield and the peak wavelength of the emitted optical spectrum were considered. The propagation probability per elementary thickness was determined by fitting the theoretical model to the experimental AE data.

Results. The emitted wavelength peak at 350 nm yields an intrinsic conversion efficiency of 0.1736. The AE at a 50 kVp spectrum at 72.5 cm distance was 15.053 μWs/mRm^2. The probability of optical photon propagation per elementary thickens layer of 5 μm thickness was found equal to 0.998344. The relative difference between the experimental and the theoretical AE was below 0.2%. By altering the LaCl3:Ce thickness it was obtained by the model that the peak AE value for 50 kVp X-rays irradiation was 118.61 μWs/mRm^2 for a thickness of 0.17 cm.

Conclusion. A 0.17cm thick $LaCl_3$:Ce crystalline scintillator can provide optimum efficiency under excitation of 50 kVp X-rays. This result may be useful for manufacturing specialized detectors for low energy industrial radiography and security applications.

Mapping the melanin concentration distribution in common nevus using hyperspectral imaging as prognostic diagnosis

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Background. Nevi are benign melanic tumors that can, under certain conditions, become premalignant or even malignant tumors. Different methods have been used for nevus characterization, but there is no consensus as to the most effective and practical approach for finding high-risk nevi. The most commonly used method in present is dermoscopy, which provides enhanced details, but its interpretation still depends on the physician's experience. Most physicians agree that careful observation with particular attention to changes in appearance and if there are changes these nevi should be biopsied or removed. One of the changes that triggers suspicion is an uneven distribution of melanin. Therefore, in this study we propose a new objective and non-invasive method for assessing the uniformity of melanin concentration distribution in nevus based on hyperspectral imaging.

Methods. The study was conducted on 10 volunteers with common nevi situated on the back, arms, legs or neck. The hyperspectral images were acquired using a pushbroom hyperspectral system. Hyperspectral image analysis was performed using software developed by us to calculate melanin concentration and generate melanin concentration distribution maps in the nevus area. The software is based on modified Beer-Lambert law and a non-linear regression. The melanin concentration distribution was visually inspected as well as statistically processed using statistical software to determine variance parameters.

Results. Visual examination highlighted that while the semivariance statistical parameter showed that at values lower than 0.24 the nevus is homogenous, making the nevus a common one. On the other hand, at semivariance values higher than 0.24 the nevus is not homogenous anymore making it a dysplastic nevus.

Conclusion. In conclusion, our proposed new method proved to detect very accurately melanin concentration changes across the nevus thus providing an objective result no prior clinical experience being needed to determine if a nevus is high risk.

Spectral characterization and detection of skin tumors based on hyperspectral imaging

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Hyperspectral imaging is a technique that allows identification of biological tissues based on their spectral signatures, providing useful information for tissue diagnosis in a non-invasive way. In this study, the authors evaluated the potential of hyperspectral imaging combined with a new skin cancer index to detect skin cancer in vivo. Hyperspectral images of different pigmented and non-pigmented malignant and benign skin tumors were acquired in the spectral range (400-800) nm and their spectral characteristics were analyzed with a new skin index, namely the hyperspectral image-based skin cancer index. In the development of this index, the following aspects were taken into account: (1) the selection of spectral bands that most clearly highlight the most important spectral differences between pathological tissues and normal ones; the key hyperspectral bands were identified to be those around the inflection point of the reflectance spectra located in the spectral range (580–600) nm and (2) defining the skin cancer index based on the values of the slopes of the spectral signatures in the established spectral range. The results showed that the spectral characteristics of tumoral and normal tissues differ in terms of number and intensity of the characteristic peaks, allowing, at first sight, for a clear differentiation of pathological tissues from normal ones. The analysis of these differences using the skin cancer index demonstrated that the method had a good accuracy in differentiating between benign and malignant skin tumors compared to histopathological examination. In conclusion, hyperspectral imaging together with the skin cancer index were proved to be a potential tool for tumor detection and characterization in dermatology.

E-ROD – A new metric to evaluate the relative detectability of two digital mammography systems

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Relative Object Detectability (ROD) is a metric used to compare the detectors in two different radiology systems objectively and quantitatively. ROD is defined as the ratio of the product of the spatial frequency integral of the Fourier transform of the object function (OBJ) and the detective quantum efficiency (DQE) of one system to the product calculated for the system to which it is being compared.

In this work, ROD was modified to include scattering and focal spot blur as well as shape, dimensions and material of imaged object in order to assess the effective performance (E-ROD) of the whole imaging system. To do this DQE was replaced by effective Noise Equivalent Quanta (eNEQ), where eNEQ is a function of effective Modulation Transfer Function (eMTF), scatter factor (SF) and effective Normalized Noise Power Spectrum (eNNPS).

The digital mammography systems compared in this work were:

- two Siemens Mammomat Inspiration units with amorphous selenium detectors (pixel size 85 μm), W/Rh target/filter combination used clinically; and a
- GE Pristina Senographe unit with CsI scintillator detector (pixel size 100 μm), Mo/Mo and Rh/Ag target/filter combinations.

E-ROD was calculated for PMMA phantoms thicknesses of 20, 40, and 70 mm, with and without an anti-scatter grid, and using a selection of clinically relevant anode/filter combinations. Exposure parameters were automatically set by the AEC system. Simulated objects were gold discs of diameters and thicknesses consistent with elements in CDMAM 3.4 phantom.

Results were compared to measurements from CDMAM phantom that were obtained under the same exposure conditions.

E-ROD was shown to allow comparison of mammography systems that differ in terms of the detectors they use, focal spot dimensions, exposure conditions and characteristics of imaging object. Obtained results may be useful in the selection of which mammography system to use in order to optimize imaging quality under specific clinical conditions.

Dental X-ray imaging: The construction of a novel teeth phantom

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The majority of teeth pathological abnormalities are indicated by dental X-ray imaging. However, research on real teeth phantoms is still an open issue requiring further progress. In this work, we present the construction of a novel phantom representing realistic teeth jaws with purpose to assess the image quality for different irradiation conditions. The main components of the phantom are briefly summarized as follows: (a) female silicone molds for the jaw shape creation, (b) resin for the simulation of the soft tissue X-ray attenuation and (c) natural anterior and posterior teeth of mandible and maxilla. In order to implement the aforementioned components, we used two silicone modules (base and catalyst), iron molds that served to obtain both jaw imprints and plasticine for the teeth integration within the resin. Several teeth were used with corresponding characterization in terms of their anatomy and pathological features, such as fillings, caries, fractures, etc. The phantom was irradiated within the common range of dental X-ray imaging (X-ray voltage: 60-70 kVp, Current: 4-8 mA). The acquisition of medical images was found to be of high quality, especially in higher X-ray voltage values (higher image contrast). As a conclusion, the present phantom could be a useful tool for future dental X-ray imaging investigations for different teeth pathological abnormalities.

Infrared thermographic imaging of the human lower limb

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Infrared radiation (IR) refers to the wavelength region spanning from 750nm to 1400nm and it is not detectable by the human eye. It is emitted by all objects at temperatures above absolute zero. The amount of emitted radiation increases with temperature of the object. Thermography is a type of infrared imaging in which a thermographic camera can convert the invisible radiation into a visual image and provide a surface temperature map of an object with no contact required.

The cardiovascular system is one of the most important systems of the human body. There are various conditions besides cardiovascular diseases that can affect blood circulation. Circulating blood has a lot of functions, one of them being regulation of body temperature. Infrared radiation is a cost-effective and a non-invasive way to record body surface temperature variation and through this to evaluate blood flow in a body area.

Alterations of normal blood flow to the lower limbs may occur due to complications of diabetes or peripheral arterial or vascular disease. Therefore, in such blood circulation assessment is a recognized diagnostic and prognostic index.

The aim of this study is a thermographic evaluation of the normal lower human limb. Thermographic images of the lower limb were recorded and analyzed to qualitatively and quantitatively characterize the normal skin temperature distribution and its variations in the human foot. The representative healthy thermal lower limb temperature map produced can be used as a useful reference in medical diagnostics.

Evaluation of a new procedure for stability checks of well-type brachytherapy chambers

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Well-type ionization chambers are routinely used for measurements in brachytherapy departments. Since there is no calibration service for brachytherapy ionization chambers available in Serbia, Secondary Standards Dosimetry Laboratory (SSDL) in Vinca Institute of Nuclear Sciences started establishing this service, using a reference well-type chamber Standard Imaging HDR-1000 plus with a PTW Unidos Webline electrometer. The outer wall of the chamber is made of 20 mm thick aluminum, which reduces the influence of the scattered radiation. For each source there is a unique source holder for placement in a reproducible geometry inside the well of the chamber.

The ionization chamber stability has to be checked periodically to ensure reliable measurements. IAEA Technical Report Series (TRS) 1274 [IAEA TRS 1247, IAEA 2002] gives guidelines on standardized procedures at SSDLs and hospitals, including the procedure for stability checks of well-type chambers. According to this procedure, ^{137}Cs or ^{60}Co check sources are inserted in the chamber well, using spacers or holders to achieve reproducible geometry. Measurements during stability checks should remain within ±0.5%.

In this research, a different procedure for stability checks was tested. A teletherapy ^{60}Co irradiator was used for external irradiation of the well-type chamber. All measurements were corrected for air density (ambient temperature and pressure). Measurements were done in a minimum scatter environment, which was achieved by positioning the ionization chamber 1 m from the irradiator, with the field size of 20x20cm. Correction for ^{60}Co half-life was applied to all measurements. First, the influence of the source holders was tested, and no significant differences were found (0.16% maximum difference when holder is placed in chamber, compared to no holder present). All the subsequent measurements were performed without source holders. During the second test, 4 stability checks were performed during a period of 4 days without moving the chamber or irradiator. The deviations were within the interval -0.39% – +0.25% compared to the first stability check measurement. During the third test, 7 stability checks were performed during a period of 7 days, and complete setup was repeated during each check (chamber positioning, bench positioning, collimator setup etc.). The purpose of the second test was to check the repeatability of positioning, because the positioning can artificially increase deviations between subsequent measurements, making the chamber stability appear worse. All the results were within the interval -0.17% – +0.27%. The results show that this procedure can be adequate for the stability checks of well-type chambers, because the repeatability due to the changes in measurement procedures setup is better than the 0.5%. Differences between second and third test could be caused by insufficient thermalization of the chamber during the second test.

Keywords: brachytherapy, HDR, dosimeters, stability control

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Simulation and characterization methods of proton beams for ultra-high dose rate irradiation

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Experiments performed with a particle accelerator require a very good knowledge of the physical beam parameters, in terms of ion optics and dosimetry. Radiobiology studies undergoing at the 3 MV Tandetron™ from IFIN-HH superimpose a few more challenges due to the high accuracy expected for the delivered dose and in-air irradiation limitations [*NIM B*, 359:12-19, 2015, *NIM B*, 528: 45-53, 2022].

In this study, we present the Fluka simulation software results for a new beamline dedicated to ultra-high dose rate proton irradiation (FLASH) [https://fluka.cern/]. The experimental setup geometry is described and scoring of proton energy, Linear Energy Transfer (LET) and dose along the beam propagation axis are detailed.

During the preliminary tests, a proton beam was extracted from an 860 Cs-sputtering ion source and, after acceleration to 3.7 MeV, it was scattered by passing through a 7 μm gold foil. The final energy of the ions at the cell interaction point was 1.7 MeV, that corresponds to LET_{water} = 18.1 keV/μm. Transversal homogeneity was verified with radiochromic films and the particle fluence was registered with plastic track detectors. A Markus ionization chamber registered the dose at the beginning of each irradiation session, while, for the live dose monitoring, a silicon particle detector positioned at a backwards angle with respect to the beam direction measured the backscattered protons from the Au foil.

As a conclusion, the work provides a thorough comparison between simulation results and experimental data, highlighting the importance of a new radiobiology ion beam setup for FLASH and the opportunities that this instrument opens up for further research.

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Experience of the calibration and testing laboratory in establishing and maintaining a management system in accordance with the ISO/IEC 17025 standard

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The Polish Secondary Standard Dosimetry Laboratory (SSDL) in Warsaw in Poland has been accredited by the Polish Centre of Accreditation for the conformity with the ISO/IEC 17025 standard *General requirements for the competence of testing and calibration laboratories*. The first accreditation (No. AB 1499) was granted on April 9, 2014. This accreditation concerns testing, namely the measurement of the dose absorbed in water, by thermoluminescent dosimetry method. The second accreditation (No. AP 155) obtained on May 28, 2014 covers the calibration of ionizing radiation dosimeters in a ^{60}Co gamma ray beam in terms of dose absorbed to water and calibration of well chambers with a ^{192}Ir source in terms of air kerma. The status of accreditation and validity of the scope of accreditation can be confirmed at PCA website www.pca.gov.pl. The Polish SSDL performs laboratory activities in both of the aforementioned accreditation scopes for the needs of all radiotherapy centers in Poland.

The material of this work was the system and technical documentation necessary to establish, document, implement and maintain a management system in the Polish SSDL that was capable of supporting and demonstrating the consistent achievements of the requirements of the ISO/IEC 17025:2017 standard and assuring the quality of the Polish SSDL results.

In addition to meeting the general, structural, resource and process requirements (Clauses 4 to 7 of the aforementioned standard) a management system in accordance with Option A was implemented in the Polish SSDL.

This work will discuss those requirements of the ISO/IEC 17025:2017 standard that caused the most difficulties in adapting the management system in accordance with the requirements of the ISO/IEC 17025:2005 to the requirements of the ISO/IEC 17025:2017 standard. One of such requirements was the requirement regarding actions to address risk and opportunities associated with the laboratory activities.

This work will also present ways of implementing selected requirements of the ISO/IEC 17025:2017, which may be helpful for other calibration and testing laboratories that plan to join the process of obtaining accreditation for compliance with the requirements of the ISO/IEC 17025:2017 or for such laboratories that would like to improve their management system.

The number of radiation beams audited during TLD postal dose audit performed by the Secondary Standards Dosimetry Laboratory in Poland in the context of the COVID-19 pandemic

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Due to the COVID-19 pandemic, an epidemic state was in force in Poland from 20 March 2020 to 15 May 2022 in accordance with Polish legislation. From 16 May 2022 until further notice, a state of epidemic emergency is in force in Poland.

The aim of this study was to check whether the COVID-19 pandemic caused a decrease in the number of total radiation beams audited by the Secondary Standards Dosimetry Laboratory in Poland during thermoluminescent dosimetric (TLD) postal dose audit.

TLD postal dose audit is conducted to radiotherapy centres in Poland by the Secondary Standards Dosimetry Laboratory (SSDL) which is part of the Medical Physics Department of the Maria Sklodowska-Curie National Research Institute of Oncology in Warsaw. The Polish SSDL is a full member of the IAEA/WHO Network of SSDLs. The Polish SSDL has been accredited for the conformity with the norm ISO/IEC 17025 by the Polish Centre for Accreditation since 09 April 2014 and has the accreditation certificate No. AB 1499. In the scope of the aforementioned accreditation is determination of the dose absorbed in water ranging from 1.5 Gy to 2.5 Gy for X-ray beams in the range 4 MV - 25 MV and for beams electrons in the energy range of 4 MeV – 22 MeV, by thermoluminescent dosimetry method.

The material of this study was data on number of radiation beams audited by SSDL in Poland in 2020, i.e. the year the COVID-19 pandemic began, and those audited in five years before and in two years after 2020. In the analyzed period, the SSDL in Poland operated as usual, carrying out orders of radiation therapy centers in Poland.

