RAP 22

INTERNATIONAL CONFERENCE ON RADIATION APPLICATIONS

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

Aristotle University Research Dissemination Center (KEDEA)
June 6-10, 2022 | Thessaloniki | Greece
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BOOK OF ABSTRACTS

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SEEIIST: a facility for research and therapy of cancer tumours with ions for the South East Europe (and capacity building)

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The South East European Institute for Sustainable Technologies, SEEIIST, has put forward as its main scientific goal the realisation of a “Facility for Tumour Hadron Therapy and Biomedical Research” in South East Europe. Such an initiative will strengthen local scientific expertise in its field of research, provide this unique treatment option for cancer patients in South East Europe and support the development of a sustainable economy and social cohesion in the region. The facility is expected to also stimulate the development of complementary technologies and to trigger spin-offs. To maximise benefits it is planned as a regionally distributed facility with hubs in different countries offering numerous opportunities for technology transfer and benefits to South-East European industry as well as international cooperation opportunities.

Thanks to the first financial support of theEuropean Commission (DG RTD) and the EU funded HITRIplus project state-of-the-art particle accelerator design and related technology are developed in collaboration with the main European research centres such as CERN and GSI-FAIR. In order to stimulate related capacity building in the SEE region, in support of such projects, a broad spectrum of activities is being developed to address diverse communities spanning from high-school students to professionals and will be outlined in this presentation.

Knowledge of SARS-CoV-2 infection and the immune system

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In 2019, a pandemic caused by the new Sars-Cov-2 virus around the world led to major health and socio-economic problems. The appearance of the new virus was associated with a complete lack of understanding of its effect on the human body and related to mortality. However, modern techniques of molecular biology and the use of PCR tests have helped to isolate and identify the virus structure. Modern biotechnology methods have been used in virus isolation, identification of genes encoding viral particles, identification of new strains and possibilities of synthesis of viral protein plasmids and finally in their application in-vitro. Production of the S (Spike) and N (nucleocapsid) proteins of the virus was successful with recombinant hybridization techniques used for various in-vitro tests for stimulation of the cell immune system. Modern science has shown the importance of immunity during illness as well as in response against virus during vaccination. However, in order to understand the pathophysiological mechanism of disease development and immune changes associated with disease development, flow cytometer immunity tests have made it possible to examine different populations of peripheral blood cells simultaneously with determination of cytokines by ELISA techniques. These techniques, together with in-vitro cell cultures, may show the effects of pathogens on cell function. Depending on the concentration of C and N proteins, the effect on human lung cells, on lymphocytes isolated from healthy volunteers as well as on convalescent samples has been shown, and complex pathophysiological mechanisms of virus action on the immune system have been confirmed. This paper also shows that after vaccine administration, the cellular population of the immune system is stimulated, as assessed by multicolor flow cytometry techniques. However, further research is needed to answer many other unresolved questions about the possibility of eradicating this disease and how long the effect of existing vaccines will last.

Current trends in Nuclear Forensics

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Nuclear Forensics Science has been defined by the IAEA as “a discipline of forensic science involving the examination of nuclear and other radioactive material, or of other evidence that is contaminated with radionuclides, in the context of legal proceedings” [IAEA Nuclear Security Series No.2-G (Rev.1)]. Nuclear Forensics is an important element in a state’s nuclear security architecture and serves to address the treats of nuclear smuggling, nuclear proliferation and nuclear terrorism [TrAC Trends in Analytical Chemistry, Volume 146, January 2022, 116503]. Nuclear Forensics Science includes set of analytical methods used for determination of properties of the materials that can help in getting more information on the origin and/or intended use of these materials. A combination of parameters that is required is referred as “signatures”. The analytical methods that are mostly used belong to radioanalytical chemistry, but there are also aspects of material science, geochemistry, nuclear physics, etc. The continuous improvement of measurement techniques, the exploration of novel signatures and the application of data analysis contribute to further advancing this discipline [TrAC Trends in Analytical Chemistry, Volume 146, January 2022, 116503].

This presentation will give an overview of the methods that are commonly used in the area of Nuclear Forensics. The novel approaches and current trends in the area will be elaborated. A special attention will be devoted to the use of gamma spectrometry as a non destructive analytical method in Nuclear Forensics. Most of the countries that belong to Western Balkan region are currently in the process of developing capabilities and knowledge needed for nuclear forensics practice.

The evolution of telecommunications networks and human exposure to radiofrequency radiation

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Since the introduction of the first mobile telecommunications network in the early 80's, a new generation (technology) of mobile networks emerges every about ten years. The fast adoption of mobile phones by the general public has rendered necessary the installation of base stations inside the urban environment and in densely populated areas, where demand for mobile services is higher. As a result, the anthropogenic radiofrequency radiation of portable devices and base station antennas has been exposing humans for some decades now, leading to concerns about the potential health effects of this radiation.

Exposure assessment to environmental radiofrequency fields is of importance to both epidemiological and compliance studies. In this talk I will present numerical and experimental techniques that are used for evaluating human exposure to the radiation of mobile telecommunications networks. I will also show the temporal and spatial changes of the electromagnetic environment at a short and long scale. The effect of introducing new network generations will also be discussed.

A sustainable approach for radiation protection applications: synthesis and characterization of waste bricks bottom ash involving Bi_2O_3

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These days, the utilization of industrial solid waste substances for gaining added-value products has become of prime importance for securing a more sustainable future. With this in mind, the present study handles using waste bricks bottom ash (*BBA*) involving bismuth oxide (Bi_2O_3) dopant for understanding the potentiality as a radiation protection material. Four different material systems, BBA-Bi0 to BBA-Bi20, were designed using the batches of xBi_2O_3 - $(100-x)BBA$ where x: 0, 5, 10, and 20 wt%. The intended pellets (D: 28 mm) were made ready after precisely weighing, mixing, and pressing steps. For sintering the prepared bodies, a heat treatment process was initiated by applying 10 ^oC/min to reach 1100 ^oC, which was then dwelled for 1h at the peak temperature. Afterward, the successfully produced waste-derived material systems were subjected to some material characterization analysis, as well as theoretical radiation shielding computations via Phy-X/PSD. According to the density measurements, we found out that the increasing doping rate from 0 to 20 wt% in Bi_2O_3 led to the improvement in bulk density from 1.3857 to 1.6177 g/cm^3 in the respective order. Additionally, the compressive strength showed an increasing trend with the increasing Bi_2O_3 contribution. On the other hand, the essential radiation shielding parameters, linear attenuation coefficient (*LAC*), and tenth-value layer (*TVL*), were figured out, and we found out that both parameters were enhanced owing to the higher Bi_2O_3 addition. As a result, the BBA-Bi20 sample can be preferred as an alternative material system where radiation protection is significant.

Radiological survey of geothermal water resources in Romania and dose estimation from their use in balneotherapy

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In Romania, geothermal waters are abundant natural resources, and considered to be an important factor in tourism and balneotherapy. Thousands of tourists and locals are visiting these spa centers and hot springs for internal and external cures.

The present work performs a radiological survey on 26 geothermal spas and hot springs, located in five counties in the western area of Romania. Gross alpha/beta, ^{226}Ra and ^{222}Rn were measured through nuclear spectrometric techniques. The results indicated activity values between 32 ± 3 and 3606 ± 432 mBq/l for gross alpha, respectively between 74 ± 8 and 2184 ± 262 mBq/l for gross beta. ^{226}Ra activities were between 34 ± 3 and 1942 ± 174 mBq/l. ^{222}Rn activities were between 3 ± 0.4 and 194 ± 23 Bq/l. X-ray fluorescence analyses were performed to determine elemental composition of the samples, the results are indicating a general presence of Al and Si in the geothermal waters, which are usually linked with zeolite rocks. Further correlations were performed in order to link radiological and elemental composition data to the geological attributes in the studied area. Ultimately, the water safety for human consumption was addressed, by comparing the obtained radioisotope data with the World Health Organization and Romanian Law No. 301/2015 parametric values.

Radiological risk assessment method for the interim storage of radioactive materials

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Safe storage of radioactive materials is based on three universal radiation protection principles. Justification, optimization and dose limits are applicable to the risk assessment, acknowledging the hazards in each procedure of delivery, usage, storage and disposal of radioactive materials. Failure Modes and Effects Analysis method (FMEA) is developed for the risk evaluation of common practices. In this work FMEA is exploited for the radiological risk assessment in practices with radioactive materials. In addition, the radiological hazard of fire is studied, in order to classify its severity for different cases of radioactive materials. The severity of the hazard, the likelihood of the hazard to occur and the detectability of its occurrence are exploited for classifying the associated risk. Appropriate measures that should be taken for the emergency preparedness and response are taken into account in order to reduce the Risk Priority Number (RPN). Scenarios of external exposure, skin contamination and inhalation are investigated, in order to calculate the received doses, for workers and members of the public. The outcomes of the analysis indicate low or medium severity of the risks for most of the examined practices, especially under the implementation of the appropriate measures, like: controlled access of the facilities, keeping of records for delivery, usage, storage and disposal of radioactive materials; presence of fire detectors and extinguishers; and removal of flammable materials from the vicinity of the radioactive materials.

Optimization of filler content and minimizing thickness of polymeric composite for shielding against neutron source by Response Surface Methodology (RSM) and Monte Carlo simulation

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Neutron shielding generally are made of polymeric base content with a neutron absorption additive material. Optimization of additive neutron absorption material and minimizing of polymeric base thickness are performed in this research. In order to design and manufacture of polymer composite neutron shielding, many parameters can be considered but specifically in this research, additive filler content and polymeric base thickness are surveyed and optimized. Response Surface Methodology (RSM) is used in this paper to investigate the simultaneous effect of the mentioned parameters on the radiation shielding efficiency of polymer composite. The RSM technique uses a second-order polynomial model for obtaining the optimum response of an outcome. With 2 independent variables including boron filler content and polymer thickness, 13 experiments are designed by Design Expert software. MCNP Monte Carlo simulation is performed for these 13 experiments according to the stand test data and designed shielding slabs and the outputs are imported to the Design Expert software which response surfaces are outcomes. Results of statistical analysis of variance (ANOVA) show that the p-value for the model is less than 0.05 and the value of R^2 is also equal to 0.9970, which demonstrate good agreement between simulation data and proposed model using RSM. For shielding efficiency of a 2 Mev neutron source, the boron percentage content is 6.2% and the shield thickness is equal to 100 mm in optimization condition. In minimizing shield thickness condition, the boron percentage content is 20% and the minimized shield thickness is 71 mm. Validation for these two conditions are carried out which errors are 0.005% and 0.01% for the minimized condition and the optimized condition respectively which shows that the presented model is suitable for the design and construction of radiation polymeric composite shields. By implementing this research results using RSM as an efficient optimization tool, additive material and base shield thickness can be optimized and also the base shield thickness can be minimized as performed in this study in order to design a desired shield with minimum thickness for multipurpose cases.

Keywords: Optimization, validation, design expert, MCNP Monte Carlo, response surface methodology

Radioactive materials transport van safety and security upgrade in Albania

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Institute of Applied Nuclear Physics (IANP) is the main user of radioactive sources in Albania and is licensed by Radiation Protection Commission by decision No. 385 dated 18.11.2016 for the activities of Use, Transport, Storage, Import-Export and treatment of radioactive waste and sources. The safety and security regime for the transport of radioactive materials addresses the radiological concerns and dangers associated with the transport of radioactive materials. IANP uses a new Volkswagen Crafter van, for the transport of radioactive materials. The Van is equipped with a central locking system of all doors and with a container for the transport of radioactive sources, to increase transport safety and security and to protect radioactive packaging during any possible accident.

IANP received also a container for the transport of radioactive materials from the International Atomic Energy Agency in 2020, which has significantly increased the physical security during transport of radioactive sources for transport of radioactive sources and also increased safety in transport to protect radioactive packaging during any possible accident. A physical security system installment with all security modules is underway to increase the physical security of radioactive sources of different categories that will be transported by this vehicle.

NORM alarms assessment safety issues in Albania

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The Republic of Albania is a non-nuclear country situated in the Balkan region. In Albania, radiation sources are mainly used in different applications including medicine, industry, agriculture, research, and education. The Institute of Applied Nuclear Physics (IANP), established in 1970, is the institution in charge of the processing of all radioactive waste produced in Albania and is licensed for import-export, transport, treatment, conditioning, and interim storage of radioactive sources and wastes. IANP is also responsible for the safe and secure transport of radioactive materials and for the response in case of radiological emergency in the country. Two structures are also operational at IANP for detecting and combating illicit trafficking and smuggling of nuclear and radioactive materials. The previous experiences in the country as well as in many other countries require enforcement of rules and regulations on radiation protection to prevent any probable accident with radioactive sources. Due to improper disposition, illicit trafficking, or a human and/or design error such sources might cause a radiological incident leading to overexposure of patients, radiation workers, and the public. As a result of concern over nuclear and radioactive materials out of regulatory control, Albania has installed a number of Radiation Portal Monitors at various border control points. The main issue in relation to illicit trafficking and smuggling in nuclear materials is to detect any possible illegal transits through Albanian territory and borders and to respond to them properly.

RPM profiles are not easily interpreted. Most of the 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 for the Front Line Officers (FLOs). The result is that the FLO becomes accustomed to a situation where even if a decision is made on a profile that may, or may not, be NORM to send it to a secondary inspection, the results of the inspection with a piece of field isotope identification equipment are inconclusive or of low confidence.

A guide and software tool to provide consistency and confidence in the interpretation of complex nuclear data from radiation detection equipment is urgently needed to support Albania's efforts. Since 2016 Albania has joined Coordinated Research Project (CRP) J02005 "Improved Assessment of Initial Alarms from Radiation Detection Instruments" organized by the International Atomic Energy Agency (IAEA).

The knowledge gained on commodities containing NORM, compliance with transportation and safety requirements, and assessment of alarms will be discussed. The importance of documentation, cooperation between safety and security agencies/organizations, and tools to assess radiation alarms will be also covered.

Radiological accidents involving industrial radiography source

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Radiation sources are used in medicine, industry, agriculture and research. The use of radioactive materials offers a wide range of benefits throughout the world. Precautions are necessary to control and limit the exposure of people to the radiation emitted. When highly radioactive material is involved, as in the case of industrial radiography, extreme care needs to be taken to prevent accidents that could have severe consequences. Industrial radiography is commonly used to detect defects in the weld joints of pipes and piping equipment. This non-destructive testing (NDT) technique detects defects using gamma radiation to penetrate components without damaging them. Despite the development of the radiation safety techniques and radiation protection procedure, accidents which injure people may happen.

The aim of the paper is to present two accidents and the medical consequences of the exposure to radiation. The paper gives an account of the events leading up to and following the accident, as well as the response actions taken. It describes in detail the methods and results of dose assessments and how these complemented the medical evaluations. It also describes the medical management of those involved in the accident, including diagnosis and treatment details for the most exposed person.

The paper ends with the findings, conclusions and lessons to be learned from these accidents.

Synthesis of antibacterial radionuclide-binding hybrid nanocomposites

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The Russian aggression in Ukraine raises the need for the development of easy synthesizable, accessible inexpensive sorbents for multi-binding of long-living radionuclides such as Cs-137, Sr-90. These radionuclides are released into the environment within incidents at nuclear power plants, during improper storage of radioactive materials, application of nuclear weapons. In the case of the Chernobyl, the Cs-137 content in significant areas (> 5000km^2) exceeded 40 Ci/km^2, made it dangerous to humans, located more than 150-200 km away. It is essential to ensure immediate access and use of antidotes for people who have been exposed to radioactive fallout.

The aim of our study was to develop sorbent composites for binding radioactive isotopes such as Cs-137, Sr-90, Rb-87 and Co-60 synthesized according to the principles of "green synthesis" using non-toxic, easily accessible raw materials. The commercial antidote Radiogardase® contains iron hexacyanoferrate, known as Prussian blue (PB), is effective for cesium and thallium. For comparative reasons the Radiogardase® antidote was used within testing multi-ion adsorption based on testing stable salts of Cs, Sr, Rb, and Co.

For the controlled synthesis of nanoparticles, we use the reduction of trivalent iron compounds with hydrogen peroxide and activated carbon. That resulted in enhanced effectiveness compared to PB particles synthesized by conventional methods and that of Radiogardase® commercial product. Our study reports of PB synthesis on the surface of activated carbon, combined with pectin to obtain hybrid composite for bonding multivariate radionuclides. The calibrated PB nanoparticles and activated carbon (d = 0.1 mm) material were dispersed in apple pectin and this newly obtained composite indicated significant higher sorption capacity for Co and Sr compared to commercial product. The studies are in the process dedicated for the improvement of composite capacity for multi-radionuclide binding.

Studies includes development of hybrid material of sorbent impregnated to fibers. Commercial synthetic fibers (50% of cotton, 50% of polyester) were impregnated by ultrasound assisted method simultaneously synthesizing PB. Obtained material was coated with silver nanoparticles which were obtained by reducing $AgNO_3$ with lemon juice, apple cider vinegar, formic acid. Obtained sorbent materials were applied to Petri dishes inoculated with *Escherichia coli* MSCL 332 and *Staphylococcus aureus* MSCL 334. The materials indicated promising antibacterial properties and adsorption capacity of radionuclides including Cs-137 and other tested radionuclides. These results indicate developed antidotes as promising component for also developing wound care bandages suitable for applications during nuclear incidents.

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Establishment of CT diagnostic reference levels in Albania

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Due to the corona virus pandemic many patients were forced to perform scans and radiographs, but there was no approximate dose estimate given to each patient while performing diagnostic medical exposures on Computed Tomography (CT) at the University Hospital “Mother Tereza” in Tirana in the Emergency Department.

The purpose of this study is to monitor and optimize the doses of patients who undergo diagnostic examinations on CT.

A very important aspect is also the establishment of DRLs (Diagnostic Reference Levels), which help to optimize the dose absorbed by patients, medical staff and nurses. DRLs also affect the image quality obtained by CT. The ages under consideration are from 18-85 years old. Dose values for the head range from 14.19 mGy to 53.07 mGy and for the neck and body range from 0.72mGy to 53.08 mGy. We compared the values obtained with the relevant DRL (ICRP 1996). From the comparison of all the values we obtained with the reference levels it turned out that they were within the allowed values. It should be noted that all these actions are performed based on the ALARA principle.

TLD postal dose audit in Poland – 2021 results

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The regulation of the Polish Ministry of Health on safe use of ionizing radiation for medical exposures (18 February, 2011) makes it obligatory for all radiotherapy centers in Poland to participate in external dosimetric audits. In Poland, the first postal dose audit was organized by the Secondary Standard Dosimetry Laboratory (SSDL) of the Institute of Oncology in Warsaw in 1991. The aim of the thermoluminescent dosimetric audits in radiotherapy centers is to assure proper calibration of radiotherapy beams to avoid mistreatment of cancer patients and prevent radiation accidents. The Polish SSDL offers dose measurement in water, for which it is accredited by the Polish Centre for Accreditation for compliance with the ISO / IEC 17025 standard (accreditation No. AB 1499). The SSDL in Warsaw is the only laboratory in Poland performing postal TLD dose audit.

In 2021, there were 165 teleradiotherapy linacs installed in Poland. These treatment units generated 443 high energy photon beams and 512 electron beams. 42 radiotherapy centers participated in the last year audit. Most of them requested an audit for more than one beam quality. Totally, 135 radiation beams were audited, including 130 photon beams (including 14 beams in non-reference conditions) and 5 electron beams. Thermoluminescent dosimeters (TLD) of Li-F MT-F type (Institute of Nuclear Physics, Cracow, Poland) were mailed to each participant. The participants were instructed to irradiate three TL detectors for each beam with a dose of 2.0 Gy in reference conditions. After irradiation the detectors were sent back to the SSDL. At the same time, set of reference detectors was irradiated with known doses at the SSDL. All detectors were read out at the SSDL with a Fimel PCL 3 TLD reader. The delta parameter was defined as the quotient of the difference between dose value reported by the participant and dose value estimated in the SSDL to the dose value estimated in SSDL. The delta parameter was calculated as a percentage value.

The biggest difference found between the dose estimated in the SSDL and the dose declared by the participant was 2.6%. The average delta value for all beams was 0.17%.

At the time of COVID-19 pandemic, TLD postal dose audits are an important element of ensuring safe and effective radiotherapy in Poland.

Results of the interlaboratory comparisons for the Polish Secondary Standard Dosimetry Laboratory in the field of testing of thermoluminescent detectors in terms of absorbed dose to water

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Every calibration and testing laboratory accredited for the conformity with the norm ISO/IEC 17025 has to fulfil the requirements of the norm. One of these requirements is monitoring the validity of the tests undertaken. The Polish Secondary Standard Dosimetry Laboratory (SSDL) has been accredited by the Polish Centre for Accreditation since April 9, 2014 and has the accreditation certificate No AB 1499. In the scope of this accreditation there is testing of thermoluminescent detectors in terms of absorbed dose to water, by thermoluminescent dosimetry method. At the Polish SSDL, it was decided that monitoring of the validity of the testing results will include, among others, participation in interlaboratory comparison between the Polish SSDL and Dosimetry Laboratory of the International Atomic Energy Agency (i.e. IAEA).

The aim of this study is to present the results of the interlaboratory comparisons and a simple method of analysis of these results that can be useful in routine activity of the testing laboratories in the above-mentioned area in order to check if these results are stable in specified limits.

The materials of the study were the results of the interlaboratory comparisons conducted from 2004 to 2021. These comparisons were carried out once a year and they consisted of a comparison of the TLD dose reported by the Polish SSDL (i.e. D_{SSDL}) with the value of the IAEA-stated dose (i.e. D_{IAEA}).

The acceptance criterion of the result was established at the Polish SSDL and was based on the relative percentage value of the combined uncertainty of the measurement of the D_{SSDL} value and D_{IAEA} value, i.e. 3.4% value of D_{SSDL} and D_{IAEA}. The result of the interlaboratory comparison was acceptable when the value of $|E_n|$ defined as the quotient of the absolute value of the difference D_{SSDL} and D_{IAEA} values to the square root of the sum of the squared combined uncertainty of D_{SSDL} value and D_{IAEA} value, did not exceed 1.0.

The maximum value of $|E_n|$ was 0.25 in 2018. The minimum value of $|E_n|$ was 0.02 in 2009. The obtained results indicated that there was no trend of changes of the interlaboratory comparisons results from 2004 to 2021. Therefore, there was no need to take appropriate action to prevent incorrect results from being included in the test results reported to Polish SSDL clients. Moreover, there was no need to perform any corrective actions specified in the current edition of the Polish SSDL management system document. In addition, there was no need to analyze the situation in the context of the risk of testing being not-conforming to the established procedure and to take appropriate actions set out in other document establishing the procedure for such non-conforming work.

The presented analysis of the results of the interlaboratory comparisons is useful in routine activity of the testing laboratories carrying out tests of the thermoluminescent detectors in terms of absorbed dose to water.

Instruments and approaches for prevention of illegal trafficking in radioactive materials: Case study INRNE-BAS

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The illegal trafficking in nuclear and radioactive materials such as uranium, plutonium, thorium, polonium, and other sources of corpuscular and gamma radiation not only threatens national security but can pose a serious threat to the entire international community, especially if diverted by terrorist groups or organizations. When intercepting and seizing such materials, it is necessary to perform in-depth analyzes of their radiological danger and evaluate the security thread of their provenance by applying tools and approaches of nuclear forensics, a science that generally serves the needs of national intelligence and law enforcement.

Bulgaria is one of the 89 member countries of the Global Initiative to Combat Nuclear Terrorism (GICNT). The mission of the GICNT is to strengthen global capacity to prevent, detect and respond to nuclear terrorism through multilateral activities that strengthen plans, policies, procedures, and the interoperability of partner countries. In the case of nuclear materials, there are additional requirements for physical protection and accountability to ensure against threats of nuclear proliferation and to safeguard against any attempts at diversion.

Here we focus on and illustrate the main activities of the Department of Analysis of Radioactive Materials of Illegal Origin (DARMIO), established at the Institute for Nuclear Research and Nuclear Energy at Bulgarian academy of sciences (INRNE-BAS), started by a group of experts at the research reactor IRT-2000 of BAS used in the past for analytical work related to the presently known nuclear forensics science. A special database on nuclear material has been collected and specific nuclear methods have been developed and implemented for the examination of abandoned radioactive substances or radioactive waste with a presumption of possible establishing their origin. At present, DARMIO provides scientific, expert and logistic assistance to governmental law enforcement agencies: Ministry of Interior, State Agency for National Security, Prosecutor's Office, Border Police, Customs Agency, etc. in the field of radioactive and nuclear materials outside regulatory control in response to decrees of the relevant authorities or a request for consultation from interested organizations. DARMIO maintains constant (24/7) readiness for action in accordance with the National Plan for Response to Radioactive and Nuclear Emergencies. Maintenance and constant readiness of high-resolution portable devices for reliable rapid detection of radioactive radiation and isotope identification as well as stationary laboratory equipment for measuring alpha, beta, gamma, and neutron radiation are provided. In brief, the manuscript gives the early history and an up-to-date survey of issues, activities, and casework regarding various aspects of nuclear forensics.

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Thermal neutron measurement in the STU Mini Labyrinth experiment

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As part of an international cooperation the research team from the Slovak University of Technology is involved in the development of new radiation shielding experimental workplaces for code verification. One of these activities is the so called “Mini Labyrinth” workplace. It is a simple neutron and gamma shielding benchmark, inspired by the ALARM-CF-AIR-LAB-001 ICSBEP experiment. In the original Labyrinth experiment a ^{252}Cf source was placed within the center of the doorway aperture constructed from concrete blocks. This experiment had dimensions of several meters. On the contrary, the STU Mini Labyrinth, as its name implies, is a mini version of the original IHEP Labyrinth, currently with dimensions of 96x60x25 cm. The experimental setup is placed on a special deck in the neutron physics laboratory of STU and uses remote source the handling mechanism and video surveillance. It consists of several NEUTRONSTOP C5 shielding blocks (polyethylene with 5 % boron), several detector positions and two options two generate thermal neutrons, i.e. a plastic tank filled with liquid moderator and a solid graphite prism, which is ideal to produce thermal neutrons. In the previous works of the research team efforts have been made to find the best setup for measurement inside and outside the Mini Labyrinth. It was found out that the 25 cm height was not appropriate, therefore it was increased to 50 cm by adding an extra level of NEUTRONSTOP blocks. This paper brings the first results of measurements performed on the new measurement geometry and their comparisons with simulations using the MONACO code from the SCALE system. In this measurement setup the neutron source is placed inside the graphite prism and the aim is to measure and simulate the thermal neutron count-rate at various positions of the Mini Labyrinth.

Characterization of the "*bGeigie Nano*" instrument used in citizen science dose rate monitoring

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Safecast [https://safecast.org/] is a Citizen Science project devoted, among other, to monitoring ambient dose rate (ADR). Initiated in Japan in 2011 after the Fukushima NPP accident, it has soon spread across the globe. It employs a standard instrument called *bGeigie Nano*, which consists of a pancake-type thin-window GM counter coupled to a GPS receiver, powered by batteries. The device comes in a sturdy plastic case, which allows easy field use. Readings are written on an SD card in 5 s intervals. Users can import the recorded ADR tracks into GIS or send them to *Safecast*, where it will be included in their map [https://map.safecast.org/]. By 2022, about 180 million records have been stored, contributed by several thousand users. The data are publicly accessible from their web site. Interpretability of results depends on QA (quality assurance) of the measurement process.

We distinguish two QA levels. The first consists in the "traditional" metrological characterization of the instrument, the second in its practical use. The second level is relevant because users are citizens who are in general not familiar with metrological procedures, measurement statistics, the concept of representativeness, etc. It appears that this level is the more difficult challenge to QAed measurement.

However, in this presentation, we focus on aspects of the first level and mention the second one only cursorily (discussed in more detail in [DOI: 10.37392/RAPPROC.2021.07]). In field use, GM response has different sources: internal background (BG) of the device, various sources of ambient gamma rays and secondary cosmic radiation (SCR), mainly muons. Since in most realistic cases, environmental gamma-ray fields have low intensity, BG and SCR cannot be ignored when interpreting ADR readings. This concerns estimation of the "true" terrestrial dose rate as well as comparison with other results by instruments of same type and with the one of other data sources. The BG signal is caused by electronic noise, radioactivity of hardware components and spontaneous events in the GM tube. Response to SCR depends on detector geometry.

Through dedicated experiments, mainly performed on lakes (where the terrestrial gamma component is largely absent) in different altitudes, we quantified the BG and response to SCR. We also investigated variance of response between instruments of same kind. Further, we investigated conformity to Poisson statistics of count rates and the occurrence of spurious extreme signals, which can lead to artefacts in ADR maps. We show experimental setups and results, as well as their impact on practical use of the *bGeigie Nano* device, and discuss uncertainty.

First tomography reconstruction application of the ANET Compact Neutron Collimator

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This communication presents the design, construction and test of a novel compact multi-channel neutron collimator developed by the INFN-ANET collaboration.

The ANET neutron collimator has a scalable structure, both in collimation power and in field of view. It needs to be coupled to a moving stage in order to smooth out its chess-board geometry from the final image as it has been fully demonstrated and tested. The dynamic acquisition mode can be tuned in size, pattern and speed to adapt to different facilities.

A complete study of its performances, evaluated at the PSI BOA facility is here presented.

An evident improvement in spatial resolution is perceivable when the ANET collimator has been introduced in the beamline. The collimator has been tested under fluxes from 10^6 up to 10^9 $cm^{-2}s^{-1}$ and no degrades of its performances have been observed.

An extensive simulation work using high-end tools has been conducted in order to study the device properties. The agreement between the experimental and simulated data is remarkable. A first application of a tomography reconstruction will be presented.

Concentrations of natural radionuclides dissolved in different hydrochemical types of spa waters of the western Izera Block (Sudety Mts., Polish-Czech borderland)

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This research is a part of a bigger project concerning the studies of natural radioactivity in water intakes from the Sudety Mts. Based on obtained results, 25 water intakes from the Izera Block were selected for detailed analysis of natural radioactivity. The samples were analyzed a few times for $^{234,238}U$, $^{226,228}Ra$ and ^{222}Rn radioactivity over a period of 10 years. This province is particularly reach in medicinal waters of different hydrochemical types, which are used for balneotherapeutical purposes. Some of them are available for free for local inhabitants and tourists. On the other hand, in this region the spots of uranic mineralisations were recognized. The concentrations of ^{226}Ra and ^{238}U isotopes in reservoir rocks reach the value of 100 Bq/kg. The water flowing through reservoir rocks characterized by elevated concentrations of radioactivity content and a higher emanation coefficient, become radon enriched. Parts of the waters were recognized as acidulous (reach with CO_2). The aggressive CO_2 reach waters interact with rocks and receive the mineralization up to 3 g/L. Furthermore, some waters have been recognized as acidulous radon enriched water. These waters contain an admixture of low mineralized waters of shallow circulation and contemporary infiltration. This shallow water being a component of acidulous radon water may also occur separately as another water type – a radon water. Radon waters from selected shallow intakes (dug wells and springs) are also used for balneotherapeutical purposes in spa resorts.

The measurements of $^{234,238}U$ activity concentrations were performed with the use of α-spectrometer. The separation of uranium from other alpha isotopes was performed with the use of the anion exchange resin Dowex 1×8 (Cl^- type, 200-400 mesh). $^{226,228}Ra$ and ^{222}Rn concentrations were measured with LSC technique. Prior to measurements of radium, a radiochemical analysis of samples was performed.

Based on obtained concentrations, the annual effective radiation doses due to the isotopes consumption with drinking waters were calculated. The activity ratios: $^{234}U/^{238}U$, $^{226}Ra/^{238}U$, $^{222}Rn/^{238}U$, $^{222}Rn/^{226}Ra$ and correlations between analyzed radionuclides content were studied.

Assessment of a NaIL detector performance for radiation monitoring applications

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The European decommissioning and dismantling (D&D) market of nuclear facilities is characterized by a significant long-term growth. So, there is an important need to develop a technological breakthrough for D&D operations that could save time, reduce costs, and minimize human intervention while increasing safety. Furthermore, the use of unmanned ground vehicles (UGV) equipped with innovative radiological sensing probes represents an interesting solution.

In this work, our group is mainly concerned on the upgrading and integrating neutron/gamma detection systems on a UGV platform for the monitoring of areas, to identify gamma emitters as hot spot presence, to identify the presence of neutrons, and to be able to discriminate between special nuclear materials (Uranium and Plutonium isotopes). One important goal is to test and optimize the performance of different detector combinations in the D&D operations.

