Book of Abstracts

VIII. Terrestrial Radioisotopes in Environment International Conference on Environmental Protection

4-7 October 2022
Vonyarcvashegy, Hungary

VIII. TERRESTRIAL RADIOISOTOPES IN ENVIRONMENT

International Conference on Environmental Protection

Organizers:

University of Pannonia, Department of Radiochemistry and Radioecology

Social Organization for Radioecological Cleanliness

Hungarian Biophysical Society, Section of Radioecology

Chair:

Tibor Kovács

Secretaries:

Edit Tóth-Bodrogi, Anita Csordás, Gergő Bátor, Erika Nagy, András Bednár

Edited by:

Tibor Kovács, Edit Tóth-Bodrogi, Gergő Bátor, Réka Nagy

VIII. TERRESTRIAL RADIOISOTOPES IN ENVIRONMENT

International Conference on Environmental Protection

ISBN 978-615-81632-2-4

DOI 10.18428/TREICEP-2022

Published by the Social Organization for Radioecological Cleanliness

József Attila str. 7/A 2/10, H-8200 Veszprém, Hungary

Phone: +36-88-624-922

E-mail: info@rttsz.hu

Homepage: http://rttsz.hu

Table of contents

Nuclear security related research activities at the Centre for Energy Research

P. Völgyesi, I. Almási, K. Bodor, Zs. Csalótzky, E. Csipa, J. Dembo, G. Dósa, A. Gulyás, Z. Hlavathy, N. Kaposy, A. Kelemen, P. Kirchknopf, A. Kovács, M. Óvári, Gy. Nagy, J. Pető, K. R. Soós, V. Sós, K. Zs. Szabó, Cs. Tóbi

Nuclear Securtiy Department, Centre for Energy Research, Budapest, Hungary

The activities of the Nuclear Security Department (NSD) of the Centre for Energy Research (EK) cover research and practical application in the field of nuclear security and nuclear safeguards. The research, method development and technical service tasks are carried out in several closely cooperating groups: non-destructive (gamma spectrometry and neutron measurement), destructive (mass spectrometry), dosimetry, instrument development, detection and mobile expert support team, and a detector testing laboratory. The task, combating illicit trafficking of nuclear materials, is delegated to the Centre by the Governmental Decree 490/2015 (XII.30). Nuclear forensics activities started in Hungary at the beginning of '90. EK presented many live demonstrations on response of a nuclear security event, like radiological crime scene management or search and recovery of RN material out of regulatory control. Besides, EK has a long-term strong relationship with the International Atomic Energy Agency in the field of nuclear safeguards and nuclear security, established after starting the first nuclear reactor in Hungary, as well as connected to real confiscations of RN materials at the Hungarian borders. In national level, standard operating procedure was developed recently for radiological crime scene management in cooperation with the Hungarian Police in the frame of a Home Security funded project. The detector testing laboratory was established at the Centre to help the development of nuclear instruments and detection systems for nuclear security purposes (e.g. detection of hidden and masked nuclear materials) using dynamic and static tests. Unique property of the laboratory is the availability of wide scale of alpha-, beta-, gamma- and neutron emitting shielded radioactive sources and nuclear materials of different activities for tests. The capabilities of this laboratory are utilized in several EU projects connected to nuclear security. The NSD has been operating training laboratories and nuclear security related activities for more than 15 years. A training facility has been established to serve national and international purposes by providing an opportunity for first responders to test and practice operating procedures using various type of scenarios. Connecting to nuclear security the NSD is participating in several international projects.

Optimisation of decontamination of Ni-alloys

[1]R. Katona, [2]A. Rivonkar, [2]M. Robin, [2]T. Suzuki-Muresan, [2]A. Abdelouas, [3]G. Bátor, [1]T. Kovács

[1]Department of Radiochemistry and Radioecology, University of Pannonia
[2]SUBATECH (IMT Atlantique, CNRS/IN2P3, Nantes University)
[3]Social Organisation for Radioecological Cleanliness

Nowadays, the nuclear power contributes to 11 % of the worldwide energy supply, however more than half of the nuclear power plant is over 25 years old. In Europe 50 out of 129 nuclear reactors in operation will need to be shut down by 2025, if no improvement measures will be taken to prolonge the operation life. The major decommissioning activity is the decontamination technology, which is used to reduce the occupational exposures, to limit the releases of radioactive materials, to permit the reuse of components, and to facilitate the waste management. According to the World Waste Report 2019 the decommissioning of the European nuclear facilities will create 1.4 million m^3 low- and intermediate level radioactive wastes. For these reasons, the optimisation of decontamination technology is major importance in the aspects of safety reasons and radioactive waste management.

Decontamination is the removal of the radioactive contamination, such as ^{60}Co, ^{58}Co, ^{51}Cr, ^{54}Mn and ^{59}Fe. During operation of nuclear reactor the most metallic surfaces oxidise, the corrosion products erode from the surface, circulate throughout the system and activate. The majority of the radioactive contamination is the deposition of these radioactive corrosion products on the surfaces.

In this study Chemical Oxidation Reduction Process decontamination (CORD) technology was studied. Non-radioactive stainless steel (1.4571) metals were oxidised to form representative industrial samples for the decontamination tests and the effects of the chemical treatment on the oxide-layer were analysed.

This project has received funding from the European Union's Horizon 2020 research and innovation programme for Nuclear Fission and Radiation Protection Research (Call NFRP-2019-2020) under grant agreement No. 945098 (PREDIS).