Statistical techniques were applied to the reviewing of the results, namely to analyze the association between the total number of beams audited in a given year counting from 2015, i.e. the first full calendar year of the SSDL's accreditation till 2022 and number of years since 2020 when the COVID-19 pandemic was declared. Moreover, an analysis of the number of X-ray beams and the number of electron beams audited in each year was performed. The number of audited beams in a given year was also analyzed in relation to the number of centers that submitted to the audit.

Results of the Pearson correlation indicated that there is a significant large positive relationship between X variable (number of years since 2020) and Y variable (total number of radiation beams audited by the SSDL in Poland in a given year), ($r(6) = 0.731$, $p = 0.039$, significance level (α) = 0.05). In addition, there is an increasing trend in the number of X-ray beams, and a decreasing trend in the number of electron beams audited in the analyzed period.

These results are in line with our expectations because the COVID-19 pandemic should have not caused a decrease in the total number of radiation beams audited by the Polish SSDL.

Secondary Standards Dosimetry Laboratory (SSDL) at the Maria Sklodowska-Curie National Research Institute of Oncology – results of the 2018-2022 activity

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The Secondary Standards Dosimetry Laboratory (SSDL) which is part of the Medical Physics Department of the Maria Sklodowska-Curie National Research Institute of Oncology in Warsaw is a full member of the IAEA/WHO Network of SSDLs.

According to Polish law (i.e. Journal of Laws of 2021, item 1941), measuring equipment used to perform operational tests of radiological equipment and auxiliary equipment used in health care units should be calibrated. Current national regulations do not impose an obligation on radiotherapy centers to undergo a dosimetry audit. However, in accordance with good dosimetry practice, SSDL in Warsaw still organizes audits for radiotherapy centers in Poland.

Since 2014, this SSDL activities have been accredited by the Polish Center for Accreditation (PCA) for compliance with the PN-EN ISO/IEC 17025 standard (accreditation No. AP 155). In the period of 2018-2022, electrometers with ionization chambers were calibrated for teleradiotherapy in the ^{60}Co gamma beam of the Theratron 780E unit, and for high dose rate brachytherapy with the ^{192}Ir source operated with Microselectron or Flexitron afterloader. All calibrations were performed by the substitution method using the SSDL working standard (electrometr with the ionization chamber). More than 700 dosimetry sets (electrometer + chamber) were calibrated at SSDL. Along with the development of irradiation techniques and the related use of new types of radiotherapy devices, SSDL extends the scope of its activities to include the calibration of new types of chambers (e.g. for the needs of tomotherapy).

In the years 2018-2022, SSDL conducted annual dosimetry audits for teleradiotherapy centers in Poland using the thermoluminescence dosimetry (TLD) method with LiF powder as a TL detector. Since 2014, this SSDL activity has been subject to PCA accreditation for compliance with the mentioned norm (accreditation No. AB 1499).

In the years 2018-2022, a dosimetry audit was performed at the SSDL for radiotherapy centers in Poland using the TLD method for 680 beams. The most common non-reference terms are fields formed by the MLC.

SSDL also conducted pilot “end-to-end” dosimetry audits. For stereotactic radiotherapy 13 radiotherapy centers were audited using a polystyrene phantom designed and manufactured at SSDL. This phantom, contains defined volumes of PTV and OAR (made of Solid Water HD tissue-like material), which are separate elements of the phantom allowing to place radiochromic films and TL detectors in them. For radiotherapy with dynamic head and neck techniques the CIRS Shoulder, Head and Neck End-to-End Verification Phantom (SHANE) was used. The SHANE phantom audit was performed in 8 centers for seven linac/beam/TPS combinations – including the CyberKnife type accelerator.

The activity of the SSDL in the field of calibrations and external dosimetric audits is an important tool to ensure the quality of treatment and safety of patients undergoing radiotherapy in oncology centers in Poland.

Results of the intermediate checks on the working standards used for routine calibrations of ionizing radiation dosimeters in a ^{60}Co gamma ray beam – experience from over a year of calibration laboratory activity

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Every calibration laboratory accredited for the conformity with the norm ISO/IEC 17025 has to fulfil its requirements. One of these requirements concerns the monitoring of the validity of results.

The Polish Secondary Standard Dosimetry Laboratory (SSDL) has been accredited by the Polish Centre of Accreditation for the conformity with the norm ISO/IEC 17025 since May 28, 2014. One of the accredited activities (according to the Scope of Accreditation No. AP 155) is calibration of ionizing radiation dosimeters in a ^{60}Co gamma ray beam in terms of dose absorbed to water. The Polish SSDL calibrates the ionizing radiation dosimeters (referred to further in the text as "customer dosimeters") in the above-mentioned field from all the radiotherapy centres in Poland.

At the Polish SSDL, it was decided that monitoring of the validity of the calibration results will include, among others, periodic intermediate checks on the working standards used for the calibration of the customer dosimeters. According to the norm, these checks shall be carried out according to a procedure defined by the accredited laboratory.

The aim of this study is to present the results of the intermediate checks on the working standard used for routine calibrations of customer dosimeters in a ^{60}Co gamma ray beam in terms of absorbed dose to water.

The material of this study were the results of 45 intermediate checks of the one working standard, used routinely at the Polish SSDL in the period from December 2021 to March 2023. These checks were carried out according to a procedure defined by the Polish SSDL, i.e. on the same day the working standard was used for the calibration of the customer dosimeter. Each intermediate check consisted of a comparison of the mean value of the absorbed dose to water: D_{mean} (based on 10 measurements of the charge M_i, in calibration conditions by substitution, as presented by the IAEA Technical reports 398 and 469) with the value of the dose absorbed to water: D_{calc}, calculated according to the radioactive decay of the ^{60}Co source.

At the Polish SSDL, Δ parameter was adopted as a measure of the intermediate check. This parameter was defined as a percentage absolute value of the difference between D_{mean} and $D_{calc,}$, in relation to the value D_{mean}. Value of 0.7 % was adopted as an acceptance criterion of the Δ parameter. In simple terms, the acceptance criterion of the result of the intermediate check was established based on the relative percentage value of the combined uncertainty of the measurement of D_{mean}.

All values of the Δ parameter were below 0.3 %, so 100 % of the results of the intermediate checks for the working standard were more than two times smaller than the acceptance criterion (i.e. 0.7 %).

The presented results of the intermediate checks indicated that the tested working standard ensured the validity of the calibration coefficients of the customer dosimeters, during the analyzed period of time.

The number of calibrations of electrometers with different types of ionization chambers performed by the calibration laboratory in Poland in the context of the COVID-19 pandemic

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Due to the COVID-19 pandemic, an epidemic state was in force in Poland from 20 March 2020 to 15 May 2022 in accordance with Polish legislation. From 16 May 2022 until further notice, a state of epidemic emergency is in force in Poland.

The aim of this study was to check whether the COVID-19 pandemic caused a decrease in the number of calibrations of electrometers with different types of ionization chambers performed by a calibration laboratory in Poland on behalf of its clients, mainly radiation therapy centers in Poland.

Calibration service of electrometers with different types of ionization chambers is provided in Poland by the Secondary Standards Dosimetry Laboratory (SSDL) run by Medical Physics Department of the Maria Sklodowska-Curie National Research Institute of Oncology, member of Secondary Standards Dosimetry Laboratories Network established by the International Atomic Energy Agency and the World Health Organization. The Polish SSDL has been accredited for the conformity with the norm ISO/IEC 17025 by the Polish Centre for Accreditation since 28 May 2014 and has the accreditation certificate No AP 155.

The material of this study was data on calibrations carried out by SSDL in Poland in 2020, i.e. the year the COVID-19 pandemic began, and those carried out in five years before and two years after 2020. In the analyzed period, the SSDL in Poland operated as usual, carrying out orders of clients, mainly radiation therapy centers in Poland.

Statistical techniques were applied to the reviewing of the results, namely to analyze the association between the total number of calibrations carried out in a given year counting from 2015, i.e. the first full calendar year of the SSDL's accreditation till 2022 and number of years since 2020 when the COVID-19 pandemic was declared. Moreover, an analysis of the number of calibrations of various types of electrometers with different types of ionization chambers, including well chambers, cylindrical chambers and flat-parallel chambers in each year was performed.

Results of the Pearson correlation indicated that there is a significant large positive relationship between X variable (number of years since 2020) and Y variable (number of calibrations carried out by SSDL in Poland in a given year), ($r(6) = 0.776$, $p = 0.024$, significance level (α) = 0.05).

These results are in line with our expectations because the time elapsed since 2015 untill 2022 should have not significantly decreased the total number of calibrations carried out by SSDL in Poland in the analyzed period, i.e. the COVID-19 pandemic should have not caused a decrease in the number of calibrations. These results may indicate the high awareness of medical physicists responsible for dosimetry in radiotherapy centers in Poland about the need to calibrate equipment used for the aforementioned activity despite the COVID-19 pandemic and related restrictions announced for the first time in the history of the SSDL and of radiation therapy centers in Poland.

Short wavelength UV in combination with cold storage can minimize postharvest gray mold losses in strawberry

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Gray mold, caused by cryptic species of *Botrytis*, is one of the most important fungal diseases that can cause severe pre and postharvest losses (quantitative and qualitative) in strawberry industry. While fungicides play key role in management of this disease, reliance on fungicides is neither sustainable, nor an environmentally friendly option. The potential of short wavelength UV in combination with storage temperature was tested on postharvest gray mold severity in strawberries. Strawberry cv Favori and Murano were grown in commercial high tunnel production system. Commercial grade mature fruits were harvested and used for experiments at controlled environment conditions. Fruits were placed on cell culture plates and inoculated by spraying conidial suspension (1 ml per fruit) prepared from 21 days old sporulating colonies of *Botrytis cinerea*. The cell culture plates were then placed in clear polystyrene boxes and sealed with UV-light transmitting cling film. Samples were treated with following daily air temperature - optical environments for 12 days.

i) No UV_ dark_ 21 °C,

ii) No UV_ dark_ 4 °C,

iii) 2 min UV_ dark_ 21 °C,

iv) 2 min UV_ dark_ 4 °C,

v) 4 min UV_ dark_ 21 °C,

vi) 4 min UV_ dark_ 4 °C,

vii) 8 min UV_ dark_ 21 °C,

viii) 8 min UV_ dark_ 4 °C.

The UV irradiance of 8±1 µmol/m²/s supplied with fluorescent lamps (Peak emission at 254 nm, T8, 36 W, Osram GmBH, Germany). Samples were assessed for severity at the end of experiment. Cold storage (4 °C) in combination with brief UV treatment showed significantly low level of gray mold severity compared with all other treatments. Even though UV treatment showed significant suppression of gray mold severity and sporulation at room temperature condition, none of the fruits were in marketable quality. Strawberries are an extremely perishable berry fruits sensitive to gray mold and can cause severe postharvest losses, if not stored properly. Our results showed that the potential of short wavelength UV radiation in combination with cold storage temperature as an option to enhance postharvest shelf life of strawberry. However, additional trails are necessary to adapt this technology into practical applications with possible modifications on packaging and storage method that are in practice now.

Investigation of the OAM EM wave interaction with tissue at microwave and millimeter wave frequencies

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Recently, there has been an increase of interest in use of electromagnetic (EM) waves with helical wavefronts, known as the orbital angular momentum (OAM) waves. The OAM waves are considered to be among the key technological resources to improve optical / wireless communication system capacity and transmission data rates. Additionally, applications in the field of biomedicine have been foreseen, such as medical imaging and diagnosis, deep-tissue imaging, biosensing, and communication with medical implants (doi: 10.1038/s41598-022-18483-3; doi: 10.1038/s41598-021-82033-6; doi: 10.1364/JOSAA.34.002046). Other possible applications include various localized tissue treatments or tissue ablation. The available references mainly study the interaction of OAM light with biological structures, offering some novel insights into the biophotonics effects. Investigations are needed and should also be carried out for other frequency ranges, such as microwaves and millimeter waves. These studies are also important for the design of recently very popular wearable antennas, in the context of body area networks that utilize OAM and the specific absorption rate (SAR) in that case (doi: 10.1109/ISWTA55313.2022.9942785).

Here we use semi-analytical modeling and full-wave numerical computations of OAM EM fields to investigate their interaction with biological tissues. Specifically, we compare the results for various OAM modes by altering the OAM beam parameters and the distance from the target tissue. The output variables of interest include the spot size obtained and the energy delivered to the tissue, expressed in terms of the Poynting vector. We also explore the possibility of combining several OAM modes. The results provide insights into potential biomedical applications of OAM EM waves at the examined frequencies and should guide the design of components and devices based on OAM EM waves.

Examining the function of NK cells towards various target tumor cells

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NK (Natural killer) cells are a special group of peripheral blood lymphocytes that act differently from T lymphocytes and that kill virus-infected cells as well as tumor cells. For testing NK cell function, the classic gold standard has been used for a long time, determining the activity towards target tumor cells using radioactive chromium. One of the classic target cells used to test the functional activity of NK lymphocytes is the tumor cell line K-562, an erythroleukemic cell line developed by Lozzio and Lozzio. However, other tumor cells are used in numerous experiments as target cells to test their sensitivity. In this paper, we examined the functional activity of healthy lymphocytes according to the cell line designated as PC-MDS, which was isolated at the Institute of Oncology of Vojvodina, Sremska Kemenica, Novi Sad, by the group of authors; as an original and new cell line isolated from the bone marrow of patients with hematological malignancies compared to standard K-562 cells. To test the function, the cells were first labeled with radioactive ^{51} Chromium (Na2CrO4, As = 3.7 MBq, Amersham, Piscataway, USA) for 30 min and mixed with lymphocytes in the ratio 100: 1, 50:1 and 25:1 (ie) in a series of dilutions and the corresponding ratio. Activity was measured based on the release of radioactive ^{51} chromium on a gamma counter according to a predetermined formula. The research compared the cytotoxicity values of NK cells obtained using this line in comparison to K-562 and other target cells. The findings indicate that the percentage of cytotoxicity depends on the characteristics of cells and the expression of molecules, but that this examined cell line shows differences compared to the standard K-562 cell line. Of course, today many other tests are used in the examination of NK cells besides the use of radioactive chromium, but this functional test always has its place in understanding the biology and function of tumor cells.

Evaluation of radiology devices quality compared to COCIR standards and the problems observed during the facing of the Covid 19 pandemic

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Albania needs to increase the quality of primary services to meet the needs of the population, especially in the conditions of the global pandemic COVID-19. The diagnostic service, which is rated as the primary service for the examination of internal diseases and the consequences of COVID-19, must be at the appropriate height to cope with the high flow of patients with coronavirus. The Covid 19 pandemic proved that even countries with developed economies and advanced hospital systems had many problems in managing the pandemic. The reasons are many and are related to factors which in these circumstances are unpredictable as it was, for example the size of this pandemic, etc.

Purpose. In this study, we aim to evaluate the important role that diagnostic imaging has played in dealing with the pandemic situation where, by X-ray imaging technologies, it has been possible to identify the severity of the disease in patients affected by Covid.