We will present the comparison between possible commercial solutions, for gamma spectroscopy identification and for monitoring survey.

For the first, we will show solutions using inorganic scintillators, sensitive both to thermal neutrons and gamma, like NaIL, CLLB (as far as the CLLB data, they have already been collected and published in [F. Pino et al 2021 JINST 16 P11034]).

For the latter solution, we will present an exhaustive study of an organic scintillator, sensitive to gamma, fast and thermal neutrons, i.e. EJ-339A boron-doped organic scintillator.

The characterization study of the scintillation detectors consists in measuring the energy resolution, the full-energy peak gamma efficiency, the neutron/gamma discrimination capability (as a function of the gamma background rate), the neutron efficiency and the time resolution.

Concerning the energy resolution of the two-inorganic scintillator, we obtained 5.2% and 4.7% @662 keV for the NaIL and CLLB detectors.

The full-energy peak efficiencies are 31% for the CLLB and 29% for the NaIl @662 keV. These results are in good agreement with the Monte Carlo simulations performed with GEANT4.

Moreover, we studied the neutron/gamma discrimination capability of the three detectors: in particular, we measured the figure of merit (FoM) of the three different detectors. The best results were obtained with the NaIL, followed by the CLLB and the liquid EJ-339A respectively.

Finally, we determined the time resolution of the detectors and the capability of discriminate neutrons from gamma, when there is a high gamma background rate. We noticed that the best performance is obtained with the NaIL. While in the case of the liquid, it is impossible to detect thermal neutrons when the counting rate is above 100Hz.

These results can be used as a starting point for future developments, to develop a future solution to in the decommissioning phase of nuclear power plants.

Radiological survey using a CLLB detector: Single unit for triple particle discrimination

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In the last years, the discovery of new inorganic scintillation materials, sensitive to several kind of radiations, brought new perspectives in nuclear research and nuclear applications such as nuclear safety and security, safeguards, radiation monitoring, etc. The Elpasolite scintillators (such as CLLB, CLYC, etc.) are some of the most interesting materials, most of them exhibits excellent performances in terms of energy resolution and thermal neutron detection. Such scintillators, capable to detect and to discriminate between gamma-rays, thermal and fast neutrons, represent an interesting solution, for example, to recognize masked and/or shield radioactive materials (gamma emitters) and special nuclear materials (SNM).

In this framework, we will present a complete characterization of a medium sized (2" x 2") CLLB ($Cs_2LiLaBr_6$:Ce) scintillation detector, in order to give the starting information to assess its deployment in applications regarding radiation monitoring in D&D operations. In particular, we have studied: the energy resolution, full-energy peak gamma efficiency, thermal neutron/gamma discrimination capability, high counting rate performance and minimum detectable activities (of ^{137}Cs and ^{252}Cf sources). We employed digital nuclear electronics combined with a pulse shape discrimination algorithm to acquire and analyze the data. Experiments were combined with Monte Carlo simulations (using GEANT4 v10.6.0 and MCNP5 v1.60) in order to complement the characterization.

Furthermore, we will show the CLLB scintillation detector ability to detect and discriminate fast neutrons (2-10 MeV energy range) from gamma-rays and thermal neutrons. Firstly, we conducted measurements in single mode with an Am-Be source, unshielded and shielded, and we tagged a new cluster of events in the fast neutron-induced zone. In order to verify this event type to be induced by fast neutrons, we conducted measurements in coincidence mode, with a mono-energetic pulsed neutron source, at the CN accelerator facility at the Legnaro National Laboratories (INFN-LNL, Legnaro-Italy), and also, with a continuous neutron spectrum (using a ^{252}Cf source).

Combining these experimental results with a Monte Carlo model of the CLLB detector, it was possible to obtain the light output function of ^{7}Li ions in the CLLB crystal ($dL/dE = k$; $k = [0.36 \pm 0.02]$MeVee/MeV). The Monte Carlo simulation was also used to get the intrinsic fast neutron efficiency, obtaining similar values between 1.5% and 2% for neutrons between 2 MeV and 10 MeV.

As a conclusion, we will present an application of this new system, in the field of nuclear security and nuclear safeguards. The obtained results in fact suggest that the CLLB detector offers better performance with respect to other scintillators of the same size such as NaI(Tl), CsI, CeBr, etc. which are commonly used in a radiation monitoring systems.

Experimental verification of ANGLE 5 software for quantitative gamma spectrometry

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The key tasks considering low-level gamma spectrometry analysis is creating an adequately accurate detection efficiency function, taking into consideration different energies, matrices and sample-detector geometries. The detection efficiency refers to the full energy peak efficiency (FEPE), which is defined as the ratio of the number of detected radiation events in the photo-peak and the total number of emitted photons by a source. This task can be achieved either by implementing the direct method- using a certified volume or point source standard with known activities of radionuclides where there is no need for approximations, or by utilizing a designated software for numerical or semi-empirical calculations. A simulation method can also be used for FEPE calculations through different software-simulation toolkits such as Geant4. ANGLE presents dedicated detection efficiency calculation software intended for high purity germanium (HPGe) and NaI detectors based on the concept of efficiency transfer. In this work, a new version of ANGLE software was tested (ANGLE 5). The improvement in this version over the previous ones is the introduction of the new functionality - true coincidence summing (TCS) corrections.

In this study, the beta version of the ANGLE 5 software was verified by using certified reference materials. Reference efficiency curves for different measuring geometries were calculated using a certified reference set of 11 point sources with an activity uncertainty of 3%. The spectra were acquired using two different HPGe detectors (ORTEC low background extended range coaxial detector GMX-20190 with a beryllium window and CANBERRA closed-end coaxial detector GC-3518). Additional verification was done by using 2 voluminous certified sources, CBSS-2 from the manufacturer - Czech Metrology Institute and Multigama Standard Resin Matrix 152Eu, manufacturer - L.E.A. FRAMATOM.

The final verification of ANGLE 5 software was performed on three real samples in different geometries which contain various actinide series radionuclides by comparing the obtained results with the Geant4 calculations.

Possible application of ionic liquid 3-methylpyridinium salicylate in LSC measurements

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This paper investigates the scintillating and wavelength shifting properties of a newly synthesized ionic liquid 3-methylpyridinium salicylate (3-MPS), presenting the first results of its possible application in various Liquid Scintillation Counting (LSC) measurements. There have been few reports so far about ionic liquids' advantages for the detection and quantification of ionizing radiation. Presented experiments involved the addition of 3-MPS in small amounts (<1 g) to aqueous solutions of several radionuclides prepared in 20 ml counting vials, which were counted on ultra Low-Level Liquid Scintillation Spectrometer Wallac 1220 Quantulus. The presence of 3-MPS significantly influenced ^{210}Pb/^{210}Bi spectra generated by Cherenkov radiation and gross alpha/beta spectra, it even impacted ^{3}H spectra, although no scintillation cocktail had been added to the counting vials.

The emission and absorption spectra of 3-MPS have proven that it manifests a substantial wavelength shifting effect. That property can be very useful during Cherenkov radiation detection when radionuclides that can be detected with relatively low efficiency (such as ^{210}Pb) are of concern. Namely, 3-MPS presence can improve the efficiency for ^{210}Pb/^{210}Bi detection via Cherenkov counting on a LS counter. The addition of 0.8 g of 3-MPS increased the efficiency from 16.4(4)% to 93.3(14)%, consequently reducing Minimal Detectable Activities (*MDA*) achieved more than five times. This discovery offers the unmatched improvement to all existing methods for ^{210}Pb determination via Cherenkov counting. Furthermore, it was determined that 3-MPS acts as a scintillator when added in the amount > 0.1 g to the counting vial, which suggests that it could find the application in the detection of various radionuclides via LSC measurements. Its influence on gross alpha/beta spectra generation of ^{210}Pb and ^{226}Ra, as well as on beta spectra of ^{3}H, was also examined and reported in the paper.

These findings should be further explored and considered since 3-MPS usage in LSC measurements might offer one innovative alternative to the commercial LSC cocktails. The presented results support the idea that 3-MPS or other ionic liquid of similar structure soon might be implemented into the common LSC practice.

Detection of baby food sterilized with Ionizing radiation using thermoluminescence

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Sterilization with ionizing radiation is a well-established technology applied to several fields including foods and drugs due to its advantages over other methods. Ionizing irradiation, mainly gamma radiation, allows the better assurance of product sterility and has a high penetrating power allowing the easy and efficient sterilization of the products while being packed in their final package and permits the heat-free sterilization of heat-sensitive products.

Irradiated foods are commercially available in many countries. However, ionizing radiation may cause several physicochemical/biological changes to such products along with nutrient degradation. Food (as drugs) is introduced in the human body and interacts with it, potentially leading to the development of malignancies if irradiated. The above have more gravity in the case of infants since commercial products can be their exclusive food source in their diet for a long period of time.

Although irradiated products should carry specific clear labeling, manufacturers may not comply with it, while food irradiation policies vary across countries. All the above, lead to the necessity for the establishment of methods to differentiate between irradiated and non-irradiated products, that can be used by governmental inspection agency, which is strongly encouraged and supported by the EU. Moreover, the document CXS 73-1981 (recently amended in 2017) signed by the Food and Agriculture Organization of the United Nations and the World Health Organization clearly states that it is prohibited to treat baby foods with ionizing radiation.

Based on the above, the scope of the present work is to explore whether potentially irradiated baby food can be identified/detected using Thermoluminescence (TL), for regulatory compliance purposes. The above is initially achieved through the thorough investigation of the luminescence properties of the glass containers of baby foods. Properties such as sensitization, dose response, saturation dose and fading have been studied in the glass containers of prepared baby meals of two different international brands.

Results are very promising and support the idea of using the glass containers as probes for the identification of irradiated commercial baby food (post-sterilization dosimetry).

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Comparative study between the ascorbic acid and some ascorbates for the application in electron paramagnetic resonance dosimetry

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Irradiation with ionizing radiation is widely used in various fields of human activity. In connection with this, it is necessary to strictly monitor the processes of radioactive irradiation and perform of a dosimetric control. Dosimetric measurements of radiation processes in industrial enterprises, as well as measurements of accidents at radiation risk, require the use of a reliable dosimetry system. It is known that the irradiation with highly ionizing beams creates free radicals in the materials.

The Electron paramagnetic resonance (EPR) spectroscopy is widely used as a method for dosimetric measurements and identification of radiation induced free radicals in different materials. The EPR spectroscopy has a special area of application in the field of the dosimetry known as "EPR dosimetry". The advantages of the EPR dosimetry are the rapid evaluation of the absorbed dose and the non-destructive character of the study, which is enabling repeated measurements. In the last three decades EPR spectroscopy has expanded significant its practical application. To be used as a dosimetric material the substance has to be sensitive to radiation, with a stable EPR spectrum and a linear dose response. Until now an alanine/EPR dosimetric system has been accepted by International Atomic Energy Agency (IAEA) as secondary, being a transfer type of system, suitable for use in dose region 0.001-100 kGy. Despite the fact, that a lot of substances are studied up to now, the investigators continuous to search new and new dosimetric materials with improved properties.

In the present work ascorbic acid, sodium ascorbate and calcium ascorbate irradiated with g rays have been studied with EPR spectroscopy. The powder samples are irradiated with different doses of radiation in two dose regions - 1 - 20 Gy and 1 – 20 kGy. After irradiation all samples exhibit typical EPR spectra due to radiation induced stable radicals. As a dosimetric index, was used the EPR signal amplitude (peak-to-peak) of the first derivative of the absorption band. The dependences of the intensity as a function of the applied microwave power, the modulation amplitude and the absorbed dose radiation were studied. The time stabilities of the radiation induced free radicals have also been studied. In conclusion the dosimetric properties of ascorbic acid and ascorbates have been compared.

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The effects of different thickness boron layers on the electrical characterization of NÜRFETs

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The aim of this study is to investigate the use of NürFET (RadFET) dosimeters as neutron dosimeters by depositing a boron layer on the gate oxide. The effect of changes in the structure of the boron layer and the NürFET on the electrical characteristics of MOS-based devices has been revealed. In addition, the effects of different thicknesses of boron layer on the electrical properties of B-NürFETs were also investigated. It has been shown that the boron layer has significant effects on the threshold voltages of the B-NürFET.

Keywords: RadFET, NürFET, MOS, structural modifications, boron

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Gamma irradiation response on SiNWs based MOS capacitor with high-k Yb_2O_3 gate dielectric

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The investigations of gamma irradiation response on silicon nanowires (SiNWs) based MOS capacitor with high- k of Yb_2O_3 is very important in the fields of semiconductors physics and nanotechnology. Therefore, in this study, we fabricated SiNWs using the metal-assisted chemical etching (MACE) technique and then Al/Yb_2O_3/SiNWs/n-Si (100)/Al MOS capacitor was exposed to gamma rays using a Co-60 source at different doses, respectively. Our experimental results demonstrated that gamma irradiation had a significant impact on the electrical parameters of the device. Moreover, these results were compared to those results reported by previous researchers.

Keywords: SiNWs, MACE, gamma irradiation, C-V, G/ω -V

Acknowledgments: This work is supported by the Presidency of Turkey, Presidency of Strategy and Budget under Contract Number: 2016K12-2834.

Frequency response on electrical characteristics of SiNWs based MOS capacitor with VO_2 as high-k material

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In this work, we report the frequency response on the electrical characteristics of SiNWs based MOS capacitors with VO_2. The capacitance-voltage (C-V) and conductance-voltage (G_m/ω -V) measurements were carried out at various frequency values. The influence of frequency on the series resistance (R_S) and interface states (N_{it}) were also investigated. It was observed that frequency had huge influence on the electrical parameters of the device. In addition, the results showed that MOS devices based on SiNWs are promising materials more especially in electronic devices and radiation sensors.

Keywords: MOS capacitor; SiNWs; Interface states; Capacitance-Voltage

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The coating of reduced graphene oxide (rGO): A novel ultrasonic-assisted method

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The graphene is one of the most popular materials of our age since its discovery. The graphene and its derivatives have gained much attention in sensor applications because of its features (e.g., electronic conductivity, specific surface area etc.). However, the coating of graphene is challenging for the researchers especially for Si/SiO_2 surfaces due to its surface tension. Many researchers tend to use chemical materials for the coating rGO onto Si/SiO_2 such as APTES, TEOS, PEG, HMDS etc. For the purpose, we discovered a novel type ultrasonic-assisted coating method for sensor applications which can be done using any chemicals. To do so, we firstly produced reduced graphene oxide (rGO) from graphite by using Hummer's method and chemical reduction process. Then, we prepared Si/SiO_2 samples and put them into plastic container. After that, we put samples into ultrasonic bath and dropped rGO suspension onto samples by using with micro-pipette. After that, the rGO coated samples were dried on hot plate at 100°C. The results showed high potential that rGO can be coated onto Si/SiO_2 surfaces with low-cost solution.

Keywords: Graphene, coating, ultrasonic-assisted method, Si/SiO_2 surface

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Investigation of annealing temperature on structural and surface morphologies, electrical properties of Y_2O_3 thin film with SiNWs

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In this paper, we report the influence of post-deposition annealing temperature on the structural, morphological, and electrical properties of silicon nanowires (SiNWs) with Y_2O_3. SiNWs were fabricated by the metal-assisted chemical etching (MACE) method at room temperature. After the fabrication process, the high-k of Y_2O_3 was deposited onto SiNW/n-Si(100) by the e-beam evaporation technique. Four samples of Y_2O_3 with SiNWs were annealed at different temperatures in N_2 ambient for 30 min, while one sample was kept as-deposited, respectively. The crystalline and morphological properties of Y_2O_3/SiNWs/n-Si(100) were analyzed by XRD and SEM techniques. On the other hand, the electrical properties of the capacitors based on SiNWs were investigated through C-V and G/ω -V measurements. We found that the post-deposition annealing temperature had a huge influence on our experimental results.

Keywords: Annealing temperature; SiNWs; MACE; C-V; XRD; SEM

Acknowledgments: This work is supported by the Presidency of Turkey, Presidency of Strategy and Budget under Contract Number: 2016K12-2834.

On the performance of carbon-free zinc-air rechargeable batteries: Characterization of some spinel and perovskite oxides as catalysts in gas diffusion electrodes

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High-capacity rechargeable batteries are increasingly needed for portable electronics and electric vehicles, and the metal-air battery is currently considered the most promising for such applications. Among various metal-air battery designs, the Zn-air rechargeable battery has attracted considerable attention as one of the most viable options because of theoretically much higher energy density, lower operational cost, longer cycle life, higher safety, and more reasonable environmental compatibility. Rechargeable Zn–air batteries typically include a metallic anode, separator, electrolyte, and bifunctional air (gas diffusion) cathode. The catalysts in the gas diffusion cathode support the electrochemical reaction with the oxygen gas. Rechargeability can be improved by developing and implementing new oxygen electrocatalysts for bifunctional air cathodes which facilitate both the oxygen reduction reaction (ORR) during discharge and the oxygen evolution reaction (OER) during charge. Of the various catalysts that attract attention to date for high battery performance through enhanced both ORR and OER, the transition metal oxides with spinel and perovskite-like structure are intensively studied because of their inherent catalytic activity and structural flexibility to adopt a large range of cation substitutions.

Here we report on the structural details of powder samples of spinels (Co_3O_4, $NiCo_2O_4$) as well as the perovskites $La_{0.80}Sr_{0.20}MnO_{3-\delta}$, (LSM) and $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF), and their mixture LSM/LSCF in ratio 50/50 vol.%. The properties of these oxides are strongly determined by the oxidation states of the constituent cations and their distribution over the two kinds of sites present in both spinel and perovskite-like structure. Using these catalysts we fabricate a new design of air electrode for zinc-air batteries, the so called “monolithic” carbon-free gas diffusion electrodes (GDEs) where the traditional gas diffusion layer made from carbon-based material is avoided and thus the corrosion rate is reduced. In an effort for improving the fundamental understanding of material properties relevant to the rechargeable GDEs structure sensitive techniques such as neutron and X-ray diffraction combined with scanning electron microscopy (SEM) were applied. The electrochemical characterization involving volt-ampere characteristics determination and charge/discharge tests at room temperature have performed. The results were compared with state-of-the-art carbon-based GDE (Teflonized carbon blacks, Ag/Co_3O_4 catalyst, PTFE) and it was confirmed that the two types of investigated catalysts can successfully replace the classic catalysts containing precious metal and carbon support. The best electrochemical performance demonstrated the LSM-based GDE.

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The study of low energy gamma-ray detection performance of SiPM with LaBr scintillator

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Low energy x-ray and gamma-ray sources are used widely in medicine, security, and industry. The development of detectors for a low-energy electromagnetic radiation ray is actual now. The scintillation detector is based on LFS, LaBr, NaI and the silicon avalanche photomultiplier is an open great capability to use for the detection of x-ray and gamma-ray. The presented work is demonstrated the gamma-ray detection performance of new MAPD array (16 (4*4) elements-15*15 cm^2) with LaBr scintillator (15*15*30 mm^3) to gamma-ray in the energy range from 20keV to 321 keV. Measurement is done inside of ultra-low background lead shield. As a gamma-ray source is used Lu-177 isotope. The obtained energy resolution is 9 % for 112 keV and 7.4 % for 208.4 keV.

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Silicon based P-I-N photodiode design by using TCAD simulation

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The Silicon PIN photodiode (Si-PIN PD) with active area (10.0 x 10.0 mm^2, 12.0 x12.0 mm^2 and 20.0 x20.0 mm^2) was designed by using Silvaco ATLAS and ATHENA tools at Nuclear Radiation Detectors Applications and Research Center (NÜRDAM). To get Si-PIN PDs' specifications, capacitance-voltage (C-V) and dark current – voltage (I-V) measurements were accomplished with Bipolar and Shr model, and Newton method. The dark current and capacitance at -90 V of designed Si-PIN PD are (7.49 nA, 39 pF), (39 nA, 51pF),(10nA, 80 pF) for 10x10 mm^2, 12x12 mm^2, 20x20mm^2 respectively. Si-PIN PDs have low dark current and capacitance at high reverse voltage and all photodiodes reach the full depletion mode at -25 V. According to obtained results, designed Si-PIN PDs are likely to be used for medical application after fabrication and radiation test.

Keywords: Silicon PIN photodiode, TCAD, current–voltage, capacitance–voltage

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Low Gain Avalanche Detectors for various applications

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Low gain avalanche detectors are a novel silicon detector technology which allows segmented silion detectors (diode) with high internal gain. A highly doped p$^+$ layer is implanted between the p-bulk and n-implant (n++-p+-p-p++ structure) leading to high enough electric field for impact ionization upon application of sufficient bias voltage. Although initially develop for tracking and timing applications in high energy physics their super signal to noise ratio, extremely fast response and ability to make them highly segmented make them suitable for many other applications such as beam monitors and medical imaging. The concept and different applications of LGADs will be presented.

Use of SiPM as direct radiation detector to measure dose-rates

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During the last years there has been a significant increase in the use of Silicon Photomultipliers (SiPM) in several research areas.

Their use is mainly due to their capability to work in hostile environments (high temperatures, cryogenic environment, intense magnetic fields, high visible light background conditions, resistance to radiation damage, etc.) and the advantage of their very small volume and low voltage operation.

One recent proposed use for SiPM, which is not yet fully tested, is the possibility of performing precise dosimetry measurements in real time and transmission mode by the measurement of the SiPM current during direct exposition of the SiPM active area to the beams, which could lead to different applications in the medical diagnostic and monitoring.

In this work, a preliminary study on the possibility of using SiPMs for the direct estimation of the dose-rate (mGy/s) for X-ray photons will be presented.

Radiation is produced by an X-ray tube with operation voltage in the range 15- 50 kV.

Furthermore, the sensor response to those X-ray spectra was measured at different distances from the source (2 - 200 mm), using motorized stages.

The whole series of measures was carried out keeping the environmental conditions almost constant throughout the entire data taking phase.

The signal of the sensor was then related to the measurements using a calibrated dosimeter, placed in the same positions of the sensor and under the same measurement conditions, to measure the actual dose-rate value for dosimetric calibration of the SiPM response and for its characterization for expositions up to 53.5 Gy.

We found a linear correlation among dose-rate and current measured by the SiPM for almost all the tests we carried out and conclude that an effective use of SiPM for real-time dosimetric measurement is possible.

We will present the detail of the experimental set-up, the measurement results and the details of the data analysis.

Femtosecond laser based TCT-TPA and IBIC microscopy: Two very powerful characterisation tools for testing micron-sized sensitive volumes in micro-strips or pixeled detectors and microdosimeters in microbeam and hadron therapy

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Depending on the radiotherapy modality, i.e. synchrotron microbeam radiation therapy (MRT) or hadron therapy (HT), different detector architectures are required. For the synchrotron MRT, silicon strip detectors are ideally suited given their excellent spatial resolution allowing for accurate measurements of X-ray microbeam full width half maximum (FWHM). For HT, devices based on the microdocumentary approach are more suitable. Micro dosimetry is a methodology to measure the distribution of radiation dose delivered to absorbing medium (tissue itself or tissue equivalent) with the micrometre-scale spatial sensitivity. Micro dosimeters are typically silicon-based radiation sensors for experimental microdosimetry in hadron therapy or in unknown mixed radiation fields typical of space. The microdosimeters are formed by a matrix of independent unit cells (microsensors) with a well-defined shape and a 3D sensitive volume similar to those of cellular structures, where the patterned array of micron-sized sensitive volumes is achieved through the basic semiconductor hetero-junction configuration and manufactured by silicon semiconductor technology, although other materials like diamond are being used more often due to the higher radiation hardness and the better biological matching with the human tissue.

Ion Beam Induced Charge (IBIC) microscopy, based on highly tuned ion microbeams seems to be very powerful tool for the analysis of the charge carrier transport properties in semiconductor devices based on semiconductor hetero-junction or metal-on-semiconductor configurations, but also for study of the 3D internal structure of sensor devices using shallow and deep penetrating ions. 2D surface imaging uing shallow ions and depth probing by more penetrating ions enables 3D microscopic scanning of charge transport and of internal structure. Alternatively, the Two Photon Absorption Transient Current Technique (TPA-TCT) as a tool to characterize semiconductor detectors using a spatially confined laser probe and where excess charge carriers are produced by the simultaneous absorption of two sub-bandgap photons in the material allows the focal point of the femtosecond laser to be moved inside the silicon detector resulting in a 3-D resolution. In addition, due to the use of strong focusing optics, the beamwidth is significantly smaller than in current conventional TCT setups, resulting in an improved spatial resolution transverse to the beam propagation direction. This development is especially important, following the trend of ever thinner detectors, detectors with implemented read-out circuitry (CMOS), and smaller read-out electrodes and interpixel isolation structures.

Here we present the potential of IBIC and fs-laser based TCT-TPA scanning technique by emphasizing the most recent applications performed on Low gain Avalanche Detector (LGAD). LGAD is mature technology, now accepted as baseline for the timing detectors at the CERN (HGTD and CMS), but also due to its excellent timing and spatial resolution now widely tested and under extensive R&D to be utilized in radiation therapy or micro dosimetry. From presented cases we will project the future potentials and opportunities of those powerful characterisation tools to be expanded in more ambitious and sophisticated R&D biomedical and physical research.

New gamma-spectroscopy laboratory for nuclear reactions at Turkish accelerator and radiation laboratory

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A new detector laboratory featuring 2 Clover HPGe, 2 single crystal HPGe with their BGO's as well as 4 large volume $LaBr_3$(Ce) detectors is being prepared at the Turkish Accelerator and Radiation Laboratory (TARLA). The laboratory primary purpose is to serve as a Nuclear Resonance Fluorescence (NRF) spectroscopy setup for the superconducting linac with 40 MeV energy and 1.6 mA current being constructed at TARLA. With a multidisciplinary, multi-purpose focus TARLA is a user facility promoting scientific research and technical development. TARLA is equipped with two beamlines one of which is intended for bremsstrahlung and electron beam use and the other for the free-electron laser (FEL). Currently, the γ/e- beamline is set to be completed by the end of the year. In NRF a nucleus absorbs and then re-emits high-energy photons up to nucleon separation energy. By observing the emitted photons one can study nuclear properties such as level schemes, spin and polarity, branching ratios, transition strengths, collective behavior, pygmy dipole resonance, and photon cross-section as well as others. By observing these quantities NRF can provide information about nuclear processes relevant to astrophysics such as wall production and the study of exotic neutron-rich nuclei. In addition, TARLA has a close connection to the 30 MeV and 1.2 mA proton cyclotron owned and operated by Türkiye Enerji, Nükleer ve Maden Araştırma Kurumu (TENMAK) where proton induced reactions can be measured. At first, the proton cross-section measurements are to be conducted offline by using the stacked foil technique and in the future, in-beam measurements are planned. Initial measurements have already been performed and a description of the activities will be presented. We aim to present both the laboratories as well as TARLA to potential users and to promote international collaborations in science research and technology development.

Transient Current Technique (TCT) versus Two Photon Absorption (TPA) measurements in Si detector characterisation

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Transient current technique (TCT) is a well-established method for Si detector characterisation where a short laser pulse creates an electron-hole group either on surface or throughout the detector. From a measured response numerous parameters like electric field, charge trapping, drift velocities, charge collection efficiency etc. can be deduced. However, the data we get from TCT is two dimensional. To overcome this short-come, a Two Photon Absorption method where an ultra-fast highly focused laser beam with below band gap energy is used to create photon densities sufficient for the simultaneous absorption of two photons at a certain point in the detector is used. Arguments for and against the implementation of each technique will be discussed.

A new life for kaonic atoms at DAΦNE: Future measurements and perspectives with advanced X-ray spectroscopy techniques

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To the present days, the fundamental parameters of low energy strangeness QCD, used to describe the low energy interaction between strange and standard matter, are based on kaonic atoms experiments carried on in the 1970s and 1980s, except for very few more recent ones on very light atoms (hydrogen and helium).

Unfortunately, not only these old measurements do have huge errors, but these more recent ones proved some of them to be wrong, making a new campaign of precision kaonic atoms measurements urgent and mandatory.

The DAΦNE machine at the INFN Laboratories of Frascati is still the most suitable facility in the world, in terms of purity of the kaon beam, luminosity, and kinematic conditions, to perform measurements of kaonic atoms. Recent progress in the field of X-ray detectors and their readout electronics contributed, in these last years, to a renewed interest in new and more precise measurements.

Beyond the SIDDHARTA-2 experiment, presently installed on the DAΦNE Interaction Point exploiting 450 mm thick Silicon Drift Detectors (SDD) to measure for the first time X-rays from kaonic transitions in deuterium, several other important measurements are still planned or proposed.

These new measurements, among which transitions in kaonic helium, carbon, sulfur, lead, wolfram, nitrogen, and molybdenum, are now feasible thanks to new technologies: 1 mm thick SDDs, CdZnTe, and HPGe detectors as well as crystal spectrometers and TES microcalorimeters.

In this talk, an overview of the already planned and foreseen measurements, together with others proposed for future campaigns, will be presented together with their physics case, possible impacts, and details of the experimental setups.

Development of a high range gamma detector with optical fiber for long transmission

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A newly developed high dose rate detector for gamma measurement is presented. High dose rate meter is built as a unique system employing the silica optical fiber for transfer radiation from the detector to fiber radiation probe. This system allows the measurement of high kerma dose rate for long distance up to 30 m.

The high dose rate system with optical fiber has been designed as an autonomous gamma dose rate meter. Gamma detector is located inside the aluminium cylindrical housing with special optical connector. Electronical parts such as preamplifier, high voltage, data processing, I/O and photomultiplier with active divider are located inside the fiber radiation probe. In front of the probe optical connector is located. Measured data are displayed via software program or display unit.

The mechanical design allows easy replacement of the radiation detector thanks to the used optical connectors. As a result, different detector sizes can be used. Each size of detector has a different sensitivity with respect to a specific purpose. The housing of the fiber radiation probe is mechanically and seismically resistant. Electromagnetic compatibility respects international standards.

The high dose rate system with optical fiber has been tested and verified with different gamma energies in the gamma accredited laboratory. We carried out radiation resistance test of the detector and fiber with Co-60 irradiator.

The system with optical fiber is suitable for high dose rate measurement in laboratories with accelerators, nuclear medicine, PET centers, etc.). We can also use it in places with a high electromagnetic field due to the fact that the detector is installed in the radiation field and the electronics part is installed in the safety distance from the radiation.

They can be installed separately with a local display unit or can be a part of larger monitoring systems with a remote display unit.

A study of using MAKROCLEAR dosimeters for the dosimetry of deuteron beams

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During our study, radiochromic integrating dosimeters MAKROCLEAR were irradiated with deuteron beams accelerated on a cyclotron U-120M. These dosimeters have been developed in CVŘ since 2016.

It is a solid-state clear polymeric material that responds to irradiation by changing its optical density. For small doses, changes occur first in the near UV region of the spectrum, they change into the light region and for even higher doses they go as far as the infrared region of the spectrum.

Samples measuring 10 x 10 x 10 mm were placed in a deuteron bundle in a special aluminum holder, behind a 10 mm thick aluminum collimator and a 9 mm diameter aperture. During irradiation, the deuteron beam was monitored before the collimator aperture with a Farmer ionization chamber connected to a UNIDOS electrometer so that the absorbed dose in the sample could be read in real time. The samples were gradually irradiated with 17 MeV deuterons at doses of 5 kGy, 10 kGy, 15 kGy.

Dosimeters were evaluated photometrically by scanning on an Epson Perfection 850-Pro transmission scanner. Scanning was performed perpendicular to the beam axis to obtain beam dose profile information and along the beam axis to obtain depth dose curve (Bragg curve) information.

The bitmaps obtained by scanning were subsequently freed of noise caused by microscopic dust particles and impurities. Low-pass filter convolution (image integration) was used for this. The convolution kernel consisted of a 3 x 3 matrix.

By accurately measuring the size of each sample and comparing it with the number of pixels, the size of one pixel was determined and thus the correct dimensional scale of individual elements in the image. This made it possible to construct graphs of depth dose curves and dose profiles of deuteron beams, on a scale corresponding to reality. Optical density was determined as the absorbance divided by the thickness of the darkening area.

The results of analyzes performed in white (polychromatic) light showed that MAKROCLEAR dosimeters are very useful as cheap and easily available integrating deuteron dosimeters in the dose range up to 15 kGy, where their response in white light is practically linear to dose. The LET (linear energy transfer) ratio for the deuterons of the energies used determines the dose equivalent.