Methodology and Results. Diagnostic equipment, to have a better operation, is important for their technical control, consisting of a series of tests that verify different elements of the X-ray equipment. These tests consist of verifying the accuracy of voltage (kV), the stability of the repetition of the values of the dependence of the voltage of the change of the power voltage, the general filtering and the exposure time. In this study, we analyzed the diagnostic system in Albania by collecting information from the public and private sectors. Regardless of the difficulties we encountered in collecting statistics, we have presented a general picture of the situation of diagnostic equipment in Albania compared to OECD and COCIR indicators and standards. The study shows that diagnostic imaging in Albania uses a large variety of equipment, but compared to the OECD standard, the ratio of units per 1 million inhabitants in Albania is below the average number (OECD Statistics Health 2021). Dental imaging has the best performance in terms of number of devices while nuclear imaging is extremely low.

Conclusions and Recommendations. We found a low level regarding the fulfillment of the COCIR standards ("Golden Rule") where more than 65% of the basic equipment of the installed equipment is between six and ten years old, 20 % is less than five years old and 15% of the installed equipment is more than ten years old. Our study comes with a series of recommendations based on COCIR international standards and the analysis carried out directly in several hospital centers in the country, taking into consideration the issues of the COVID 19 pandemic.

Keywords: COCIR, radiology, diagnostics, COVID, X-ray, OECD

Evaluation of planter fascia among patients with painful heel in Sudan: Sonographic findings

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Background and Aim. The plantar fascia is a thick connective tissue that supports the medial longitudinal arch of the foot on the sole (plantar side). Ultrasound (U/S) can have a role in assessing the plantar facia. Present study evaluated the efficacy of ultrasound technique in assessing the plantar facia cases and correlated the gender, age and side with the ultrasound findings.

Methodology. A cross-sectional descriptive hospital-based study was conducted in Omdurman Teaching Hospital which is one of the Khartoum State's central hospitals in Sudan. The study comprises a total of 179 cases where 90 was control group and 89 was study group. Exclusion criteria included diabetic and hyper tension or any malformation patients. Ultrasound was performed with specific protocol using ECUBE scanner of a 5MH linear probe in college of medical radiological sciences and the results was evaluated by four orthopedic surgeons to decide the suitable treatment.

Results. Male/female represented 96/83 patients among the sample that included 88.8% overweight patient. Right foot was commonly affected side to 48 patients compared to the 41 patients in left foot. The thickness of plantar facia was found to be 4.4 mm in the right foot compared to 4.3 mm for the left foot with p value of 0.001 and 0.02, respectively.

Conclusion. Ultrasound has significant role in the diagnosis of plantar facia and classifying the severity of it.

Keywords: planter fasciitis, ultrasound, heel pain, flat foot, arches of the foot

Comparison of different immunological techniques for the detection of anti-cytomegalovirus IgM antibodies in pregnant women

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Aim. Evaluation of electrochemiluminescence technique (ECL), enzyme-linked immunosorbent assay (ELISA) and enzyme-linked fluorescent assay (ELFA) for an early diagnosis of *Cytomegalovirus* infections in pregnant women. In medical diagnostics, it is necessary to determine the most sensitive techniques for the detection of this pathogen, in the framework of which is developed this scientific work. This is very important due to *Cytomegalovirus* multiple fetal infections during pregnancy.

Methods. 200 samples, taken from pregnant women in their first trimester of pregnancy, were tested with ECL, ELISA and ELFA techniques for the detection of anti-cytomegalovirus IgM antibodies. The statistical processing of the data was carried out, as well as the evaluation of sensitivity and specificity values for each technique.

Results. The ECL technique resulted with the highest sensitivity and specificity values (98%-100%), while the ELISA technique (applied on the Chorus device) resulted with the lowest sensitivity and specificity values (86.7%-97.3%).

Conclusions. The evaluation of the results confirmed the importance of ECL technique for an early diagnosis of *Cytomegalovirus* infections in pregnant women. However, for diagnostic purposes, the results should always be assessed in conjunction with the patient's medical history and other clinical examinations.

Changes in various amino acid concentrations in the small intestine and pathogenesis of an intestinal injury caused by carbon-ion irradiation

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The intestinal crypt stem cells in gut have a high growth potential and radiosensitivity, it is dose-dependently reduced by heavy-ion irradiation and intestinal death occurs by arrest of epithelial cells supply in high dose area. Therefore, the development of intestinal radioprotection methods may contribute to more effective and less harmful carbon-ion radiotherapy. The N-methyl-D-aspartate (NMDA) receptor antagonists have been reported to prevent radiation-induced central nervous system damage. We have also reported that NMDA receptor antagonists reduced radiation-induced intestinal injury, activation of NMDA receptors was significantly increased 24 hours after irradiation. Thus, we investigated the association with amino acid concentration that activates NMDA receptors in intestinal injury in irradiated mice.

C3H/He female mice anesthetized with pentobarbital were whole body irradiated with carbon ion at doses of 9 Gy (20 keV/μm, 290 MeV/u, accelerated by HIMAC synchrotron at NIRS, Japan). We developed the HPLC method for the determination of 6 amino acids and related compounds – glycine (Gly), serine (Ser), aspartic acid (Asp), glutamic acid (Glu), taurine (Tau), and γ-aminobutyric acid (GABA) - in mouse intestine with pre-column derivatization with fluorogenic reagent, NBD-F (4-Fluoro-7-nitrobenzofurazan).

After carbon-ion irradiation, the concentration of Tau was significantly decreased with time. Tau, a sulfur-containing amino acid-related compound, has been reported to have a radioprotective effect. Therefore, the decrease in Tau concentration was inferred to be a decrease in radioprotective ability on mouse intestine. On the other hand, the concentration of Glu was significantly increased with time dependence by the irradiation. These results suggested that the increase in glutamate concentration after irradiation causes activation of NMDA receptors, radiation-induced intestinal injuries could be suppressed by NMDA receptor antagonists as radioprotective agents after carbon-ion exposure.

Investigation of proton irradiation induced effects in chondrosarcoma and bystander normal chondrocytes and endothelial cells

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Chondrosarcoma is a chemo and radioresistant tumour for which the main treatment remains surgery. Hadron therapy has shown better specificity and lower toxicity for the surrounding normal tissue when compared to conventional photon therapy. This study focuses on analysing cellular mechanisms involved in stress and response to DNA damage induced by proton irradiation in tumour cells and bystander normal cells.

The SW1353 chondrosarcoma cells were irradiated with low energy protons at doses in the range 0.1-2 Gy. To study the bystander phenomena we used a medium transfer protocol using as recipient cells the normal chondrocyte (T/C-28a2) and endothelial (EA.hy926) cells. Cellular response to proton radiation was investigated by using flow cytometry to quantify the oxidative stress and the cell cycle modifications at 3h and 24h and mass spectrometry to assess proteomic evaluation at 24h, both in directly exposed chondrosarcoma as well as in bystander cells.

The proteomic assay of the chondrosarcoma cells revealed changes in the expression of an increased number of proteins related to mitochondrial function after exposure at 0.1 Gy of radiation. However, increased ROS production (global and mitochondrial ROS) was found at the higher dose of 2Gy. This may suggest that the cells responded to radiation starting from the low dose by modulation of protein expression being able to maintain cellular homeostasis in this case, while at the higher dose the mechanisms seem to be overcame. Following irradiation with 2Gy, the main proteins with modified expressions are involved in apoptosis and cell cycle control, results that are in correlation with the identified G1-cell cycle arrest.

Bystander responses evaluated by cell survival were triggered in T/C-28a2 cells at 0.1 Gy and in EA.hy 926 cells at 2 Gy. The proteomic analysis showed modulation of the pathways involved in RNA signalling, mitochondria, inflammation and apoptosis in the case of the bystander chondrocytes, and in mitochondrial function for endothelial cells, while no changes were observed analysing ROS signalling and cell cycle.

The outcomes showed the impact of proton irradiation on chondrosarcoma cells at the molecular level including the complex mechanisms involved in bystander signalling.

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Radiosensitizing effect of ATM and ATR kinase inhibitors on glioblastoma

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Glioblastoma multiform (GBM) is an aggressive and invasive brain cancer, with a 5-years survival rate of 5.5% and a mean survival rate of less than 15 months. The conventional GBM treatment include surgical resection, radiotherapy, and chemotherapy. To overcome radioresistance, the prevention of the DNA repair with an additional chemical treatment was investigated for proton irradiation, as well as reference X-ray irradiation.

The U251-MG cell line was used as a GBM model. Cells were treated with inhibitors of DNA repair, namely ATM inhibitor (AZD1390) and ATR inhibitor (VE882), followed by X-ray or high energy proton irradiation at doses in the range of 0-6 Gy.

The following parameters were determined after the combined treatments: survival fraction of U251-MG using clonogenic survival assay, the γH2AX foci formation and the cell cycle investigation through flow cytometry.

The survival fraction of the cells decreased with the increase of the dose (≈50 times less cells at 4 Gy compared to 0 Gy for the proton irradiated samples, ≈2 times less cells at 4 Gy for the samples irradiated with X-rays), the proton irradiation showed a stronger effect than the X-rays (the protons were ≈25 times more efficient). The inhibitors induced a radiosensitizing effect for both types of irradiation.

γH2AX foci formation was higher in the 6 Gy samples harvested at 6 hours after the proton irradiation alone (≈3.5x) compared to the untreated 6 Gy samples irradiated with X-rays (≈1.5x). The treated samples showed a slight decrease in the number of foci formed (6 Gy protons with inhibitors ≈2.4x; 6 Gy X-rays with inhibitors ≈1.35x).

The treated samples harvested at 24 hours after irradiation were arrested in the G2 checkpoint of the cell cycle, especially the 6 Gy ones treated with the ATM inhibitor.

The present study showed that the combined treatments with the ATM and ATR inhibitors increased the radiosensitivity of glioblastoma for both proton and X-ray irradiation.

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The appearance of prion-like proteins in descendants of soybean planted under radionuclide contamination in Chornobyl aliened zone for several generations

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The prion-like proteins have a unique biochemical memory through destructive self-organizing conformation changes. Plants may synthesize prion-like proteins, able to self-assemble into amyloid fibrils, and amyloidogenesis may be activated in response to radionuclide pollution. Hence, we suggested that soybean plants that grew several generations at the Chornobyl aliened zone on the plot contaminated by 137Cs, 90Sr, 241Am, etc., might produce the appearance of proteins with prion-like properties. Our previous proteomic studies of soybean seeds sown for several years in soil contaminated with radioactive isotopes revealed that since the second generation, the contents of the cupin superfamily proteins, glycinin, and conglycinin proteins in the matured seeds were increased (Gábrišová et al., 2016). These prion-like proteins are known to trigger allergies.

In the current study, the contents of prion-like proteins in soybean seeds were estimated by the ratio between alpha-helices and beta-sheets determined with the ATR-FTIR spectroscopy (Nicolet FTIR IS50 spectrometer, Thermo Fisher Scientific, USA). Obtained specters were analyzed with OMNIC software (Thermo Fisher Scientific, USA). Experimental soybean seeds were 3rd and 5th generations of plants' descendants cultivated on soil contaminated with radionuclides.

The data obtained indicate a significant increase in the proportion of β-sheets, up to 20-30%, in the soybean proteome from the radioactively contaminated territory, which may reveal the appearance of proteins with prion-like properties. At the same time, the ratio of β-sheets and α-helices decreased during three generations to control values. The results demonstrated a probable transition of the alpha-state of proteins to beta-conformation in descendants of plants that were cultivated on radionuclide-polluted soil, assuming increasing the contents of prion-like proteins. Experiments elucidating the appearance of prion-like proteins in plants could have consequences for mammal health, as consuming such proteins may be dangerous.

Keywords: prion-like proteins, FTIR-spectrometry, proteins with β-sheets, radionuclide contamination

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Pilot lung cancer screening program in Serbia after 2-year results and challenges

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Introduction. Lung cancer (LC) is one of the leading causes of mortality worldwide. Incidence and mortality of LC in Serbia are among the highest in Europe. After smoking cessation, lung cancer screening (LCS) is the best prevention method for reducing LC mortality. Diagnosing the disease in early stages significantly increases survival rate. Therefore, early diagnosis is very important, and it is best achievable by screening. Importance of LC screening is highlighted during past decade in order to improve early diagnosis and treatment. The first pilot LCS program in Serbia started in October 2020.

Aims and Objectives. To present the 2-year results and challenges in implementing LCS.

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

Results. During a 2-year period, a total of 3432 LDCT scans were performed on 2138 screen responders. The majority were females (58.1%). Females compared to males were often active smokers (87.1% vs. 78.7%, $p<0.001$) and frequently reported respiratory symptoms (72.1% vs.65.5%, p=001). Lung RADS score positive screens were found in 9.2% (199/2135). The screening respond rate to control LDCT after 12 months (Lung RADS 1 and 2) was 76.5% (786/1027). The invasive diagnostic was performed in 2.3% of participants, while 0.5% refused invasive procedures. The rate of false positive findings was 1.17 % (25/2138). The LC detection rate was 1.96% (42/2138) and 72.4% of LC were diagnosed on baseline screening. Among LC, 88.1% were NCSLC (adenocarcinoma 54.8%, squamous 21.4% and NOS 9.5%) and 11.9% were SCLC. The stage of disease of 52.4% of participants was I or II. LC was significantly common in males compared to females (1.7% vs. 0.9%, p=0.04). Radiation dose CTDI vol (mGy) mean±SD)=0.67 (0.6757±0.301) DLP=30.501±16.073 mAs=0.427014±0.225 kVp=91.2176±19.142.

Conclusion. Decreased irradiation dose, together with higher accuracy (CAD software package) compared to chest X-rays, makes LDCT excellent screening tool, which allows early detection of lung cancer, and therefore improves survival rate. Innovative approaches, education and a more recognizable campaign are necessary to increase the responds rate among participants with negative baseline LDCT.

The importance of immunization as a preventive measure in the fight against tuberculosis

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Introduction. Tuberculosis (TB) is an infectious granulomatous disease caused by the human type of bacillus Mycobacterium tuberculosis. TB infection begins when mycobacteria reach the pulmonary alveoli, where they penetrate and replicate within the endosomes of alveolar macrophages. Bacilli in the alveoli are phagocytosed by alveolar macrophages, where they multiply and spread to regional lymph glands and through the bloodstream to distant organs (miliary tuberculosis). A scar and a cavern filled with caseous necrotic material are created at the site of the affected tissue. The treatment is carried out with a combination of several drugs, most often with the joint use of rifampicin, isoniazid and pyrazinamide, and lasts six months and continues for three months after Koch's bacillus is not found in the sputum culture. The BCG vaccine is intended for the active immunization of all newborns and high-risk children in order to prevent severe clinical forms of tuberculosis, as well as for the active immunization of adults with a high risk of developing tuberculosis.

The Aim and Methodology of the research work is to get acquainted with the epidemiological situation of TB in the territory of the Pomoravlje District based on the collected data for the time period from 2010-2014. year on the number of new cases of TB, as well as the number of patients with active tuberculosis, observing the number of relapses of the disease and those who have changed to an inactive form, as well as mortality from it according to gender and age. The results of successful vaccination against TB in the territory of Pomoravlje District were also summarized and statistically processed.

Results and Discussion. Based on the processed statistical data, it was observed that the total number of people suffering from tuberculosis in the Pomoravlje District in 2014 was 9 and that it was less than in 2010 (16). Therefore, it can be seen that the highest incidence of the disease occurs in adulthood, while no cases of clinical manifestations of the disease have been recorded in infants, small children and in the period of adolescence. In relation to gender, it was noted that in 2010, the number of sick men between the ages of 30 and 49 was higher than in 2014.