Proton beam dosimetry using integrating radiochromic dosimeters MAKROCLEAR

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

These dosimeters have been developed in the Research centre Rez since 2016. It is a solid-state clear polymeric material that responds to irradiation by changes in its optical density. The dosimeters can be very easily prepared in the required shape and size. Their availability is easy, the purchase price is very low (approximately 1 eurocent per piece). Their evaluation is cheap, easy and fast, without the need for expensive or bulky laboratory equipment. In literally minutes, 3D information on the hadron beam dose profile and depth dose curve can be obtained, including the position of the Bragg peak, the dose at the Bragg peak, the dose ratio at the Bragg maximum to the plateau dose, and the maximum particles range. Because the material of dosimeter has only an 8 % higher density than the average density of the human body, the method can also be applied in hadron therapy of oncological diseases.

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

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

It was followed by scanning the irradiated dosimeters on an Epson Perfection 850-Pro transmission scanner. The bitmaps obtained by scanning were subsequently freed of noise caused by microscopic dust particles and impurities, which adhered on the surface of the samples. Low-pass filter convolution (image integration) was used for this. The convolution kernel consisted of a 3 x 3 matrix.

The results of analyzes, performed so far only in white (polychromatic) light, have shown that MAKROCLEAR dosimeters are excellent as cheap and easily available integrating dosimeters of protons in the dose range up to about 10 kGy, where their response in white light is practically linear to dose (with detectability threshold of about 100 Gy). This is approximately 20 times less than was previously observed with the same dosimeters after exposure to gamma photons of cobalt 60. However, this corresponds to the LET ratio for the photons and protons of the energies used, indicating that MAKROCLEAR dosimeters respond to relative biological efficiency (RBE) of different types of radiation, not just to absorbed dose. The MAKROCLEAR dosimeters so directly measure a dose equivalent.

Repairing and calibration of malfunctioned radiation detectors

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In this work we present the review of the malfunctions of the available to the AUTH Lab radiation meters and the repairing and calibration procedures of one radiation detector.

Detailed technical report is given with a detailed guide for repairing and calibration of one specific radiation meter with diagnostic procedures and fast solutions including analysis of repairs that can be taken without voiding warranty and those that may void warranty is provided.

The procedure followed and the guidance document developed are the basis for a more general guidance document with procedures and instructions for different types of radiation meters for nuclear security.

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Beryllium-7 activity concentration trends in Serbia and Slovenia

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Beryllium-7 is a natural radionuclide used as a tracer of the stratospheric-tropospheric exchange. Its abundance in the surface air is expected to change as the temperatures in the atmosphere increase.

To investigate the temporal trends of the beryllium-7 activity concentrations and temperature, we apply spectral analysis to time series from three sampling sites: Belgrade in Serbia, and Ljubljana and Krško in Slovenia. The sites lie close to the 45 ºN parallel, with Krško approximately 400 km and Ljubljana around 500 km west of Belgrade. Between January 1991 and December 2019, the air filter samples were collected using air samplers; a monthly composite sample was formed and analysed by gamma spectrometry. We use monthly mean temperature records from the European Climate Assessment & Dataset, the Republic Hydrometeorological Service of Serbia for Belgrade, and the Slovenian Environment Agency for the sites in Slovenia.

In the spectral analysis decomposition, we look into a term called trend that represents the overall growth (increase or decrease) in the data records. The trend is calculated using a linear fit. All three sites show 1) positive temperature trends, however statistically insignificant (at the 95 % confidence level), and 2) statistically significant beryllium-7 activity concentration trends of 2.26 %/year, 1.13 %/year, and 0.50 %/year in Belgrade, Ljubljana, and Krško, respectively.

The results confirm our initial hypothesis–over the 28 investigated years, the beryllium-7 activity concentrations increase in the surface air. On the other hand, the non-significant temperature rise in our records suggests that within our method, the temporal resolution of one month is insufficient for obtaining a statistically significant temperature trend.

Radiological properties and elemental composition of spring water related to the volcanic geological environment of the Eastern Carpathians, Romania

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Natural spring waters are representing an important segment of the hydrological resources of Romania, with more than 2000 of them being located within the country borders. These resources are most abundant in the proximity of the Călimani-Gurghiu-Harghita (CGH) Neogene/Quaternary volcanic chain, the southeasternmost part and the longest continuous portion of the Carpathian volcanic arc. Spring mineral waters in this area are used as a primary source of drinking water by thousands of local inhabitants and tourists. The interactions of groundwater with the aquifer volcanic geological environment can lead to elevated radioisotopes concentrations in water.

The present work performs a radiological and elemental composition analysis on natural spring waters in the CGH area with the purpose of establishing relationships with the geological volcanic features of the study site. Furthermore, an assessment regarding the safety for human consumption of the investigated springs was performed, in accordance to the Commission Directive 2003/40/EC and the Council Directive 2013/51/EURATOM standards for quality of drinking water.

In this regard, forty natural spring water samples were collected from Harghita County, Romania, which incorporates a major area of CGH volcanic chain. Radiological measurements of gross alpha/beta, ^{222}Rn, ^{226}Ra and ^{40}K were performed using nuclear spectrometric techniques. X-ray fluorescence analyses were conducted to determine the elemental composition of the water samples, and the physico-chemical parameters were measured. The results indicated that 28 samples exceeded the 0.1 Bq/L parametric value for gross alpha, established by EU Directive 2013/51/EURATOM, and 6 samples that of 1 Bq/L for gross beta. ^{226}Ra parametric value of 0.5 Bq/L was exceeded in one sample, and another 2 samples were above the ^{222}Rn value of 100 Bq/L. The concentration of trace elements in the collected water samples is generally low, but in some sources, they present higher values. The median value measured for Zn (3.2 µg/L) is three times the median value for European bottled waters (EBW). The lead concentration in 8 water sources is higher than EBW median value of 0.016µg/L and in 5 water sources, it exceeds the maximum value recorded in EBW. In two water sources, the lead concentration exceeds the EU drinking water standard EU Directive 2003/40/EC. Arsenic concentration is below the allowable value of 10 µg/L, except for one source, where the value is almost three times higher than the allowed value.

The presence of trace elements can be linked to the geological background, and the correlations between specific activities of the radionuclides and geological features of the study site may imply difference of host rock's bearing-radioactive-mineral contents among rock types of the aquifers.

Last 150 years of human impact on high altitude lakes in Eastern and Southern Carpathians, Romania

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Nowadays the worldwide human impact on ecosystems grows alarmingly. Lake sediment depositions can be used as a live data storage systems that are recording changes manifested in the catchment area. It is difficult to discern between the human and natural contributions to sedimentation rates, yet it is critical in data interpretation, for making better decisions in land management plans.

This work focuses on the study of sedimentation processes from four lakes located in Parâng mountains (Latoriţa and Iezerul Muntiu lake), Făgăraș mountains (Bâlea lake), and Retezat mountains (Zănoaga lake), Romania. All the lakes are situated in protected natural areas, in which human activities are reduced or missing in the catchment. A peat bog accumulation (Latoriței peat bog) was chosen to study the natural factors which are influencing the sediment deposition in the area, as the peat accumulation is only controlled by climate variations. With the gathered data sets, an appropriate strategic approach can be built, that may be applied in the future to other lake systems with human influenced cahments.

For the determination of sedimentation and growth rate, the ^{210}Pb dating method was selected. ^{210}Pb, ^{226}Ra and ^{137}Cs concentrations in sediment and peat samples were measured by gamma spectrometry, using a HPGe detector. In samples with low activity, in order to maintain the accuracy of the chronology, ^{210}Pb was measured by ^{210}Po using alpha spectrometry. The CRS model was selected for constructing the sediment chronologies, respectively, the CIC model for peat growth. The sedimentation rate of the Latoriţa lake shows a slight increase in last 100 years period, from 0.1±0.02 g/cm^2 to 0.3±0.01 g/cm^2. Three periods can be identified with high sediment depositions peaks, first in 1860 (0.25±0.02 g/cm^2) followed by 1975 (0.3±0.02 g/cm^2) and 2000 (0.3±0.02 g/cm^2). In Zănoaga lake, the highest mass sedimentation can be identified in the 1977-1986 period, in which the value peaked at 0.169±0.02 g/cm^2. In the case of Bâlea lake, the peak in sedimentation rate corresponds to year 1989, with a value of 0.057±0.013 g/cm^2, comparing to the average sedimentation rate of 0.012±0.004 g/cm^2 between 1814 and 1989. The obtained data proves the applicability of ^{210}Pb dating techniques for peat bog accumulations.

Dose-dependent effects of ionizing radiation on aquatic biota in gradient of long-term radionuclide contamination of water bodies

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The effects of chronic irradiation of aquatic biota in water bodies within the Chernobyl exclusion zone (CEZ) during 1998-2021 were studied. It is determined that the rate of chromosomal aberrations in the root meristem tissues of aquatic plants in the most radioactive contaminated lakes on average in 2-3 times, and in cells of the pond snail embryos in 4-6 times exceeding the spontaneous mutagenesis level, inherent to aquatic organisms. During the period of studies a tendency to decrease of chromosomal aberration level in molluscs from all lakes of the exclusion zone was registered. The probabilistic prediction of the chromosomal aberration rate for gastropod snails in lakes of the CEZ have shown that spontaneous mutagenesis level (2.0-2.5 %) can be reach in some water bodies with middle levels of radioactive contamination in 2020-s - 2030-s and in the most contaminated by radionuclides lakes - in 2060-s - 2070-s. Analysis of leukograms of fish peripheral blood showed the decrease of lymphocyte cells, as well as the increase in the number of granulocytic cells (neutrophils and pseudoeosinophils) with increase of radiation dose rate. Along with changes in leukograms an increased level of morphological damages of erythrocytes (structural and proliferation abnormalities) was determined, which is generally for pray fish in 4-12 times and for predatory fish in 7-15 times higher than in fish from reference lakes. High amount of erythrocytes with structural and proliferation abnormalities in the peripheral blood of fish from lakes with high levels of radioactive contamination allows us to assume that the qualitative indexes of red cells in blood of fish are more sensitive to chronic radiation influence in comparison with the elements of white blood. A variety of forms of pathological changes in the structure of blood cells, mainly erythrocytes, may indicate low resistance of cytogenetic apparatus of fish in the face of considerable mutagenicity and genotoxicity of environment. In this situation the ionizing radiation causes damage to the lipid structures of biological membranes (e. g. lysosomes) and violation of their barrier functions that ensure compartmentalization in the cell. This leads to disruption of spatial isolation of enzymes to their substrates and release enzymes to further destruction of macromolecules and intracellular structures. As a result, there are changes not only in the cytoskeleton, but also in functioning of all the organelles in the cell. Analysis of the viability of the seed progeny of the common reed from contaminated lakes at germination in the laboratory showed a reduction in technical germination, germination energy and seed viability with increase of radiation dose rate. At the same time significantly increased the number of abnormalities of seed seedlings in view of necrosis of roots, disturbance of gravitropism, damages of organogenesis and disorder of chlorophyll synthesis were discovered.

Preliminary investigation of naturally occurring radionuclides in some spices used in Albania

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We are using everyday spices in food as pigment taste, flavour of foods or in human diet and some of them have great benefits for our health and body. In Albania the type of spices in food has been increased in recent years and these vary from country to country depending on the type of soil and how they are grown. Thus, the aim of this current study attempts to determine the level of radioactivity in different types of spices which are consumed by people living in the city of Tirana in Albania, where is concentrated the largest number of the population and to estimate their effective dose to the human body. Samples of spices are collected randomly in some different markets in Tirana city, which may be produced in Albania or imported. The activity concentration of natural radionuclides of ^{40}K, ^{226}Ra and ^{232}Th were measured in twenty types of spices. A high-resolution HPGe detector was employed to perform the measurements. The obtained results indicate that ^{40}K, ^{226}Ra and ^{232}Th was detected in all selected samples for study, whereas the presence of artificial radionuclide of ^{137}Cs was found only in two spices samples. ^{40}K activity concentration varies from 173.72 ± 9.34 Bq kg^{-1} to 849.47 ± 39.36 Bq kg^{-1}. For the activity concentration of ^{226}Ra, it ranges from 5.15 ± 0.52 Bq kg^{-1} to 21.01 ± 1.80 Bq kg^{-1}. The activity concentration of ^{232}Th varies from 2.04 ± 0.31 Bq kg^{-1} to 21.90 ± 1.78 Bq kg^{-1}. The estimated Average Annual Commited Effective Dose (AACED) due to ingestion of these spices varied from 5.61 ± 0.29 μSv y^{-1} to 10.91 ± 0.56 μSv y^{-1}. All these values are far below than the world average value dose for individual of 290 μSv y^{-1} for all foods reported by UNSCEAR 2000. This indicates that no risk is expected by the intake of spices samples in food. The obtained data provide us the baseline levels of natural radioactivity and background information for future research on foodstuff for radiological protection of the human.

Keywords: Spices, ingestion dose, HPGe gamma-ray spectrometry

Monitoring of cosmogenic and terrestrial radionuclides in ground level air samples by gamma spectrometry in Albania

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The activity concentrations of ^{7}Be, ^{210}Pb, ^{40}K and ^{137}Cs in ground level air at the monitoring station in Tirana, Albania were determined during the period from January 2021 to January 2022. The radioactivity may be present in the atmosphere as the result of a radiological or nuclear event or due to natural processes. The ASS-500 is a typical aerosol sampler located in the Institute of Applied Nuclear Physics in Tirana not only for routine air radioactivity monitoring, but also to monitor the air in the institute from the radiation protection point of view because in the institute are located the temporary radioactive waste site, ^{137}Cs source used in the secondary standard dosimetry laboratory and ^{137}Cs irradiation source. Activities in all aerosol samples are measured by gamma spectrometer with High Purity Germanium detector (HPGe). The cylinder geometry efficiency curve generated by Canberra's Laboratory Sourceless Calibration Software (LabSOCS) was used in order to analyze the air filters.

The obtained results show the activity concentrations of cosmogenic ^{7}Be, ranged from 2.38 to 6.82 mBq m^{-3} with a maximum in the spring/summer period. The activity concentrations for ^{210}Pb were in the range 0.37 to 1.27 mBq m^{-3}. The activity concentrations of anthropogenic ^{137}Cs in ground level air were observed only in three air filters in the range 0.30–6.01 μBq m^{-3}. This monitoring is done for the first time, providing us the data of cosmogenic and terrestrial radionuclides in ground level air. This study will continue also in the future in order to see the variation of radionuclides during the years.

Keywords: Air filter, cosmogenic radionuclides, aerosol samples, HPGe gamma-ray spectrometry

Effect of silver and iron nanoparticles on the bioavailability of cesium radioisotopes for *Triticum aestivum* plants

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Interactions of various substances coexisting in the environment are currently one of the important issues of ecotoxicology. Development of nuclear science and industry resulted in large scale anthropogenic release of radioactive isotopes, including cesium-137, into the environment. Due to the physical and chemical similarity of cesium and potassium, it can easily be taken up by plants and thus enter the food chain. Therefore, cesium-137 accumulation by plants represents one of the main sources of human exposure to radionuclides. Another type of xenobiotics, relatively new in the environment, are the nanoparticles. Because of their exceptional properties, they are increasingly produced and used in many areas, including agriculture. Silver nanoparticles, for instance, are applied as nanopesticides for plant protection, while iron oxide nanoparticles are being used as iron fertilizers. The increasing use of nanoparticles in agriculture draws attention to the issue of the influence that nanoparticles may exert on the bioaccumulation of radioisotopes by plants. There are several possible mechanisms for this interaction e.g. nanoparticles can absorb various ions and, therefore, remove them from the substrate, reducing their bioavailability or nanoparticles can be adsorbed on the plant roots disturbing bioaccumulation of ions.

The aim of the presented studies was to investigate effect of silver and iron oxide nanoparticles on bioaccumulation and biodistribution of radioisotope of cesium in a plant of agricultural importance - wheat *Triticum aestivum*. According to the Food and Agriculture Organization of the United Nations, in 2020, world production of wheat was 761 million tonnes, making it the second most-produced cereal after maize (FAOSTAT, 2022).

T. aestivum sprouts were cultivated in hydroponics for 2 weeks on a growth medium supplemented with cesium or with cesium and nanoparticles. After finishing the cultivation, the content of cesium-137 in the post-cultivation solution as well as in the plants shoots and roots were determined. In order to investigate the effect of cesium and nanoparticles on the plants, the degree of tissue hydration and the content of chlorophyll and anthocyans were determined. The obtained results indicated a negative influence of cesium on the T. *aestivum* plants. Based on the data received, the cesium bioavailability modification as a result of nanoparticles co-existence was discussed.

Skeletal anomalies in juvenile fish from the cooling pond of the Chornobyl NPP

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The skeleton abnormalities in juvenile fish of the common roach (*Rutilus rutilus)* and sunbleak (*Scardinius erythrophthalmus*) from the cooling pond (CP) of the Chornobyl NPP were studied. The samples were taken in 2016. All specimens were cleared and stained for bone with alizarin red following the method of T. Potthoff. 40 individuals of each species were selected on the stages of development of fish E (L = 15.5-17.5 mm) and D (L = 13.5-17.0 mm). The radiation exposure for fish in the Chornobyl Exclusion Zone water bodies is mainly formed by ^{90}Sr and ^{137}Cs. The average current absorbed dose rate for studied parental fish in the CP was 2.3-17.4 μGy h^{-1}. The absorbed dose rate for fish from the reference Pidbirna Lake did not exceed 0.07 μGy h^{-1}.

Among the observed anomalies in the common roach, the rib deformities consequence prevailed: Pidbirna Lake - 93% and CP - 95% of the total individuals. At that the degree of complexity of this anomaly was different. In reference lake the deformation of the ribs was least expressed. Among the anomalies the prevailing a different stage of spine deformation, among which there were lordosis, kyphosis and scoliosis: Pidbirna Lake – 40% and CP - 44% of the total number of individuals. Also, a significant percentage of such anomalies as additional processes of neural arches were found: Pidbirna Lake - 31% and CP - 21% of the total number of individuals. In addition for the juvenile common roach from contaminated water bodies the multiple and severe vertebral anomalies, as well as deformation of neural and haemal arches were discovered. In fish from the reference lake 73% of individuals have 1-3 anomalies per individual. The fish from CP was characterized by the largest number of anomalies per individual: 16% of juveniles have 4-6 anomalies.

Among the observed anomalies in the sunbleak, various manifestations of deformation of neural and haemal arches prevailed - 37 and 14%, respectively. Also, individuals of the sunbleak are characterized by the appearance of additional processes of neural arches (18%) and bifurcation of neural and haemal processes (13%). In skeleton of the sunbleak 73% of individuals had from 1 to 3 anomalies per individual. At the same time, the number of anomalies in some individuals reached 23 per individual due to multiple abnormalities.

Among the spinal deformities the lordosis and scoliosis predominated. In most cases the presence of curvature of the spine leads to compression of the vertebrae and various anomalies of the neural and haemal arches. Also, the complex anomalies of the ribs were registered.

Comparison of the prevalence of anomalies in above two species of fish from the CP showed that such anomalies as deformations of neural and haemal arches and the emergence additional processes of neural arches for both species are predominated. At the same time, the predominance of vertebral deformities for the common roach (11%), and bifurcation of neural and haemal arches (13%) for the sunbleak was registered.

Natural and artificial radionuclides in herbal teas from Serbia

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Due to their therapeutic and pharmacologic properties, medicinal herbs have a long history of use around the world. The objective of this study is to determine the activity concentration of natural (^{40}K, ^{226}Ra, ^{232}Th, and ^{238}U) and artificial (^{137}Cs) radionuclides in samples of herbal teas from Serbia.

The samples of the following commercially available teas: dandelion leaf (*Taraxaci folium*), mulberry leaf (*Mori nigrae folium*), ground ivy (*Glechoma hederacea*), sweet wormwood (*Artemisia annua*), rose hip (*Cynosbati fructus*), wall germander (*Teucrium chamaedrys*), and thyme (*Thymus vulgaris*), were collected in Serbia in 2021. The radionuclides' activity concentrations were determined using gamma spectrometry.

The results show that among the natural radionuclides, ^{40}K is dominant (316–1616 Bq/kg), while the activity concentration of ^{226}Ra and ^{232}Th ranges from below the minimum detectable activity (MDA) to 12.3 Bq/kg, and below the MDA to 13.4 Bq/kg, respectively. In all investigated samples, the ^{238}U activity concentration is below the MDA. Cesium-137 is detected in five out of seven analysed samples (0.3–2.9 Bq/kg).

The results indicate that ^{137}Cs, released into the atmosphere after the Chernobyl accident in 1986, is still present in the environment of Serbia. Nevertheless, according to the Serbian legislation regulating the maximum permitted levels of radionuclides in foodstuffs, all of the investigated samples of herbal teas are safe for human consumption.

Study of radionuclides concentrations in Greek vineyards: from cultivation to consumers' table

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Natural radionuclides (^{40}K and ^{238}U, ^{235}U and ^{232}Th series and their decay products) and the artificial ones (e.g. ^{137}Cs) are widespread in the environment in varying concentrations. They can be found in different materials in the surrounding, contributing an important fraction of the radiation dose to natural ecosystems, including human beings. Plants are absorbing them, and they ultimately reach up humans through the food chain. High concentrations of radionuclides can be dangerous for human and animal populations. The estimation of the amount of radioactivity transferred from soil to plants as well as the radiation doses to humans is considered crucial.

The aim of this study is to determine the activities of natural and artificial radionuclides in grape vines and the surrounding soil and to understand the mechanism of their transfer from soil to plants/grapes, and later in human beings. Samples of grape leaves, bunches and dried grapes of three different varieties (Mavroudi, Cabernet Sauvignon and Merlot), as well as surface soil samples were collected and analyzed by means of gamma spectrometry.

The concentrations of ^{7}Be, ^{137}Cs, ^{40}K, ^{226}Ra, ^{232}Th and ^{210}Pb were determined. The concentrations of ^{137}Cs and ^{226}Ra are negligible in all grape samples. The activities of ^{40}K and ^{7}Be of Merlot leaves are 1.5 times higher than Mavroudi's, while Cabernet bunches present the highest concentration of ^{40}K. ^{232}Th is detected only in Cabernet Sauvignon variety including both leaves, dried grapes and bunches. Merlot variety is the one that favors the most the transfer of ^{40}K from soil to grapes, followed by Cabernet Sauvignon variety.

More measurements are needed, and are indeed currently under progress, revealing information about the path of radionuclides from soil to grapes and their impact on human health through the different phases of the food chain.

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Assessment of temporal variations of radionuclides close to a coal power plant in Northern Greece using moss bags

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Mosses are ideal bioindicators. They are suitable for monitoring the deposition of different radioactive nuclides from the atmosphere to terrestrial systems, as they obtain all the nutrients directly from the air. The absence of an elaborate rooting system means that the uptake from the substrate is insignificant. This gives the advantage of estimating the concentrations of radionuclides in the atmosphere in a low-cost and easy operating way.

Different species of naturally growing mosses can be used for biomonitoring purposes. In some cases, due to their unavailability in a specific area or due to the difficulty of their collection, transplanted mosses can be used instead. This introduces another active moss-based biomonitoring method, the "moss bag technique". This technique can be performed in industrial areas too, providing information about the air quality, and revealing the impact of the anthropogenic activities (like the coal fired power plants) on the environment.

Coal is the most dominant fossil fuel and plays a significant role in the global energy world. It contains naturally occurring radionuclides, such as ^{40}K, ^{232}Th, ^{238}U and their decay products. The aforementioned radionuclides are emitted during coal combustion. They are deposited to the environment and they contribute to the radiation exposure of people that are working and living nearby, thus making their study really important.

The aim of this research is to determine the concentrations of different radionuclides (^{210}Pb, ^{40}K, ^{137}Cs, ^{7}Be) in moss bags close to a coal power plant in Northern Greece. For this purpose, moss species *Hypnum Cupressiforme* Hedw. were packed into special bags and placed close to the coal power plant. After a six months exposure (spring to summer), they were analyzed by means of gamma spectrometry. The majority of the radionuclides present higher activities during summer period. ^{210}Pb and ^{7}Be in mosses arrived from aerosol deposition, while ^{137}Cs was transferred to mosses due to soil re-suspension. These are some preliminary results, and more measurements are needed.

Analysis of biosphere models describing the behaviour of natural and artificial radionuclides in the environment

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Compartment models can be used to describe the decay, transformation and environmental movement of radionuclides in the biosphere using differential equations. Several software tools have been developed for its practical implementation (e.g. ERICA tool, SADA, etc.). Although the basic is the same, there may be differences between the existing biosphere models, depending on which parameters are taken into account and how. Hence, there are also differences in the applicability of each model.

One important application of multicompartment biosphere models is the nuclear facilities monitoring (nuclear power plants, waste repositories). Nuclear power plants also emit radionuclides during normal operation. The models can be used to estimate the contribution of these nuclides to the radiation exposure of the population and to establish compliance with dose limits. In the case of waste repositories, biosphere models are used in safety analyses to analyse the short- and long-term effects of radionuclides that may escape from the repositories.

The input parameters and constants used in each model may come from other databases, which further increases the number of possible variations. The content of the databases is mostly derived from results supported by a large number of studies, but there are cases where this is not possible. This is because the determination of certain parameters is extremely difficult and complex, and therefore few results are available in the literature.

The aim of this study is to investigate the differences between the input parameters and the possibilities of estimating parameters that are not included in the databases.

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Environmental impact modelling and radiological risk assessment of NORM repositories in Hungary

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The human population is exposed to the natural radionuclides in the environment elements continuously. The concentration of these nuclides is usually low, but the different technological processes and activities can concentrate them in products, by-products, or wastes. These activities are for example coal mining, fertilizer production, ores mining and metal production, etc. These materials are called NORM (Naturally Occurring Radioactive Material). The most common method of disposal for the NORMs is deposition in different types of depositories. The long-term effects of these depositories on the environment and on human health are hard to estimate.

The determination of the human radiation dose is a very important task. In default to the numerous measurement results, different models are used for the dose estimation. These models used integrated output models and they contain several universalisations.

The human body can reach the radiation from the primordial radionuclides in the soil in two ways: the external dose is from the radionuclides out of the body and the internal dose is from the radionuclides in the human body (inhalation or ingestion). In the case of external radiation, the human exposure is estimated easily when the radionuclide's concentration is known, but the internal dose depends on several parameters. For the true dose estimation, several parameters have to be known: types of the plants in the investigated area, type and quality of soil, radionuclides' concentration in the soil, and the transfer factors between the plants and soil.

The aim of the study is to assess radiation risk from the selected NORM depositories for members of the public and biota. The radionuclide concentrations were determined HPGe gamma-spectrometry. The dose estimation was investigated using RESRAD-ONSITE and RESRAD BIOTA.

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THe effect of chronic radiation exposure on zooplankton communities of radioactively contaminated reservoirs of “Mayak” PA

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The reservoirs of the Techa cascade have been used for many years as storage reservoirs for liquid radioactive waste at “Mayak” Production Association (South Ural, Russia). At the same time, there is a pronounced gradient in the content of radionuclides in these reservoirs in ascending order - R-11, R-10, R-4, R-17, which makes it possible to study the radiobiological patterns of the reaction of zooplankton communities [Pryakhin E. A., 2016]. We studied the state of zooplankton communities in the period August-September in 2009, 2010, 2015 and 2016.

The content of ^{137}Cs, ^{90}Sr radionuclides and alpha-emitting radionuclides in water, bottom sediments and zooplankton was determined. For the studied reservoirs, the dose rate for zooplankton was: for reservoir R-11 - $1.2x10^2$ μGy/h; R-10 - $3.5x10^2$ μGy/h; R-4 - $1.8x10^3$ μGy/h; R-17 - $4.7x10^3$ μGy/h.

In the studied water bodies, the contribution of rotifera was invariably higher than the contribution of cladocerans and copepods. In reservoir R-11, the proportion of rotifers was 49±5%, cladocerans - 27.6±3.0%, of copepods - 23.7±2.1%. In reservoir R-10, rotifers accounted for 57±3%, copepods and cladocerans accounted for 21.0±2.6% and 21.6±1.6%, respectively. In the water body R-4, on average for the studied years, the proportion of rotifera was 67±6%, cladocerans - 17±4%, copepods - 17±3%. In reservoir R-17, on average for the studied years, the proportion of rotifers was 95.60±0.20%, cladocerans - 2.8±1.4%, copepods - 1.6±1.6%.

To determine the species richness, species diversity and evenness of the reservoir, the Margalef index and Shannon index was used. The average value of the Margalef index for zooplankton from reservoir R-11 was 2.1±0.6, R-10 - 2.1±0.3; R-4 - 2.4±0.3; R-17 - 0.56±0.06. The average values of the Shannon index from the studied reservoirs were 2.82±0.14, 2.55±0.27, 2.4±0.6 and 0.99±0.23, respectively, for the reservoir R-11, R-10, R-4 and R-17.

To evaluate the Shannon and Margalef indices on the dose rate the Regression analysis was performed. It was found that the dependence of indexes values was described by an exponential function best of all. The equation for the Shannon index was: $SI = 2.94 * \exp(-0.0002*P)$, ($R^2 = 0.71$; $F=24.96$; $p=0.0005$), where, SI is the Shannon Index, P– dose rate, μGy/h. The equation of the Margalef Index was: $MI = 2.46*\exp(-0.0003*P)$, ($R^2 = 0.64$; $F=17.45$; $p=0.002$), where, MI is the Margalef Index, P is the dose rate, μGy/h.

Thus, a dose-dependent change in the indices of species diversity was revealed, which may indicate the influence of chronic radiation exposure on these zooplankton species richness and species diversity. It should be noted that the above results do not take into account the influence of the characteristics of the chemical composition of water in the studied reservoirs. It requires further study of the influence of chemical factor on the analyzed indicators.

Assessment of radiocarbon concentration in soils of the "Experimental Field" site

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Soil has a key role in carbon cycle of the biological chain. The main part of carbon stream emitted into environment results from transformations in soil and in dying biomass. Presence of radioactive carbon isotope (^{14}C) in soil can result in radioactive contamination of plants, surface and ground water, as a result of redistribution. When ^{14}C comes into soil in increased concentrations, the environmental objects accumulate it in amounts exceeding the natural background (230 Bq/kg). This paper was aimed at research of ^{14}C distribution in soil, contaminated as the result of nuclear tests at Semipalatinsk Test Site (the STS). One of the ways to form ^{14}C is interaction between neutrons resulted from a nuclear explosion, with nitrogen nuclei. Due to this, one of the STS testing sites, the "Experimental Filed" site, where 116 nuclear tests (86 atmospheric and 30 surface tests x) were conducted from 1949 to 1962 was chosen for the research purpose. Territory of the "Experimental Filed" represents a flat area with the diameter of approximately 20 km, and the area of about 300 sq.km., surrounded with low hills from three sides. To prepare soil specimens for radiocarbon analysis, Pyrolyser-6 Trio system for samples ignition and ashing was used. Burning the specimen using this system, makes ^{14}C oxygenated and also results in formation of radioactive carbon dioxide ($^{14}CO_2$). Efficiency of the procedure of burning using Pyrolyser-6 Trio was estimated by means of analysis of certified radiocarbon standard. Chemical yield of ^{14}C as the result of burning certified standard in form of ^{14}C-carbonate was 95 %. ^{14}C activity was measured using "SL-300" alpha-beta radiometer. As the result of the researches it was found, that the average specific activity of ^{14}C in the area researched is 170 Bq/kg. The maximum ^{14}C concentration in soil of 2500 Bq/kg was registered directly in the epicenters of the "Experimental Field" site. The researches performed revealed significant amounts of ^{14}C in soils of the venues of nuclear tests. Therefore, there arises a necessity in comprehensive researches, allowing to understand the peculiarities of ^{14}C accumulation, as well as to reveal the main factors contributing to its distribution and contamination of other environmental objects.

The character of the vertical distribution of radionuclide pollution in bottom sediments of natural lakes in the territory of the Semipalatinsk test site

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The paper presents data on the nature of the vertical distribution of radionuclide contamination in the bottom sediments of natural lakes of the Semipalatinsk test site. The objects of research are lake b / n 4, lake Zhyngyldy, lake Shubran and lake Kishkensor. The distribution of technogenic radionuclides ^{137}Cs, ^{241}Am and ^{3}H was studied. Spot sampling was carried out on 1 undisturbed core of bottom sediments. The height of the selected columns was up to 20 cm. The separation of the column in layers was carried out immediately at the sampling sites. The thickness of one layer was 10-12 mm, weight 0.25-0.30 kg.