Conclusion. Control of the tuberculosis epidemic requires detection and treatment of bacillary positive patients. Disease prevention through immunization (vaccination and chemoprophylaxis) not only reduces mortality, but also morbidity, as well as direct and indirect costs in healthcare. It is very important to emphasize the essential measures that should be taken in every country of the world with the aim of developing and implementing national programs for the prevention, control and treatment of this disease.

Keywords: tuberculosis, Koch's bacillus, treatment, prevention, immunization

The role of the pharmacist in the implementation of self-medication

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Introduction. In addition to the traditional role of pharmacists in the preparation, distribution and dispensing of medicines, today pharmacists represent an important link in the health system with their active participation in health promotion and prevention of many diseases. There are a number of educational activities of pharmacists aimed at familiarizing the population with the importance of a healthy lifestyle and risk factors for the development of diseases. Self-medication is defined as the application of drugs for the treatment of symptoms and diseases that the patient himself recognizes. Self-medication is the primary resource of any healthcare system. However, only with adequate, professional advice from pharmacists, who can identify, prevent and solve problems related to self-medication, an optimal and safe outcome of therapy can be achieved, as well as improving the quality of life of patients.

Research Objective and Methodology is to examine the frequency and reasons for the use of self-medication preparations, as well as the key role of pharmacists in the self-medication process. The research was conducted in pharmacies in Serbia during 2022, and the study included 300 respondents. An anonymous survey questionnaire was used for the research, and the collected data were statistically processed.

Results and Discussion. According to the research, the largest number of surveyed respondents use drugs in self-medication, on average once a month, and a very small number once a week. The most common reasons for resorting to self-medication are headaches, mild cold symptoms, fever, cough as well as menstrual pain and pain in bones and joints. Respondents' information about the medicine they use in self-medication is the highest through the media, the Internet and by pharmacists about the method of administration of the medicine, as well as the duration of the therapy, but they are insufficiently familiar with adverse reactions to the medicine. The pharmacist as a health expert is expected to influence the awareness of individuals not to resort to independent self-medication, because it carries numerous risks.

Conclusion. More attention and efforts should be devoted to the health education of the population at the level of primary health care, as well as to the education of young people through all levels of education with a multidisciplinary approach of all health workers, both medical and pharmaceutical. In this way, health education of the population and a certain higher level of health culture of the population about the use of OTC preparations would be carried out.

Keywords: self-medication, pharmacist, education

Health education of the population about the prevention possibilities of HPV infection

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Introduction. Human papillomaviruses (*Human Papillomavirus*-HPV) are DNA viruses, belonging to the family Papillomaviridae, genus Papillomavirus. It is estimated that at least 80%-100% of people between the ages of 18-25 come into contact with this virus during sexual contact, while only about 30% of people develop symptoms of infection. Chronic HPV infection increases the risk of cervical cancer by 65 times, and in the case of oncogenic "high-risk" types by 130 times (HPV 16, HPV 18, HPV 31, HPV 35), namely cancer of the cervix, vulva and vagina in women, genital organs in men, as well as throat and anus cancer in both sexes. CIN within the framework of HPV infection and pathogenesis can be viewed as a productive infection (replicative) that is most often transient and spontaneously regresses (viral phase) and transformational with the development of dysplasia in a smaller number of HPV-infection-related lesions (neoplastic phase).

As a preventive measure, there are vaccines against HPV (Gardasil, Gardasil 9 and Cervarix), which are not mandatory according to the vaccination calendar and contribute to preventing the development of HPV infection, and are particularly effective in the fight against HPV types 16 and 18, which in most cases cause cervical cancer.

The Aim of this work is to compare the obtained data on the optional Gardasil 9 vaccination carried out on the territory of the Pomoravlje and Pčinj districts in Serbia during 2022.

Results and Discussion. Statistical processing of the obtained data showed that the Gardasil 9 vaccination with the first and second doses of the vaccine in persons older than 9 years and persons older than 15 years was best carried out in 2022. of the the territory of the Pomoravlje District in the cities of Ćuprija (59.65%) and Despotovac (57.69%), while the least was implemented in the territory of the Pčinj district in 2022 were in the cities: Bosilegrad, Preševo and Trgovište based on distributed doses and remaining unused vaccines (stock).

Conclusion. Through educational lectures on vaccination against HPVirus children, adults and the entire population acquire positive attitudes about prevention as one of the most effective methods in suppressing and spreading the said disease. This is all with the aim of raising health awareness among the population and reducing the costs of the health system during the treatment of possible complications of HPV infection, as well as reducing the morbidity and mortality of this disease at the level of one country.

Keywords: HPV infection, cervical cancer, vaccine prophylaxis, education

Vaccine prophylaxis as the key to success against polio

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Introduction. Polio (lat. *acute anterior poliomyelitis*, Henne-Medin's disease) is an acute infectious disease caused by Poliovirus (types 1, 2 and 3). The disease most often occurs in childhood, either individually or in epidemics. The routes of transmission of the infection are the oral-fecal route. The infection can occur without any symptoms or as a general infection, such as meningitis or paralysis. The clinical picture of the disease shows the appearance of several stages: the pre-lytic stage, the paralysis stage and the recovery stage. The fastest way to confirm the diagnosis is to prove viral RNA by PCR in stool, blood or cerebrospinal fluid. There are also serological neutralization tests. During the acute phase, symptomatic and supportive therapy is carried out, and after the acute phase, active physical therapy and rehabilitation are carried out in more severe forms of the disease. Today, this disease is very rare, thanks to systemic active immunization. Primary immunization against polio is in the first year of life with three doses of pentavalent Pentaxim vaccine, six weeks apart, and revaccinations are carried out according to the mandatory vaccination calendar in the second, seventh and fourteenth years of life. The vaccine given in multiple doses provides protection throughout life.

The Aim of this paper is to compare the results of successfully implemented vaccine prophylaxis at the level of primary health care for the territory of the Pomoravlje District in Serbia in the period from 2016-2020.

Results and Discussion. Based on processed statistical data for the period 2016-2020, it can be seen that by far the largest number of persons vaccinated with the OPV vaccine was in 2016 in the municipalities of Despotovac and Paraćin, and in 2020 the smallest response is in the territory of the municipalities of Rekovac and Svilajnac, where the percentage of vaccinated was less than 95%.

Conclusion. The key to success in the fight against infectious diseases is reflected in the implementation of mandatory immunizations according to the vaccination calendar prescribed by each country and is considered one of the best ways to reduce morbidity, eliminate, even eradicate infectious diseases.

Keywords: polio, vaccination calendar, immunization

Investigation of the effect of surface roughness on the structural features of dental implants

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Teeth are crucial for the complete start of digestive function, speech and aesthetics and can be lost for various reasons. Dental implant applications are the first choice in tooth loss. These implants, which are usually made of pure titanium or its alloy, are structures that imitate lost tooth roots. High osseointegration occurs as a result of a successful implant planning. Osseointegration refers that the implant placed is compatible with the jawbone, accepted and wrapped by the bone tissue.

There are various factors that affect osseointegration. It is believed that the roughness and morphological changes applied on the dental implant surface affect the responses of tissues and cells to the implant. With the increase in surface roughness, an increase in primary and mechanical stability occurs. Thus, it is thought that the osseointegration time and recovery time can be shortened, so that failures can be prevented. Despite the high success rates, implants may fall off after placement for various reasons. Factors that cause the implant to fall can be classified as stemming from the patient's habits and health status, implant stemming, surgical procedure and mechanical stemming. Among these factors, the hardness, purity or sterility of the implant surface is not suitable, damage and fractures on the implant and superstructures, the formation of periimplantitis can be shown.

There are many surface modification methods available to increase the surface roughness. One of these methods is standard sandblasted-acid etched (SLA) implants. The purpose of SLA application is to roughen the surface by etching and sandblasting with acid. Despite the advantages of this method, it has been observed that it leaves acidic waste residue and destroys the surface during the sandblasting process.

In this study, it was compared to 4 sandblasted and acid-etched failed implants with 4 unroughened and untreated implant surfaces. The radiography examination method was performed to detect defects both inside and on the surface of the implants. The effect of the surface modification on the physical properties was evaluated considering the implant's roughness as the result of the comparison with SLA surface modification and untreated implant surfaces.

Evaluating changes in retinal nerve fiber layer and photopic negative response for patients under glaucoma treatment

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We assessed the structural and functional changes of the optic nerve in patients under glaucoma treatment. Our study was carried out by evaluating: (a) the retinal nerve fiber layer (RNFL) thickness taken from the spectral-domain optical coherence tomography (OCT) system and (b) the photopic negative response (PhNR) of the electroretinogram (ERG) test recorded by the RETeval portable device. The RETeval system and the corresponding sensor strip electrodes were provided from the LKC Technologies Inc. We performed examinations at the Ophthalmology Clinic of the "Elpis" General Hospital of Athens on a sample of 114 eyes in total. Several parameters were examined under statistical correlations via the SPSS software package. Amongst the most important were the: age, RNFL, Pmin, W-Ratio, a-wave and b-wave. Statistical analysis was performed by bivariate linear correlation tests with RNFL as the independent parameter. Results showed that there were no statistical differences between age interval subgroups (30-50 and 51-80 years old) for the control group, especially on the time responses of amplitudes on PhNR parameters. In addition, statistical difference was found between the control group and the group under glaucoma treatment for both OCT and RETeval parameters, including RNFL thickness and PhNR. More specifically, RNFL turned out to be correlated to bwave (ms) and W-ratio parameters. Our findings indicate that the PhNR obtained by the RETeval system may be a useful tool to accompany the routine diagnostic systems on Opthalmology, in order to follow up the patients under glaucoma treatment.

Keywords: electroretinography, glaucoma, ophthalmology

Ethical approval. Approval by the Research Ethics Committee of the University of West Attica, Greece, Approval number 82608/19-09-2022.

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Effects of seeds irradiation with a microwave on the properties of wheat

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Increasing plant yield and improving their quality as one of the grand challenges leads to stimulating the search for new methods of seed treatment before their seeding. Therefore, it is important to explore alternative methods of seed management such as using irradiation in seed treatment. This is essential prior to conventional options failure. Physical methods of seed material refining have been developed as an alternative to the crops' chemicalization. Refining the seed material should not only increase its vigor and reduce the variability of physical and chemical properties but also should have a beneficial effect on the growth and development of plants even in the next generation.

Microwave irradiation of seeds is one of the methods of physical stimulation of seed material. Irradiation by microwave as non-ionizing radiation has been applied in several studies in microbiology, soil, and food sciences.

The present study explores the effect of microwave energy on wheat seeds. As the exposure of seeds to microwave radiation and then planting these seeds, the effect of microwave radiation on germination, growth, and different morphological parameters will discuss to confirm that microwave treatment is effective in this field. A microwave emitter with a frequency of 9.88 GHz and power of 4.6 mW is applied on wheat seeds for times 10, 20, 30, and 40 min at distance of 1 cm from the Microwave window.

After that, the germination process was carried out under the same conditions in the designated dishes. Germination properties were recorded and compared with the reference sample.

Determination of the original dose of irradiated fruits by EPR spectroscopy

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In the last three decades, the irradiation of food with ionizing radiation has been introduced as an easy, cheap, clean and safe technological process, reducing the spoilage of food products and improving their quality. Electron Paramagnetic Resonance (EPR) is one of the most promising methods for identification of irradiated foodstuffs. In the present study, we refer to two of the Standards for irradiated foods using EPR technique adopted by the European Committee for Standardization - EN 1787 and EN 13708. The fruits were gamma-sterilized with different doses. For dried figs gamma-induced free radicals are due to the paramagnetic centers, generated in the sugar crystals while in rosehip samples in cellulose. After irradiation of dried figs, a complex signal was observed as the various mono- and di-saccharides are present in different amounts in the sample as a result may dominate different lines in the EPR spectrum. Carbon-centered free radicals from the cellulose are generated in rosehip. The intensity increases with the dose used. The dependence of EPR signal intensity on instrumental parameters (modulation amplitude and microwave power) was made as it is essential to obtain a maximal intense and undistorted EPR spectrum. The radiation induced radicals in figs stored at different conditions are stable over time thus the radiation identification is possible for long time after radiation treatment unlike rosehip samples. Single Aliquot Additive Dose method was applied to estimate the original dose.

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Evaluation of gamma irradiation effects on antioxidant capacity of propolis

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Propolis is a beekeeping product known to be beneficial for human health, with high content in polyphenol substances which may act as powerful antioxidants. A wide range of pharmacological properties were demonstrated for this substance which suggest to use it in medicine and as additive to some cosmetics. In connection with the increasingly widespread application of gamma radiation in pharmaceutical and cosmetic industry as a non-thermal technology for microbial decontamination, the aim of this study was to evaluate the irradiation effects on the antioxidant capacity of propolis. In view of this, the content of phenolic compounds of irradiated propolis ethanolic extracts were studied. It was found that gamma treatment of samples with 2 kGy and 10 kGy had a weak decreasing effect on the total phenolic content (TPC), while no change was observed in the propolis irradiated with 5 kGy. The antiradical activity of extracts was assessed by the DPPH free radical scavenging activity evaluated by Electron Paramagnetic Resonance (EPR) spectroscopy. The EPR results were in agreement with TPC. A noticeable negative effect on radical scavenging activity was observed in the samples irradiated with 2 kGy. Some main phenolic compounds of the studied non-irradiated and irradiated samples were identified and compared by high performance liquid chromatography (HPLC).

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Detection of chemical changes in X-rayed potato tubers using fingerprinting technique

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The growth in the popularity of irradiation treatment in food industry and agriculture calls for a methodology to facilitate the detection of irradiated foodstuff since the current analytical methods not only have a limited scope and a low sensitivity to irradiation at low doses, but also require sophisticated and expensive equipment.

The change in the chemical composition of foods during irradiation allows for the use of physical and chemical methods of analysis. Considering that fingerprinting technique, based on the analysis of spectra, chromatograms and voltammograms, is more rapid and more affordable than other detection methods, it is seen as a promising method of food irradiation detection.

The study focuses on the prospects of using the fluorometric fingerprinting technique to distinguish between irradiated and non-irradiated potato samples immediately after irradiation and after storage.

Potato tubers of the Agatha and Lina varieties, provided by the Siberian Institute of Agriculture and Chemistry under the Siberian Federal Scientific Research Center of the RAS, were X-rayed using a DRON UM-2 unit with a BSV-23 copper anode X-ray tube.

Potatoes were cut into (15 x 5 x 5) mm^3 parallelepipeds, put into polypropylene test tubes and then placed in front of the beryllium window of the X-ray tube. The dose rate absorbed by potato samples was determined using a Fricke dosimeter and amounted to 1.8 Gy/s. The samples were irradiated with the doses 100 and 1000 Gy and then analyzed using fingerprinting technique on the day of irradiation, as well as on the days 2 and 6 after it.

For extraction, the samples were mixed with a solution of distilled water and ascorbic acid to prevent their darkening and then placed in an orbital shaker for 12-20 hours. Samples which were not used for extraction were stored at 4°C for further detection.

Carbocyanine dyes were added to the resulting extracts to detect redox and aggregate type indicator reactions. After filling in polystyrene plates the indicator reactions were conducted in the obtained solutions. Then the solutions were photographed in the visible spectrum, as well as in the IR and UV wave ranges in order to register the intensity of fluorescence and change in the color of solutions. The resulting images were digitized using ImageJ software and processed using the XLSTAT Excel add-in. The visualization consisted of two-dimensional graphs in the coordinates of LDA factors.