According to the results in the bottom sediments of the lake b/n 4, there is a shift in activities along the ^{137}Cs radionuclide profile to a depth of 6-9 cm. In this range, the specific activity for ^{137}Cs is from 2.2±1 to 3.0±1.0 Bq/kg. The specific activity of ^{241}Am in bottom sediments is observed from 5 to 9 cm, which is consistent with the results for ^{137}Cs, the values vary from 2±0.5 to 3.0±1.0 Bq/kg. The uneven distribution of ^{3}H over the entire depth is explained by the high migration abilities of this radionuclide. The maximum content of ^{3}H is fixed at a depth of 5-6 cm, and is 2100±210 Bq/kg.

In study of bottom sediments of lake Zhyngyldy, the peak of activity of radionuclide ^{137}Cs is observed in a surface layer of 0-1 cm, the specific activity was 6.0±1.0 Bq/kg. The values of specific activity of ^{241}Am in bottom sediments of the lake are below the detection limit of used equipment and methodological support. The peak of activity of ^{3}H is fixed at the depth of 9 cm (2250±200 Bq/kg), also there are numerical values at the level of 2-3 cm which are equal to 110±10 Bq/kg and 80±8 Bq/kg respectively.

Numerical value of ^{241}Am (1.6±0.3 Bq/kg) was recorded in bottom sediments of Lake Shubran only at the depth of 4 cm. Maximum values of ^{137}Cs were also recorded at a depth of 4-5 cm and were 11.0±1.2 Bq/kg and 13.0±1.4 Bq/kg. The values of specific activity of ^{3}H in bottom sediments are below the detection limit according to studies of bottom sediments of the lake. Kishkensor, the obtained numerical values of the ^{137}Cs radionuclide do not exceed 6.0±1.0 Bq/kg. The specific activity values of ^{241}Am in bottom sediments are below the detection limit. The content of ^{3}H in the bottom sediments of the lake. The gut is fixed from a minimum of 112±10 Bq/kg to a maximum of 12600±1200 Bq/kg over the entire depth. According to the results of previous work, it was found that the pollution of the lake. Kishkensor with ^{3}H radionuclide occurs as a result of the release of contaminated groundwater to the daytime surface of the lake.

Analysis of bottom sediments showed that ^{137}Cs accumulates mainly in the surface layers, the exception is lake b/n 4. Radionuclide ^{241}Am was not fixed in all objects of research. Regularity of ^{3}H distribution in the studied lakes is not established, as a result, the results are not indicative.

The current radiation state of water bodies at the sites of "peaceful" nuclear explosions at the territory of the Semipalatinsk test site

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In the period from 1965 to 1988, as part of the implementation of the state program No. 7 "Nuclear explosions for the national economy", 7 explosions (9 charges) were made at the territory of the Semipalatinsk test site (STS). One of the areas of industrial use of underground nuclear tests was the creation of artificial reservoirs through excavation nuclear explosions (with ejection of soil). As a result at the STS territory, the "Telkem-1" and "Telkem-2" craters were formed at the "Telkem" site, a crater (borehole 1003) at the "Sary-Uzen" site and the "Atomic" Lake at the "Balapan" site, which became objects of this research.

For research, samples of water, sediments and plants were taken. The plants belong to 3 ecological groups depending on the place of their growth: aquatic, coastal-aquatic and coastal. The contents of ^{137}Cs, ^{90}Sr, ^{241}Am and $^{239+240}$Pu were determined in all taken samples.

According to the obtained data, the ^{241}Am and ^{137}Cs content in water is below the detection limit (<1 Bq/l and <0.01 Bq/l, respectively), $^{239+240}$Pu varies from $7.4*10^{-4}$ to 0.21 Bq/l, ^{90}Sr - reaches 170 Bq/l. The radionuclides content in sediments was: for ^{90}Sr - from 74 to 710 Bq/kg, for $^{239+240}$Pu - from $7.0*10^{3}$ to $2.7*10^{4}$ Bq/kg, for ^{241}Am - from 320 to $7.1*10^{3}$ Bq/kg, ^{137}Cs - at the level of $2.8*10^{3}$ Bq/kg.

Aquatic plants grow only on 2 water bodies: in the "Atomic" Lake and in the "Telkem-1". The maximum values of the radionuclides content were fixed in aquatic plants growing in the "Telkem-1": for $^{239+240}$Pu - from $4.3*10^{3}$ to $1.6*10^{4}$ Bq/kg, for ^{90}Sr - from $1.2*10^{3}$ to $5.4*10^{3}$ Bq/kg, for ^{137}Cs - from 40 to $1.6*10^{3}$ Bq/kg, for ^{241}Am - from 250 to $1.3*10^{3}$ Bq/kg.

Aquatic-coastal plants include south cane (*Phrágmites austrális)*, cattail angustifolia (*Týpha angustifólia)* and lake bulrush (*Schoenoplēctus lacūstris)*. The maximum values are set for ^{90}Sr - from 24 to 390 Bq/kg, less high for $^{239+240}$Pu - from <0.04 to 150 Bq/kg and for ^{137}Cs from <1 to 20 Bq/kg.

In the coastal shrub of the french tamarisk (*Tamarix ramosissima*), the numerical values of the ^{241}Am content were fixed only in the samples growing on the Telkem-2 (at the level of 9 Bq/kg), ^{137}Cs, ^{90}Sr and $^{239+240}$Pu - in all the samples (^{90}Sr – from 100 to 960 Bq/kg, $^{239+240}$Pu - from 0.4 to 11 Bq/kg, ^{137}Cs - from 3 to 45 Bq/kg).

As the obtained data show, despite the fact that excavation explosions at the STS territory were carried out more than 50 years ago, a high level of radioactive contamination of water bodies still remains, both for sediments and plants (^{137}Cs, ^{241}Am, ^{90}Sr and $^{239+240}$Pu), and for water (^{90}Sr). Thus, from an ecological point of view, each "peaceful" nuclear explosion, regardless of the purpose of its use, poses a significant danger to the environment and humans, since it is still a source of radioactive contamination.

Tritium incorporation by eggplant and pepper after short-term exposure to atmospheric HTO vapor under different growth periods

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The plants play important role in tritium transfer. The study objective is to investigate experimentally the tritium uptake and incorporation in eggplant and pepper under different growth periods. All plants were grown preliminary in the plastic boxes until the flowering and ripening stage in the greenhouse condition. Potted plants were exposed for 6 hours of atmospheric HTO vapor under the field (at the former Semipalatinsk nuclear test site) and laboratory condition (into the climate chamber). In both experiments, soil in pots was covered with vinyl film to prevent HTO by root uptake. Every two hours during the exposure, primary parameters were measured (temperature, air humidity, atmospheric pressure, light intensity, HTO activity in the air). All taken plant samples were divided into parts (leaves, stems, inflorescences, and fruits) and immediately frozen. Air sampling was carried out using a tritium collector.

The tissue free water tritium (TFWT) was extracted using a specially designed installation. Organically bound tritium (OBT) was measured in combusting water of dried plant samples. Tritium activity concentration was determined using a liquid scintillation counter.

The tritium activity in the air of the climate chamber varied in the range 35-60 Bq m^{-3}, in field experiment – 13-30 Bq m^{-3}.

In all experiments, the leaf TFWT activity exceeds similar values in stems and fruits by a factor of 1-2. The OBT activity in all plant parts was lower compared to TFWT by a factor 1-2.

The distribution of tritium in plants can be presented as decreasing rows: for TFWT – "leaves < stems < fruits"; for OBT – "leaves < fruits< stems".

In the climate chamber at the end of exposure, the specific activity ratio (SAR) for pepper and eggplant was an average of 0.013 and 0.018, respectively. In the field, SAR was obtained only for pepper, and it was higher by a factor of 5 (SAR – 0.07). Minimal SAR values are explained by a short exposure period. As a whole, the conversion rate of tritium reached the highest value at the beginning 2 hours of exposure in the first 2 hours then it was decreasing by 2-3 times in both experiments. But the average conversion rate values of the OBT obtained in the laboratory conditions for pepper at the flowering and maturation phase were 0.22 and 0.19%h^{-1}, and for eggplant – 0.61, and 0.46%h^{-1}, respectively. The average conversion rate in the field conditions was obtained only for pepper at the maturation phase (1.81% h^{-1}), which is 10 times higher than the corresponding indicator established in laboratory conditions due to the more active solar radiation.

The OBT translocation to the edible parts in field conditions also was more intense compares to in laboratory experiments (TLI obtained in the field were higher by a factor of 2-4), despite the fact, that during exposure tritium activity in the air of the climate chamber was significantly higher compared to field experiments.

Study of speciation of technogenic radionuclides in surface waters of the Degelen site

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The study of the forms of radionuclides in water, which largely determine their bioavailability, is of scientific and practical importance in assessing and predicting the migration of radionuclides in ecosystems.

As a result of nuclear tests at the Semipalatinsk test site, there was significant radioactive contamination of the environment, including surface water. At the same time, the forms of radionuclides in water and their distribution are poorly studied, which may lead to an incorrect assessment of contaminated water bodies as sources of radiation hazards for the natural environment and humans.

The methodology of this study is based on the cascade filtration method, which allows to separate suspended, colloidal and dissolved forms of radionuclides. A cascade of 6 filters is selected to separate the different forms. During fractionation, water was sequentially passed through filters with different pore diameters - from 8 μm to 0.003 μm. After each fractionation step, an aliquot was taken to determine the radionuclide content in each fraction.

The waterways of tunnels 104, 165, 504 and 609 of the former Degelen test site were selected for research.

As a result of this work, we studied the distribution of radionuclides in the surface waters of the Degelen site by cascade filtration. It was found that the main form of ^{90}Sr in the studied mine waters is a dissolved substance, and only in the water from the water flow of the adit 165 to 10% of this radionuclide is in the form of colloids, while the radionuclide ^{90}Sr content varies from 110±10 to 1400±150 Bq/kg. The predominant form of ^{137}Cs in the studied waters is the dissolved form, but the distribution of this radionuclide is also noted in the form of a coarse suspension (up to 2%). The specific activity of ^{137}Cs was from 150±15 to 330±30 Bq/kg, in the water of the 104 adit water - 8±1 Bq/kg. For $^{239+240}Pu$ it is characteristic to be found in different forms, with a predominance of dissolved and suspended. In the water from the water flow of adits 104 and 504 up to 67% of this radionuclide is in the form of suspended matter, in the water of adit 609 up to 60% of the total content is in the form of dissolved matter. The content of $^{239+240}Pu$ is below the detection limit of the hardware and methodology used in the water from the water stream of adit 165.

The results obtained allow us to view about the migration capacity of man-made radionuclides in the most contaminated water bodies of the Degelen site in order to make predictive assessments of the radiation situation in the contaminated areas.

The ratio of gross and water-soluble potassium in the upper soil layer in the area of influence of the thermal power plant

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The main source of air pollution in Prykarpattia (Ukraine) is Burshtyn TPP (BuTES), which operates on combustible coal and contributes 84.4% of total emissions from stationary sources in the region. The ratio of gross content and water-soluble form of potassium ions in the upper layer of soil was used as a marker of pollution of the upper soil layer by atmospheric emissions from coal burned at a thermal power plant.

During 2014-2020, 39 samples of the upper soil layer at a depth of 0-5 cm were taken at the ash dump and in the soil at different distances from the TPP. A fraction of less than 0.25 mm was isolated from the dried samples and used for further analysis. The gross content of potassium ions in the samples was determined by radiospectrometry using ^{40}K concentration analysis. The concentration of soluble forms of potassium was measured in aqueous extracts from soil samples by ionometry. Statistical analysis of measurement results was performed in the software application Past 4.03.

In the soil, insoluble forms of potassium are present in the grains of the mineral base. In addition, from the atmospheric emissions of BuTes on the soil surface are sediminated mainly insoluble forms of potassium associated with fly ash and dusty slag particles. Sand selected from a local quarry was used to analyze the concentration of gross and water-soluble forms of potassium in the mineral base of the soil. Sample analysis showed that the concentration of sparingly soluble forms of potassium in the sand from local quarries (n = 3) is 2300 ppm, and soluble - 4.8 ppm, with a ratio of soluble to gross forms of potassium -0.2%. In the preparations of the dusty fraction of slag (n = 3) found the gross content of potassium - 31000 ppm, soluble - 3 ppm, with a ratio of soluble to gross - 0.09%. In the preparations of fly ash (n = 3) the gross content of potassium - 14500 ppm, soluble - 30 ppm, with a ratio of soluble to gross - 0.2%. In the material from ash and slag dumps (n = 14) the gross content of potassium is 21130 ppm, soluble - 19 ppm, with a ratio of soluble to gross - 0.09%. In all these measurements, the coefficients of variation (V) varied from 8 to 14%.

The median value of the concentrations of potassium forms measured in the soil (n = 15) at a distance of 50 m to 3 km from BuTES was 20380 ppm in terms of gross content, at V = 46%. Soluble form - 32 ppm at V = 49%, with a ratio of soluble to gross - 0.16%. Correlation analysis of samples of these distances of soil sampling sites from the emission source and the proportion of insoluble potassium in the upper soil layer performed by Spearman's method showed close feedback with a coefficient of -0.8 between the analyzed samples.

It was found that the proportion of insoluble potassium in the upper soil layer increases as it approaches the emission source due to sedimentation of dusty particles of ash and slag on the soil surface.

Retrospective estimation of radiation dose rate and morphometric parameters of leaf venation of the common reed in the Chornobyl Exclusion Zone

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The common reed (*Phragmites australis* (Cav.) Trin. Ex Steud), which is geophyte and hydrophyte, has a high ability to accumulate dissolved chemical elements from the water and under long-term radiation exposure exhibits radiomorphism of leaves, which makes this species suitable for radioecological research.

Observations were conducted in the Chornobyl Exclusion Zone from 2000 to 2020 in 6 water bodies with different levels of radioactive contamination: from background to the most contaminated ones (e.g. Glyboke Lake). Samples of water, soil and bottom sediments at the water's edge, and reed leaves were taken. Gamma-ray radiometric measurements were also performed above the soil surface at the water's edge. The concentration of ^{90}Sr and ^{137}Cs was determined in the selected samples as well. The samples were analyzed at the Institute of Hydrobiology of the NAS of Ukraine and in the SSE "Ecocentre" of the State Agency of Ukraine on Exclusion Zone Management. Retrospective estimation of external and internal radiation dose rate for ^{90}Sr, ^{137}Cs and total dose rate within sampling sites (n = 115) was performed using the ERICA Assessment Tool software 1.2.1. The microscopy of the thickness of the central veins of reed leaves was conducted at 30x magnification. Statistical analysis of measurement results was performed in the software application "Past 4.03".

To assess the dynamics of dose rate, the data were ranked according to the date of observation, and then the samples of the first (2000-2005) and fourth (2017-2020) quartiles of the data were compared. The median value of the total dose rate for the first quartile is 6.5 μSv/h, with coefficient of variation (V) 410%, the fourth quartile - 9.8 μSv/h, with V = 150%, respectively. Comparison of the total dose rate of the first and fourth quartiles showed no significant differences between the medians of the samples. Despite the fact that during the 20-year observation period, reed leaves have statistically the same radiation dose rate, the coefficient of variation of the first quartile of observations is three times higher than a similar parameter of the fourth quartile.

According to the results of measurements of 688 common reed leaves, collected during 2017-2020, it was found that the width of the central veins varies from 0.13 to 0.21 mm, with median of 0.14 at V = 12%. The median total dose rate was 6.5 μSv/h at V = 220%, the ^{90}Sr external dose – was 0.36 μSv/h at V = 120%, and ^{137}Cs - 4.7 μSv/h at V = 180%; ^{90}Sr internal dose was 0.15 μSv/h at V = 220%, and ^{137}Cs - 3.25 μSv/h at V = 300%. The analysis, performed using the Spearman correlation coefficient (rS), showed the dependence of the thickness of the central veins on the dose rate: total - rS = 0.49; from external ^{90}Sr - rS = 0.47, and ^{137}Cs (rS = 0.37); internal ^{90}Sr - rS = 0.42, and ^{137}Cs - rS = 0.39. The dependence of the thickness of the central veins of the common reed leaves on the dose rate was established.

Study of radiotracers diffusion through cement matrices

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During the interim storage or final disposal of low or intermediate level of radioactive waste, migration/diffusion of radionuclides can occur when the waste comes in contact with water. Cementitious materials are intensively used in disposal facility construction and also as waste immobilization matrix due to their ability to act as mechanical barriers and to prevent convective water flow. Furthermore, these barriers will retard the transport (diffusion controlled) of dissolved radionuclides by a combination of mechanical constraints and chemical interaction with solid matrix.

This paper presents the long-term leaching behavior into surrounding fluid of ^{137}Cs, ^{60}Co and ^{152}Eu radionuclides, artificially incorporated in mortar matrices made from natural aggregates and recycled radioactive concrete. Results were obtained in several years of mortar testing and will help to increase the safety storage of low and intermediate level of radioactive waste. To assess the safety disposal of radioactive waste material in mortar matrices, the influence of type and size distribution of the aggregates and the curing time on leaching behavior was studied.

After a series of studies made to get a mortar proper recipe, several samples were artificially contaminated with specific radiotracers were created which were immersed in liquid for a period of 30 days. The leached activity was evaluated for each sample from the immersing water through gamma-ray spectrometry method using an HPGe detector. GESPECOR software was used to evaluate the efficiencies.

Spatial analysis of natural and artificial radioactivity levels of marine sediments with geographical indication

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Turkey has planned to build 4 nuclear power plants by 2030 in order to meet the increasing energy demand in parallel with its increasing population and developing industry. The Akkuyu Nuclear Power Plant, first one to be build, will have four VVER-1200 type units (with a total capacity of 4800 MWe) and will be located in the Büyükeceli town of Mersin province. According to the plans first unit will be up and producing energy in 2023. In order to monitor the potential impacts of the NPP, the current radio-ecological state of the environment must be recorded prior to the NPP becomes operational.

Within the scope of the present study, both natural ^{226}Ra, ^{232}Th, ^{40}K and artificial ^{137}Cs radionuclide activity concentration levels of the marine sediments, collected from Mediterranean coast of the Turkiye were measured. Three different sub sampling areas (East-Mediterranean - Antalya Bay, West-Mediterranean - Mersin Bay/shores 10-200m and 400-800m/deep offshore) within the sampling region were evaluated. Up to 200m deep a Van Veen Grab device was used to collect sediment samples from shores. For the offshore areas sediments accumulated in the deep-sea trawl nets were sampled. All samples were placed in plastic bags on board, labeled and then transferred to the Akdeniz University, Faculty of Fisheries laboratory for further analysis. Before the measurements, all sediment samples were stored (air-dried) 4–7 d until they reached a constant weight in a ventilated room. All samples were homogenised with the grinding machine and sieved through a 2-mm mesh in order to remove foreign materials and impurities. The sieved samples were then filled into hermetically sealed (6cm x 5cm) 150 cc polyethylene cylindrical containers, labelled, weighed and stored for 4 weeks in order to reach secular equilibrium between ^{226}Ra and ^{222}Rn prior to counting. Approximately 5 g of sludge from each sample were put in 6-cm diameter cylindrical containers and dried at 80^{o}C for 14 h to determine the moisture rate of the samples.

Radioactivity measurement was conducted by using a p-type, coaxial, electrically cooled, high-purity germanium gamma-ray detector AMATEK-ORTEC with Full Width Half Maximum (FWHM) at 122 keV for ^{57}Co and 1.85-keV FWHM at 1332 keV for ^{60}Co. It is connected to an NIM consisting of ORTEC bias supply, spectroscopy amplifier, analogue-to-digital converter and a computer. The detector was placed into a 10-cm thick lead shield with an inner surface covered by a 2-mm thick copper foil to shield from the X-rays originating in lead. Data acquisition and analysis were carried out with MAESTRO32 software. All samples were placed to the front face of the detector and counted for 50 000 s. Background intensities were obtained with an empty beaker for 50 000 s under the same conditions before and after measurement of the samples. Then, the average of the background counts was subtracted from the sample spectrums. ^{238}U and ^{232}Th activity concentrations were determined from their daughter products indirectly, while ^{137}Cs and ^{40}K were determined directly by their gamma-ray peaks. To determine the activity concentration of the ^{238}U nuclide, daughter nuclides ^{214}Pb and ^{214}Bi were used, while ^{228}Ac concentration was chosen for the parent ^{232}Th. The gamma transitions of 351.9 keV ^{214}Pb and 609.3 keV ^{214}Bi were used to determine the concentrations of ^{238}U. The gamma transition of 911.2 keV ^{228}Ac was used to determine the concentration of ^{232}Th. 661.6 keV and 1461.0 keV gamma transitions were used to determine the concentration of ^{137}Cs and ^{40}K, respectively. Details of the activity and dose calculations were presented by Ozmen et al.

Results obtained from analysis indicate the presence of a homogeneous distribution of natural (^{226}Ra, ^{228}Ac, ^{40}K) and artificial (^{137}Cs), originated from the Chernobyl accident and other nuclear activities radionuclides, in the study area. The calculated average ^{226}Ra (21.93±6.32 Bq kg^{-1}), ^{232}Th (18.31±5.09 Bq kg^{-1}), ^{40}K (314.40±107.79 Bq kg^{-1}) and ^{137}Cs (3.24±2.19 Bq kg^{-1}") activity concentrations of the sediments were below reported world averages [2]. Moreover, our findings were consistent with the previous studies carried out on marine sediments in the Turkish coastline and surrounding countries. In addition, the absorbed gamma dose rate, radium equivalent activity, annual equivalent dose, internal and external hazard indices were calculated by using sample activity concentrations. The calculated average values for D, Ra_{eq} and AED are in the permissible limits published by IAEA.

^{210}Pb as a tracer of air pollution in central Helsinki

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Airborne ^{210}Pb is a decay product of ^{222}Rn emanating from the soil. Due to its long half-life (22.3 y) ^{210}Pb accumulates relatively slowly into the atmosphere. Thus, it can be used as an atmospheric tracer for long-range transported air masses. Anthropogenic lead emissions have low content of ^{210}Pb, so the anthropogenic lead emissions tend to decrease the specific activity of ^{210}Pb in the atmosphere. The ^{210}Pb specific activity is the ratio of the ^{210}Pb activity concentration to the total concentration of stable lead.

The Finnish Meteorological Institute (FMI) is monitoring, since 1960, airborne radioactivity collecting aerosol samples with air filters and measuring alpha and beta radioactivity as well as ^{210}Pb and other radionuclides. ^{210}Pb in air filters from Finland for the period 1980-2005 are presented in this work. By studying especially weekly cycles of air pollution and using the natural radionuclide ^{210}Pb as a tracer, several features of air pollution in central Helsinki are examined. The correlation with the air temperature and the precipitation amount for heavy metals and ^{210}Pb is also examined.

Aerosols samples were carried out with high-volume air sampler. Glass-fiber filters were used as collection material. The filters were changed every morning. The sampling site was on the roof of the FMI's main building, near the city centre, 27 m above sea level.

The ^{210}Pb daily concentrations are compared to the elemental lead and other metals concentrations, determined by EDXRF technique, which carried out by the Environmental Radioactivity Laboratory,"Demokritos".

In Helsinki metropolitan area, vehicular traffic is the most significant local particle source affecting urban air quality. Also, the effects of wood combustion can be considerable. Additionally, a large portion of fine particles originates from long-range transport in the Helsinki area. Southern Finland is strongly affected by deposition from neighboring's areas, central Europe and domestic emissions, whereas in central and northern Finland deposition levels are much lower and dominated by long-range transboundary air pollution.

The observed average concentration of lead between 1980-2005, equals with 39.3 ngr m^{-3}, reveals a decrease of the order of one magnitude since the 70s. Pb concentrations are partly associated with long-range transport to southern Scandinavia from the heavily industrialized areas in Central and Eastern Europe and partly with pollution from local emissions.

Regarding the local traffic pollution, Zn, Cu and Pb, can be characterized as being road-specific heavy metals, mainly derived from combustion residues and losses from fuels and engine, transmission oils and abrasion from tires. The simultaneous decrease over the time of all these metals is an index of decreasing traffic pollution at Helsinki, while on average the TSP has decreased almost 1 μg/m^3 per year for the study period. The TSP decrease has been steeper than the decrease of TSP/^{210}Pb ratio, indicating that the contribution of local sources to TSP has decreased more rapidly than the long-range transported component. Finally, the observed values of specific activity ^{210}Pb/Pb vary between 1.63-85.59 kBq/g, showing a decrease in values of local Pb about 200 ngm^{-3}.

HAH 346 chondrites from joint fall in Al-Dżabal al-Gharbi, Libya

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In this study, low-background gamma spectrometry was used to confirm the identity of a set of ordinary chondrites found in 2019 in part of the Al-Hamada al-Hamra desert, in the region of Al-Dżabal al-Gharbi, in Libya. Chondrite radiometric studies enabled detailed analysis of the composition of radioactive isotopes – the short-lived ^{22}Na, ^{54}Mn, and ^{60}Co, and the long-lived ^{26}Al. The compositions of radioactive isotopes are specific for ordinary chondrites with the same history and can be considered as a specific fingerprint of the chondrite. Analysis was carried out using a unique passive and active shielded gamma spectrometry system to obtain optimal measurement conditions for quantitative and qualitative identification of the radioactive isotopes and their activity ratios. Ten specimens of ordinary chondrites from two different expeditions were investigated to assess their history of their falls. Some of the chondrites were from the HaH 346 group that was classified in February 2021. The data sets have been analyzed based on principal component analysis (PCA) to selectively derive essential information.

Novel method of ancient pottery analysis based on radioactive isotope ratios - a pilot study

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The proposed method has been applied to a multi-phased settlement complex and pottery manufacturing centre in Ostrowite in northern Poland. In this study the radioactive isotope ratios method has been applied to a set of ceramic pottery specimens from the same multi-layered archaeological site and probably produced from local raw material. The method shows the similarities within the ceramic material used to manufacture the pottery. The variations in the quantitative and qualitative compositions of the basic products (clay, silt, loam, sand, ash and organic admixtures) used in the preparation of the ceramic paste change the isotopic composition and activity ratios. Pottery from each ceramic manufacturing centre, based on the specific composition of the raw materials, have characteristic isotope ratios. Radioactive isotope ratios as fingerprints of ancient ceramic manufacturing centres have not yet been applied as an archaeometric method. In this study two isotope ratios have been selected and applied: $^{40}K/^{228}Ac$ and $^{226}Ra/^{208}Tl$. The pilot study confirms the grouping of isotope ratio results for each sample type, even in terms of similarities with the base clay material collected in this region.

On the microscopic description of irradiation dynamics

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We discuss microscopic mechanisms of irradiation in clusters and molecules. We have considered isolated molecules/clusters [Phys. Reports 337(2000)493] and/or in contact with an environment [Phys. Reports 485 (2009) 43]. Examples are taken from free metal clusters, from fullerenes, from molecules of biological interest and from clusters deposited on a surface or embedded in a matrix. We analyse in particular the properties of emitted electrons (photo electron spectra, angular distributions...) which constitute a key tool of analysis of the properties of irradiated clusters and molecules [Phys. Rep. 562(2015)1].

The microscopic real time description of irradiation processes requires an explicit dynamical account of electronic degrees of freedom. But it is necessary to treat electrons in a non-adiabatic way and to allow for ionization and/or electron transport. Basis of the description is Time Dependent Density Functional Theory (TDDFT, for electrons) coupled to Molecular Dynamics (for ions). Widely used TDDFT approaches such as Local Density Approximation (LDA) however lack crucial dynamical correlations responsible for energy redistribution and thermalization after irradiation.

We thus propose a quantum Relaxation Time Ansatz (RTA) providing an approximate quantum kinetic treatment [Ann. Phys (NY) 354 (2015) 183]. The RTA has allowed us to access realistic irradiation scenarios and study the impact of dissipation on electron emission in moderate size systems. RTA has recently been included in an open source software package entitled QDD (Quantum Dissipative Dynamics) which allows to study moderate to large systems such as fullerenes. We shall discuss the capabilities of this new open source software [https://www.irsamc.ups-tlse.fr/qdd/].

Development of a compact multi-elements activation neutron spectrometer for BNCT

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The need of neutron spectrometry techniques for beams QA purposes as well as for comparing different facilities and accelerator types, is a well-known topic in the Boron Neutron Capture Therapy (BNCT) community.

In the framework of the INFN project ENTER_BNCT an activation spectrometer with isotropic response, called NCT-ACS (NCT-Activation-Compact-Spectrometer), is under development.

The spectrometer consists in several sets of activation foils in a cubic geometry, where every face is a sandwich of foils of different elements (In, Au, Mn, Cu, Na, Cl, V, Ti). Each element presents its capture resonance at a different energy ranging from the thermal to the epithermal region. The response interval ranges from thermal up to 100 keV. The device shows an isotropic response due to its geometry and it will be able to work in a single exposure and gamma-reading phase, allowing to reduce the total measurement time. Indications about the neutron energy distribution will be derived from unfolding the activation data.

This contribution describes the most relevant results of the extensive simulation work which has been performed with the MCNP6 code for the choice of the device geometry and its materials composition. Some the preliminary measurements made with NCT-ACS prototype geometry at the LINAC-based thermal and epithermal neutron source of INFN-Torino/Università di Torino are also reported. These results can be considered as a first proof of the novel concept capability.

Ex vivo apoptosis detection as a new tool in biodosimetry

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Apoptosis detection an effective tool in biodosimetry has been limited to *in vitro* systems, mostly because apoptotic cells are recognized by peripheral and tissue macrophage phagocytes overseeing the removal of damaged cells from the body, thus eliminating the possibility of their detection *in vivo*. The present study establishes a new experimental approach for retrospective biodosimetric assessment by apoptosis detection *ex vivo*. For this purpose, we used mononuclear blood leukocytes isolated from the peripheral blood of irradiated Wistar rats and cultured them *ex vivo* for posterior analysis. Using flow cytometry, we distinguished apoptotic lymphocyte subsets individual biodosimetric potential at different time periods after exposure. This novel experimental design innovates through the need of a single blood sample from irradiated individuals for a complete biodosimetric assessment.

Based on multicolor immunophenotyping, we analyzed the ratio of non-apoptotic T_C cells, T_H cells, B-lymphocytes (B-ly) and natural killer (NK) cells in the samples cultured *ex vivo* for 0-23 hours. The analysis made immediately after blood collection (0 hours) did not show any significant difference between individual lymphocyte subsets, regardless of the absorbed dose of radiation. A unique decline in the number of B-ly was observed 5 hours after *ex vivo* cultivation, whereas that T-lymphocytes (T-ly) and NK cells retained high viability. This could be considered as a specific phenomenon of the irradiation effect. The representation of non-apoptotic T- and B-ly decreased in a dose dependent manner and could be appreciated as soon as 7 hours after *ex vivo* cultivation. The relative number of living T-ly decreased in a linear manner after 23 hours of *ex vivo* cultivation; suggesting that the evaluation of T-ly number and live:dead ratio enables the back estimation of low doses of absorbed irradiation (0-1 Gy).

Overall, the hereby shown experimental approach presents a promising tool in biodosimetry through the detection of apoptosis in lymphocytes cultured *ex vivo* after irradiation *in vivo*. The obtained results suggest a high biodosimetric potential in the tested lymphocyte subsets, which may vary according to their radiosensitivity and time after exposure: B-ly 6-8 hours (0-7 Gy), NK cells 24 hours (0-7 Gy), and T-ly 24 hours (0-1 Gy).

New model of pulmonary fibrosis treatment based on hyaluronic acid nanoparticles

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Pulmonary fibrosis is a serious, lifelong lung disease. It causes lung scarring, making it harder to breathe. Lung fibrosis is an end-stage tissue disorder characterized by an excessive and self-sustaining process of extracellular matrix proteins, fibronectin and collagen accumulation leading to physiological tissue damage and organ dysfunction. From another point of view, lung fibrosis has been described as a dysregulated wound-healing response. Progression into lung fibrosis may be induced by various conditions, the most common triggers e radiation therapy, pharmacological substances, bacterial or viral infection or inflammatory lung disease. Radiation-induced pulmonary fibrosis (RIPF) can develop as a late effect of radiation therapy due to tissue exposure to ionizing radiation. RIPF is described as a slow, irreversible process and recent studies propose that it is not necessarily a fixed process.

Over the past few decades research of the role of hyaluronic acid (HA) in pulmonary homeostasis and pathobiology has shown that HA is one of the key factors in lung tissue. HA is an important regulator of inflammation, restoration of homeostasis after insult and repair of the injured lung.

Our main aim was to identify whether treatment of C57Bl/6J mice with hyaluronic acid nanoparticles (HANPs) could attenuated the effects on lung tissue after irradiation. Our study is the first of its kind to confirm that intramolecularly cross-linked HA into HANPs prevents ionizing radiation defragmentation.

The results suggest that HANPs in our experimental model significantly contribute to mitigation of the process of RIPF. The most significant effects were observed in molecular and cellular patterns. In the blood, population of B-lymphocytes and neutrophils were significantly changed. On the other hand, level of TGF-β, crucial factor of lung tissues fibrosis after irradiation, were significantly affected by HANP-s treatment and population of T helper and neutrophils in the lung during intermediate and fibrotic phases. According to our findings HA-NPs can control and modify the outgoing fibrotic response in lung tissue, mainly during chronic, fibrotic phase.

Study of the influence of the radiation factor on the morpho-anatomical parameters of plants in the conditions of a model experiment

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Leaves are most susceptible to the influence of the radiation factor, since they can accumulate radioactive fission products both as a result of root absorption and from the atmosphere through the foliar route. Thus, the leaf plate of plants is a promising organ for morphological and anatomical studies. The purpose of this work is to study the influence of the radiation factor on the morpho-anatomical parameters of leaves during the root uptake of the ^{90}Sr radionuclide on the example of the common bean (Phaseolus vulgaris) culture under the conditions of a model experiment. The choice of this culture is due to the short growing season and resistance to pests and diseases, which is important for conducting a vegetation experiment. As the main morphological and anatomical parameters, the thickness of the mesophyll of the leaf plate and the thickness of the upper and lower epidermis were used.

Experimental plants were grown under controlled greenhouse conditions on soil samples from the former test site "4A", on the territory of which tests of military radioactive substances were carried out. The main pollutant in the soil of this site is the ^{90}Sr radionuclide, the specific activity of which reaches (5×10^8)Bq/kg. As a control group, this crop was grown on soil from the background area.

During the experiment, throughout the entire growing cycle, the optimal soil moisture was maintained (60% of the total moisture capacity), and a favorable level of illumination (10,000 Lx) and temperature conditions (25-27 C^o) were provided through phyto-lighting and thermal control systems.

Leaf sampling was carried out after their full formation at the end of the growing season, then preserved with a Copenhagen mixture (70% alcohol, 27% water, and 3% glycerol).

Each section was examined at 4, 10, 20, 40, and 100x magnifications. The maximum value of the coefficient of variation was noted for the thickness of the mesophyll (19%), the minimum for the thickness of the upper epidermis (11%).

For the leaves of Phaseolus vulgaris grown on radioactively contaminated soil, significant ($p=0.05$) changes in the studied parameters were established. Thus, the thickness of the mesophyll of the leaf plate in the experimental group is greater than in the control group by an average of 37%, and the upper and lower epidermis - by 23 and 20%, respectively. The difference in the thickness of the upper and lower leaf epidermis of Phaseolus vulgaris will remain within 20%, both in the experimental and control groups of plants, and probably does not depend on the impact of the radiation factor.

It has been established that a high level of specific activity of ^{90}Sr in the soil cover affects the morpho-anatomical structure of the leaves of Phaseolus vulgaris during root absorption of the radionuclide. The action of this radiation factor causes a significant change in the thickness of the mesophyll, as well as the upper and lower epidermis of the leaf plate. The established patterns are of practical importance and can be used as an express method of passive bioindication in monitoring radioactively contaminated areas.

Effects of low doses of short-term gamma radiation on growth and photosynthetic activity of *Cyanidioschyzon merolae*

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As the nuclear physics developed, humanity studied the impact of ionizing radiation on living organisms, including higher plants and algae. Negative impact of the radiation on organisms is very well documented. However, it is also possible to observe positive effect of the radiation as well. Scientists have found that combining the effects of visible light along with gamma rays, can have specific benefits in plant growth e.g. vascular plants grown under such conditions were often larger and had a denser rosette. The studies of organisms showing high resistance to environmental conditions seem to be exceptionally interesting. One of such organisms is microalgae *Cyanidioschyzon merolae*, unicellular haploid red alga adapted to acidic hot spring environments with high sulfur content. It is characterized by simple cellular architecture, with a single chloroplast and a single mitochondrion.

The purpose of the study was to analyse the effect of low doses of short-term gamma radiation on growth parameters and photosynthetic activity of *C. merolae*. The research included investigation of the possible impact of gamma radiation energy on the tested species in the absence of visible light. For this purpose *C. merolae* was cultivated for 2 weeks in specially designed containers with modified Allen medium. Research variants included, among others, cultivation of *C. merolae* without access to visible light but under gamma radiation at three different approximate dose rates: 260 mGy/h, 120 mGy/h and 62 mGy/h. As a source of radiation ^{137}Cs isotope from the Central Laboratory for Radiological Protection in Warsaw was used. Growth of *C. merolae* was controlled by measuring every few days the optical density of the culture at the wavelength λ = 750 nm. After finishing the cultivation, the photosynthetic activity was determined by using high performance fluorimetry. In order to investigate the effect of gamma radiation on synthesis of photosynthetic pigments, the content of chlorophyll a, carotenoids and phycocyanin were spectrophotometrically determined. The most important part of the studies was development of the experimental strategy, including selection of the appropriate radiation dose. The proposed dose levels of radiation did not exert any significant negative effect on algae. The effect of low doses of short-term gamma radiation on growth parameters and photosynthetic activity of *C. merolae* was analysed on the basis of obtained results.

Effects of high-dose ionizing gamma radiation on the growth and survivability of *Cyanidioschyzon merolae*

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Since the discovery of ionizing radiation, its effect on organisms, including higher plants and algae, has been studied. In addition, it has been proven that organisms differ in their resistance to radiation. Scientists have found that after exceeding certain dose, inhibition of the organism's growth, development of a disease or death are observed. *Cyanidioschyzon merolae* is a unicellular haploid red alga with simple cellular architecture, adapted to acidic hot spring environments with high sulfur content. Due to *C. merolae*'s resistance to extreme conditions, it seems to be a good model organism to investigate impact of miscellaneous stressors, e.g. ionizing irradiation, which has not yet been inspected.

The aim of this study was to analyse the effect of high doses of gamma radiation on growth parameters and survivability of *C. merolae*. The research included investigation of the possible impact of gamma radiation on the tested species. For this purpose, irradiated *C. merolae* had been cultivated for two weeks in modified Allen medium after exposition to gamma radiation at seven different approximate dose rates: 2, 4, 6, 8, 10, 20, 40 kGy. As a source of radiation electron accelerator "Elektronika" from the Institute of Nuclear Chemistry and Technology in Warsaw was used. Growth and content of photosynthetic pigments of *C. merolae* were estimated by measuring at certain time points the optical density of the culture at the three wavelengths: 750, 663, 470 nm. The negative effect of radiation on algae's vitality has been observed for the relatively high dose above 8 kGy. The impact of high doses of gamma radiation on growth parameters and survivability of *C. merolae* were qualitatively analysed based on obtained results.

Analysis of cell response to single-pulse proton irradiation

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Promising prospects are associated with proton flash therapy, since protons and ions make it possible to increase the conformality of irradiation compared to light particles further enhancing the sparing effect of flash therapy. A unique feature of the proton beam facility at the Institute of Nuclear Research [Bull. Russ. Acad. sci. Phys. 84, 1325–1329 (2020)], is that it makes it possible to deliver the total irradiation dose in one pulse with a duration of less than 100 μs. Such a single-pulse flash mode (splash) of radiotherapy may be of interest for clinical applications in oncology and for fundamental radiobiological research. We have carried out a series of several runs of our proton accelerator in a wide range of modes: the conventional mode with an average dose rate $\dot{D} < 3$ Gy/s, the flash mode with $\dot{D} \sim 100$Gy/s and the splash mode with $\dot{D} > 10^4$Gy/s. Two types of tumor cells were irradiated in these experiments: human colon adenocarcinoma (HT-29) and human colon cancer (HCT116). Human adipose tissue mesenchymal stem cells (ADSC) – fibroblasts were taken as normal cells. Cell cultures were irradiated in the region of the Bragg peak (SOBP) and on the plateau. We carried out a comprehensive analysis of the cell response to various modes of proton irradiation, both using flow cytometry and using another method, e.g. real-time PCR. Flow cytometry showed significantly increased apoptosis of only tumor cells in the splash mode compared to other irradiation modes. According to preliminary results, the levels of expression of genes involved in apoptosis and genome integrity control under flash/splash irradiation differ from those under conventional irradiation both in the studied tumor lines and in normal fibroblasts.

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A novel analytical approach to biological-to-radiotherapy treatment plan optimization

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Modern radiation therapy techniques (e.g. VMAT) allow the treatment planning and delivery of complex treatments. Figures of merit for the quality of a plan have evolved during the past years, that is the reason why a complex set of parameters needs to be evaluated when assessing an irradiation plan. Radiobiological indices, relating plans to specific clinical goals, have been proven useful tools for this kind of assessment. The process of optimization of a treatment plan is greatly facilitated when plans can be characterized according to the degree of closeness to their radiobiological indices target values. This characterization requires the availability of a measure of closeness to the objective dose distribution that can be related to the values of the index. One such measure of closeness is presented in this study.

For a particular *DVH* curve, the function *F(z)=1-DVH* is a distribution function for some random variable (absorbed dose for random points inside the tumour, in this case). Between distribution functions, such as *F* and *G*, the Lévy distance $d_L(F,G)$ is available, and therefore, it can be defined as a measure of closeness between absorbed dose distributions.

The issue we have assessed is whether all dose distributions within a given Lévy distance from a given reference plan correspond to values of tumour control probabilities within a specified interval around the reference plan *TCP*. Conversely, the maximum margin in terms of Lévy distance that allows to comply with a given *TCP* tolerance can be found.

TCP is represented as an operator on the set of probability distributions *T*. Its continuity ensures that upper and lower bounds for its values can be found for all distribution functions within distance R_O from F_O. Hence, given a tolerance on *TCP*, tolerances on dose distributions can be designed.

TCP is just one of the functionals on *DVHs* that can be treated within this framework, as long as their properties of continuity and differentiability can be assessed. Other radiobiological indices could be treated using this same approach.

This novel approach leads to a simple method which can help facilitate the choice of a treatment plan.

Laboratory testing and preanalytical errors: Where are we in 2022?

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Background. Standardization of conditions under the principles of good clinical practice (GCP), monitoring of modern medicine according to evidence based medicine (EBM) and good laboratory practice (GLP) reduces the possibility of action of various factors. Inaccurate results of laboratory testing are results mostly of errors in preanalytical phase. Inadequate preparation of the patients and skills of medical phlebotomists are sources of errors in preanalytical phases. The aim of this retrospective study is monitoring, documenting and preventing errors in pre-analytical phase for better health care of patients.

Methods. The study has been done from 2017 to 2021 yrs and involves monitoring, documenting and preventing errors with aspect to phlebotomy in clinical biochemical laboratory of primary health care, in Students Health Protection Institute. Errors are classified according to IFCC recommendation as quality indicators: insufficient sample volume, inappropriately labeled sample and sample damage.

Results. The study has shown that the most common errors are insufficient sample volume and sample damage (0.97 %). Inappropriately labeled samples were significantly lower and completely eliminated during period of study (2017 was 0.34 %, 2021 was 0 %; $p<0.01$). No significantly decrease in number of sample damaged (2017- 0.50 % - 2021- 0.30 %) was shown and insufficient sample volume (2017- 0.43% - 2021-0.32%) were constantly persisting during the period of study.

Conclusion. Factors of quality such as: personnel, education and training of employees, dependence on adequate equipment, innovation of services, quality and standardization of performed services through the application of quality management system (QMS) is necessary. Through permanently improvement of the QMS, implementation of certification and accreditation of laboratories according to the ISO15189, 2018- (QM / QA) standard for medical laboratories with a special requirement of the entire laboratory testing and implementation of LIS (Laboratory Information System), the standard for POCT-ISO22870: 2006 Point of care testing, clear, transparent and available procedures, errors from pre-analytical phase can be minimized. Special attention should be paid on errors that continue to exist in the study. A smaller number of errors in pre-analytical phase mean more accurate, precise and valid results, correct and fast diagnosis, satisfied patients and principle of cost benefit with guidelines: “no blood sample is better than a bad blood sample” and “more is better”. The more you perform on each service attribute –the more satisfied the customers will be in health care system.

Keywords: Accreditation, laboratory testing, GLP, preanalytical errors, health care, patients

Modulated electrohyperthermia (mEHT) during conventional pelvic radiotherapy and chemoradiation enhances tumor cells apoptosis and improves the survival in advanced IIb-IVa cervical cancer patients

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Objectives. Advanced cervical cancer treatment long-term results are not so impressive in patients with bulky tumors and lateral parametrium involvement. Modulated electrohyperthermia (oncothermia), based on alternating high-frequency electric field (13.56 MHz), modulated by fractal harmonic oscillations 0-5 KHz, performed by capacitive coupling of asymmetric electrodes, incorporated in chemo- or radiotherapy, shows clinically significant sensitizing activity, but molecular mechanisms of impressive biological effects are still unclear and cannot be completely associated only with mild hyperthermia (39-42C) during mEHT session.

Aim. To assess mEHT effects on treatment results, toxicity and tumor apoptosis in advanced IIb-IVa cervical cancer patients with bulky tumors and lateral parametrium involvement.

Methods. 197 pts, T2b–T4aN0-1 cervical cancer, were randomised in 2 groups, with or without mEHT. Conformal EBRT (3D–CRT, IMRT) in 2Gy, 46–48Gy for pelvic or extended paraaortic fields was performed in all pts; concomittant Cisplatin 40mg\m2 or Carboplatinum AUC2 weekly – in 138 pts (68 pts in research branch A (mEHT+EBRT+chemo), 70 pts – in control C branch (EBRT+chemo). 59 pts with contradictions to chemosensatizing were treated in research branch B (29 pts, mEHT+EBRT) and control branch D (30 pts, EBRT). mEHT (EHY-2000) was performed before irradiation in 90-120Wt for 60-90 min, 3 times a week, mean 10–13 fractions per course – in 97 pts, research A and B (mEHT+EBRT) branches, 1027 mEHT sessions in total. For dynamic tumor apoptosis assessment, we used 20-genes panel. Expression was evaluated in 4 quadrant cervical tumor samples (to avoid tumor cell heterogeneity influence) in 90 patients (30 pts. from A, B, C subgroups, statistical pairing method), taken before treatment, at half-course dose 25-30Gy and after the last EBRT session.

Results. Tumor apoptosis was expressed in all tumor samples, significantly higher in A vs B and C ($p<0.05$), B vs C ($p<0.05$) branches in intergroup comparison. BCL2, p16INK4a and BAG1 expression level after the treatment had a predictive value for complete local response. 12 mnth, 36 mnth and 60 mnth OS in pts with mEHT (98% ± 1.8%, 90.7% ± 3.8%, 87%± 5.6% respectively) was significantly higher, than the same values in pts after conventional radiation and chemoradiation ($p<0.05$ for all comparisons), as well as DFS (88.4% ± 2.8%, 81% ± 6.9%, 69.9% ± 4.1% vs 77.4% ± 1.6%, 57% ± 4.3%, 54% ± 2.4% respectively ($p<0.05$ for all comparisons). No difference in early and late toxicity (skin, bladder, rectum, sigmoid, vagina) were observed between research and control groups.

Conclusion. mEHT enhances radiotherapeutic effects on tumor cell apoptosis and significantly improves the immediate and long-term results of chemoradiation and radiotherapy alone in advanced cervical cancer patients, with acceptable local and systemic toxicity.

Relative resistance of CD4+CD25 high CD127 low regulatory T cell subpopulation in the peripheral blood to the treatment of different types of cancers

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Background. Very important factor in curing cancer is an efficient immune system. Regulatory T cells (Tregs) are currently under extensive investigation in different forms of human cancers. Tregs maintain the immune cell homeostasis. Recent papers have demonstrated previously elevated number of Tregs in lung, breast, pancreatic, ovarian, melanoma, digestive system cancers, CLL, T cell ALL, and B cell NHL. Elevated number and increased suppressor properties of Tregs are sometimes observed after cancer treatment. Therefore, an intensive further intensive study sensitivity of Tregs to the toxic effects of chemo(radiation)therapy and combine therapy is necessary.

Objective. Purpose of this investigation - determination of the level of Tregs in the peripheral blood of patients before and after treatment of different forms of human cancers.

Materials and methods. This study was approved by the A. Tsyb MRRC, Obninsk. The peripheral blood were obtained at diagnosis and after chemo(radiation) therapy for lymphoproliferative disorders (Hodgkin lymphoma, HL; non-Hodgkin lymphoma/B-cell chronic lymphocytic leukemia, NHL/CLL,140 tests) and after combined therapy for colorectal cancer, CC, 108 tests. In our work, we studied the population of CD4+CD25highCD127low/– Tregs of peripheral blood. In addition, their level was compared with the dynamics of the relative and absolute number of T- (CD3+CD19-) and B- (CD19+CD3-) cells. All of the antibodies were obtained from BD Bioscience, USA. In the control group 50 peripheral blood samples were tested. Data were analyzed using Statistica software version 8.0. Parametric Student's t-test was used. Significance level was $p < 0.05$.

Results. The aim of our study was to confirm the observation of an increased level of Tregs in the peripheral blood of patients with HL, NHL/CLL and CC made by other researchers. Statistical analysis revealed the untreated patients showed an increase in the relative and absolute numbers of Tregs than control number of regulatory lymphocytes. We assessed the response of circulating Tregs following chemo(radiation) therapy for HL, NHL/CLL and combined therapy for CC. It has also been shown that the sensitivity of Tregs to chemotherapy of lymphoproliferative diseases and to the combined treatment of CC was less than other types of immunocompetent cells (T and B cells). Therefore, they can be considered more resistant cells in relation to the implemented treatment.

Conclusion. Tregs are group of cells that might play important role in the development of cancer including HL, NHL/CLL and CC. Their elevated in peripheral blood might be linked to the development of the disease. Tregs can be considered more resistant cells in relation to the implemented treatment. These results indicate that the level of Tregs may influence on the final therapeutic effect. Tregs are a potential target of immunotherapy. Targetting their might represent as therapeutic option to enhance the final antitumor effect. Larger studies are now warranted to validate these findings and determine their clinical implications.

Disorders of immune status are determined with the level of tumor cells in the peripheral blood circulation in small lymphocytic lymphoma/B-cell chronic lymphocytic leukemia

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Background. The study of the relationship between changes in immunity and the rate of tumor growth allows us to form a new understanding of the progression of antitumor immunity dysfunction during the development and progression of lymphoproliferation.

Purpose. This study was conducted to compare quantitative parameters of lymphocyte subpopulations in the different extent of proliferation of mature small lymphocytic lymphoma and B-cell c*hronic* lymphocytic *leukemia* based on the results of *peripheral blood* tests.

Materials and methods. For this purpose, a unique model of lymphoproliferative disease was used. This model represents localized disease (small lymphocytic non-Hodgkin lymphoma, SNHL) and common systemic disease (B-cell c*hronic* lymphocytic *leukemia*). According to the World Health Organization (WHO) classification of lymphoid tumors, B-cell chronic lymphocytic leukemia (B-CLL) and small lymphocytic lymphoma (SNHL) are considered one nosological group. Immunocompetent cells (relative and absolute numbers of T- and NK-lymphocytes, CD3, CD4, CD8 and CD16), immunophenotype and size of a tumor clone were determined by a two-platform method using 6-color flow cytometry by the expression of the CD19, CD20, CD23, CD5, CD79b, FMC7, CD22, CD43 and CD38 antigens, immunoglobulin kappa light chains (Igκ) and lambda light chains (Igλ). Before the onset of disease-specific therapy, the data of 25 patients with SNHL were compared to those of 101 patients with B-CLL (27 patients had proliferation of tumor B-lymphocytes in 35-79% and 74 patients in 80-99%). 50 practically healthy people (blood donors) served as a control.

Results. The analysis of the initial amount of NK-cells and T-lymphocyte subpopulations in SNHL revealed preserved killer/cytotoxic cells of the congenital and adaptive immune response (CD16+, CD8+), decreased CD4+T-cell count and CD4/CD8–ratio. With developing B-CLL, a significant increase in the number of major subpopulations of normal residual lymphocytes occurred, which was indicative of an elevation of immunoreactivity due increased proliferation. However, the degree of their elevation was considerably lower than the increase in the size of a malignant B-cell clone, which suggested that anti-tumor immunity tended to become more exhausted.

Conclusion. The degree of lagging reactivity of antitumor immunity and the acceleration of the development of antitumor immune dysfunction is clearly interrelated with the rate of progression of lymphoproliferation in SNHL/B-CLL. Comparison of the immune response with the size of a proliferating clone in blood can serve as an additional criterion for assessing the competence (degree of dysfunction) of anti-tumor immunity and as a probably prognostic factor in SNHL/B-CLL.

The need to plan human resources for the work of the health institution

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Many of the challenges that health organizations face today are different in their work and depend on regulations, changes in business, competition, but also insufficient amounts of all resources. The main goal of health organizations is to achieve high quality service. Today, the health sector is facing competition that leads to the need to gather information about current and potential users of adequate medical services. The efficiency and quality of services provided by health care institutions largely depends on the qualifications of the staff and the quality of the work of the entire team. This should be set in conditions of increased need for better and more accurate diagnosis of various diseases and better treatment of patients. Therefore, the leaders of the organization of the health institution have a difficult task in terms of implementing strategic management in order to better organize good working conditions in the team and create success in the treatment of patients. The success that the health institution will achieve depends on the education of employees, but also the application of new technologies, but also the procurement and provision of modern and adequate equipment. All this together can lead to significant and notable results in treating patients and achieving success and progress. An appropriate strategy is needed that will be implemented, but also overcome the challenges of today. That is why human resource management is one of the important tasks of an organization to survive in a changing environment and achieve success. There are three important goals in this. First of all, it is necessary to solve the problem and define the terms related to the process of human resource planning. The second part is the one related to achieving competitiveness and specificity of the health institution. The third part included continuous training of health workers through scientific research, education and training and adaptation of innovations in health. Based on all the achieved results, it is necessary to draw conclusions and give guidelines for further work, which indicates the need for continuous monitoring and constant creation of plans for the future.

Measures to prevent reduced birth rates in the Republic of Serbia

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Introduction. In recent years, the analysis of data on the number of births and deaths in Serbia has shown that there is a steady trend of declining birth rates: That is why a strategy has been developed to raise the birth rate.

Objectives. The aim of this paper is to present an overview of measures to prevent falling birth rates in the Republic of Serbia, as well as to assess their effects.

Materials and methods. In this paper, various databases are reviewed and analyzed, selected references are analyzed, systematized and presented in this paper.

Results. The most significant proposed measures to overcome the current situation are the need to increase the parental allowance and the salary allowance for mothers. Like the parental allowance, the salary allowance for mothers is defined by the Law on Financial Support to Families with Children. One of the recommended measures would be that families whose monthly income for the last three months does not exceed the established threshold are entitled to child allowance. In 2020, the Republic Health Insurance Fund enabled insured women up to the age of 43, who are being treated for infertility, to be entitled to an unlimited number of attempts at biomedically assisted artificial insemination. The state has also adopted a Strategy for Encouraging Birth, and based on the already proposed plan, statistics show that in the previous decade there was a slight increase in the fertility rate, which amounted to (1.43 in 2013; 1.46 in 2016; 1.46 in 2018. 1.49, and 2019. 1.52).

Conclusion. It is still early to talk about the effects of the measures, given that some of them have only recently been introduced and that it is necessary to pass a certain period of time to see the results. The historical context, economic and social factors, but also the global pandemic of the SARS-COV-2 virus should be taken into account. With all this in mind, we emphasize that it is necessary to continue to find new solutions and lead a better implementation of existing measures in order to have better results in the future. We hope that will happen.

Keywords: Population policy, population, birth rate, health system

Cyberbullying research on the youth population in Serbia

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With the advent of the Internet and social networks, we are increasingly encountering the term "Cyberbullying" – electronic violence, harassment through digital technologies, mobile phones, correspondence platforms and the like. It is a behavior that is repeated with the intention of intimidating, embarrassing and humiliating a certain person. Live abuse and cyberbullying can often go hand in hand, with cyberbullying leaving a digital footprint that can be helpful in stopping it. The Cyberbullying survey was conducted in April 2022 on 150 respondents of both genders, aged 16-25 in Serbia, with an online Questionnaire containing 16 questions with offered answers. The results of the research indicate that 90% of the respondents have heard about violence on social networks, over 30% stated that they have experienced some kind of violence on social networks. It was determined that women are more exposed to cyber violence, most often by the opposite sex, most often on Instagram (24.7%) and Facebook (19.3%), and a larger number of respondents report violence to friends rather than parents. The negative consequences that cyber violence has left on the victim are mostly emotional (30%). The largest number of respondents (85.3%) believes that the best form of protection is blocking and reporting a person who is trying to commit violence.

The results of the research confirmed our hypothesis about the significant prevalence of violence on social networks, the complexity of its manifestation and the impact on the mental and emotional state of victims. Further research of this social phenomenon on a larger sample is necessary in order to create prevention and protection measures as successfully as possible.

Keywords: Electronic violence, social networks, internet, research

Computer skills of health professionals

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Introduction. Healthcare professionals have a key role to play in the introduction, application and use of technology in clinical practice. Lack of technical expertise and technological understanding poses a challenge to the quality of health services, which affects the overall quality of life of patients. Experience so far shows that computer literacy, which is the basis for the implementation of the health information system, varies according to gender, age and years of work experience.

The goal. Determine whether computer literacy depends on the gender, age and years of service of health professionals.

Methods. The research was conducted according to the type of cross-sectional study, in the population of health workers employed at the Health Center in Jagodina and the General Hospital in Ćuprija. Yesterday's sample consisted of 142 respondents. Analysis of variance was used from statistical tests. The value of $p<0.05$ was taken as the level of statistical significance of the differences.

Results. The sample consisted of 78.2% of respondents and 27.2% of respondents; in both groups of respondents, the average achievement on the literacy scale is around 17 points. Age 40 and over is 59%; younger respondents showed a higher level of knowledge than older respondents ($F = 4.949$, $p = 0.003$, $df = 3$). The largest percentage of respondents have a work experience of 10-29 years; respondents with less years of work experience have more knowledge of computers ($F = 7.239$, $p = 0.000$, $df = 3$).

Conclusion. Computer skills depend on age and years of service.

Heterogeneity of the distribution of genetic variants of the rabies virus in the territory of the Russian Federation

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Rabies is a disease that poses a huge threat, both in medical and veterinary aspects. To control the relevance of traditional vaccine strains, it is necessary, among other things, to monitor changes in the genome of various “wild” strains.

The selection of sequences for the study was carried out according to the description in the *GenBank* database. Phylogenetic analysis of nucleotide sequences was carried out using the *MEGA X* program with an open license. The construction method was the maximum likelihood method incorporated in the program algorithms.

Before phylogenetic analysis, automatic alignment of sequences was carried out, which was incorporated in the *MEGA X* program using the *Alignment Clustal W* algorithm. Two phylogenetic trees were built: according to the N (nucleoprotein) gene sequences and according to the G (glycoprotein) gene sequences.

Analysis of phylogenetic trees showed the presence of clusters of closely related sequences from a number of regions (Lipetsk region, Tyva, Altai) with the simultaneous presence of heterogeneous clusters into which sequences from different regions were combined. From the point of view of molecular evolution, this fact suggests that *in a number of regions of the country there are conditions for the isolated circulation of genetic variants*. At the same time, carriers of the rabies virus are migrating from region to region. After adding to the analysis additionally those nucleotide sequences that were obtained in other countries, it is possible to see the distribution of rabies virus gene sequences obtained in Russia over various groups of sequences. Therefore, we see the absence of a single phyletic group with the sequences of any other countries. These results are confirmed by constructing trees for both genes. It can be assumed that in the future the heterogeneity of strains will continue to increase, and in the future, updating of vaccine strains of the rabies virus will be required.

Regeneration processes in hip cartilage promoted by new magnetic (MADU) method

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Introduction. Static magnetic fields (SMFs) are permanent magnetic fields that could be either natural or artificial (upward and downward oriented). Upward oriented SMF corresponds to the North (N) geographic pole, and downward oriented SMF corresponds to the South (S) geographic pole. The magnetic deep unipolar (MADU) oriented strips and magnetophores are the SMFs of small induction, unipolar N oriented towards the body, that have therapeutic effects on various tissues and systems, including osteochondral tissues and their diseases such as osteoarthritis s. osteoarthrosis coxae.

Purpose. The aim of this work is to show the effectiveness of treatment the osteoarthritis s. osteoarthrosis coxae by applying the MADU strips and magnetophores on affected regions, reflexogenic (acupuncture) zones and reflexogenic (acupuncture) points according to traditional Chinese medicine.

Materials and methods. The SMFs in form of MADU strips and magnetophores are applied to the skin and have 10-15 times weaker induction compared to the tested and approved levels prescribed by the World Health Organization (WHO). The MADU strips were applied for the period ranging from 6 months to 5 years, and magnetophores from 14 to 21 days during every 3 months.

Results: The therapy effectiveness was evaluated on the group of 87 patents: 31 (35.60%) male and 56 (64.40%) female concerning subjective and objective health status. The improvement was achieved in 69 (79.30%) patients: 24 (34.80%) male, 45 (65.20%) female in the period ranging from 6 months to 5 years ($p<0.01$; χ^2 test). The health status was unchanged in total 7 (22.60%) male and 11 (19.70%) female, i.e. it was really unchanged 13 (14.90%) patients, and was worse in 5 (5.70%) patients (4 female and 1 male).

Conclusion: The SMFs in form of MADU strips and magnetophores applied from 6 months to 5 years on affected hip regions provided regenerative processes of the bones, cartilage and soft tissues as a result of the influence on vascular, metabolic and enzymatic processes. Due to its principal effects, the application of this non-invasive and environment friendly medical device opens new possibilities in providing efficacious health care and better quality of life.

Keywords: Static magnetic fields, small induction, unipolar [north (N)] oriented, MADU strips, magnetophores, hip joint, reflexogenic (acupuncture) zones, reflexogenic (acupuncture) points

Knee articular cartilage regeneration by new magnetic (MADU) method

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Introduction. Static magnetic fields (SMFs) are permanent magnetic fields that could be either natural or artificial (upward and downward oriented). Upward oriented SMF corresponds to the North (N) geographic pole, and downward oriented SMF corresponds to the South (S) geographic pole. The magnetic deep unipolar (MADU) oriented strips and magnetophores are the SMFs of small induction, unipolar N oriented towards the body, that have therapeutic effects on various tissues and systems, including osteochondral tissues and their diseases such as osteoarthritis s. osteoarthrosis genu.

Purpose. The aim of this work is to show the effectiveness of treatment the osteoarthritis s. osteoarthrosis genu by applying the MADU strips and magnetophores on affected regions, reflexogenic (acupuncture) zones and reflexogenic (acupuncture) points according to traditional Chinese medicine.

Materials and methods. The SMFs in form of MADU strips and magnetophores are applied to the skin and have 10-15 times weaker induction compared to the tested and approved levels prescribed by the World Health Organization (WHO). The MADU strips were applied for the period ranging from 6 months to 5 years, and magnetophores from 14 to 21 days during every 3 months.

Results: The therapy effectiveness was evaluated on the group of 158 patents: 73 (46.20%) male and 85 (53.80%) female concerning subjective and objective health status. The improvement was achieved in 39 (24.68%) patients: 18 (22.78%) male, 21 (26.58%) female in the period ranging from 6 months to 5 years ($p<0.01$; t-test). The health status was unchanged in 108 (68.35%) patients: 50 (67.13%) male and 58 (69.57%) female), and was worse in 11 (6.97%) patients: 5 (6.78%) male and 6 (7.16%) female.

Conclusion. The SMFs in form of MADU strips and magnetophores applied from 6 months to 5 years on affected genu regions provided regenerative processes of the bones, cartilage and soft tissues as a result of the influence on vascular, metabolic and enzymatic processes. This application enables patients to have a better quality of life by alleviating or eliminating difficulties in everyday life activities.

Keywords: Static magnetic fields, small induction, unipolar [north (N)] oriented, MADU strips, magnetophores, knee joint, reflexogenic (acupuncture) zones, reflexogenic (acupuncture) points.

Vascular diseases treated by new magnetic (MADU) technology in medicine

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Purpose. The aim of this work is to show the effectiveness of treatment of vascular diseases by applying the MADU strips and magnetophores on affected regions, reflexogenic (acupuncture) zones and reflexogenic (acupuncture) points according to traditional Chinese medicine.

Materials and methods. The SMFs in form of MADU strips and magnetophores are applied to the skin and have 10-15 times weaker induction compared to the tested and approved levels prescribed by the World Health Organization (WHO). The MADU strips were applied for the period ranging from 4 months to 10 years, and magnetophores from 14 to 21 days during every 3 months.