Using analysis, it was possible to distinguish between non-irradiated samples and potato samples irradiated with the doses of 100 and 1000 Gy. The samples were successfully identified on all days of the experiment from the 0 to 6, which proves that the fingerprinting method allows to reveal the fact of irradiation of potatoes tubers both immediately after irradiation and a few days after it.

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Development of a method to identify and quantify the content of the active form of protein molecules after exposure to radiation using enzymatic hydrolysis by trypsin

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One of the main objectives of the food industry is to increase the shelf life of food while maintaining its nutritional value and safety. Ionising radiation treatment is an effective method of inhibiting the growth of pathogens that lead to food spoilage without the use of chemicals and temperature increases.

Radiation treatment breaks the chemical bonds of protein molecules both by interaction with radicals produced by radiolysis of water and by direct absorption of radiation energy. In amino acids, forming the native structure of protein molecules, hydrogen detachment or addition, amino acid cross-linking and other changes occur. As a result of molecular processes, protein disintegration or aggregation, and the formation of new polypeptide compounds are possible.

The aim of this work was to develop a method for identification and quantitative estimation of content of active form of protein molecules in aqueous solution using high resolution liquid chromatography-mass spectrometry (HPLC) when investigating the effect of radiation exposure on its structural characteristics.

Bovine serum albumin (BSA fraction V, BioClot) was used as an object of investigation. BSA fraction V was diluted in physiological solution of 0.9 % NaCl in the concentration of 500 mg/l.

The choice of bovine serum albumin (BSA) as an object of study was due to its frequent use as a model protein in many studies, because it contains 8 essential amino acids and comprises 60% of all plasma proteins, is present in the cellular space and performs a wide range of functions.

The samples were irradiated using continuous electron accelerator UELR-1-25-T-001 (Research Institute of Nuclear Physics, Moscow State University, Russia) with the energy of 1 MeV.

Method for identification and quantitative estimation of content of active form of BSA using enzymatic hydrolysis by trypsin method was developed and tested in aqueous samples of BSA by HPLC-MS/MS, which is characterized by high sensitivity (0.5 μg/ml BSA) and specificity in study of irradiation effect on structural characteristics of protein.

For the first time, the data on effect of accelerated electrons with 1 MeV on protein structural properties in BSA solution irradiated at 18.5 Gy/s in doses of 0.3 kGy, 0.6 kGy, 1 kGy, 4 kGy, 8 kGy and 20 kGy were obtained. This method allowed to detect a significant decrease of native protein BSA content in samples for all irradiated samples. Using the developed approach, it was shown that irradiation in doses 0.3 kGy, 0.6 kGy and 1 kGy leads to denaturation of protein in BSA solution and to threefold decrease of active protein form content in comparison with control samples. At high doses of irradiation, a further decrease in the native form of BSA in the solution is observed, and at a dose of 20 kGy no unique peptide was detected.

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Valence distribution of As-76 atoms in arsenic thiocompounds irradiated with neutrons

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The distribution of the valence states III and V of radioactive ^{76}As after neutron irradiations of thioarsenic compounds has been investigated. The irradiated compounds were thioarsenites as well as sodium thioarsenate; fresh precipitated arsenic trisulfide was also investigated. Materials were irradiated with neutrons at a flux of 10^{12} n cm^{-2} s^{-1}. The radioisotope formed by (n, γ) reaction is ^{76}As with $T_{1/2}$= 26,4h. Separations of valence states were performed by high voltage electrophoresis at a gradient of 35V cm^{-1} on 3MM Whatmann paper. Radiochemical yield of As^{V} in the hydrated thioarsenites was very high but when dehydrated thioarsenite is irradiated, the yield of the radioactive As ^{V} was much lower and similar to that obtained in the irradiated disordered trisulfide. On irradiated thioarsenate the retention was also very high. These yields are like those found in the previous work on irradiating As sulfides and it seems to be related to the covalent character of the As-S bond; likewise, internal conversion accounts for the primary oxidation of recoil atoms.

Radiation-induced catalysis in the presence of metal oxide nanoparticles produced by pulsed electron beam evaporation

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Organic dyes used in various industries in the textile, cosmetic, chemical and pharmaceutical industries are one of the main sources of chemical pollutants (Qian et al., 2021). They can easily dissolve in local bodies of water and can pose a threat to the environment and human health. Metal oxide nanoparticles (NPtles) have been found to be suitable candidates for water purification due to their ability to generate or absorb free radicals and reactive oxygen species. Accelerated X-ray-induced degradation of nitrophenol has been reported (Shaoqingetal., 2010) in the presence of NPs TiO_2. At the same time, the catalytic activity of metal oxide nanoparticles strongly depends on their physical properties, such as size, shape, specific surface area and various defects.

Promising materials for research in this direction are nanostructures in mesoporous aggregates/agglomerates, which are characteristic of NPs produced by pulsed electron beam evaporation (PEBE) (Sokovnin and Ilves, 2022). The purpose of this work is to evaluate the catalytic degradation of the organic dye under pulsed bremsstrahlung in the presence of NPs prepared by PEBE method, SiO2 with and without a nanosilver coating, CeO_2 and Bi_2O_3.

Aqueous suspensions of the test NPs at a concentration of 300 μg/ml were prepared for the study. Methyl violet (MV) (10 μg/mL) was used as the organic contaminant. The samples were irradiated with bremsstrahlung (convector was from low carbon steel) on a repetitive nanosecond accelerator URT-0,5 M (0.5 MeV, 60 ns, 10 pps). The exposure time was 2-20 min, the absorbed doses were measured with a dosimeter ID-1 (Δ±20%) and were 1.2-12 Gy, respectively. The absorption spectra of the samples before and after irradiation (500-700 nm) were measured using a spectrophotometer SF-2000. The peak absorption of the MV dye was recorded at a wavelength of 584 nm. For analysis of catalytic activity, the rate of discoloration of MV was calculated. Measurement error was 9.2%, $p = 0.95$.

The results of the study showed that all examined NPs show sufficient radiolytic ability. The highest rate of MV degradation was found for Bi_2O_3 and CeO_2 samples, which accelerates discoloration by 6.3 and 4.8 times, respectively, compared to the control sample. This effect appears to arise from the absorption of low-energy photons, resulting in secondary highly ionizing radiation. However, the radiolytic activity of the SiO_2 + Ag sample was lower than that of the original SiO_2. This decrease in the activity of this material under these experimental conditions is contrary to the synergistic effect in the metal-semiconductor pair (Guoetal., 2021) and requires further research.

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^{236}U and its determination with accelerator mass spectrometry

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The uranium isotope ^{236}U has recently become one of the established tools of isotopic analysis, with a wide range of applications not only in nuclear safeguards and forensics, but also increasingly in environmental analysis. Its determination allows both quantitative and qualitative analysis of possible emissions, including identification of the nature of the source. Due to its almost entirely anthropogenic origin, combined with highly chemically conservative behaviour, it is often used as a tracer for ocean currents as an alternative to the ^{137}Cs approach. As trace concentrations of this radionuclide are present in environmental samples, accelerator mass spectrometry (AMS) is used almost exclusively for this purpose, allowing accurate determination of ^{236}U/^{238}U ratios routinely down to 10^{-14}. The first such facility in the Czech Republic, based on the multi-isotope MILEA system from Swiss manufacturer IonPlus AG, has recently been built in Řež near Prague.

Keywords: ^{236}U, accelerator mass spectrometry, environmental analysis, nuclear safeguards

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Radioisotopic ratios in marine research – a multi-case study

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Radioisotopes play an important role in studying marine environment due to their unique properties and ability to act as tracers. The study of marine environments is crucial, as oceans and seas play a significant role in global climate and are home to diverse ecosystems that are essential to human well-being. Radioisotopic research allows for a better understanding of the biogeochemical cycles and transport pathways of elements in the marine environment, and provides insights into the impacts of human activities on marine ecosystems. Apart from examining the impact of human activities on marine environments, the radioisotopic research also provides insights into the functioning of marine ecosystems. Even no less important, radioisotopic tracers such as ^{137}Cs and ^{235,236,238}U address the need to depict the dynamic circulation in areas especially in subsurface layers, and the water spread providing insights into the mechanisms that control their cycling.

Uranium, plutonium, and iodine radioisotopes are particularly important in marine radioisotopic research due to their prevalence and potential for environmental impacts. Uranium is a naturally occurring element (with manmade isotopes such as ^{236}U) that is found in the ocean and can act as a tracer for oceanic processes such as mixing and upwelling. Plutonium, on the other hand, is a man-made element that was introduced to the environment through nuclear weapons testing and nuclear accidents. Its long half-life and potential for bioaccumulation make it a significant environmental contaminant. Iodine radioisotopes are also important in marine environments as they are released during nuclear accidents and have the potential to impact marine life. The studies of the ratios between their radioisotopes, ^{235,236,238}U, ^{241,244}Pu & ^{129,127}I, require comprehensive research with a high level of technicism. Radioisotopic research can also help to determine the fate and transport of these contaminants (data feeds models) as well as their potential impacts on the environment and human health.

The presented study pursues different regions and their dynamic developments through a multi-technical research study on environmental samples from Vefsna Fjord in Norway and Kolpo Almirou in Crete. The study involved 26 sediment samples, 3 soil samples, 6 water samples, together with 16 test-blank-reference samples analysed by various techniques. Distinct isotope ratios ^{235,236,238}U, ^{241,244}Pu, and ^{129,127}I were measured using the accelerator mass spectrometry (AMS) with the ultimate goal to estimate their origin, spreading, and environmental stability. The study forms part of the larger environmental program, RAMSES, that employs ultra-trace isotopes using accelerator mass spectrometry to conduct impactful research.

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Isotopic signature and mixing between groundwater, surface water and precipitation in the Zagreb aquifer area

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Zagreb aquifer presents the main source of potable water for the inhabitants of the City of Zagreb and Zagreb County. It presents strategic water reserves and is protected by the Republic of Croatia. Within this study new results from the Zagreb aquifer area related to the tritium activity and stable isotopes of water are presented. The research was done within the IAEA Regional Technical Cooperation Project RER 7013 „Evaluating Groundwater Resources and Groundwater–Surface Water Interactions in the Context of Adapting to Climate Change", case study SAVA. Tritium activity was measured by the liquid scintillation counter Quantulus at the Ruđer Bošković Institute, Zagreb, Croatia, and at the Faculty of Sciences, Novi Sad, Serbia. All samples were electrolytically enriched before the measurements. Stable isotopes of water (δ^2H and $\delta^{18}O$) were determined by laser absorption spectroscopy at the Laboratory for Spectroscopy, Faculty of Mining, Geology and Petroleum Engineering, University of Zagreb.

Isotopic composition was measured in precipitation, groundwater and at two locations in the Sava River, one at the entrance and the other at the exit of the Zagreb aquifer. The data presented in this study cover the period from May 2021 to April 2022. Both the Sava River and groundwater isotopic compositions fall on the Zagreb LMWL during the observed period, while the two-component mixing model suggests slightly higher river fraction in groundwater compared to precipitation. Although previous studies have shown that the Sava River is the main source of recharge to the Zagreb aquifer, these results suggest that the influence of the Sava River is less pronounced during the low water level periods.

Elevated tritium activity was determined in both monitoring points in the Sava River, in three occasions, with the highest value of approximately 122 TU. Tritium activity in precipitation varied from approximately 4 to 13 TU, while groundwater showed the smallest variation, mostly between 6 and 9 TU. Although peaks of tritium activity have been observed in the Sava River, they were not seen in the groundwater of the Zagreb aquifer (observation well Pzo-21), which corresponds to the higher precipitation fraction in the Zagreb aquifer than usual. However, monitoring must be continued to see how recharge fractions will change in time, but also to inspect if tritium activity will be observed in groundwater with delay.

Concentration of selected radionuclides in high dust deposition areas: Consideration of depleted uranium

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The activity concentration of the natural radionuclides and ^{137}Cs has been determined in two years of collected dust fallout samples from ten locations in the Northern Arabian Gulf. A single-piece PVC bucket of 0.2 m diameter and 0.4 m depth was used to collect dust fallout samples. Adequate quantities of collected dust were measured by ultra-low background gamma spectrometry equipped with a large diameter broad energy germanium detector (BEGe) that enables to resolve low energies gamma emitters such as 234Th and 210Pb. The detection efficiency of different dust masses and cascade correction were applied using LabSOCS simulation software. The average monthly concentration of ^{137}Cs, ^{210}Pb, ^{7}Be, ^{40}K, ^{224}Ra, ^{226}Ra, ^{228}Ra, and ^{234}Th radionuclides obtained was considerably varied from interior to coastal areas. Direct measurement of ^{234}Th was used to estimate ^{238}U, considering a secular equilibrium. The ^{235}U concentration was calculated using the highest intense gamma line, 185.7 keV (0.57), and taking into consideration the interferences with the ^{226}Ra (186.2 keV) gamma line with a low gamma yield (0.036). The calculated radioactivity ratio of the uranium ^{235}U and ^{238}U indicated normal activity relative to the amount of natural uranium. The measured activity ratios of ^{224}Ra and ^{228}Ra and $^{7}Be/^{210}Pb$ confirmed the effects of the regional dust sources.

Sorption of Europium and Cobalt using thermally modified winery waste

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Radioactive pollutants present in liquid wastes pose significant threats to the environment and human health as they can contaminate water sources, soil and air. They can be found in liquid wastes produced by various industries such as nuclear power plants, hospitals, mines, laboratories, etc. and can cause long term health problems due to their toxicity and emitted radiation. So, it is really important to be removed from the environment with application of several techniques such as biosorption using agricultural byproducts as sorbents.

In this study, the sorption of europium and cobalt onto thermally modified winery waste was explored using a batch technique in aqueous solutions of different initial concentrations. The sorption capacity of the biosorbents was investigated under batch conditions at room temperature (20 ± 1 ^{o}C) in the concentration range 5–500 mg L^{-1} at pH 4 and 8 for Eu and Co, respectively and dosage 1 g L^{-1}.

The investigation was performed with gamma-spectrometry using radioactive tracers. Recycling and modification of winery waste was tested as a possible method for the production of biosorbents. The modification was achieved after thermal modifications with and without activation via oxidation.

The overall objective of this study was first, to apply nuclear spectrometric techniques for determination of the sorption capacity and second, to investigate whether sorbents based on agricultural wastes could be used for the removal of radionuclides from low level wastewater.

The results showed significant sorption capacity of the tested materials demonstrating their effectivity and possible use in nuclear waste treatment.

Production yield analysis of ^{97,95}Ru radionuclides from Li-induced reactions

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Accelerator-based production of radionuclides opens up a doorway to modern-day pharmaceutical or industrial demands. Generally, light-ion-induced reactions are preferred for the large-scale production of nuclides. However, sometimes the heavy-ion-induced reactions (with proper optimization) offer substantial yield for the desired radionuclide with minimal impurities. The medically relevant ^{95,97}Ru radio-isotopes produced in ^{6,7}Li reactions on the ^{93}Nb target may be exploited in this endeavor. The experimental residual yields have been measured within the 20-45 MeV energy range employing the activation technique followed by offline γ-activity measurements at the BARC-TIFR Pelletron facility in Mumbai, India.