Results. Effectiveness of therapy was evaluated on the group of 72 patients (26 males and 46 females) concerning subjective and objective health status: 51 (70.83%) with vascular stenosis and 21 (29.16%) with angiopathia diabetica. In the period ranging from 3 to 12 months, the improvement was achieved in 38 (52.77%) (14 males and 24 females), respectively 31 (60.78%) (10 males and 21 females) with vascular stenosis vs. 7 (33.33%) (4 males and 3 females) with angiopathia diabetica [$p<0.01$; Kolmogarov-Smirnov (K-S) test]. The health status was relatively unchanged in 19 (26.39%) patients (6 males and 13 females), and was worse in 15 (20.83%) patients (4 males and 11 females).

Conclusion. The SMFs in form of MADU strips and magnetophores applied from 4 months to 10 years on affected regions provided vasodilatation and possible regenerative effects on the blood vessels, lymphatics and soft tissues as a result of their influence on metabolic, enzymatic, humoral and neuronal, i.e. neurohumoral and neurohormonal processes.

Keywords: Static magnetic fields, small induction, unipolar [north (N)] oriented, MADU strips, magnetophores, vascular diseases, reflexogenic (acupuncture) zones, reflexogenic (acupuncture) points

Osteochondral regenerative processes in vertebral bodies by new magnetic (MADU) method

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Introduction. Static magnetic fields (SMFs) are permanent magnetic fields that could be either natural or artificial (upward and downward oriented). Upward oriented SMF corresponds to the North (N) geographic pole, and downward oriented SMF corresponds to the South (S) geographic pole. The magnetic deep unipolar (MADU) oriented strips and magnetophores are the SMFs of small induction, unipolar N oriented towards the body, that have therapeutic effects on various tissues and systems, including osteochondral tissues and their disorders or diseases.

Purpose. The aim of this study is to show possibilities of the musculosceletal spine system treatment applying the MADU strips and magnetophores on affected regions, reflexogenic (acupuncture) zones and reflexogenic (acupuncture) points according to traditional Chinese medicine.

Materials and methods. The SMFs in form of MADU strips and magnetophores are applied to the skin and have 10-15 times weaker induction compared to the tested and approved levels prescribed by the World Health Organization (WHO). The MADU strips were applied for the period ranging from 6 months to 5 years, and magnetophores from 14 to 21 days during every 3 months.

Results. The therapy effectiveness was evaluated on the group of 38 patents (9 male, 29 female) concerning subjective and objective health status. The improvement was achieved in 25 (65.79%) patients (6 male, 19 female) in the period ranging from 3 to 9 months [$p<0.01$; Kolmogarov-Smirnov (K-S) test]. The health status was unchanged in 8 (21.05%) patients (2 male, 6 female), and the health status was worse in 5 (13.16%) patients (4 female and 1 male).

Conclusion. The SMFs in form of MADU strips and magnetophores applied from 6 months to 5 years on affected spinal regions provided regenerative processes of the bones, cartilage and soft tissues as a result of the influence on vascular, metabolic and enzymatic processes. Due to its principal effects, the application of this non-invasive and environment friendly medical device opens new possibilities in providing efficacious health care and better quality of life.

Keywords: Static magnetic fields, small induction, unipolar [north (N)] oriented, MADU strips, magnetophores, spinal joints, reflexogenic (acupuncture) zones, reflexogenic (acupuncture) points.

Morphological changes of Harderian glands after the implantation of PET track-etched membranes into the anterior chamber of the eye

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Track-etched membranes (TM) are membranes with a unique structure, the production method of which allows achieving the necessary transport and retention characteristics. TM from PET have a high potential for use in corneal surgery (for the treatment of bullous keratopathy). The bullous keratopathy is a severe and progressive disease associated with a violation of the endothelial layer of the cornea, an increase in stromal edema, the formation of bullae. The study of the effect of PET TM eye implantation on the morphological changes of Harderian glands (HG) will expand fundamental knowledge about this type of glands.The purpose of this research is to determine the morphological changes in Harderian glands after implantation of PET TM into the anterior chamber of the eye. The PET track-etched membranes were obtained by irradiating the polymeric film with the $^{40}Ar^{+8}$ ion beam with the radiant energy of 41 MeV, which was followed-up by the chemical etching in an aqueous solution of NaOH with the concentration of 1.5 N in the range of temperature 72–82°C. 10 pubescent male Sylvilagus bachmani rabbits weighing 2.5-3.0 kg were used. The animals were divided into 2 groups: 1st group (n = 5) – the intact (control) group; 2nd group (n = 5) – animals with an implanted PET TM into the anterior chamber of the eye. The overall duration of the experiment comprised 30 days. Sampling (HG) was performed on day 30 after the start of the experiment for morphology studying. The counting and photographing of HG cross-sections was carried out at a magnification of 400 times using a Mikmed-6 microscope (LOMO, Russia) and an MPKS digital video camera (LOMO, Russia). The specific volumes (%) of the epithelium and stroma of the HG were calculated using Avtandilov's ocular insert. The epithelial/stromal ratio (ESR) was also calculated. The optical coherent tomography of cornea was carried out on Cirrus HD-OCT 5000 (Germany). As a result of the research, the implantation of PET TM into the anterior chamber of the eye is accompanied by the development of minor reactive changes in the HG, such as edema of the interlobular stroma, vascular congestion in HG, which cause with nonspecific reactive changes in the gland.

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Morphology of Harderian glands after the polycaprolactone implantation

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

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

Neovascularization and tractography in obese children

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Background. The development of cognitive functions is associated with the maturation of the brain in childhood and adolescence.

The aim was to analyze the association of cognitive functions and childhood obesity with differences in the structure of white matter and neurovascularization.

Methods. The study was carried out in accordance with the standards of Good Clinical Practice and the principles of the Helsinki Declaration. The protocol of the study was approved by the Ethics Committee of the Siberian State Medical University (No. 8108 of 27.03.2020). We included 64 obese patients aged 12-18 years and 54 patients were in a control group. We conducted a general clinical examination, neuropsychological testing (the Raven test with the calculation of the IQ coefficient, the MoCA test, the Ray test 1 and 2 versions), and analyzed the tractography and contactless perfusion of the brain obtained using magnetic resonance imaging (MRI) in obese children selected according to the protocol. Statistical data processing was carried out using Statistica Statsoft (version 10).

Results. There was a decrease in scores on the MoCA and Raven tests, as well as IQ in obese adolescents ($p \leq 0.05$). While there were significant differences in the two groups according to version 1 of the Ray test ($p \leq 0.05$). While in the version 2, the variants of the groups were comparable. Perfusion analysis showed changes in vascularization in the left areas of the white matter: reduction of perfusion in the occipital lobe and its increase in the temporal lobe area. When according to MR tractography of the white matter was noted a decrease in fractional anisotropy in the area of the hook-shaped beam on the right and left, and in the anterior and posterior adhesive pathways. These changes correlated with neuropsychological scales.

Conclusion. Obese children had a violation of the integrity of the white matter and neurovascularization of the brain, which were associated with a deficiency of cognitive functions.

Printed circuit heat exchangers and fast neutron radiography

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Non-destructive testing is capable of detecting defects of important components, where a failure could pose a significant hazard and cause severe economic losses. Currently, imaging techniques utilizing gamma or X-ray sources are mainly used and allow to examine of devices ranging in size from units to tens of centimeters, but for industrial-sized large components, these methods usually fail. The utilization of fast neutrons in radiography is a promising alternative, especially for industrial applications. Currently, due to the higher neutron-matter interaction probabilities, most neutron-imaging systems use thermal neutrons originating from research reactors. Due to the intention of on-site inspection of revealing the possible ruptures and failures, this option is not applicable. The paper presents the newly developed neutronic models of printed circuit heat exchangers where the specific ruptures are defined. Next, neutron transport simulations are performed to investigate the different irradiation geometries, various neutron sources, and backfill materials to access the principal detectability of these ruptures in the industrial environment. Finally, conclusions are drawn ant the best backfill material and neutron source is identified in the simplified model.

GTA-PVA Fricke gels as 3D dosimeters for radiotherapy

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The "Fricke solution" chemical dosimeter was first introduced in 1927, while in the mid-1980's gels infused with ferrous sulfate were proposed as a three-dimensional dosimeter for radiotherapy. Since then, intensive studies have been performed on gel dosimetry. However, gel dosimeters are not yet adopted as a routine technique in 3D dosimetry in radiation therapy due to two main shortcomings: spontaneous oxidation and diffusion of Fe^{3+} ions carrying dosimetric information.

GTA-PVA Fricke gels based on a polyvinyl alcohol (PVA) matrix chemically cross-linked with glutaraldehyde (GTA) provide an excellent performance (d'Errico et al., Radiation Measurements 106 (2017) 612-617) and were proposed by our collaborative group for the present studies. The production of these gels is relatively simple since it essentially requires high temperature dissolving and mixing of all chemical reagents. The addition of a crosslinker allows to easily form a transparent gel at room temperature. This synthetic gel dosimeter offers a sensitivity comparable to that of natural polymer matrices, such as gelatin or agarose, and a lower diffusion coefficient. In addition, the GTA concentration determines the degree of matrix crosslinking and, in turn, affects the gel diffusion coefficient. After irradiation, gels can be read using commonly available optical instruments, such as a spectrophotometer, or magnetic resonance imaging.

In this study, GTA-PVA Fricke gels were independently characterized in terms of gelation time as a function of temperature, GTA concentration, dose response and stability over time, as well as diffusion characteristics. Our own results and intercomparisons with previously reported literature data support the reliable reproducibility and easy applicability of this technology.

Analytical dependence of the electron beam spectrum after passing through aluminum plates

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Effective radiation treatment of most materials and biological objects requires a uniform dose distribution throughout the entire volume of the treated object.

Radiation treatment with accelerated electrons ensuring dose uniformity, within the permissible dose range for each category of objects, is a complex task. The method of varying energy of the electron beam, which is used to solve this problem, does not allow for varying the energy within a single irradiation session, which increases the time and cost of radiation treatment. Our research team proposed a method for increasing the uniformity of the absorbed dose throughout the volume of the object under treatment involving the use of aluminum modifier plates [*Mos. Univ. Phys. Bull. 76, 2021*]. This method makes it possible to increase dose uniformity highly efficiently; however, it requires laborious computer calculations to select the optimal thickness and material of modifier plates.

The purpose of this study was to optimize the calculations of irradiation parameters for a quick assessment of the dose distribution over the volume of the treated object. The main task was to obtain an analytical expression describing the spectrum of an electron beam after passing through aluminum modifier plates of various thicknesses.

After passing through the modifier plates, the electron spectrum was decomposed into two components: the first one, which describes the change in the energy of primary electrons, is a modified Landau distribution with the parameters depending on the electron energy and the thickness of the modifier plates; and the second one, obtained by linear interpolation of a set of monoenergetic electron beams with different analytically calculated weights.

To obtain an analytical expression and its verification, a computer simulation was carried out on Geant4 toolkit, using Monte Carlo method. We simulated the spectra of monoenergetic beams with the energies ranging from 1 to 10 MeV with a step of 0.5 MeV after their passage through 1-5 mm aluminum modifier plates with a step of 0.5 mm. The spectra obtained by the simulation were used to calculate the approximating expression coefficients and the errors of the constructed model in order to determine the area of its applicability.

The resulting approximating expression allows, without additional computer modelling, to calculate the spectrum of electrons with initial energies from 1 to 10 MeV after passing 1-5 mm thick aluminum modifier plates. In the range of applicability, the analytical expression gives an error of spectrum reconstruction after passing through the plates no more than 10% and no more than 5% when restoring depth dose distributions from the calculated spectra.

Thus, this analytical expression allows to quickly and highly accurately select the optimal thickness of modifier plates, which guarantees the best dose uniformity over the volume of the treated object with the specified parameters.

Method for increasing the dose distribution uniformity during electron radiation treatment

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During irradiation treatment it's important to ensure the uniformity of the dose distribution absorbed by the object treated with electrons. This study explores the relationship between the minimum and the maximum values of the dose that can depend on the initial electron energy, the geometry of object, its density and chemical composition [IOP Conference Series: Earth and Environmental Science, v.365, p. 012002, 2019].

This paper proposes a method of improving dose distribution homogeneity of an object using the combination of aluminum plates of different thickness.

Such methods are used in proton irradiation therapy to modify Bragg peak in order to maximize the dose uniformity at the specified depth in tissues [Spiral comb filter. Medical Radiology, 1987, vol.32 no.8, p.76-80].

The initial monoenergetic spectrum of electron beam disperses after passing through the combination of aluminum plates of different thickness. The total dose distribution in an object is a superposition of dose distributions created by electrons of different energy.

The purpose of the study is to determine the multipliers for dose distributions generated by monoenergetic electrons of different energy in the object to ensure that the relationship between the minimum and the maximum values of the dose absorbed by different parts of the object tends to 100 %.

Computer simulation of the passage of electrons with the energy ranging from 1 MeV to 10 MeV through a water cube with the edge of 155 mm was carried out using the Geant4 toolkit. The irradiation method used in the simulation involved 0.5 to 6 mm thickness aluminum plates placed between the object and electron output.

The simulation shows that the use of the combination of aluminum plates allows to increase the dose uniformity to 60% for the objects with the thicknesses up to 100 mm during electron irradiation with the initial energy of 10 MeV. To compare 10 MeV monoenergetic beam irradiation provides similar uniformity for the object with the thicknesses not greater than 60 mm.

Method to increase the uniformity of the irradiation treatment on electron accelerations

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Every year the significance of radiation technologies is expanding in science, in different countries of the national economy and medicine. The development of radiation technologies makes it possible to solve a wider range of problems and introduces significant changes in established technological processes. For example, the method of processing objects with ionizing radiation has become widespread in industry and has now replaced chemical and thermal methods of processing for some categories of objects. Processing products with accelerated electron beams is one of the most efficient methods of processing. To ensure the high quality of the resulting products, it is important to control the absorbed dose in volume of the object. Since the uneven processing can lead to an irreversible change in the physicochemical and organoleptic characteristics of the processed object.

The purpose of the research carried out at Moscow State University (MSU) in collaboration with the D.V. Skobeltsyn Scientific Research Institute of Nuclear Physics, is the study of the effect of ionizing radiation on biological objects and the development of methods for increasing the efficiency of radiation processing.

It is proposed to use aluminum modifier plates of various thicknesses installed between the irradiated object and the accelerated electron beam to increase the degree of irradiation homogeneity.

A phantom of PETG plastic was made for experimental verification of the method, consisting of 50 2.5 mm thick plates with the possibility of deployment of dosimetric films in 0.5 mm deep grooves. A series of irradiation of the phantom was carried out with the addition of aluminum modifier plates 1 - 5 mm thick, as well as irradiation without modifier plates. An industrial continuous electron accelerators UELR-10-15-S-1 and ILU-14 was chosen as a source of ionizing radiation, operating on a mode with a maximum effective processing energy of 10 MeV and a surface dose of 35 kGy.

The experimentally obtained values of the absorbed dose versus depth in layers of cubic phantoms made of PETG plastic after beam processing demonstrated that the addition of a 2 mm thick aluminum plate leads to an increase in the degree of irradiation homogeneity (the ratio of the dose on the phantom's surface to the maximum absorbed dose in the phantom's volume) from 0.82 to 0.97.

The results of this work allow us to make a conclusion that it is possible to use aluminum modifier plates to increase the absorbed dose distribution homogeneity over the depth of the irradiated object during processing with accelerated electrons.

Absorbed dose in humerus for breast cancer and regional lymph nodes involement simulated by FOTELP–VOX code comparison with calculations by treatment planing system

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Determining the dose of scattered radiation absorbed by specific body organs and tissues in radiotherapy is very important. In this study, we chose the humerus as one of the radiosensitive tissues in the human body to determine the absorbed dose in patients with breast cancer and lymph nodes involvement who have undergone radiotherapy. In addition to direct dosimetry, another way to determine the absorbed dose to an identified organ of the human body is the FOTELP–VOX simulation. Selected three patients were treated at the University Clinical Center Kragujevac during 2021. Technique for making radiotherapy plans were designed for each patient using the CT scans. All plans were done on the treatment planning system ECLIPSE- Version 15 (Varian). The results of the comparison of the calculated dose in the tumor and humerus using simulations show that the bulk dose to the humerus was not large. However, clinicians and radiotherapists need to be aware of the magnitude of the risk in order to expose the humerus as little as possible. Exposure to radiation of this muscle can significantly affect shoulder function. The FOTELP–VOX code, a modification of the general-purpose FOTELP code, used in this study has proven to be a valid practical way to perform accurate calculations of three-dimensional dose distribution from the interactions of particles in a complex target such as the human body.

Numerical calculation method for medical radioisotope production with compact linear accelerators

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Accelerator-produced radioisotopes are increasingly used in modern medicine, for imaging, for cancer therapy, and for combinations of diagnostic and therapeutic purposes (theragnostics). Promising radioisotopes resulting in interesting clinical trial outcomes as well as the emerging need for efficient and low-cost standard isotopes lead to a strong request of specific accelerator systems dedicated to radioisotope production.

While cyclotrons are the standard apparatus in this domain, linear accelerators can provide a viable alternative in operations of comparable beam specifications. Linacs offer the advantage of modularity, compactness, and reduced beam loss with lower shielding requirements while being also cost-effective for production of low-energy proton beams, or of intense beams of heavier particles.

After a review of radioisotopes produced with low-energy protons or helium, two linac-based isotope production systems are presented. The first is a compact RFQ-based system for PET (Positron Emission Tomography) isotopes, and the second is an alpha-particle linac for production of alpha-emitters.

A novel numerical calculation method for radioisotope production has been developed and applied for the yield estimation of three PET (**18**F, **11**C, **43**Sc) and one Targeted-Alpha-Therapy, TAT, (**211**At) radioisotopes. The dose quantities available for patient administration in a medium-size hospital, for each one of the linac-based isotope production systems have been also calculated, also considering the radiopharmaceutical preparation time.

Tensile force analysis for sutures most commonly used in dentistry during surgical procedures

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Introduction. Suturing as a procedure of joining the lips of the lembo or wound, is important in the beginnings of the healing process. This procedure helps to pass the healing process from the procedure per secundam to the stages of healing per primam, thus logically reducing the healing time of the wound. The element that remains in the individual selection of the dentist applying the suture is the selection of the suture material. At moment when some types of sutures are offered for use, some elements should be considered in the selection of the suture depending on the constituent material, the cross-section of the suture elements on whether it collects bacteria in the "pits" created by the material. The presence of bacteria is a source of infection and possible delay in healing of the sutured wound.

Materials and methods. Experimental study performed by applying different types of sutures, on soft tissues taken from goat head, in vitro, in terms of code of ethics. After application, the suture tensile force was checked by applying a dynamometer with a traction force of 25 cm / mm then re-examination of the suture tensile force was performed after 3 days of storage of the secondary tissue under conditions of the presence of physiological solution.

Results. Sutures have tensile forces distinct from each other, but which are also influenced by the type of yarn used for suturing the reduction of tensile force after 3 days of application was significant but higher in absorbable sutures.

Conclusion. The marketing of suture types offers a variety of materials, from which the selection of the most suitable suture type for specific application cases is a personal indication of the dental surgeon, based on professional experiences and knowledge in the field.

Keywords: Types of suture, material, tensile force, in vitro, experiment

Dosimetry evaluation in Lu-177-labeled somatostatin analogue internal radiotherapy

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Determination of radiation doses from internal sources raises specific difficulties. Due to the lack of complete control over radiation uptake in the human body, in particular the magnitude of radionuclide accumulation in target areas and the effective half-life. The ongoing development and increasing use of new radionuclide therapy methods, create an urgent need to develop reliable and effective manner of dosimetric evaluation. This study describes dosimetric evaluation of 20 patients treated for neuroendocrine tumors (NET) who received radioactive lutetium in the form of 177Lu-DOTATOC therapy with activity in the range of 2 - 8 GBq. A minimum of three SPECT/CT imaging examinations were performed for each patient, and the images were analyzed quantitatively to calculate activity accumulated in organs and target areas, and effective half-life. Radionuclide uptake in different target areas were compared with radioactive accumulation in analogous regions in a diagnostic study performed before Lu-177 therapy in eight of these patients, using 99mTc-HYNIC-TOC. The average accumulation difference was 4.8% for liver (R-squared = 0.7761, Pearson correlation r = 0.88), 0.39% for kidneys (R-squared = 0.8267, Pearson correlation r = 0.91) and 2.1% for spleen (R-squared = 0.8572, Pearson correlation r = 0.93) and 0.067% for local accumulation hot spots (R-squared = 0.9992, Pearson correlation = 0.9996). The data obtained from imaging analysis were exported to external software, where model calculations were performed based on MIRD scheme. Dosimetric calculations were performed for the specific organs targeted by the therapy - the liver, kidneys and spleen. Additionally, local hot spots of increased accumulation corresponding to the patient's tumors were determined, and doses were also calculated for these areas. Treatment clinical outcome was assessed using the Response Evaluation Criteria In Solid Tumors (RECIST) scale and associated with appropriate calculated doses. In general, the accuracy of prediction was significantly higher for uptake hot spots than for organs at risk. This may be attributed to the different metabolic activity of organs and the overall physiological state of the individual patients. In addition, Lu-177 treatment turned out to be highly kidney-sparing, as determined by biochemical markers of renal function.

Qualitative analysis of X-ray images of the temporomandibular joint

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The effectiveness of CT and cone beam CT (CBCT) examination of the temporomandibular joint (TMJ) is determined by the sensitivity and independence of the method used for analysis of the image obtained. The optical system of the human eye cannot detect changes in the radiographic (graphics) information within 10%.

Objective. To improve the quality and objectivity of the analysis of CT and CBCT of the TMJ by the creation of parameters of the x-ray image.

Diagnostic techniques. Bilateral TMJ CTs and CBCTs at follow-up involved standardized acquisition protocols of 62 CTs and 54 CBCTs of the TMJ by the creation of parameters for the visual information pattern of the x-ray image.

Results. We found that, for qualitative analysis of the x-ray image of the anatomical region, it is possible to use graphics information from the image obtained, with a one-pixel scale of sensitivity. For the visual information patterns of the x-ray image, we applied the Bounded Knapsack Problem. We interpreted the number of pixels on the x-ray image with specific grey gradations as a sequence of normalized square areas, corresponding to 256 grey gradations within the range (0; 1). We placed the indicated squares orthogonally without any intersections in a square with an unregulated area № 2. We used the perimeter of the figure formed from the normalized squares to create a numerical evaluation of the dynamics of the changes in the x-ray image design.

Conclusion. In the dynamics of quality observations of a patient, parameters of image information and the numerical parameter of the package may be used as predictors of structural changes of the investigated anatomical region that cannot be detected by the naked eye in an X-ray image.

Effect of reader software to image quality metrics of X-ray Computed Radiography systems

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X-rays are used in medical imaging. The derived image demonstrates the information created by X-rays interactions. The diagnostic quality of the final image depends upon the X-ray energy spectrum, which affects subject contrast and noise. Another important part is the X-ray detector. It is consisted either by a scintillator component coupled to semiconductor, (indirect detection), or by a semiconductor that converts the X-rays to electron-hole pairs which impinge onto an electronic circuit (direct detection). An intermediate solution is the use of a Computed Radiography cassette (CR). CR has a scintillator component with introduced defaults in its lattice. The defaults trap the radiation excited electrons and prohibit the spontaneous optical photon generation. The cassette is then excited by a LASER beam provoking the de-excitation of the trapped electrons. The optical photons generated are collected by a photocathode and digitized. The software of the CR manipulates the image according to the examination type. This work has examined the effect of the software manipulation to image quality. A theoretical model based in the linear cascade system theory was utilized. The model took into account the incident X-rays, their absorption in the CR, the generation and trap of electrons, the LASER excitation, the optical photon generation, emission and capture at the photocathode. The model predicted the electrons per incident X-ray, as well as the pre-sampled Modulation Transfer Function (MTF), which defines the spatial resolution of the system. The model data needed were obtained from literature. The calculation of optical photon transport was done by an analytical solution of Boltzmann diffusion equation. The MTF of the LASER beam was simulated as the sum of two Gaussian distributions. The theoretical MTF results were compared to published experimental results and were in reasonable agreement. In order to find the effect of the software a PTW edge phantom were irradiated by a BMI GMM X-ray generator and imaged by a FujiFilm, ST-VI cassette and a Capsule-X scanner. The images were shown in 'chest', 'patella' and 'PDR' mode to simulate a high latitude, a high contrast and a generic imaging window respectively. The MTF was estimated by Fourier transforming the differentiated PTW imaged edge profile. The contrast was obtained by irradiating the Artinis CDRAD low contrast PMMA phantom and a 3D printed phantom, for 'breast' imaging conditions. The data were processed through ImageJ and Octave free software. The best MTF agreement was found for patella imaging conditions in the subscan direction. Higher value MTF experimental results were found for the 'patella' presentation software algorithm and lowers for the 'chest'. The image contrast was found to be affected by the phantom type. The PMMA phantom showed better agreement with the experimental results. Since image quality parameters are phantom material based, each new phantom should have a reference image.

Classification of endo-perio lesions based on radiographic examinations

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Introduction. Endo-perio lesions are lesions that differ from each other, depending on the different classifications of these pathologies, in close connection with the place of onset of infection, and then, the appearance of primary signs of inflammation. Despite the different classifications of endo-perio lesions, the oral flora that promotes the onset of the lesion is different, also depending on the site of onset of infection-inflammation.

Aim of the study. The study is cross-sectional based on the collection of radiographic data on the occurrence of endo-perio lesions presented on accurate periapical radiographs. As a primary goal or objective, the study has the evaluation of radiographic signs of endo-perio lesions, to enable the radiographic diagnosis of lesions and then the division according to the subdivisions of the endo-perio lesion classification system.

Materials and methods. In the study, 104 periapical radiographs of patients presented in a dental clinic were reviewed, with objective and subjective complaints of the presence of endo-perio lesions. Radiographs were classified according to periapical radiographic accuracy criteria, criteria set by Prichard. Accurate periapical radiographs were used to classify endo, perio, endo-perio lesions. Endo-perio lesions were classified based on the classification of Simon et al. and the Torabinejad and Trope classification.

Results. The division of radiographs depending on the fulfillment of the accuracy criteria showed that 81% of the radiographs met the periodontal and radiographic criteria simultaneously. 9% were perio correct and radiologically incorrect; perio erroneously and radiologically correct, were in 6% and recently in both erroneous evaluation criteria were 5% of the cases included. The distribution of radiographs depending on the presence of endo or perio lesions varies as follows: endo lesions occurred in 32 cases or in 38% of radiographs; perio lesions occurred in 22 cases or in 26% of radiographs and endo-perio lesions were in 30 cases, or in 36% of radiographs included in the study. According to the classification Simon et al. radiographs were divided: class a 40%, class b 20% class c 7% class d 10% and class 23%. According to the Tobabinejad and Trope classification endo-perio lesions were by classes specifically: class a 60% class b 17% class c 23%.

Conclusion. The relatively low percentage of inaccurate radiographs, both for radiographic criteria and for periodontal criteria, can also be justified as human error. The tangible percentage in sensitive and visible values is when the error occurs for radiographic criteria, or when the error occurs for both radiographic and periodontal criteria. The use of an accurate radiograph is what matters during periodontal examination. The main violation of the accuracy criteria of radiographs is mostly related to the displacement of the cone in the up-down direction, which is performed in support of the routine protocol in performing periapical radiographs. The values in the study showed results on the frequency of occurrence relatively the same for both endo lesions and periodontals and in cases of occurrence of endo-perio combination. This data confirms the fact that endo-perio lesions have the same possibility of occurrence, both for endo-only lesions and for perio-only lesions. Despite the different types of endo-perio lesion classification, the distribution across the classification classes shows the same values in equal percentages for true combined endo-perio lesions. For other subclasses, classifications with several subclasses are more sensitive to the course and prognosis of endo-perio lesions, but difficult to determine which class this lesion belongs to.

Keywords: Endo-perio lesions, Prichard criteria, periapical radiography, Tobabinejad and Trope classification, Simon et al.

Tissue reaction of the periodontal ligament presented with radiographic width, numerical correlations

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Introduction. The prosthetic and functional value of a tooth depends on the continuous effect of forces applied on the occlusal surface or on the incisal edge of the tooth. Resistance to forces exerted on the tooth, without damage to the periodontal ligament, is performed by adjusting the size of the force versus the duration of its application. This element presents with widening or narrowing of the radiographic width of the periodontal ligament.

Materials and methods. The teeth included in the study are classified as function teeth, with light function and without function depending on the presence of the point of contact and the presence of occlusion. The same teeth are taken in equal amounts and numbers depending on the group of teeth: molar, premolars, canine and incisors. Periodontal ligament width measurements were performed at the neck of the tooth, between the tooth axis and at the apex of each tooth. 204 measurements in total, for each of the groups of teeth.

Results. The width of the periodontal ligament varied in values for teeth with function: incisive 0.24, canine 0.37, premolar 0.34 and molar 0.36; mesial surface 0.3 distal surface 0.296; for slightly incisor teeth 0.073, canine 0.12, premolar 0.14 and molar 0.1, medial mesial surface 0.13 and distal surface 0.13; teeth without function: incisor 0.06, canine 0.13, premolar 0.1 and molar 0.06, mean mesial 0.08 and distal 0.09.

Conclusions. Forces applied to the teeth included in the study were within the limit and not at the limits of trauma from the occlusion, nevertheless there is a difference in apparent greater width in cases of application of forces on the periodontal ligament and radiographic tightness in cases of lack of application of occlusal forces. The tooth with the points of contact and the presence of the antagonist creates the complexity of the discharge of occlusal forces from the occlusal surface according to the longitudinal axis of the tooth in the periodontal ligament and in the absence of indoor reaction of the periodontal ligament the transmissions of forces to the joint are felt.

Keywords: Axial force, function, periodontal ligament, periapical rtg, incisor, premolar, molar, canine

Stomach cancer – data on diagnostic methodology

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Introduction. Stomach cancer is a pathology that is not uncommon in our country and that includes almost all age groups but much more common in the geriatric age. The study is organized in two parts: in the general part which gives an anatomo-physiological description of the stomach intertwined with the clinic and the necessary examinations and in the special part that is presented as an exposition of stomach cancer intertwined with the study conducted in our clinic.

Materials and methods. In the study were examined about 50 patients with gastric cancer, operated in the clinic, for a period of 2 months. The defined order of diagnostic examinations for gastric cancer is as follows: Careful physical examination to find pathological signs that may be subject to biopsy such as. palpable lymph nodes or palpable liver; Double contrast radiographic study of the upper gastrointestinal tract to capture intraluminal pathology; Endoscopy with biopsy and cytology; Diagnostic laparoscopy; Diagnostic and / or treatment laparotomy.

Results. The incidence of pathology on the female-male ratio is presented in a 2: 1 ratio that is completely consistent with those of other authors. The disease is seen most often between the ages of 50 and 70 with a peak at the age of 60 in about 60% of cases. Gastric cancer is very rare under the age of 30 in 4% of cases predominates antral cancer which does not match the data of the literature where it is seen that cardiac cancer is presented with an increase of almost 2 times (from 21% to 44%) these last four decades. It turns out that in our country predominates a larger percentage of patients with blood group O (I). The occurrence of gastrointestinal hemorrhage in patients with stomach cancer is one of its signs, but as seen it is rare 4%. A predominance of abundant hemorrhage is seen, melena 20%, hematemesis 4% compared to the occult form 4%. What stands out is that the examination that has diagnosed in almost all cases is fibrogastroscopy that is accompanied by preoperative biopsy in 72.8% of cases. The only case where preoperative fibrogastroscopy was not performed was a case of perforation of the stomach cancer (emergency). The accuracy of the preoperative biopsy is 68%, having a false negative of about 32%, having no white laparotomy in these patients. This may be due to a small sample of biopsy material, a shallow sample that is not at the right depth, or a few places.

Conclusion. Although the largest number of inhabitants lives in the countryside, especially the main age group affected by stomach cancer, there is a slightly higher number of patients from the city. This contradicts the above data since the lower socio-economic strata live in the village. In the literature on this problem there are different opinions for and against the predominance of blood group A (II) in stomach cancer. According to all data in the literature, epigastric pain and weight loss are the most common symptoms presented to the patient in the study a slight predominance of weight loss compared to epigastric pain was observed.

Keywords: Fibrogastroscopy, laparotomy, hematemesis, melena, epigastric pain, stomach cancer, endoscopy

Comparison of two digital mammography systems using quantitative methods

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Optimal assessment of imaging systems and patient dose is an important task in digital mammography. Digital detector technology makes it possible to use objective, computational methods to compare digital mammography systems. In our work we compared two digital systems using different quantitative methods to determine the differences between them, to select the better option for specific applications:

- Siemens Mammomat Inspiration unit with direct conversion, amorphous selenium detector (pixel size 85 μm), W/Rh anode/filter combination used clinically and,
- GE Pristina Senographe unit with indirect conversion, CsI scintillator and a-Si detector (pixel size 100 μm), Mo/Mo and Rh/Ag anode/filter combinations.

We compared different performance aspects of mentioned systems using:

- effective Modulation Transfer Function (eMTF)
- effective Normalized Noise Power Spectrum (eNNPS)
- effective Detective Quantum Efficiency (eDQE).

Measurements were performed for using polymethyl methacrylate (PMMA) of three thicknesses (20, 40 and 70 mm) as breast substitute material with an anti-scatter grid. A/F combinations and exposure levels (mAs) were set by automatic exposure control (AEC) system. For the GE unit, additional measurements were made using a Mo/Mo combination for 40 mm PMMA. We also analyzed average glandular dose (AGD) levels for each PMMA thickness.

In mammography, it is crucial to detect the smallest possible lesions. In our study, spatial frequencies up to 0.5 mm^{-1} were omitted from the analysis. Noise examination showed significant difference in system performance. For the Siemens unit, eNNPS appeared to be constant for the spatial frequency range that was considered, but the GE system's eNNPS varied across the spatial frequency domain. There was also a significant difference between A/F configurations in GE unit, where lower noise for the same PMMA thickness was observed with Rh/Ag. eMTF also varied between the two systems, with the Siemens unit recording higher values regardless of PMMA thickness. However, this strong advantage was not seen in respect to eDQE. For the Siemens unit, the highest values of eDQE were observed with the thinnest phantoms. In contrast, the highest values observed for the GE system occurred with the thicker phantom. Additionally, AGD analysis shows that by using a thinner phantom, dosage with the GE unit can be reduced up to 20%, but this is accompanied by a significant drop in system performance and higher noise in lower spatial frequency range. On the other hand, eDQE and noise were improved using the thicker phantom, with dose reduction up to 13%.

Analysis of computational parameters in different types of mammography systems can provide valuable information on the performance of these units under semi-clinical conditions. This information may potentially be useful for optimization of imaging, especially regarding which unit to choose for specific breast thicknesses.

Infrared imaging of venipuncture sites: An evaluation of effectiveness on vein visualisation

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Infrared radiation (IR) covers the region of the electromagnetic spectrum with wavelengths from 750nm to 1400nm. It is emitted by all objects at temperatures above absolute zero and the amount of radiation increases with temperature of the object. It is not detectable by the human eye. Thermography is a type of infrared imaging in which a thermographic camera can convert the invisible radiation into a visual image providing a temperature distribution map of an object's surface without any contact with it.

Venipuncture is a necessary procedure to gain intravenous access thus collecting blood samples for clinical testing and intravenous therapy. Certain groups of people might have difficult veins to access, such as patients with chronic disease or patients with fear of needles. Patients with difficult venous access (DiVA) may undergo multiple venipuncture attempts. In such cases the procedure is always painful and very stressful, and it could delay the diagnosis or the intravenous treatment.

In order to reduce the patient's stress and pain, various methods have been developed to create a real-time venous image on the selected area and project the most appropriate vein to draw the blood sample or place a peripheral intravenous catheter. These methods are usually based on infrared radiation, due to the generally higher temperature of blood relative to the surrounding tissue as well as its infrared radiation absorption characteristics.

This study aims to record the use of infrared "light" to obtain a real-time image of the venous system of the venipuncture sites, such as the cubital area and the hand, in order to select the right vein for drawing the blood sample in the first attempt with as less pain as possible for the patient.

Potential venipuncture sites were imaged thermographically and the obtained images were analysed qualitatively and quantitatively to evaluate vein projection in each case. Results indicate the effectivity of infrared thermography on providing an image that could assist on the choice of the appropriate venipuncture site regardless the medical professional's experience.

A preliminary study: in vitro test for lung cancer detection with GFET based biosensor

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Cancer is one of the dangerous and deadly diseases of our age. Every year more than 8 million people, unfortunately, die for cancer-related causes. Lung, stomach, and lymphoma cancers are among the leading types of cancer that cause death. Early diagnosis is vital in the treatment of cancer while the standard diagnosis of cancer is made with a series of tests that cost a long time and financially. Due to this situation, many studies have been carried out on the subject recently. This study is about production and development of graphene-field effect transistor (GFET) based biosensor for using in the early diagnosis of lung cancer. In this study, some microRNAs related to lung cancer were preferred as biomarkers to increase the sensitivity and selectivity of the biosensor. In addition, the sensory region of the device was modified with graphene to increase the electrical properties of the biosensor and its compatibility with the biomarker. The results of the preliminary study present a promising picture for the future.

Keywords: Biosensor, GFET, miRNA, Lung Cancer

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Infrared thermography as a measure of emotion response

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The exposure of humans to an external, emotion arousing, stimulus causes activation of certain brain regions which in turn lead to certain physiological responses, among them alteration of the heart and circulatory function of the subject. The resulting changes in blood supply can have an impact on the temperature of the person rather on its whole body or in specific regions. This study attempts to investigate whether experiencing an emotion can cause measurable alterations in human facial temperature distribution.

The facial temperature of people exposed to a series of audiovisual media specifically designed to activate certain emotions is recorded by an infrared camera. The type of experienced emotion is stated by the exposed individual. Quantitative processing of the obtained thermographic images aims to determine if the experienced emotion altered the facial temperature map.

The results indicate that detecting emotions through changes of facial temperature is a promising technique, worth of further investigation. The method is non invasive, cheap and could have an important role in BCI applications.

Influence of dose uncertainty on TCP estimates – a model study

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Purpose. To theoretically determine the effect of 3% uncertainty in the received dose per fraction during radiotherapy on the tumour control probability, taking into account the process of tumour resensitization. The investigation is carried out for irradiation with different timing schemes and dose per fraction.

Method. The good clinical outcome relies on high dose accuracy delivered to the malignant structure. It is commonly accepted that 3% dose uncertainty is currently achievable. In order to investigate the impact of such uncertainty, a MATLAB code has been developed that simulates tumour irradiation with different fractions and dose per fraction. The dose per fraction has a normally (Gaussian) distributed uncertainty of 3%. Initial parameters used for the TCP calculation are taken from [Stavrev et al: The Impact of Different Timing Schedules on Prostate HDR-Mono-Brachytherapy. A TCP Modeling Investigation; Cancers 2021, 13(19), 4899]. Zaider-Minerbo-Stavreva (ZMS's) TCP model [Stavreva et al: Effect of resensitization on TCP modeling of fractionation; Med. Phys. 32(3), 2005] was used for the calculations, as well as linear-quadratic (LQ) model of cell killing. Histograms of the tumour control probability corresponding to the respective prescribed dose were obtained and analyzed.

Results. Two different methods of irradiation are considered. The conventional radiotherapy (20 fractions with 2.4Gy per fraction (20x2.4Gy); 25x2Gy and 30x2Gy), and hypofractionated radiotherapy (3x15Gy; 4x11Gy; 5x9Gy; 5x10Gy). For the first case (20x2.4Gy) TCP_{mean} = 43.2+- 4.8% (1 standard deviation) is obtained when resensitization is taken into account and TCP without deviation in dose per fraction is calculated TCP=43.1%). In the case with 25x2Gy: TCP_{mean}= 30.8+-4.0% and TCP=30.6%. For 30x2 Gy: TCP_{mean}= 98.10+-0.24% and TCP=98.1%. When using SBRT technique and 3x15 Gy dose prescription: TCP_{mean}= 99.90+-0.06% and TCP=99.9%. For 4x11Gy: TCP_{mean}= 94.2+-2.1% and TCP=94.5%. For 5x9Gy: TCP_{mean}= 89.4+-3.3% and TCP=89.8%. And for 5x10 Gy: TCP_{mean}= 99.80+-0.08% and TCP=99.8%.

Conclusion. Uncertainties in dose delivery in patient play significant role on treatment outcome in some treatment regimens, especially where TCP is relatively low (the steepest part of the curve – between 20% and 80%). In most of the considered SBRT regimens, the obtained TCP is more than 90% and dose uncertainty plays statistically insignificant role on treatment outcome

Increased apoptosis of tumor cells with a combination of photodynamics and radiation therapy

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A combination of radiation therapy (RT) and photodynamic therapy (PDT) can be another way of a treatment effectiveness increase. In order to study the possibility of mutual enhancement of photodynamic and radiation therapy, experiments were carried out on irradiation of human lung adenocarcinoma cells A549 with light with a fixed wavelength and X-ray radiation with an energy of 60 keV. A modification of chlorin E6, which has an absorption peak at a wavelength of 663 nm, was used as a photosensitizer. Using the MTT test and flow cytometry, the survival rate of irradiated cells and the level of apoptosis, as well as some other reactions of cells to irradiation, were investigated. The cytometry used a kit containing FITC-labeled Annexin V, staining buffer and propidium iodide. A steady increase in apoptosis was found under the simultaneous effects of photodynamic and radiation therapy, exceeding the additivity of these two independent treatments.The main qualitative conclusion from the experiments carried out is as follows: the level of apoptosis of tumor cells under the combined effect of PDT and RT significantly (by 35-40%) exceeds the sum of the levels of apoptosis from separately performed PDT and RT. The statement that PDT and RT reinforce each other while being performed simultaneously has a high reliability in the ordinary t-test $p < 0.001$. The discovered synergy of the two types of tumor therapy can reduce treatment-induced damage to normal tissues and organs.

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Seasonal biochemical parameters of domestic dogs' blood from various breeds

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Monitoring of the health status of domestic dogs included seasonal measurements of blood serum indicators of dog breeds: *Beagle, Pomeranian, German Shepherd, Russian-European Laika, Bull Terrier, Black Russian Terrier, Toller, Jack Russell Terrier, Sheltie, Labrador Retriever, Shih Tzu, Dogo Argentino, Briard, Toy Terrier, Pug, Dachshund, Yorkshire Terrier, Kerry Blue Terrier, Rottweiler, French Bulldog, Zwerk Schnauzer, Scotch Terrier, Bullmastiff, English Bulldog, Chinese Crested, Biewer York, Maltese, King Charles Spaniel, American cocker spaniel, Russian spaniel, Golden Retriever*. Based on the results of biochemical studies of the blood serum of healthy and sick domestic dogs of different ages and sex, carried out during the year, the parameters of the breed and seasonal features of the functioning of the homeostasis system were revealed. In addition, the characteristic directions of the combined changes in the activity of enzymes and the concentration of trace elements in blood serum in diseases of the cardiovascular system, kidneys and liver of dogs of non-invasive etiology were determined.

Of considerable interest for practical application are the data obtained in the work, indicating the possibility of using seasonal monitoring of the activity of homeostasis enzymes as a test system for the simultaneous assessment of the functional activity of the cardiovascular and endocrine systems of dogs with internal non-communicable diseases. The developed parameters should be taken into account to create roadmaps for therapeutic and diagnostic measures in veterinary medicine. The facts may be of interest for the development of methods of pharmacology, experimental medicine, individual selection of drugs and gerondoprotectors, diagnosis and therapy of internal non-communicable diseases and malignant neoplasms.

Biophysical indicators of deer skin derivatives from different habitats

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The values of redox potentials of alkaline hair hydrolysates from different deer species — reindeer, sika and red deer — were studied. Hairs were taken from different parts of the body of healthy animals of different sex and age (males, pregnant and non-pregnant females, cubs), living in different climatic zones. In Russia, the reindeer lives in the north of the Russian-European plain, in the Ural mountains, in the Siberian taiga and in the Far East. It inhabits both flat and mountainous regions, lives in the tundra, forest-tundra, and coniferous forests. The Ussuri spotted deer is one of the rare species of animals; in Russia it lives in the Primorsky Territory. The red deer is represented mainly by the subspecies of the Altai deer (maral), which lives in Russia - in the mountain forests of Altai, in the Sayans and in the Baikal region in Siberia.

The redox potential of hair was determined according to the author's method [Utility model patent No. 171788 "Device for determining the parameters of the photoredox effect in alkaline solutions of keratins", DOI: 10.21175/RadProc.2020.20]. 20-25 samples from each of 8 habitats were examined. Significant differences in the values of redox potentials depending on the type of animal were revealed; no dependence of the redox potential on age, gender, area of residence and climatic conditions was found. In reindeer samples, the potential during incubation in the dark was in the range of 55-57 mV, when irradiated with visible light, the range was 50-53 mV, and then, upon incubation in the dark, it returned to the original dark values.

In sika deer wool, the potential during incubation in the dark was in the range of 48-51 mV, when irradiated with visible light, the range was 40-41 mV, and then, upon incubation in the dark, it returned to the original dark values. In red deer hair, the potential during incubation in the dark was in the range of 60-64 mV, when irradiated with visible light, the range was 56.5-58.5 mV, and then returned to the original dark values when incubated in the dark.

Investigation of frequency of dielectric relaxation of water molecules in blood cells of cancer patients

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To determine the causes and specific mechanisms of disruption of biochemical, physiological and other processes in the irradiated body, it is necessary to study post-radiation changes in the structure and functioning of cells [Int. J. Biosen. Bioelectron. 2018;4(6):242-247]. The paper presents the results of a biophysical study of the frequency of dielectric relaxation (f_d) of water molecules in blood cells (erythrocytes) of breast cancer patients (n = 32), under conditions of radiation exposure to the tumor (a single focal dose was 6 Gy), which were obtained for using the method of microwave dielectrometry, at a frequency of 9.2 GHz [AS Cancer Biology. 2018; 2(10):55-60]. The value of the real part of the dielectric permittivity (ε') was determined by the change in the resonant frequency of the resonator with the sample relative to the empty resonator, and the imaginary part of the dielectric permittivity (ε'') was determined by the magnitude of the attenuation of the microwave field power due to the introduction of a dielectric into the resonator. The temperature of the test sample was recorded with an accuracy of ± 0.1 °C. Blood from healthy donors was used as a control (n = 30). Statistical processing of the obtained data was performed using the MATLAB program and Mann-Whitney nonparametric test.

For the real and imaginary parts of the complex dielectric permittivity and the frequency of dielectric relaxation of water molecules in the suspensions of erythrocytes of donors and patients dependences on the range temperature of 2-47 °C were obtained. The activation energy of the dielectric relaxation time of water molecules in the studied systems and the magnitude of the degree of hydration of the erythrocyte membranes of donors and patients before and after irradiation were calculated. It was found that at temperatures of 10-12 ° C, 20-23 ° C and 30-36 ° C structural changes of erythrocyte membranes of donors and patients with malignant neoplasms are observed, which are accompanied by changes in activation energy. The increase in activation energy in the range of 8-12 ° C, the frequency of dielectric relaxation of water molecules in erythrocyte membranes of patients may be associated with a global structural transition in cell membranes, which affects both peripheral proteins of the cytoskeletal complex and integral proteins of membrane 3, in particular membrane proteins [2018 IEEE 8th International Conference Nanomaterials: Application & Properties (NAP)]. It is established that radiation therapy approximates the value of the frequency of dielectric relaxation (f_d) of water molecules in suspensions of erythrocytes of patients to the indicators of healthy donors. The breakpoints of the Arrhenius dependency diagrams lie in the range of temperatures known as critical, in which the velocities of many physiological processes associated with erythrocyte membranes change.

Pilot phase in the development of vaccines against Marek's disease

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Marek's disease (MD), a lymphoproliferative disease of chickens, is a serious problem for the poultry industry. The causative agent, an oncogenic DNA-containing alphaherpesvirus, has the ability to persist both in the host and in the ecosystem. In this case, the virus evolves, which leads to the emergence of more virulent populations of ***Marek's disease virus (MDV)*** pathotypes. In addition to virulent strains of MDV of the first serotype, there are two non-oncogenic ones in nature: the second serotype is the ***chicken herpes virus (CHV)*** and the third serotype is the ***turkey herpes virus (THV)***. The purpose of this work was to conduct a theoretical and experimental substantiation of the possibility of developing new vaccine preparations against Marek's disease.

Research results. Dry and reconstituted with saline ultrasonic lysates of cells infected with ***CHV*** and ***THV*** were subjected to thermal denaturation. The specificity, antigenic and infectious activity of heat-treated and untreated cell lysates were determined by ELISA and titration on cell cultures of SPF chicken embryos.

In drug samples of turkey herpes virus, dry-heat-treated at 100°C, the infectivity of the virus sharply decreased after 15 minutes (by 98%) and completely disappeared after 30 minutes. Structural components of the antigen cross-reacting in ELISA with an antibody to ***MDV*** and with an antibody to ***THV*** were completely preserved during the entire period of heat treatment. Therefore, with this method of exposure to dry preparations, viral antigens reacting with an antibody to ***MDV*** and an antibody to ***THV*** proved to be thermostable.

Influence of X-ray irradiation on germination of fusarium infested wheat seeds

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There is a serious concern that food shortage will be a major issue across the globe in the coming decades due to the population growth and the potential effects of climate change. However, food shortage has been a long-lasting problem in developing countries. This situation is worsened due to decrease in germination of infested seeds and food spoilage due to the toxicants. Irradiation with sources such as ^{137}Cs, ^{60}Co or electron beams is commonly employed as remedies to enhance/safeguard the food supply. As the purpose of irradiation is to induce photochemical reactions without causing nuclear transformations, we are of the view that low energy X-ray irradiation is more effective than gamma rays of higher energies due to higher attenuation coefficients at lower energies. Therefore, we embarked on irradiation with compact X-ray beams of less than a few hundred keV to study the efficiency of such beams.

For irradiation, we use X-RAD225 with 225 kVp rating at a current of about 13 mA with a dose rate of about 4-5 Gy/minute. We prepared fusarium infested wheat durum seeds and stored them in a refrigerator prior to irradiations. We arranged samples of 100 seeds each for irradiation levels of 500, 1000, 1500, 1750, 2000, 2250, 2500, 3000 Gy. Post irradiation, we tested the seed germination in these samples. Unirradiated fusarium infested and clean (uninfested) seeds were used as controls. Our results show that irradiated infested seeds germinated significantly better than unirradiated infested seeds. From our measurements, we estimate that about 40-50% of seeds germinate showing promise that such treatment will contribute to address the food shortage.

In coming months, we will test the germination in the field soil setting to confirm the usability in real farm operations. It is believed that this method, if successful, will enable to employ field deployable irradiation system to be taken to the farmlands in rural areas, making it unnecessary for heavily fortified irradiation facilities, currently in use.

The effect of accelerated electrons on the chemical parameters of chilled poultry meat

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Today, radiation technology is widely used in the food industry. Irradiation of food products ensures food safety and allows to increase the shelf life of products. Radiation processing with carefully selected dose range, dose rate, irradiation method, etc. effectively suppresses pathogens, while preserving the taste and other properties of the product.

The degree of exposure to irradiation affects the biochemical processes occurring in foodstuffs. One of the most sensitive components to ionizing radiation are lipids consisting of fatty acids. The hydroxyl radicals formed during radiolysis of water cause oxidation processes of fatty acids, which can decompose into volatile compounds, such as alcohols, aldehydes and ketones.

The aim of this work is to determine the dependency of volatile organic compound concentrations in poultry meat on the irradiation dose when exposed to a beam of accelerated electrons with the energy of 1 MeV.

Chilled turkey and chicken meat were chosen as an object of the study. The samples were irradiated with 1 MeV electrons using UELR-1-25-T-001 accelerator. The samples were irradiated with 0.25, 0.5, 1, 2, 5, 10 kGy, and 20 kGy. Identification of organic volatile compounds and determination of their concentrations were performed using a GC Agilent 8890 MSD 5977 E gas chromatography-mass spectrometer with a vapor sample input.

It was shown that after the radiation processing the dependency of concentrations of alcohols (hexanol-1, octen-1-ol-3, pentalol-1), aldehydes (nonanal, hexanal, octanal, heptanal, acetal, pentalol) and ketones (3-methylbutanone-2, 2,3-butanedione, butanone-2, acetone, pentalol-2) on the radiation dose had a non-linear character.

Based on the analysis of the obtained dose-dependent concentrations of organic compounds in poultry samples, it was concluded that two competing processes occur in all of the samples studied: the breakdown of a chemical compound and the formation of molecules of a given compound due to the breakdown of other compounds. For each group of substances, similar changes were observed in concentrations depending on the rate of decomposition of fatty acids, the rate of formation of stable molecules, the rate of breakdown of the compound itself into molecules, the rate of free-radical processes, enzymatic and oxidative processes in the samples, etc.

The applicability of the proposed model for the description of changes in chemical parameters of poultry meat from the radiation dose was shown for all identified organic compounds.

Effects of gamma irradiation on phenolic content and antioxidant activity of bee bread and bee pollen

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Gamma irradiation could be used as a safe method for disinfection and shelf-life prolongation of bee bread and bee pollen. By means of the using of ionizing radiation can be avoided proteins and sugars deterioration, no changes to flavor, taste and texture also were observed. The effect of gamma treatment of the honey bee products on antiradical activity was evaluated by Electron paramagnetic resonance (EPR) spectroscopy and also the total phenolic content was spectrophotometrically determined. An analysis of some main phenolic constituents before and after gamma treatment was performed by high performance liquid chromatography (HPLC).

The antiradical activity of extracts was assessed by the DPPH free radical scavenging activity (FRSA). The EPR study shows that FRSA increased after irradiation with 5 kGy for both samples, more significantly in bee bread. Radiation treatment with 10 kGy leads to an increase in antiradical activity in pollen, while in the bee bread decreasing was observed. The EPR results are in good correspondence with the determined contents of polyphenol compounds. It was found that phenolic content values increased after bee bread and pollen irradiation depending on the dose. The HPLC analysis of tested samples showed that irradiation leads to change in the concentration of identified polyphenols and the formation of some new ones was observed in regard to non-irradiated honeybee products.

The study shows that gamma treatment has a greater effect on phenolic compounds and antioxidant activity of bee bread compared to pollen samples.

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EPR study of gamma radiation effects on free radicals and antiradical activity of royal jelly

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Royal jelly is characterized by high consumer and market value. Unique qualities make it indispensable in various fields of food industry, medicine, cosmetics and others. Royal jelly is extremely rich in healthy compounds, such as enzymes, proteins, amino acids, lipids, phenolic compounds, vitamins and minerals, antioxidants and is one of the first in our personal list of foods that significantly improve health. Bee products must not be sterilized by heat treatment to prevent the decomposition of sugars and proteins. Therefore, cold decontamination with gamma rays is becoming more popular. The EPR spectra of royal jelly samples before and after irradiation show Cu^{2+} ions. After gamma-irradiation a narrow signal appeared whose intensity increases significantly with the increase in the dose used. It is attributed to O-centered free radicals. The kinetic behavior of gamma-induced free radicals with time was studied for a period of 150 days after irradiation. Gamma rays induce the largest amount of free radicals in samples irradiated with 10 kGy and the difference between those sterilized with 5 and 10 kGy is insignificant. There is a clear difference at 1 kGy. Free radicals recombine over time after irradiation or were quenched by antioxidant molecules. The O-centered radicals are stable for 5 months in royal jelly samples thus the gamma irradiation enables identification in this time interval. The effect of gamma irradiation on free radical scavenging activity of royal jelly extracts was studied by using the stable free radical 1,1-diphenyl-2-picrylhydrazyl (DPPH) and the antioxidant activity was represented in Trolox Equivalents. The results show that after irradiation the DPPH free radical scavenging activity of studied samples has different dose dependence.

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Structure and extraction-spectrophotometric determination of an Iron(II) ternary complex

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The complex formation in a liquid-liquid extraction system containing iron(II), 4-nitrocatechol (4NC), 2,3,5-triphenyl-2H-tetrazolium chloride (TTC), water and chloroform were studied. Under the optimum conditions, the extracted complex has a composition of 1:1:2 (Fe–4NC–TTC) and could be represented with the formula $(TT^{+})_2[Fe^{II}(4NC^{2-})(OH)_2]$. Theoretical calculations were performed at the HF/3-21G* level in order to elucidate the geometric structure of the complex and electron distribution according to the crystal field theory. The results showed that the most stable configuration is tetrahedral low-spin structure. Some equilibrium constants (association, distribution, and extraction) and characteristics (absorption maximum, molar absorption coefficient, recovery factor, Beer's law limits, etc.) concerning the application potential of the studied extraction–chromogenic system were determined.

Keywords: Iron, liquid-liquid extraction, 4-nitrocatechol, spectrophotometric determination

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Method for indirect radiofluorination with [^{18}F]-FDG by bioorthogonal reaction

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The [^{18}F]-fluorodeoxyglucose ([^{18}F] FDG) is produced in the Clinic of Nuclear Medicine at the University Hospital "St. Marina" - Varna (Bulgaria) for clinical routine purposes, using a nucleophilic method for radiofluorination. The [^{18}F$^-$] anion is produced in a BG-75 biomedical cyclotron by bombarding ^{18}O-enriched water with the ^{18}O(p, n)^{18}F nuclear reaction. [^{18}F]-FDG is one of the most widely used radiopharmaceuticals. It is used in oncology, cardiology and neurology. Apart from being a universal PET - radiopharmaceutical [^{18}F]-FDG can be used as a convenient prosthetic group for indirect labeling of aminooxy functionalized compounds by chemoselective oxime bond formation. The oxime ligation is widely used for the synthesis of cyclic peptides, large proteins by assembling fragments, protein-polymer conjugates, oligonucleotide conjugates, glycoconjugates and labeled bioconjugates.

We developed a method for oxyme formation between [^{18}F]-FDG and a bifunctional tetrazine derivative which is appropriate for the further biorthogonal reaction. Our procedure is applicable for standard clinical laboratory settings. The synthesis is carried out in weakly acidic conditions - pH 4-4.3; at 70°C and in the presence of p-methoxyaniline as a catalyst. The reactions were monitored by radio-TLC and HPLC.

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The effect of irradiation on the sorption properties of Greek Bentonite: Cs and Co-sorption studies

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Natural bentonites exhibit high removal capacity for some radionuclides as cesium, and strontium and are widely used as permeable reactive barriers (PRB) isolating the radioactive waste in geological facilities for disposal of long-lived intermediate- and high-level radioactive waste.

This work focuses on the adsorption properties of Greek bentonite from Kimolos island (Cyclades, Greece), after irradiation. The irradiation was performed using an ^{241}Am source for different time (one up to five days) and the Cs- and Co-sorption, was investigated in aqueous solutions using the batch system. The experiments were performed using as tracers ^{137}Cs and ^{60}Co and γ-ray spectroscopy. The initial concentration of the Cs^+ solutions in contact with bentonite was in the range of 25-1500 mgL^{-1}, with pH ranging from 4-6. For Co^{2+} solutions the initial concentration range was 10-1000 mgL^{-1}, with pH ranging from 5-6. The effect of different parameters such as pH, concentration, competitive ions (Na^+) and temperature (20, 25, 35, 45 °C), on the sorption onto bentonite was also studied.

The structural changes of the sorbents were examined before and after irradiation through XRD analysis, as well as Fourier transform infrared spectroscopy (FT-IR), and scanning electron microscopy (SEM-EDS) were applied for the materials characterization. The environmental compatibility of the non-irradiated material after loading was assessed using the Toxicity Characteristic Leaching Procedure. Furthermore, the sorption in binary Cs-Co system was investigated with concentration ratio 1:1, 2:1 in order to determine the selectivity of the non-irradiated bentonite in regard to these metals.

The sorption isotherms were satisfactorily reproduced by the Langmuir and Freundlich equations with Langmuir model to give better correlation coefficients. The kinetic experiments and the calculation of the thermodynamic parameters (ΔH, ΔS° and ΔG°) indicated that Cs- and Co-sorption were spontaneous and exothermic processes.

From the batch experiments it was concluded that the adsorption capacity of bentonite for Cs was increased while for Co it decreased significantly after irradiation. XRD showed that the irradiated bentonite has increased montmorillonite and less quartz content compared to the non-irradiated and also after Cs adsorption the irradiated bentonite loses its crystallinity.

From the binary Cs-Co system study it was concluded that for ratio 1:1 the bentonite selectivity is $Co^{2+}>Cs^+$ and the adsorption capacity for both metals was decreased due to antagonistic effects, while for 2:1 coexistence of Cs resulted in significant decrease in Co-uptake onto bentonite.

The TCLP tests showed that the Cs- and Co-loaded materials can be safely disposed.

Removal of actinides from waste and waters using different sorbents

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The actinide elements (U(VI), Th(IV), Am(III), Pu(IV)) exhibit many oxidation states and show a complex environmental chemistry. The hydrolysis of the actinides plays the determining role in the interaction processes with many substances. The presence of actinides in the environment is connected to several reasons, such as nuclear and conventional energy production, nuclear weapons and production and use of fertilizers. On the other hand, their transport depends on the geologic environment, the temperature and pressure profiles, the pH of the local waters, the redox potential (Eh) and concentration of inorganic (e.g. carbonates) or organic (e.g. humic acids) ligands.

The removal of uranium, thorium and europium (as chemical homologue for trivalent actinides) from aqueous solutions can be performed by sorption techniques using a variety of materials. At the radiochemical laboratory of the Chemistry Department of AuTh different sorbents such as natural and synthetic zeolites and clays, organic and inorganic compounds as well as nanoparticles have been developed and tested for retention of actinides under different conditions (pH, concentration, contact time, temperature, ionic strength). Depending on their properties the sorbents exhibit enhanced sorption capacity and can be successfully used in waste treatment technology.

The conditions of elaboration of the tested sorbents, the characterization and their sorption behaviour will be presented along with examples of applications in waste and natural water treatment.

Bioinspired elelctrospun hybrid nanofibers based on biomass templated within polymeric matrix for metal removal from wastewater

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Bioinspired hybrid nanofibers on the basis of polystyrene and Spirulina biomass: pristine and modified were produced. These nanofibers were characterized by scanning electron microscopy, Fourier transform infrared, and thermogravimetric analysis. The hybrid nanofibers have been utilized as adsorbents for the removal of copper and manganese ions from synthetic solution in batch mode at pH =7, during two-hour experiment. The sorption capacity of produced nanofibers was assessed using neutron activation analysis. The maximum adsorption capacity was achieved for nanofibers with maximum Spirulina biomass loading: q=8.7 mg/g for copper and 7.3 mg/g for manganese (with pristine biomass); q=8.2 mg/g for copper and 7.0 mg/g for manganese (with modified biomass). The obtained results showed that the hybrid nanofiber could be successfully applied for metal removal from industrial effluents.

Bioremediation capacity of edaphic cyanobacteria *Nostoc linckia* for chromium in association with other heavy-metals-contaminated soils

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Anthropogenic activity is the main factor contributing to soil pollution with various toxic metals, including Cr(VI), which dictates the need for decontamination. Often, the traditionally used remediation methods (soil removal, stabilization/solidification, physicochemical extraction, and soil washing) are not sufficiently efficient. Among gentle soil remediation, options can be considered. The aim of this study is to assess the ability of *Nostoc linckia* to remediate soils contaminated with Cr(VI) in association with other metals. Metal uptake by biomass was assessed using neutron activation analysis, while the components of Nostoc biomass were determined using specific methods. The capacity to accumulate chromium from the contaminated environment (Cr in association with Fe, Ni, Cu, and Zn) by the *Nostoc linckia* is kept at a high level for three generations of cyanobacterium, and the capacity to accumulate Fe, Ni, Cu, and Zn is growing over the cultivation cycles. The process of accumulation of heavy metals is associated with significant changes in the biochemical composition of Nostoc biomass. Due to the high bioaccumulation capacity and the specific growth mode with the formation of crusts on the soil surface, the edaphic cyanobacteria *Nostoc linckia* is an important candidate for the bioremediation of soil contaminated with chromium in association with other metals.

Monitoring and evaluation of factors affecting radio labeling with [^{18}F]-FDG by oxime formation

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The reaction conditions required for direct radiofluorination are not suitable for labeling sensitive biomolecules. In this case, it is necessary to apply indirect labeling using pre-fluorinated groups, known as "prosthetic groups". The [^{18}F]-fluorodeoxyglucose ([^{18}F] –FDG) molecule is suitable for use as a prostatic group in the indirect labeling of various aminooxy-functionalized compounds by chemoselective oxime formation. The oxime ligation is particularly attractive because it is a very efficient reaction in aqueous systems under mild acidic conditions.