The measured production cross sections lie in the range 56.9±6.3-3.2±0.8 mb for ^{97}Ru (2n-channel) with a maximum of 56.9 mb at 24.2 MeV and 0.1±0.02-249.8±23.9 mb for ^{95}Ru (4n-channel) with a maximum of 249.8 mb at 41.8 MeV in ^{6}Li reaction. Whereas it was 587.3±52.7-80.6±11.2 mb with a maximum of 587.3 mb at 28.5 MeV for ^{97}Ru (3n-channel) and 2.3±0.4-87.5±13.9 mb with a maximum of 87.5 mb at 44.9 MeV for ^{95}Ru (5n-channel) from ^{7}Li reaction [PRC 94, 044603 (2016)] studied by us. The corresponding highest experimental yields for unit parameters (1μA beam current irradiated for 1 h on 1 mg/cm^2 thick target) such that the production becomes free of experimental conditions have been achieved to be 6.5±0.9 MBq/C and 967.5±116.2 MBq/C for ^{97}Ru and ^{95}Ru, respectively, from ^{6}Li reaction, while 67.1±7.7 MBq/C for ^{97}Ru and 339±59.3 MBq/C for ^{95}Ru in ^{7}Li reaction. The estimated thick-target yield over the studied range is 812.9 MBq/C for ^{97}Ru from 49.2 mg/cm^2 thick target in the ^{7}Li reaction and 9719.5 MBq/C for ^{95}Ru from 19.6 mg/cm^2 thick target in the ^{6}Li reaction. For the ^{7}Li reaction, one may choose the energy window of 20-44 MeV for the dominating production of ^{9}7Ru with no contamination from coproduced ^{95}Ru isotopic impurity. Similarly, the experimentally explored energy window of 30-43 MeV extended to 60 MeV (suggested by theoretical calculations) could be assessed from the ^{6}Li reaction for the appreciably high yield of ^{95}Ru with minimal traces of ^{97,94}Ru isotopes. It is pertinent to mention that the maximum purity of medical isotopes could be achieved by optimizing the reaction parameters such as beam current, target thickness, and energy window depending on the half-life of the coproduced isotopic impurities. However, one may avoid the coproduced non-isotopic radionuclides through chemical separation methods. Thus, from the application perspective, the ^{7}Li reaction may be opted for producing ^{97}Ru, while the ^{6}Li reaction may be proposed for producing ^{95}Ru with minimal contamination. Moreover, the generated reaction data may be of great value for optimizing theoretical model parameters to assess the high-purity viable production of novel isotopes.

Visualizing industrial processes with gamma process tomography: A non-invasive approach

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Gamma scanning is a useful and non-intrusive technique for inspecting dense and critical parts of distillation columns in petroleum refineries and chemical plants. This technique, also known as column scanning, is cost-effective and efficient, allowing engineers to examine the inner details of a distillation column while it is in operation. This provides valuable information on tray or packing hydraulics under different online conditions, which can help optimize column performance, extend column run times, track performance-deteriorating effects of fouling and solids deposition, and identify maintenance requirements well in advance of scheduled turnarounds. By reducing repair downtime, this online knowledge can greatly benefit industrial operations.

Similarly, gamma process tomography is a non-invasive imaging method that utilizes gamma rays from a radioactive source to create images of the internal structure of materials, including pipelines, reactors, and chemical process vessels. By measuring gamma ray attenuation in different materials, gamma process tomography can identify the presence of solids, liquids, and gases within a structure. This technique can be used to optimize process efficiency and detect potential problems or defects, as it provides valuable information about the flow patterns and distribution of materials within a structure. This study using gamma process tomography demonstrated its potential to improve industrial processes by providing information on material distribution.

Assessment of Ho(III), Er(III) and Gd(III) uptake by cyanobacteria *Arthrospira platensis* using neutron activation analysis and their effects on biomass biochemical composition

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Intensive exploitation of rare earth resources and their wide application in industry and agriculture results in their release in aquatic environment and can have negative impact on water organisms. The effect of Ho(III), Er(III) and Gd(III) introduced in the cultivation medium at the third day in concentrations 10-30 mg/L on *Arthrospira platensis* accumulation capacity and biochemical composition was investigated. The uptake of elements by cyanobacteria biomass was traced using neutron activation analysis. The dose dependent accumulation of elements in biomass was observed. Supplementation of medium with Gd(III) did not influence considerably amount of biomass, while Er(III) and Ho(III) reduced it up to 22% in comparison with control. The changes in the content of proteins, carbohydrates, phycobiliproteins, lipids, β carotene and chlorophyll a under influence of rare earth elements were assessed. Studied elements affected differently the content of the main biomolecules and allow to draw a conclusion that Ho(III) and Er(III) are more toxic for *Arthrospira platensis* than Gd(III).

Previous impoundment studies on Itaipu Dam: submerged biomass effect in water quality

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Building up by Paraguay and Brazil on Alto Parana River (APR) the reservoir cover in area 1440 km². Its impoundment of the right bank, Paraguayan side, flooded about 570km² of vegetation, mainly of height and lower forest, crops and soil. Prior to the impoundment Itaipu Binacional conducted a large number of environmental studies, some of them in reference of the chemical effects of the biomass (BM) on water quality such us phosphorus supply and reduction of dissolved oxygen (DO) concentration, inter alia. In the latter, simulation experiment provides interesting data. This submersion/ incubation experiment on DO consumption were carried out with appropriate amounts of BM samples and APR water, in which DO were determined. Through the oxygen consumption decay curves and their kinetic analysis of the oxidation of the BM, they were found, fast processes with a high oxygen avidity, as well as others slower, with a relative low oxygen consumption, following both, e-ln2t/Tkinetic; the former, of the order of days, are due to the oxidation of soft parts of the plants, like lives, shoots, petioles and twigs, while the latter, of the order of years are resultant to the hard parts, like trunks, logs, etc. The phosphorus supply by decaying vegetation at the right bank, was low in comparison to the amount carried by the APR. In addition, the low residence time of water in the reservoir allows fast DO input renovations.

Effect of mycelium-based biosorbent modifications on efficiency of strontium removal from aqueous solutions

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Biosorption is a physico-chemical, metabolically-independent process that can be applied to the removal or recovery of organic and inorganic substances from solution by biological material. It is a very promising, ecological and cost-effective clean-up biotechnology. Various biomasses, including both living and dead organisms or their components, have been tested for different pollutants biosorption with very encouraging results. As a promising class of low-cost biosorbents fungi have been recognized. Biosorption based on fungal biomass can be successfully used to remove radioisotopes, including strontium-90, from the aquatic environment. The efficiency of the process of removing pollutants by biomass can be increased by appropriate chemical or physical modifications of biosorbents.

The purpose of the research was to analyse the possibility of using the dried mycelium of two species: king oyster mushroom *Pleurotus eryngii* and turkey tail *Trametes versicolor* for effective removal of strontium-90 radioisotope from the aquatic environment. For the studies mycelia were cultivated in liquid growth medium. In order to obtain the highest efficiency of the strontium biosorption process, the dried mycelia were modified by high temperature and gamma radiation. In addition, the efficiencies of radioisotope biosorption for other natural materials, including coffee grounds and citrus fruit peels, were compered.

It has been shown that the applied mycelium-based biosorbents can effectively remove strontium from the aqueous solution with an efficiency of up to 60%. This is a relatively high efficiency, although it is lower than in the case of other biosorbents used in the studies – coffee grounds and citrus fruit peels, where more than 80% of the strontium radioisotope can be removed from the solution. The use of high temperature and gamma radiation significantly modified the properties of mycelium-based biosorbents, changing their sorption capacity and thus the efficiency of strontium removal from aqueous solutions.

The conducted research showed that biosorbents based on the modified fungal material can potentially be used to remove radioisotopes from the aquatic environment. It was confirmed that the sorption of radioactive nuclides in biomass can be an alternative to traditional physical and chemical methods of water remediation or waste water treatment.

Natural and artificial radionuclides in wood biomass used for heating – comparison of North-East Italy and imported wood pellets

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The problem of radionuclides contamination in imported wood pellet, used for industrial and domestic heating, rose for the first time in Italy in June 2009 in a batch from Lithuania, in which a concentration of ^{137}Cs of about 300 Bq/kg was measured, increased to about 40000 Bq/kg in the residual ashes after burning.

The radioactive fall-out due to the Chernobyl accident (24 April 1986) deposited over extensive areas of central and northern Europe and affected also areas exploited for agroforestry and forestry resources.

As it is known, in fact, the soil contamination occurred almost like "leopard spot" i.e. in a heterogeneous way also at thousand kilometres away from the Chernobyl site. The potential radioactive contamination that might be currently present in woody biomasses is almost due to ^{137}Cs radionuclide, which has a half-life of about 30 years and therefore (depending on the contamination of the investigated area) is still potentially present in variable quantities in soils and vegetation.

The interest in the exploitation of biomass represented by pellet and wood chips (*cippato*) is nowadays of great importance due to its extreme thermal efficiency, its cheapness and its relatively low environmental impact in terms of carbon dioxide emissions.

A problem involved in this biomass, in the Italian context, is represented by the fact that the demand for pellets is much greater than the territorial possibility of self-production, therefore there is the need to import this resource from external countries and so with potentially non-negligible levels of radioactivity.

This work, conducted at ICMATE-CNR in Padua, aimed to investigate the presence and the quantity of ^{137}Cs, ^{40}K and other radionuclides possibly present in 27 samples of forest chips (mainly produced by *Picea abies* species) collected in the Trento province and in the ashes produced by the same samples burned in similar to domestic combustion conditions after been transformed into pellet (pellet stove at about 550° C). The latter data is of great importance since combustion in conditions similar to domestic ones made possible to reproduce conditions that could occur in domestic and collective uses.

The collected samples were subsequently analysed by high-resolution gamma spectrometry with a high purity germanium detector in order to evaluate the activity concentration of the artificial radionuclide ^{137}Cs and of the natural ^{40}K, first in the "fresh" samples of forest chips and subsequently in the same samples incinerated after their pelletization, with the aim of comparing the number of radionuclides of the former with respect to the latter and to determine the concentration factor.

The sampling extended to the whole province has allowed the authors to have a reliable and composite map of distribution of ^{137}Cs radioactivity in the wooded areas on the territory of the Trento province. ^{137}Cs was found in very low activity concentrations. ^{134}Cs was also searched but was found to be below the instrumental limits of detection in all the samples.

The results thus obtained were then compared and evaluated with respect both to dataset previously obtained from the same ICMATE-CNR laboratory consisting of 65 pellet samples from different areas of Eastern Europe (Bosnia, Croatia, Ukraine, Serbia and Russia) (rif. AIRP, 35° Congress, Venetia (VE), 17-19 October 2012) analysed in 2010-2011, and with respect to literature data relating to woody biomass for combustion of European origin.

Athermal healing of preexisting defect in crystalline silicon under local electronic excitation processes

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Irradiation of pre-damaged Si with intermediate-energy ions (12 MeV O and 12 MeV Si ions) reveals that preexisting disorders in Si (~70%) can be almost fully annealed. Compared to previous ionization-induced recovery reported for predamaged Si, the current study demonstrates that the same process is driven by ions with electronic energy loss (S_e) values lower to any values reported to date. For O and Si ions, the recovery cross-sections increases from 0.039 to 0.168 nm^2 with rising the S_e values from 1.58 to 3.05 keV/nm. In conjunction with theoretical calculations, we have noticed that with increasing S_e value a much higher temperatures during the transient thermal spike are obtained, leading to increased susceptibility of pre-damaged material to damage annealing.

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Structural characteristics of some bifunctional catalysts for rechargeable zinc-air batteries

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Zinc air batteries are reputedly known as a reliable option for sustainable energy storage due to their high energy density, low cost, high efficiency and environmental friendliness. Indeed, some problems are encountered in practice and need to be overcome with the eventually slow oxygen evolution reaction (OER) and oxygen reduction reaction (ORR), and the integration with an oxygen electrocatalyst was identified as the most critical component inevitably determining the operation of a rechargeable Zn-air battery, as its performance depends on the cathode material [DOI:10.1039/C9TA14231B]. Spinel-structured base metal oxides have attracted attention for long due to their satisfactory electrochemical performance and stability for OER in alkaline solution. We present here additional results on the performance of the recently developed carbon-free gas-diffusion electrode (GDE) - a mixture of catalyst (Co_3O_4, $NiCo_2O_4$) and polytetrafluoroethylene (PTFE) hot-pressed onto a stainless-steel mesh that works as a current collector [*Emerging Science Journal*, Vol 7, No 3 (2023)]. The electrochemical characteristics were investigated, including volt-ampere characteristics, charge/discharge tests and electrochemical impedance measurements Sensitive techniques such as neutron and X-ray diffraction combined with scanning electron microscopy and EDX-analysis were applied to improve the understanding of structural stability and recharge-related properties as an important step in the development of an innovative design of rechargeable zinc-air cells with high performance carbon-free reversible gas diffusion electrodes.

$NiCo_2O_4$ oxide showed better bifunctional behaviour and it was tested as a GDE in secondary tri-electrode Zn–air. The cell was cycled at 17 $mAcm^{-2}$ for a period of 380 h in alkaline media and the $NiCo_2O_4$ electrode displayed good performance. Acceptable coulombic and energy efficiencies were obtained. The results show that prepared in this way carbon-free gas-diffusion electrode is enough competitive to those prepared by classical technology using carbon black, which stability is the limiting factor for the cycle life of bifunctional air electrodes.

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Biocompatible collagen-based hydrogels with a hybrid structure developed by e-beam irradiation technology

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Hydrogels with a hybrid structure were formulated of collagen, carboxymethylcellulose, and chitosan as the main components of natural origin. The synthetic moiety was based on the different proportions of the high and medium molecular weights of poly(vinylpyrrolidone), respectively poly(ethylene oxide). The cross-linking reaction was carried out only through e-beam irradiation without the addition of cross-linking agents. The cross-linked structure of the hydrogels was characterized by correlating the rheological properties and the cross-linking degree with the specific structural parameters of the hydrogels. The collagen based-hydrogels showed the highest elastic modulus of ~15 000 Pa, while chitosan based-hydrogels have a lower elastic modulus. The hydrogel structure varied according to their chemical composition, so the collagen based-hydrogels showed a porous structure with interconnected and homogeneously distributed pores, which highlights a network structure with a three-dimensional conformation. The analysis of the C1s spectra evinced peaks of significant intensity specific to C-C bonds (284.4 eV), which suggests that the structure of the hydrogels is not degraded as a result of the irradiation process. In the case of chitosan based-hydrogel, a higher contribution of (C=O) and (O=C–O) bonds was observed, which can be associated with degradative processes in the chitosan hydrogel structure. The *in vitro* performance of the analyzed hydrogels was assessed through direct and indirect contact cytotoxicity tests following the ISO 10993-5 standards. The possible toxic effects were investigated using the epithelial VERO cells through viability/proliferation examination and phase contrast morphological characterization. Altogether, the obtained results suggested that between the three analyzed hydrogels, the collagen based-hydrogels exhibited the best cellular behavior in terms of cell survival and proliferation, the reason why it was chosen as a primary material for further studies.

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Speciation of fission products in the grey phases of spent nuclear fuel: A study of novel complex sodium, barium, and strontium molybdates

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When uranium-235 is used to generate electricity in nuclear facilities, fission fragments are produced as a result of the interaction of these fissile nuclides and neutrons. As these fission products accumulate within the fuel, they interact and form various phases. Elements with high fission yield such as strontium, barium, and molybdenum are of interest as they are known to combine with oxygen to form various species of complex oxides as part of the perovskite, or grey, phase of nuclear fuels. Understanding the complex speciation and thermodynamics (*i.e.*, thermal stability, heat capacity, enthalpy, *etc.*) of these fission products is important to provide an accurate description of the nuclear fuel behaviour under normal and abnormal reactor operating conditions. As such, contributors to the Thermodynamics of Advanced Fuels – International Database (TAF-ID) gather thermodynamic data of key fission product species. These data provide valuable input for dynamic simulations of nuclear fuel behaviour for a wide range of operational conditions, as well as interaction between fission products and the environment. This work synthesizes and measures the thermodynamic properties of a series of novel complex Ba-Sr-Mo-O compounds. Further, this work also includes thermodynamic information about Na-Mo-O species of interest to Generation IV sodium-cooled nuclear reactors to be included in future iterations of the TAF-ID.

In keeping with ALARA statutes, this study employed non-radioactive homologues of the fission product elements to aqueously synthesize various complex species. This ensured a high-purity sample for characterization and assessment of thermal behaviour. Unlike $Na_6Mo_7O_{24}$, which has been fully characterized in the literature, the existence of $Ba_3Mo_7O_{24}$ and $Sr_3Mo_7O_{24}$ have only been suggested. In this work, full characterization of these novel species includes a wide range of techniques: *i*) Fourier-Transform Infrared Spectroscopy, *ii*) Powder X-Ray Diffraction, *iii*) Energy Dispersive X-Ray Spectroscopy (EDAX), *iv*) Scanning Electron Microscopy, and *v*) Gravimetric Analysis. With these methods, the compounds were confidently identified. Both compounds then underwent a full thermal stability assessment using Thermo-Gravimetric Analysis and Differential Scanning Calorimetry, which provides insight into their thermal stability, decomposition, and sub-speciation. Obtained results indicate that the hydrated form of $Na_6Mo_7O_{24}$ is stable below 373 K. Decomposition at higher temperature is related to the loss of structural water. The rearrangement of the structure leads to sub-speciation into the simpler, more stable $Na_2Mo_2O_7$ and MoO_3, both of which are stable under a wide temperature range (*i.e.,* 298 – 973 K).

Effects of preparation route on magnetic ordering near room temperature in Al-substituted Ba-Sr Y-type hexaferrites

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Y-type hexaferrite $A_2Me_2Fe_{12}O_{22}$, where A = Ba, Sr and Me is a divalent cation, is an important class of soft magnetic materials in very high and ultra-high frequency ranges with numerous applications as radio-frequency and microwave components for the fast-growing industry of multifunctional mobile devices. Recent interest in the study of Y-type $Ba_{0.5}Sr_{1.5}Zn_2Fe_{12}O_{22}$ hexaferrite and its derivatives arose from the appearance in single crystals of an appreciably large near-room-temperature magnetoelectric effect in a reasonably low magnetic field. A helical spin arrangement was found to stabilize in the undoped crystal below the Neel temperature of $T_N \approx 326$ K. Obtaining sufficiently large single phase monocrystals has encountered great difficulties and in most of the current studies on possible utilization of multiferroic properties, polycrystalline powder samples have been prepared by solid-state synthesis or soft chemistry methods, such as sol-gel auto-combustion, which are well-established methods for synthesis of complex oxides. We present here a comparative study of the structure and magnetic properties of $Ba_{0.5}Sr_{1.5}Zn_2Fe_{12}O_{22}$ and its Aluminium-doped derivative $Ba_{0.5}Sr_{1.5}Zn_2Al_{0.08}Fe_{1.92}O_{22}$ synthesized by citric-acid sol-gel auto-combustion and sonochemistry methods. Since the magnetoelectric effect is related to the magnetic spin ordering, but through chemical doping a wide variety of non-collinear stable magnetic phases can be realized in the phase diagrams of hexaferrites, by combining new results from magnetization and neutron diffraction measurements, we give here an additional information on the influence of cation substitutions on the temperature of the magnetic phase transition, recently commented in connection with the observation of magneto-electric phases in hexaferrites [https://doi.org/10.1021/acsomega.2c05689]. The neutron diffraction data on powder materials taken at selected temperatures on the diffractometer SPODI installed at the research reactor FRM II present clear evidence for the destruction of the conical spin structure with the propagation vector along the *c*- axis between 298 K and 300 K. We address the influence of the route of preparation of Y-type hexaferrites on their magnetic properties and conclude that tuning magnetic symmetry is an effective path to enhance the magnetoelectric effects in multiferroic hexaferrites.

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Radiation-induced modification effects in covalent-network glass formers: phenomenological description within unified configuration-enthalpy diagram

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Radiation effects related to destruction-polymerization transformations induced by high-energy gamma-irradiation from a source ^{60}Co (structural changes where one covalent chemical bond is destroyed under irradiation but other bond is formed instead) are considered in chalcogenide glassy semiconductors at the example of their model representative, which is vitreous arsenic trisulphide As_2S_3, in transition to multicomponent systems (Ge-As/Sb-S/Se). The boundary cases of radiation-induced modification effects are considered for quasi-binary network glass-formers such as mixed-cation systems (MCS) like As_2S_3-Sb_2S_3, and mixed-anion systems (MAS) like As_2S_3-As_2Se_3. The unified configuration-enthalpy model based on configuration-coordinate and enthalpy/entropy/free volume diagrams is proposed to describe optical response in metastability of these glassy-like systems caused by combined action of physical ageing and high-energy gamma-irradiation. Within this phenomenological approach, the studied chalcogenide glasses are supposed to be stabilized in the ground and variety of temporary excited states, presented by interconnected wells corresponding to rejuvenation-, irradiation-induced, aged and thermodynamically-stable glass states tightly interlinked by thermally-activated over-barrier jump and through-barrier tunneling transitions.

On the numerical criterion of radiation-modification efficiency in chalcogenide glasses

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Phenomenological description of structural-modification effects stimulated by gamma-irradiation (from high-energy Co^{60} source) in semiconductor Ge-As/Sb/Bi-S/Se glasses is critically examined with respect to the role of intrinsic free volume determining compactness of their glass-forming network. Destruction of covalent chemical bonds in these chalcogenide glasses under irradiation is accompanied by structural relaxation, the phenomenon known as radiation-induced physical ageing tending these glasses towards novel metastable state. Within such relaxation occurring via direct interaction of bond-constituting atoms and nearest neighbors, the pairs of over-coordinated and under-coordinated atoms possessing an excess of positive and negative charge appear. The final optical response in metastability of these glasses is defined by combining irradiation-excitation and physical ageing-relaxation effects. In this report, the role of structural compactness in the efficiency of relaxation pathways is analyzed in chalcogenide glass-forming systems possessing different intrinsic free volumes.

Sequential dual ion beam irradiation effects on $KTaO_3$

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Pre-damaged $KTaO_3$ has been irradiated with several ion species (5 MeV C, 7 MeV Si, 12 MeV O and 18 MeV Si ions) over an extended selection of ion fluences at 300 K to explore how $KTaO_3$, with existing disorder induced by nuclear energy transfer (S_n), responds to subsequent electronic energy transfer (S_e). The experimental characterization and computer simulations demonstrates that, for a pre-damaged fractional disorder level of 0.3 and $S_e \geq 4.65$ keV/nm (7 MeV Si ions), the synergistic effect is active, which enables ion track creation under these conditions. In additions, we further show that the size of these ion tracks increases with S_e and level of pre-existing damage. For $S_e \leq 3.03$ keV/nm (5 MeV C and 12 MeV O), a transition from irradiation-induced disorder production to ionization-induced damage recovery processes is revealed.

X-ray induced structural changes in germanium sulfide glasses

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Unique physical properties of germanium sulfide glasses, such as relatively wide optical gap, high refractive index, low optical losses, satisfactory solubility of rare-earth ions and high sensitivity to the external factors, make them an attractive active and passive medium for various applications in modern optoelectronics. In this work, a high-resolution X-ray Photoelectron spectroscopy (XPS) is used to show the structural evolution of S-rich Ge_xS_{100-x} glasses within wide range of compositions (x =10 to 30). The influence of prolong X-ray exposure on their structure is studied in situ. XPS measurements show that with increasing Ge content, the glass short-range order evolves from individual tetrahedra connected through S chains towards the structural fragments that are found in high-temperature crystalline phase of GeS_2 (so-called 'outrigger raft' structural motive) embedded into S-based chain/ring network. The structure is described by a combination of 'chain crossing' and 'outrigger raft' models throughout the investigated compositions (x=10 to 30). It is shown that under prolonged in-situ X-ray irradiation the local network environment tends toward the ideal 'chain crossing' model, having more homogeneous distribution of the constituent chemical elements than the as-prepared samples.

Radiation synthesis of microemulsion-based hydrogels loaded with lavender oil

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The administration of drugs with poorly water-soluble molecules through the skin has better advantages compared to the oral administration of drugs used for skin healing. Microemulsion hydrogels have recently generated considerable interest in the biomedical field to develop devices for the topical and controlled administration of hydrophobic compounds with low solubility and permeability under physiological conditions, but with excellent properties for rapid wound healing. The essential oil included in the microemulsion-based hydrogels (MEH) in our study is volatile lavender oil (LO), due to its active principles such as anti-inflammatory, analgesic, and cicatrizing. The e-beam radiation synthesis of MEH is an attractive method because it includes several advantages compared to chemical methods, such as no toxic residue result, process control being easy to achieve, and simultaneously ensuring cross-linking and sterilization in the same technological step.

This study presents the e-beam radiation synthesis and characterization of MEH, consisting of carboxymethylcellulose (CMC), poly(vinylpyrrolidone) (PVP), poly(ethylene oxide) (PEO) loaded with LO. To optimize the emulsions, three mixtures consisting of surfactant (Tween 80) and co-surfactant (isopropyl alcohol) (IPA) with different ratios were prepared to form the microemulsion basis (Smix 3, Smix 4, and Smix 5). LO was dispersed into the Smix mixture in various mass ratios. The MEHs were characterized from a physicochemical point of view by gel fraction, swelling capacity, stability and biodegradation (physiological pH), rheology, and optical transparency, and from the morphological and structural point of view, by SEM and FTIR analysis.

The MEH formulated according to Smix 4 and 5 recipes, are not adhesive, retain their shape when handled, have an elastic character, and presented a moderate gel fraction of 55%. The hydrogels showed different swelling degrees, between 7700 - 18000 %, which proves that they are superabsorbent materials. The emulsions showed prolonged stability in different pH conditions, without dissolving and maintaining their structure, which proves that through the chosen composition and irradiation conditions, the emulsions are stable due to the formation of covalent bonds between the functional groups specific to the compounds used. Hydrogels with a high swelling degree and moderate biodegradation were selected for further studies since these compositions indicate that they contain a polymeric matrix with increased structural stability.

The new MEHs presented above are elastic and have a permanent network and increased liquid absorption capacity, specific to cross-linked hydrogels.

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Evaluation of biopolymers modified by ionizing radiation and cold plasma processing based on a multivariate statistical approach

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Background. Ionizing radiation and cold plasma treatments are emerging non-thermal and environmentally friendly practices that may change the functionality of natural polymers. Recent research in the field of biopolymer modification involves the approach of dual modification by combining different single modification methods to enhance the physicochemical and functional features of biopolymers as well as to optimize the performances of the methods in dual modification. Starch is one of the most widespread biopolymers which is often modified to enhance its functionality and to extend its range of uses. Multivariate analysis methods are widely used in a variety of scientific fields, where complex systems and multiple variables are involved and can provide insights and information to improve decision-making and optimize outcomes.

Purpose. The goal of this study was to evaluate the variable interrelation in the dual processing of starch for distinction of the dual modification methods depending on the sequence of single method application.

Methodology. The starch was single and dual modified by irradiation and cold plasma technique with the variation of sequence of single method application. Properties such as amylose content, granule solubility, apparent viscosity, and crystal short-range order of control and modified starch samples were determined. Multivariate analysis techniques regarding factorial analysis (FA) in principal components and hierarchical cluster analysis (HCA) were used.

Results. FA allowed the grouping of variables into three principal factors that explained ~84% of the cumulative variance. Each sequence of single methods applied made a major contribution to different factors. The plasma pre-treatment of the starch showed the most influence on its properties, especially its solubility, compared to the plasma post-treatment. The samples were divided into four major clusters according to the extent of modification of the starch properties. Cluster 1 included non-irradiated samples; cluster 2 included single and double modified samples, mainly irradiated with the lowest irradiation dose; cluster 3 generally consisted of single-irradiated samples, while cluster four grouped only dual modified samples, mainly pre-treated with plasma, which had the largest extent of property modification in investigated samples.

Conclusion. Dual modification of starch revealed that the extent of its modification was correlated with the sequence of single method application. The greatest increase in the effects induced by ionizing radiation on the properties of starch occurred when plasma was used as pre-treatment.

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Gold nanoparticle-composite hydrogel synthesized by e-beam irradiation

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The incorporation of gold nanoparticles into hydrogels produces novel superstructures that have become increasingly popular in the biomedical field. In this study, the obtaining and structural characterization of composite hydrogels based on complex polymeric mixtures of chitosan, poly(vinylpyrrolidone), poly(ethylene oxide), and lactic acid incorporated with gold (due to its antimicrobial and antiviral activity) nanoparticles synthesized by e-beam cross-linking were investigated. Different concentrations of gold nanoparticles suspension were dispersed in the polymer solution and cross-linked with e-beam in the range dose of 10-25 kGy.

The composite hydrogels were characterized following gel fraction, swelling capacity, and stability in environments similar to the human body and FTIR. The experimental results were correlated and analyzed according to the absorbed dose and the concentration of gold nanoparticles.

Composite hydrogels have a gel fraction of over 85% at a dose of 25 kGy and a swelling capacity between 1500-2500% in PBS and over 2500% in water. The mentioned values correspond to hydrogels with superabsorbent properties. The network parameters specific to hydrogels, Mc, ξ, and Ve are influenced by the concentration of gold nanoparticles, in the sense that by increasing the concentration of gold nanoparticles, the parameters Mc and ξ decrease, which leads to the formation of a hydrogel with a dense network. The hydrogel pore size was between 14-41 nm, being comparable to those of hydrogels intended for dressings. FTIR analysis demonstrated the formation of a miscible composite hydrogel. All results indicate that composite hydrogels have great potential for biomedical applications.

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Investigation and characterization of 2D materials and vdW heterostructures by application of Raman spectroscopy

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The development of two-dimensional (2D) layered with their novel physics (unique electrical, optical, thermal properties) and structure (unique band structures of strong in-plane chemical bonds and weak out-of-plane van der Waals (vdW) interactions), which do not exist in their bulk counterparts, make these materials promising for nanodevices and various other applications.

Raman spectroscopy has been proven to be a fast, convenient, and nondestructive technique to characterize the fundamental properties of 2D materials (2DMs) and vdW heterostructures (vdWHs), including layer number, doping type, strain and interlayer coupling. This technique is so important that most of the papers published concerning these materials contain at least one Raman spectrum.

In our work, we present the main achievements and, in the perspective, to find new ones, in the application of Raman spectroscopy to 2DMs and vdWHs to study their fundamental properties. Raman spectra were collected using excitation wavelengths 633 nm (1.96 eV), 532 nm (2.34 eV) and 473 nm (2.63 eV).