The easy availability of [^{18}F] -FDG makes the labeling methodology attractive and allows it to be done in a very short time, about 20-30 minutes. [^{18}F] -fluorodeoxyglucose ([^{18}F] FDG) is produced in the Clinic of Nuclear Medicine at the University Hospital "St. Marina" - Varna (Bulgaria), using nucleophilic fluorination for clinical routine purposes. The [^{18}F-] anion is produced in a BG-75 biomedical cyclotron by bombarding ^{18}O-enriched water with the ^{18}O(p, n)^{18}F nuclear reaction.

We developed a method for oxime conjugation between [^{18}F]-FDG and bifunctional tetrazine production in a clinical laboratory setting. We tracked and evaluated the factors that influence the oxime formation reaction. Carry out the synthesis temperature during treatment and vary the pH in the range of 3 to 7.5. We monitored the effect of temperature in the range from 20^{o}C to 80^{o}C. We also evaluated the effect of the catalyst. This helped us to optimize the methodology and the obtained radiochemical yield.

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Assessment of the radiological risk in marine area close to an oil factory at Kavala Gulf-Greece

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In this article the assessment of the radiological risk in marine area close to an oil factory at Kavala Gulf in North-Western Greece is presented. As it is known oil and oil products are characterized as Naturally Occurring Radioactive Materials-NOPMs due to the presence of natural radionuclides as uranium, thorium, and radium. In the present study, a two-year survey was performed in marine area close to an oil factory. The radioactivity of natural radionuclides ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K was measured concerning their spatial and temporal variation. The study includes beyond of sea water samples of sediments, and seaweed. Both are a critical index of marine ecosystems and reflect the quality of water pollution because they act as a reservoir of pollutants, and their situation is less variable in time. The measurements were performed by γ-and α-ray spectrometry during two seasons in 2019 and 2020 and the values were compared to that of a reference site and literature data. Selective metals concentration was determined by XRF (X-ray Fluorescence). Moreover, radiation and pollution risks were estimated by determination of different contamination factors, and the results showed that the radiation hazard due to oil-NORMs and the environmental pollution in this area was moderate.

Application of new biosorbents for removal of uranium, thorium and europium from aqueous solutions

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The removal of uranium, thorium and europium (as homologue for trivalent actinides) from aqueous solutions was explored using by biosorption in batch-type systems. New biosorbents were tested such as winery and food by-products in raw and modified form after chemical or/and thermal modifications. and at variable actinide initial concentrations. These sorbents due to the presence of functional groups which have affinity to actinides can be successfully applied for removal of the above metals from radioactive waste.

The experiments were performed using radioactive tracers (e.g. ^{152}Eu) and gamma-spectrometry as well as optical spectroscopy (UV-Vis). The effect of different parameters such as pH, concentration, competitive ions (Na^+) and temperature on the sorption was also studied. Modification of the biosorbents was tested as a possible method for improvement of their sorption efficiency. The modification was achieved after chemical treatment with NaOH, $NaCO_3$ and NaCl reagents and thermal modifications at high temperature (500-600 ^oC). Maximum sorption capacity was observed for the chemically treated sorbents.

Characterization techniques as FTIR, XRD, XPS and SEM-EDS and mathematical models were used to explore the biosorption mechanism which in most of the cases is combination of different processes (physical or chemical sorption or ion exchange) whereas desorption tests demonstrated the safe disposal of the loaded sorbents.

The results showed significant sorption capacity of the tested materials for most of the radionuclides under investigation demonstrating that it is possible to use them for applications in waste treatment technology.

Keywords: Actinide sorption, winery waste, biosorbents, qmax; thermodynamic and kinetic parameters, uranium, thorium, europium

Combined XRF and NAA study of depth migration, ecological and health risk of trace elements in soils adjacent to metallurgical industry

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The management of soil quality in the vicinity of industrial areas is very important for ecosystems and human health and sensitive techniques should be employed for precise assessment of chemical elements (heavy metals and toxic elements) in soil and further evaluation of potential ecological and health risk.

In this paper two multielemental and non-destructive analytical techniques were used in combination for the elemental quantification in soils located around a large integrated iron and steel works in Southeastern part of Romania: instrumental neutron activation analysis (INAA) and X-ray fluorescence analysis (XRF).

INAA was applied at IBR-2 nuclear reactor of Frank Laboratory of Neutron Physics (FLNP), Joint Institute of Nuclear Research (JINR) at Dubna and energy-dispersive XRF at INPOLDE interdisciplinary international research center of "Dunarea de Jos" University of Galati, Romania, using a Genius spectrometer, Skyray Instruments Inc. The total concentrations of 43 major, minor and trace elements (Na, Mg, Al, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Co, Cu, Zn, As, Br, Rb, Sr, Y, Zr, Nb, Mo, Sb, I, Cs, Ba, La, Ce, Nd, Sm, Eu, Tb, Dy, Tm, Yb, Hf, Ta, W, Au, Hg, Pb, Th and U) were determined.

The results obtained for various depths in the interval (0-30 cm) were used to assess the migration degree of selected elements in the soil matrix along the depth and the distribution patterns. For selected heavy metals, toxic and radioelements it was calculated the migration index in soil depth in the regions affected by metallurgical industry, which might have important impact on underground water, aquatic resources and process of transfer from soil to vegetation and crops. For toxic elements, a comparison with world and legislated concentration values was performed and a set of single and complex indices and potential risks to human's health were assessed.

Nuclear and atomic analytical techniques applied for the composition characterization of industrial wastes and soils

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Trace and toxic elements present in industrial waste materials and soils negatively affect the environment and ecosystems health and, for their quantification, high precision analytical techniques should be employed.

In this paper, two ion beam analysis (IBA) techniques, Particle Induced X-Ray Emission (PIXE) and Particle Induced Gamma-ray Emission (PIGE), were used in complementarity with energy-dispersive X-ray fluorescence analysis (EDXRF) for the determination of total concentrations of several major, minor and trace elements in various industrial wastes (chemical, shipbuilding) and soils located around chemical industry in Romania.

Thick target PIXE and PIGE were applied at the 3 MV Tandetron at *Horia Hulubei* National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH), Romania, using a 3 MeV proton beam as projectile particles. The elements determined by PIXE were: Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, As, Br, Rb, Sr, Ag and Pb. In the case of PIGE, the elements of interest F, Na, Mg, Al, Si, Mn and Fe were determined based on the nuclear reaction of (p,p´γ) type of the protons "p" on the target samples, as well as on the (p,nγ) type reaction in the case of Mn. EDXRF was employed at INPOLDE interdisciplinary international research center of "Dunarea de Jos" University of Galati (UDJG), Romania, for the quantification of K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, As, Rb, Sr, Y, Zr, Nb, Mo, Sn, Sb and Pb.

The non-destructive multielemental techniques proved to be very useful for the waste management and hazards monitoring in environment and identification of a large series of trace elements in complex environmental studies, some of them being toxic for living organisms and humans and others contributing to the elemental cycling in natural environments.

The obtained results will complete the compositional schemes obtained by using atomic absorption spectrometry for the investigated materials at INPOLDE research center of UDJG, Romania.

Current topic discussions in radon research

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Believed to be scientifically exhausted 25 years ago, radon (Rn) research is livelier than ever. Steps towards regulation since the late 2000s (IAEA: International Basic Safety Standards; GSR Part 3; EU: European Council Directive 2013/59/Euratom) and integration into the general radioprotection regime (e.g. ICRP-137, Occupational Intakes of Radionuclides: Part 3) motivated various research projects, and their number seems to be still increasing. It turned out that compliance with action according to regulation, aimed to prevent, mitigate and remediate Rn exposure in a quality assured manner raised questions that warranted thorough investigation. In this contribution, we address a few. Among them are:

Hazard and risk. Until not long ago, the terms have mostly been used interchangeably. However, this blurs an important difference which has consequences for Rn abatement policy. Hazard denotes the physical cause of a detriment, but only under certain conditions (summarized as the vulnerability factor) and the presence of persons affected, it becomes risk. While it is important to know the geographical distribution of hazard (leading to Rn maps), policy that aims to reduce the detriment to society (represented by collective risk) also requires to investigate the distribution of risk. Due to different factors contributing, Rn hazard and risk maps look differently.

Decision QA. Decisions to comply with regulation can have far-reaching economical and political consequences. They must therefore be legally proof, which means that their elements must be QAed. This implies QA of all steps whose result is a decision; therefore one speaks of the QA chain. Part of QA is estimation of uncertainty, which for decisions means assessment of the chance of ill-decision.

Temporal dynamic of radon concentration. Maps that visualize the spatial dynamic of Rn concentration usually have long-term means as their target variable. However, indoor Rn in particular is known to be subject to strong temporal variability. This is practically relevant if decisions about action must be based on measurements shorter than one year. The question is: Under which circumstances and how can one derive reliable decisions about whether certain action (such as remediating a building) is necessary?

Mapping techniques: Maps are important tools to visualize the presence of ambient hazards and resulting risks, and thus are important as decision support. This has motivated, among other, the European Atlas of Natural Radiation (doi:10.2760/520053) which covers Rn among other agents that may represent environmental hazards. Global Rn mapping is in discussion since recently. Progress in mapping techniques is still ongoing, in particular regarding inclusion of multiple predictors and classification problems, typically delineation of Rn priority areas.

Direct measurements of radon and radon progeny in different public places

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Radon is an important source of indoor air pollution not only in dwelling, but in public buildings and workplaces. The evaluation of the results of radon measurement in public buildings and workplaces could not be as for dwellings, due to different forms of utilization, constructional conditions, time of exposure, heating and ventilation conditions etc. Therefore, the approach to managing radon exposure in buildings with public access and workplaces depends on many factors. The measurements in public buildings and workplaces were started under the Bulgarian National Action Plan years before with passive detectors. In order to investigate the peculiarities of the radon and its progeny the direct measurement for 24 hours in different environment in public buildings was performed under the national project of National Science Fund of Bulgaria, in the framework of grant No КП-06- Н23/1/07.12.2018.

Materials and methods. The radon concentration measurements were carried out with AlphaE, which is based on a silicon diode diffusion chamber, developed by a cooperation of the Munich Helmholtz Centre and Saphymo GmbH, Germany. The radon progeny was measure with DOSEman PRO of SARAD GmbH, which collected the radon daughter products at the surface of a filter. The semiconductor detector placed directly above the filter and connected to an alpha spectroscope, allows the independent determination of the filter activities of radon progeny. The measurements were performed for 24 hours simultaneously with both devices. The measurements were performed for 24 hours simultaneously with both devices. The study was carried out in the treatment rooms with mineral water of spa hotel and specialized rehabilitation hospitals in Narechen, Asenovgrad, where the radon in water in spring is 428 Bq/l (measured in 2019). The other place was an old mine made into a museum in Pernik town.

Results and discussion. The average values of the results for the period in baths of the spa hotel for the radon concentration (CRn) was 250 Bq/m^3 and for equilibrium equivalent concentration (EEC) was 111 Bq/m^3, so the determined equilibrium factor (F) was 0.44. The measured value of The Potential Alpha Energy Concentration (PAEC) was 618.7 nJ/m^3. The results for the treatment room in rehabilitation hospital CRn = 332 Bq/m^3, EEC = 122 Bq/m^3; F=0.37 and PAEC=678.8 nJ/m^3. The highest values of the radon were measured in treatment room “pavilion” and were as follows: CRn = 3254 Bq/m^3, EEC = 1284 Bq/m^3; F=0.39 and PAEC=7148 nJ/m^3. The results for the underground gallery in the museum were CRn = 109 Bq/m^3, EEC = 35 Bq/m^3; F=0.32 and PAEC=195 nJ/m^3, because there is ventilation system that works almost all the time. The evaluation of the radon exposure was performed, using the ICRP recommendation.

CR-39 detector-based Radon dosimetry system calibration in the self-decay mode

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This paper describes a cooperation of Slovak University of Technology in Bratislava (STU) and Slovak Institute of Metrology (SMU) in the verification of the calibration factors for the solid-state nuclear track (SSNT) detector utilized for radon dosimetry and establishing traceability for STU laboratory. The SMU operates the Air Radon Standard which consists of radon chamber and calibrated radon atmosphere monitoring system. A specification of the radon chamber is that the radon concentration changes during the exposure time. The radon atmosphere is created by the insertion of a specified amount of radon gas into the chamber, which subsequently decay over time. The STU laboratory is equipped by the TASLImage™ system for radon dosimetry with corresponding TASTRAK CR-39 type detectors and diffusion containers. These containers allow radon to diffuse inside and prevent dust and radon progeny to enter the container. Each diffusion container is characterized by its own diffusion rate, which should be considered in the metrology calibration approach, especially when the radon chamber is operated in the decay mode. Therefore, several measurements were carried out to determine the optimal condition for conversion factor verification. The experiments were conducted for multiple radon concentrations in the range which the radon chamber can reliably provide (100 Bq.m-3 to 10 kBq.m-3) and in combination with several times of exposure. Based on the achieved results the default calibration factor was verified, and optimal calibration approach was determined. To improve capability of the radon measurement, a custom diffusion container design was proposed. The design incorporates compact dimensions with an aerosol filter at the entrance to the container. This allows to increase an entry hole and thus increase the diffusion rate. Subsequently, the homogeneity of radon atmosphere in the chamber was tested. Small dimensions of the diffusion container allowed to create tight mesh of the detectors within the chamber and the spatial distribution of the radon concentration was determined.

A study on IOT-based continuous radon monitoring

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Radon exposure is a real environmental problem closely related to public health. Monitoring indoor radon levels is of crucial importance especially for the people, who live in the regions with medium or high level natural radiation. The atmospheric radon level of the dwellings in Turkey is around 80 Bq/m^3, however, much higher indoor radon concentrations have been observed in Isparta city centre. In this work, an IoT-based radon monitoring system is introduced, which can measure indoor radon concentrations continuously through an electronic radon detector connected wirelessly to an SBC (single board computer). This individual monitoring arrangement can transfer and store the obtained data to the internet environment with the aid of the code developed in Python language. Thus, one can process and visualise the data anywhere by using a PC connected to the internet. The performance of our system was tested in a dwelling located in Isparta city centre. The indoor radon concentration of this house was previously determined as ~ 700 Bq/m^3 in autumn 2018. The ground floor of the building was then insulated in 2019. After the mitigation process, the long-term measurement efficiency of our radon monitoring system was tested at the same measurement point for 8 months between the dates of 1 June 2020 and 31 January 2021. The system successfully accomplished the continuous radon measurement task by recording 5848 hourly data ranged from 2 Bq/m^3 to 178 Bq/m^3 with an average of 59 Bq/m^3. So, the results of the test measurements verified the effectiveness of the mitigation. Within the limitations of this study, it can be stated that this cost-effective system can be used confidently to determine atmospheric radon levels in enclosed spaces. Additionally, the proposed system also makes temporal indoor radon behaviour research simpler in long-term measurement studies.

Keywords: Isparta, indoor radon, active measurement technique, Raspberry Pi, wireless communication, IoT, Python, ThingSpeak, continuous monitoring

Results of Albania public opinion survey on radon risk perception

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This study provides information about the general health of the population, the risk perception due to radon exposure, and the socio-demographic characteristics of the target age groups through a survey in which participated 152 people. The questionnaire was part of the Public Opinion Survey (STEAM project) in the framework of the IAEA technical cooperation project RER9153: Enhancing the Regional Capacity to Control Long Term Risks to the Public due to Radon in Dwellings and Workplaces. This survey includes 152 respondents who took part in an Internet through email and WhatsApp application questionnaire conducted from October 2020 to March 2021 in Albania. The purpose of the questionnaire was to investigate what attitudes people had towards their health and towards radon as a possible health risk factor. The results of this survey which was the first social survey focusing on the radon problem and conducted throughout the country can be used as a basis for planning communication strategies and national radon programs. The survey revealed that in Albania people were poorly aware of radon risk perception on their health. Random sampling error did not exceed 5% for the 95% confidence interval calculated according to the sample size based on the desired accuracy with a 95% confidence level by reference (Gill et al., 2010).

Radon detector development using a PIN photodiode

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An active device for radon detection in air has been developed in the frame of a project financially supported by the Physics Department of the University of Torino with the aim to create a monitoring network of radon concentration in the University workplaces.

The device, characterized by low cost and by the possibility to monitoring several parameters beyond radon level, uses a commercial sensor, a Hamamatsu planar photodiode (S3590-09), with an area of 10×10 mm^2, sensitive to alpha particles.

The electronic chain is constituted by a charge to voltage preamplifier, a shaper amplifier and a discriminator that drive the digital output.

All the SMD electronic components, integrated in an approx. 30 by 50 mm PCB, have been chosen in order to minimize the power consumption. This guarantees the possibility to use the detector for a long period without a charger or without any batteries replacement. The device operates with low voltage power supply that is used both for the electronic components and for the photodiode polarization obtained by means of a voltage multiplier.

The device can be used not only as alpha particles counter (using the digital output) but also for alpha spectroscopy, connecting the analogue signal output from the shaper amplifier to an MCA analyzer.

In this paper, the final prototype will be presented along with the preliminary experimental results.

The spectroscopic performances of the device have been tested, integrating the sensor in a commercial aluminum box and acquiring the alpha particle spectrum from a calibration source (Am241-Cm244-Pu239) and from an autunite rock sample used as radon source.

The radon sensitivity of the detector, in terms of cph/Bq/m^3, has been assessed comparing the performances of our prototype with the ones of a professional commercial radon detector (RAD7 Durridge inc.).

A 3d-printed plastic case has been realized in black PA12 for light shielding, while the electromagnetic shielding has been realized using a conductive paint, electrically linked to the ground.

Further developments will be focused on the integration of temperature, pressure and RH sensors, data acquisition system using a commercial CPU (Arduino/PIC) and data download using SD Card or USB port.

A study on the correlation between indoor radon concentrations and the construction year of the dwellings

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The aim of this study is to assess the variation of indoor radon concentrations as a function of the construction year of the dwellings. It is based on the data gathered during the Greek Radon survey performed in the framework of the Greek Radon Action Plan (GRAP). The GRAP has been established as a ministerial decision since 2020. Under the GRAP three actions have been designed to cover all topics referred to ANNEX XVIII of the European Council Directive 2013/59/EURATOM. One of the main elements of the first action is the implementation of a representative nationwide survey in dwellings. In parallel with the survey, which is ongoing, a radon measurements management system is developed to host all measurements from all contributing laboratories. The system is developed under Angular framework connected to a Microsoft SQL Database. For better user experience, a dynamic map plug-in had been established through an API connected to a Regional Database. The user inserts an address and in return gets all the hierarchical "regional" structure of Greece and the coordinates of the point. The measurements from past surveys are, also, incorporated to the database. Besides the location and the radon concentration, several other data are entered. Among them are the construction year of the dwelling, the ventilation method and frequency, building materials, energy saving status etc. The database is connected to the Power BI platform to visualize the data. Through this platform we checked the correlation between the construction year and the indoor radon concentration in the country and in the individual prefectures where data were sufficient as Attica, Thessaly etc. The first observation from this correlation was that the radon concentration decreases substantially as we move from the oldest dwellings to those constructed to the 60's, which is totally understandable since old dwellings present more structural problems such as cracks and gaps. Dwellings built from the 1960 to 2000 show no trend. Newly built dwellings tend to show an increase in radon concentration, even in areas as Attica where radon concentration is really low. This can be attributed to the Regulation of Energy Efficiency of Buildings, which was established in the country the last decade. The Greek Atomic Energy Commission (EEAE) in 2021 published guidelines for the reduction of radon concentration in new buildings. These recommendations refer to the whole of the country and not only the possible prone areas. The data coming from the analyses of the indoor radon measurements justifies the decision of EEAE to publish guidelines for all new dwellings.

Multiparametric analysis for determining radon potential areas in the Metropolitan Area of Tenerife Island

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Several measurement campaigns were carried out aimed at characterizing areas with radon ^{222}Rn potential in the Metropolitan Area of Tenerife Island (Spain), where 42.6% of the population of the island inhabit (928,604 inh.), almost a fifth part of the population of the Canary archipelago. The island has a volcanic origin and a very heterogeneous geology, and it was classified as radon risk zone 2 by the Technical Building Code of Spain.

In this work three variables have been selected to study the radon potential: terrestrial gamma radiation (TGR), geogenic radon potential (GRP) and radiosotopic composition of top soils (^{40}K, ^{226}Ra, ^{232}Th). A total of 235 measurements of TGR have been distributed in a 3 km x 3 km grid, beings its density proportionally to the percentage of the urban area, up to 10 measurements in grids that cover urban areas and 3 measurements in sparsely populated areas. The values obtained at each point have been taken with a manual radiometer (Ludlum Model 3019) placed 1 m above the surface. The cosmic component was subtracted by means of UNSCEAR 93 formula adapted for the latitude of the Canary Islands. GRP is a magnitude which combines both radon activity concentration in soils (80 cm) and permeability. It was proposed by Neznal et al. (M. Neznal, M. Neznal, M. Matolín, I. Barnet, and J. Miksova, *The new method for assessing the radon risk of building sites*, 2004). A total of 57 values are available in the study area, making one measurement per 3 km x 3 km grid at least. A soil sample has been taken at each GRP measurement point, analysing their radioisotope content by high resolution gamma spectrometry.

On the other hand, a direct measurement campaign for indoor radon activity concentration (IRC) was carried out in dwellings and workplaces. Duplicated CR-39 dosimeters were used for measurements in a representative building enclosures (RBE) of the buildings (inhabited rooms with sufficient lighting and natural ventilation closer to the ground, preferably on the ground floor). A total of 263 measurements have been carried out, distributed mainly in the areas with the highest population.

In this work, the results will be discussed with the aim of defining a map of priority action areas against the radon risk in habitable building enclosures that better adjusts to the geological reality of the study area, and looking for a method applicable to the rest of the Canarian geography that allows improving the current existing maps.

A novel sensitive radon and thoron DVD-based detector for environmental monitoring

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In the last years, the interest in measuring low radon (^{222}Rn) levels in the environment has raised significantly both to precise radon exposure estimates and to serve climate changes research. As the information about atmospheric radon can be usable in modeling the greenhouse gases transport, it is planned to include sensitive radon detectors/monitors in climate monitoring networks. Usually, the detection limit of the existing passive radon detectors is close to the environmental concentrations that should be measured. In this respect new sensitive radon detectors should be designed for more precise quantitative radon measurements, incl. at levels < 10 Bq m^{-3}. In the same time data about thoron (^{220}Rn) in the atmospheric air is very scarce, although it is needed to gather information about environmental thoron exposure as well as to take thoron into account, as thoron contribution to the signal may bias radon measurements.

In this report we describe a simple and sufficiently sensitive radon and thoron detector based on DVDs. DVDs consist of two thinner disks stuck together one of which is made of polycarbonate. After splitting the two parts, the inner surface of the polycarbonate half is used as track detectors of large area and low background. The background track density is usually < 4 cm^{-2} and after thermal annealing it may be reduced to 0.5 cm^{-2}. The detector for radon consists of a spindle for 25 DVDs used as a large "diffusion chamber". Inside the spindle one DVD is fixed on the base with sensitive surface looking to the interior. Another DVD is fixed outside the spindle and is used as thoron detector. After exposure the radon DVD is etched electrochemically on the surface, while that used for thoron is etched at depth 64 μm. The signal at that depth can be used, after subtracting the radon contribution to it, to determine thoron concentration, as described elsewhere (Rom. J. Phys. 58 (2013) S221-S229). The detector was calibrated by exposures to reference radon and thoron concentrations using the exposure facility described by Pressyanov et al. (J. Envir. Radioact. 166 (2017) 181-187). Numerical estimates showed that after 3 months of exposure the limits of detection might be < 0.3 Bq m^{-3} for radon and < 2 Bq m^{-3} for thoron. The thoron interference on radon results is 2.3%. If the background is preliminary reduced by thermal annealing detection limits of 0.1 and 0.6 Bq m^{-3} are achievable for radon and thoron, respectively. This sensitivity, together with the simple design of this detector make it useful for measuring the environmental radon and thoron levels in the outdoor air, as well as for measurements indoors, when high sensitivity is required.

Recent work with electronic radon detectors for continuous Radon-222 monitoring

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Significant number of electronic radon monitors has emerged in the last two decades. These detectors offer an interesting possibility for continuous radon monitoring in dwellings and workplaces. However, prior their wide-scale usage, the electronic radon detectors should be a subject of sound metrological assurance in which many aspects of their performance should be tested. Among these are: calibration factor, linearity of response, temporal response, thoron cross-interference, etc. In this work, we will present results from such metrological tests of two types of electronic radon detectors: RadonEye+2 and AlphaE, performed in Sofia University and in the French primary metrology laboratory LNHB (Laboratoire National Henri Becquerel). We will show results from the calibration and studies of the temporal response of 30 RadonEye+2 detectors and one AlphaE detector. To facilitate the application of these detectors, we developed a database for storage, online visualization and analysis of the radon data gathered continuously by them. The features of the database and the applicability of the electronic detectors for field studies will be discussed. Pilot results from the applications of such detectors in radon surveys in dwellings and workplaces will also be presented and discussed.

Radon in groundwater from selected private wells and boreholes in Osogbo, Southwest Nigeria

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Water plays an important role in human life and essential for food security, making it one of the major route of exposure. This study investigated radon activity of water in some selected places within a university community in Osogbo, Osun State, Nigeria was carried out. Fifteen (15) water (from wells and boreholes) were collected and the radon concentration was measured using DURRIDGE RAD7 H2O accessory radon detector. The results of the radon activity ranged from 6.3 ± 1.7 BqL^{-1} to 60.8 ± 5.6 BqL^{-1} with a mean of 21.33 ± 2.95 BqL^{-1}.

Nine (9) out of the fifteen (15) water samples measured were observed to be higher than EPA's maximum contaminant level of 11.1BqL^{-1} while the other six (6) water samples were within the range. The annual effective dose values lie within the recommendation of International Commission on Radiological Protection of 3-10mSv/y. The ^{222}Rn activity concentration in the study could be termed as safe and not detrimental to human health.

Continuous diurnal radon measurements in Bulgarian caves

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Bulgaria is a country in the eastern part of the Balkan Peninsula, in Southeastern Europe. The presence of many mountains and karst areas is a prerequisite for the many caves in the country, but only some of them are managed and accessible for tourists. Tourist caves are a case of special environmental conditions that may be affected by high radon concentration. The typical remedial actions like forced ventilation, sealing or reducing pressure in the source rock could-not be applied because these measures would be affecting and damage the environment in caves. The purpose of the study is continuous measurement of radon concentration in six popular Bulgarian tourist caves (Bacho Kiro, Magura, Veneca, Saeva dupka, Snejanka and Uxlovica), analysis of the diurnal variation and exposure assessment. The direct, continuous radon measurements were performed with TERA (TSR3D) system (Tesla, Czech Republic). The 29 spectra were considered for evaluation radon variations during the day and night. The period of the measurement was carried out was the autumn of 2019, only one cave (Bacho Kiro Cave) was measured during the winter. Direct measurements duration was from 24 hours to 96 hours. The measurements were performed at different points (gallery, halls or other cave formation) in each of the caves. The number of the points depends on the size of the caves and the length of the route for tourists. All the data were compiled into Microsoft Excel spread sheets for analysis and evaluation. The radon exposure was assessed, as the ICRP recommendation and coefficients was applied. The average radon concentration in the different caves varied from 590 Bq/m^3 (Magura cave) to 5970 Bq/m^3 (Veneca cave). The radon concentration varied at different measurement points in the in the cave itself. The variation in most caves was approximately 1 to 2 kBq/m^3 between points. This is probably due to the size of the various cave formations, such as halls and galleries and the air exchange between them, as well as their depth. Only in two caves (Magura and Snejanka caves) there is no significant difference between the values in the cave, which could be due to their size or that they have only one hall. No significant variations in radon concentrations were observed between night and day in a 24-96 hours' period measurement in the investigated caves. It was found that temperature and humidity in the caves are constant for the measurement period. The temperature is low and humidity is high these facts and poor ventilation rates, determine the weak diurnal variation in radon concentration. A difference was found in cave with two entrances. In cave Magura are large fluctuations between the values measured at the entry and exit compared to those inside the cave. Most likely, these differences are due to the natural ventilation of the entrance with variations from 10 Bq/m^3 to 640 Bq/m^3 and the exit with variations from 165 Bq/m^3 to 927 Bq/m^3.

Indoor radon monitoring in two seasons in the public kindergartens of Tirana city

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Nowadays, the health effects of radon exposure are well confirmed, so the purpose of this study is to evaluate the radon concentrations in the indoor air of kindergartens, which are frequented by the young population. This study evaluates the radon (Rn-222) concentration in the indoor air in kindergartens in Tirana city. The measurements have been made in 23 kindergartens during winter period, using alpha track detectors (RadTrack Cr-39).

This study is a continuation of a study conducted in the same kindergartens but during the spring period of the previous year. The results of both seasons comply with each other. In all kindergartens except kindergartens 20 and 60, the measured values are lower than the value of 200 Bq m^{-3} set for new buildings. The highest radon concentration value of 410 Bq / m^3, with effective dose of 2.87 mSv y^{-1}, is measured in kindergarten 60 during the spring period.

This study is recommended to be followed by other studies for all the kindergartens in the biggest cities of Albania, where do live most of the population.

The radon flux measurement intercomparison and the use of radon flux in determination of indoor radon concentration

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Radon gas (^{222}Rn), which is recognized as one of the leading causes of lung cancer after smoking, has been included in the legal framework within the Basic Safety Standards (BSS) Directive – Directive 2013/59/Euratom, in which EU member states are obliged to identify areas (known as Radon Priority Areas - RPAs) where annual average radon concentration is expected to exceed the national reference level in significant number of buildings. This led to several activities in EU, such as conducting new or improved national radon surveys and delineation of RPAs.

Some of the objectives of the recently finished EMPIR 16ENV10 MetroRADON project were to propose methodology for identification of the RPAs and to investigate the influence of geogenic radon on the indoor radon concentration. Within the ongoing metrological project, EMPIR 19ENV01 (traceRadon), one of the goals is to improve methods of RPA identification by including radon flux measurements.

Recently performed literature review has revealed that only a few simultaneous measurements of indoor radon and radon flux were performed worldwide. In order to shed a light on relationship between radon flux and indoor radon concentrations, authors have started this kind of investigations in selected dwellings in Serbia.

At each measuring location: indoor radon concentrations, radon in soil gas and radon flux from soil were measured. In addition, as these are the first radon flux measurements performed in Serbia, authors have performed an intercomparison of available methods of radon flux measurements. Direct measurements were performed using: accumulation of radon in charcoal canister, accumulation of radon in an H-chamber of 960 ml volume measured with a short-term ST electret of E-PERM, and using active device RTM1688-2 of SARAD GmbH and corresponding accumulation box. At the same time, gamma dose rate was measured at 1m above the ground, and soil sample was collected for determination of ^{226}Ra concentration in soil. Radon flux was then estimated using empirical relation between measured gamma dose rate as well as ^{226}Ra concentration in soil and radon flux. Advantages and disadvantages of each applied method for radon flux determination are analysed. Finally, influence of radon flux on indoor radon concentration is discussed.

Determination of the radioactivity level of concrete used as shielding for medical ^{60}Co source

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This study examines the natural and artificial radioactivity in concrete used as shielding material for medical ^{60}Co source temporary stored in our waste storage site. The determination of the radioactivity level is done to see if any leakage or contamination occurred in concrete material after the dislocation of ^{60}Co source to another destination. Concrete samples were taken from the three barrels located in the temporary waste storage site and after preparation of samples were placed in a marinelli beaker with a volume of 500 ml and left in isolation for one month in order to achieve the secular equilibrium. The activity concentrations of ^{40}K, ^{226}Ra and ^{232}Th in ten samples are determined by using gamma-ray spectrometry method with HPGe detector. The average values of activity concentration are found to be 147.56 ± 6.97 Bq kg^{-1} for ^{40}K, 18.09 ± 0.64 Bq kg^{-1} for ^{226}Ra and 16.90 ± 0.68 Bq kg^{-1} for ^{232}Th, respectively. The activity concentration index (ACI) is used as a screening tool to assess the radiological hazard due to possible release of the concrete in environment or to reuse it as building materials. From the all analysis performed the maximum value of ACI was 0.21. This value was found to be lower than 1 and in none of them was found the presence of ^{60}Co radionuclide. We conclude depending on the Decision No. 638, dated 07.09.2016 “On the approval of the regulation for the safe treatment of radioactive waste in the Republic of Albania” that the concrete could be discharged freely in environment or it can be used as building material because do not pose any significant risk to humans.

Keywords: Radioactivity, waste storage site, gamma-ray spectrometry, radiological hazard

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