Investigated materials and structure, such as graphene and MoS_2 film was first prepared by the chemical vapor deposition (CVD) method; then different aligned graphene/MoS_2 hetero-structures was transferred to SiO_2/Si substrate.

We describe the essential Raman scattering processes of the entire first- and second-order modes, power and energy dependence, detection intralayer and interlayer modes. Furthermore, the shear, layer-breathing, G and 2D modes of monolayer graphene, strong excitonic effects of transition metal dichalcogenides (TMDs), covering both intralayer and interlayer excitons are discussed. The results show that the monolayer G, MoS_2 can be distinguished by analyzing the intensity ratio and frequency difference of its dominant Raman vibration modes. In addition, an increase in the incident light's power intensity causes the Raman peaks to red/blue shift due to the photothermal effect. The anomalous lattice vibrations of monolayer MoS_2 is originating from the built-in strain introduced by the SiO_2/Si substrate. The test characterization of graphene/TMDs hetero-structures was performed by Raman spectroscopy to obtain information above morphology and luminescence. The results show that they have the excellent spectral characteristics.

We hope that this work will be helpful to study the basic properties of 2DMs and vdWHs themselves and those present in the related devices by Raman spectroscopy.

Photo-induced neutrophil extracellular traps: The role of cytochromes

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Neutrophils play an important role in the pathogenesis of inflammatory, autoimmune, and oncological diseases. In this study, we investigated the role of radiation in a wide range of wavelengths, from UV-A to red visible light, based on the concept of photoacceptance by two cytochromes: cytochrome_b558 and cytochrome_c oxidase. Raman spectroscopy was applied to record characteristic Raman frequencies of various reactive oxygen species (ROS), and low-frequency lattice vibrational modes for citrulline. Using selective inhibitors of NADPH oxidase (apocynin) and PAD4 (GSK484), it was established that exposure of neutrophils to light of different wavelengths activates signaling pathway of NETs formation via NADPH oxidase and PAD4. We recorded sharp peaks of ROS and citrulline in the process of neutrophil irradiation, indicating the involvement of intracellular ROS during light exposure. In conclusion, we believe that the development of new drugs designed to suppress NETs can lead to the inhibition of the NET formation at sites of UV and visible light exposure and, as a result, to decrease in the symptoms of UV-induced photoaging and other organ damage.

Application of electron beam radiation for the development of conductive thermoplastic elastomers with improved mechanical and physicochemical properties

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Recently, ionizing radiation has found an application in nanotechnology especially attributed to development and improvement of polyolefin nanocomposites with carbon nanofillers used as relatively cheap and easy adjustable conductive thermoplastics [*Materials Today Advances*, 17, 100333, 2023].

In this study, nanocomposites of Engage™ ethylene-octene copolymer (EOC) with different octene-1 comonomer contents were analysed. EOC nanocomposites, containing 0-15 wt% of multi-walled carbon nanotubes (MWCNT), were manufactured from master-batches followed by thermoplastic mixing. The obtained EOC/MWCNT films were irradiated by accelerated electrons up to the absorbed doses of 75-300 kGy and their structural, mechanical and thermal properties were investigated.

The effect of radiation cross-linking on the materials' performance was evaluated using mechanical, thermomechanical and spectroscopic methods. The influence of two types of MWCNTs as nanofillers at various concentration levels (0-15 wt.%) on the thermal and electrical conductivity of the developed EOC based nanocomposites were analysed. The cross-linking efficiency, crystallinity and structure properties were also evaluated. The results indicated improvement in tensile properties with an increase of MWCNT content and the irradiation up to 150 kGy dose. The combined influence of the both factors (irradiation dose and the nanofiller concentration) on the development/promotion of the nucleation effect was determined. The gel content of the irradiated EOC/MWCNTs was equal to 70-90% that indicated sufficient cross-linking efficiency of EOC with MWCNTs acting as nucleating fillers in the matrix. An increase of MWCNTs content reduced undesired oxidation effects and ensured relatively high strength properties and sufficient deformation of the composites.

The obtained results allowed to conclude that the developed EOC based nanocomposites could find application in different fields such as sensors, and smart devices with improved thermal and mechanical stability as well as potential shape memory effect that could be also used in harsh environments due to the crosslinked structure [*Polymers*, 12(6), 1316, 2020; *Materials & Design*, 222, 111041, 2022; *Radiation Physics and Chemistry*, 120, 56-62].

Effect of surfactants on the luminescence of ZnO nano particles

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In the nanotechnology era, the research in the field of nanomaterials with improved properties are of real interest. Zinc oxide nanoparticles (ZnO-NP) due to excellent electronic, physico-chemical, catalytic, and optic properties find its use in broad applications domains such as: environmental, opto-electronics, sensing, drug delivery, imaging. Along with its remarkable properties ZnO exhibits also low toxicity and low price.

This study aims to present the preparation of pure ZnO-NP with a well-defined morpho-structure without any calcination stage during the preparation procedure. The synthesis is performed using a simple, low-cost precipitation technique at room temperature in presence of various anionic, cationic and nonionic surfactants. FT-IR analysis, X-ray diffraction, scanning electron microscopy, surface area analysis and luminescence spectroscopy, were used to characterize the ZnO-NP.

Under excitation with 365 nm, all samples exhibit a broad structured green emission at 550 nm. The emission intensities vary depending on the type of surfactants and are assigned to multiple deep levels defects found in ZnO. The presence of cetyltrimethylammonium bromide improve the luminescent response with 30%. Electron paramagnetic resonance (EPR) spectroscopy measured before irradiation and during irradiation with UV light indicate the presence of oxygen vacancies (V_O^+) and zinc vacancies (V_{Zn}^-). The intensity of the EPR signal is proportional to the defect concentration and depends on the nature of the surfactant.

Keywords: ZnO, defect state, luminescence, surfactants

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Heavy metals effect on optical properties of zinc oxidic compounds

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Environmental pollution, resulting from rapid industrialization has become a source of general serious concern. Metal ions are a major source of water contamination and this has encouraged researchers to develop novel low-cost metal ion sensors to detect their presence.

Generally, zinc oxidic compounds are used for the preparation of ZnO nanoparticles as well as for different functional materials such as thin films, nanocomposites, or inorganic-organic hybrid compounds. Also, due to their strong luminescent characteristics, are good candidates for sensing, imaging, drug delivery or optical-electrical display. Due to the high defect surface states of zinc oxidic compounds, heavy metals ions may easily interact with different active species to form shallow and deep defects fact that can influence the optical properties.

In this work, various luminescent zinc oxidic compounds were prepared by precipitation using different precipitating agents in different conditions. The morpho-structure and optical properties of samples are investigated by X-Ray diffraction, infrared spectroscopy, scanning electron microscopy, adsorption and porosity measurements, optical (UV-Vis) and photoluminescent (PL) spectroscopy. The spherical nano-particles ranging between 5 nm and 20 nm, present a porosity distributed either at the surface or in the depth of the particles. Under interaction with UV radiation the samples exhibit luminescence in blue-green spectral domain and their interaction with different heavy metals ions (Cu^{2+}, Ni^{2+}, Pb^{2+}, Fe^{3+}, Cd^{2+}) from aqueous solutions is also discussed.

Keywords: ZnO, zinc compounds, luminescence, heavy metals

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Proton irradiation effects on optical properties of undoped $Gd_3Al_xGa_{5-x}O_{12}$ single crystals

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The crystals of Ce-doped garnets $Gd_3Al_xGa_{5-x}O_{12}$ (GAGG) attract attention as multipurpose scintillating material due to the combination of high density, chemical stability, high light yield and reasonable energy resolution [*Nucl. Instr. Meth. A.* 809 (2016) 130; *Cryst. Res. Technol.* 54 (2019) 1800172.]. Radiation resistance, which is an essential property for scintillators, has been previously studied for the crystals doped with Ce^{3+} ions [*Nucl. Instr. Meth. A.* 916 (2019) 226; *Journal of Surface Investigation: X-ray, Synchrotron and Neutron Techniques* 15 (2021) 1259.]. However, the presence of Ce^{3+} - related absorption bands in UV and visible spectral regions hinders observation of induced absorption bands. The studies of undoped crystals allows to avoid this problem and to obtain more reliable data on the parameters of the bands of induced absorption. Here we present the study of the proton radiation effects on the optical transmission of the undoped $Gd_3Al_xGa_{5-x}O_{12}$ (x = 0,1,2,3) garnet crystals. 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 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. Irradiation of the single crystals was carried out with 6.7 MeV protons from 120 cm cyclotron. Proton beam fluence at the crystals surface was obtained using current integrator as $1.4 \cdot 10^{14}$ protons/cm^2. It is shown that the irradiation results in the appearance of induced absorption bands in the region 1.8 - 4.4 eV as well as attenuation of the absorption bands situated at higher energies. The effect is ascribed to the recharge of the defects already exiting in the crystals as well as to the creation of new defects under proton irradiation. It is also shown that the intensity of the bands of induced absorption 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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Luminescence of undoped and RE doped $Na_3Sc_2(PO_4)_3$ under high energy irradiation

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Phosphates with a NASICON-type structure such as $Na_3Sc_2(PO_4)_3$ are known as superionic conductors applied in solid state batteries. Recently, it was shown that $Na_3Sc_2(PO_4)_3$ doped with Eu^{2+} demonstrates excellent stability of luminescence in a wide temperature range that makes it promising for lightning applications, e.g., in pcLEDs. The processes of the conversion of high-energy irradiation into intrinsic or dopant luminescence have not been studied for this compound so far. In the case a high efficiency of energy transfer from the host to emission centers was revealed for $Na_3Sc_2(PO_4)_3$, the possible application range of this material could be extended. Here, we present the results of the study of the luminescent properties of undoped and RE-doped $Na_3Sc_2(PO_4)_3$ under high energy irradiation.

$Na_3Sc_2(PO_4)_3$ phosphates, undoped and doped with 0.02 mol% Ce^{3+} or 0.01 mol% Eu^{3+}, were synthesized in the reduction atmosphere using a high-temperature solid-state method. Powder X-ray diffraction study revealed that all synthesized samples were single phased with a NASICON-type structure. The studies of luminescence properties in the energy range of 2.5 - 9 eV were performed using laboratory set-ups. The studies under higher excitation energies up to 40 eV were performed at photoluminescence endstation of the FinEstBeAMS beamline of the MAX IV synchrotron radiation facility. Luminescence spectra and emission decay curves were also recorded at the laboratory pulsed cathodoluminescence setup.

The bandgap value of $Na_3Sc_2(PO_4)_3$ was estimated on the basis of excitation spectra analysis to ~8 eV. The origin of the emission bands was determined. It was shown that the intrinsic emission is represented with a broad band peaking at 260 nm related to radiative annihilation of self-trapped excitons. Additional broad emission bands peaking at 325 and 530 nm were ascribed to the defects of crystal structure, presumably to the complexes with oxygen vacancies. The emission spectra of $Na_3Sc_2(PO_4)_3$ doped by Ce^{3+} or Eu^{3+} ions demonstrate intense dopant emission only under intraband excitation. The dopant emission is weak under excitation above the fundamental absorption edge due to a low efficiency of energy transfer from the host to impurity centers as well as due to the presence of competitive radiative relaxation channels related to intrinsic and defect emission centers.

Analytical investigations concerning copies after Roman Imperial Denarius – case study

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12 coins from the Iezer hoard (Vaslui county), located in the collection of the "Vasile Pârvan" Museum in Bârlad, were investigated using the X-ray Fluorescence method. The elemental composition of the alloy was determined using the TRACER 5[i] portable spectrometer produced by Bruker Instruments whose principle of operation is based on Energy Dispersive X-Ray Fluorescence (EDXRF) with high analysis speed and sensitivity. Surface examination along with compositional analysis was conducted to explore the alloys and manufacturing techniques of the artefacts. All the coins can be considered copies of the Roman Imperial Denarius and can be divided into two categories: examples made by casting (the first 8 pieces) and by striking (the piece with no. 9), and "barbaric" imitations (3 coins). Denarii made by casting have recently been attested, in numerous finds from western Moldova probably originating from Dacia, they are made both of bronze with the addition of lead Cu-Sn(Pb), and of an alloy formed of Cu-As-Ag used to give a silver color and which constitutes an unknown category of counterfeits in the Roman era. Among the cast coins, three pieces show most of the casting marks, and were made from an alloy composed mainly of copper (77.37-81.91%), tin (15.46-19.35%) and lead (1.16-3.16%), and five specimens were cast from an alloy in which copper predominates (79.55-89.01%), with arsenic (8.56-10.97%) being associated and silver (5.19-8.95%). As for the counterfeit coin represented by "barbaric" imitations of Roman Imperial Denarii, two have a very similar chemical composition, being minted from an alloy composed mainly of silver (89.94-91.63%), a small amount of copper (approx. 7.47-9.23%) and some minor elements such as lead and gold that have higher values (approx. 0.2-0.3%), the last metal being present only in one of the pieces. The analysis of the elemental chemical composition of the coins from the Iezer hoard, kept in the collection of the Bârlad Museum, revealed that almost a quarter of the pieces in this lot are private issues, of various nature and origin.

Alloy composition studies on some silver coins from the Hellenistic period. Case study: posthumous Macedonian silver coins and imitations of Histrian coins - Apollo type

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This paper presents a series of analyzes regarding the elemental composition of the alloy of some posthumous Macedonian silver coins - Alexander III (from the hoard discovered in Satu Nou, Oltina commune, Constanţa county) and some imitations of the Histrian silver coins – Apollo type. These analyzes were performed by X-ray fluorescence (XRF) method using the X-MET TX3000 portable spectrometer. The treasure includes five silver pieces, two tetradrachms and three Macedonian-type drachmas, minted for Alexander III. All are posthumous issues, the earliest being drachmas (323-319, 319-305 and 310-301 BC), and the latest being tetradrachms (275-230 BC). The title of the coins was determined, the concentration of silver being between 96.4% and 98.2%, gold between 0.4% - 0.9%, and also minor elements and trace elements (Cu, Pb, Bi, Sn). For the 3 drachmas, two types of silver were identified: silver with a little gold, traces of copper and bismuth, and the second silver with more gold and copper, approximately 0.1%. These coins show traces of tin, most likely due to impurities resulting from the beating process. Regarding the composition of the two tetradrachms, silver is similar to two of the drachmas, the difference being the much larger addition of copper (contained between 1.1% and 1.3%) to increase the mechanical strength of the coins. One of the histrian silver issues (out of a total of three) shows a normal title, the percentage of 1.7% copper being added to increase the mechanical strength, while the rest show an Ag-Cu alloy (billon) and Ag - (Cu- Sn) with traces of Bi. Imitations after Histrian silver coins are made of different materials such as: bronze mixed with brass (Zn 16.5%), tin-enriched bronze (Sn 63.6%) to obtain a silvery color and bronze with a little zinc (Zn 2.9%) which can be a vintage alloy. The latter also had traces of silver that may come from a possible silvering of the coin. From a monetary point of view, the treasure was discovered during archaeological excavations in a settlement specific to the Getic population, fortified with a rampart and a defense ditch. He was found in a badly burned layer of a house, due to an attack from the Bastar population. The treasure was either brought by trade, or following robbery expeditions, or it represents the payment of a mercenary soldier from the local environment. The imitations of Histrian coins mostly belong to the III-II centuries BC, the initiation of their production in local environments being a reflection of the economic and financial prestige gained within the transactions specific to the Greek-autochthonous Dobrogean realities of the original Histrian coin, throughout several centuries of broadcasting.

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