Hydrogeological investigation of the natural radioactivity in the vicinity of Sopron Mountains

[1]P. Baják, [2]B. Molnár, [1]K. Hegedűs-Csondor, [3]V. Jobbágy, [4]Á. Horváth, [5]V. Kohuth-Ötvös, [3]K. Pelczar, [3]M. Hult, [1]A. Erőss

[1]József and Erzsébet Tóth Endowed Hydrogeology Chair, Department of Geology, ELTE Eötvös Loránd University, Budapest, Hungary
[2]Department of Geophysics and Space Science, ELTE Eötvös Loránd University, Budapest, Hungary
[3]European Commission, Joint Research Centre (JRC), Geel, Belgium
[4]Department of Atomic Physics, ELTE Eötvös Loránd University, Budapest, Hungary
[5]Sopron Waterworks Co., Sopron, Hungary

Geogenic contamination arising from rock-water interactions can limit the use of groundwater resources in the drinking water supply. Among others, radionuclide content can pose a health risk due to water consumption. The geologic background primarily determines the natural radionuclide content of groundwater but their re-distribution by groundwater flow systems can extend the exposed areas. The vicinity of Sopron Mountains is in the scope of the present study, where drinking water quality monitoring found gross alpha activity exceeding the 0.1 Bq L^{-1} limit. Our study aimed to understand the origin of the elevated gross alpha activity measured in the groundwater. Therefore, we collected water samples from 10 springs and 7 water wells. Samples were analyzed for total U and ^{226}Ra by alpha spectrometry using Nucfilm discs. ^{222}Rn activity was determined by liquid scintillation counting. $^{234}U/^{238}U$ ratio was measured in 5 samples. To get an insight into the dynamics of the groundwater flow system and to better understand the radionuclide mobilization and transport processes, the results were evaluated in groundwater flow system context. The interpretation of the results revealed that the springs are the discharge points of local flow systems given their low discharge rate (< 5 L min^{-1}), low dissolved solid content (< 450 mg L^{-1} TDS), and temperature (10–12°C). Uranium content was relatively low (up to 93 mBq L^{-1}) possibly due to the short residence time of groundwater. Groundwater samples taken from wells showed higher uranium activity (up to 540 mBq L^{-1}). $^{234}U/^{238}U$ ratio below 1 indicates greater distance and a longer flow path from the recharge area. It can be concluded that uranium is most likely leached out from the metamorphic rocks of the Mountains and is transported along flow paths under oxidizing conditions. The longer the flow route the higher the uranium concentration, though no health risk arises from the elevated uranium concentration in the drinking water.

The research was funded by the National Multidisciplinary Laboratory for Climate Change, RRF-2.3.1-21-2021 project. Some radioactivity measurements were supported by the European Commission's Joint Research Centre (JRC) – Research Infrastructure Access Agreement No. 36227-1 / 2021-1-RD-EUFRAT-RADMET.

Nuclear Forensic Examination of Uranium Ore Concentrate Samples

[1,2]Cs. Tóbi, [3]L. Illés, [4]K. Fél, [5]K. Süvegh, [5]Z. Homonnay

[1]Hevesy György Phd School of Chemistry, Eötvös Loránd University, Budapest, Hungary
[2]Nuclear Security Department, Centre for Energy Research, Budapest, Hungary
[3]Nanosensors Department, Centre for Energy Research, Budapest, Hungary
[4]Radioation Chemistry Department, Centre for Energy Research, Budapest, Hungary
[5]Institute of Chemistry, Eötvös Loránd University, Budapest, Hungary

"Nuclear forensics is the examination of nuclear or other radioactive material, or of evidence that is contaminated with radionuclides, in the context of legal proceedings under international or national law related to nuclear security". The purpose of the nuclear forensic examinaton is to determine the origin of confiscated and other unknown nuclear of other radioactive material out of regulatory control in order to return them under regulatory control, to identify the origin and history of the material in order to strengthen physical protection systems of nuclear facilities and to support the investigation behind to link the material to people, places and different events. Main focus of origin assessment is to determin characteristic parameters, so called signatures of the materials that are uique for the production technology and can be helpful for identify or exclude producers and the last license of the material. The term uranium ore concentrate (UOC) refers to the product resulting from the mining, milling and leaching of the uranium ores in the front-end of the nuclear fuel cycle. The UOC powders contain about 60–80 % uranium in different chemical compositions based on the prodiction technology. As the UOC is the second step in uranium fuel production, that is why the UOC-s still contains the natural characteristics of the uranium ores but already artificialy modified. Therefore, if UOC with unknown origin (out of regulatory control) has been found at a crime scene (that is a radiological crime scene), nuclear forensic examination is necessary to identify the possible origin of the material.

The aim of this study is to develop or further develop new or novel analytical methods for nuclear forensic purposes focusing for UOC as target material and identify new signatures and determin the origin of materials. During this work, 17 different UOC samples were examined, which are certified reference materials from different sources. Together with method developments, as sample preparation methods and measurement parameters the samples were measured by the following analytical techniques: positron annihilation spectroscopy (PAS), scanning electron microscope-energy dispersive X-ray (SEM-EDX) and Fourier transform infrared spectroscopy (FTIR).

The method development and the result of the measurements can contribute to the extension of the national nuclear forensic library and connect to international and national deficiencies in the case of nuclear forensic measurements of UOC.

Testing the radioactive isotope ion retention capacity of a radioactive waste cementation binder from the Paks nuclear power plant

[1]Gy. Pátzay, [2]O. Zsille, [3]J. Csurgai, [1]J. Nyőgér, [4]T. Kovács

[1]Department of Chemical and Environmental Process Engineering, Faculty of Chemical Technology and Biotechnology, Budapest University of Technology and Economics, Budapest, Hungary
[2]Somos Ltd, Budapest, Hungary
[3]National University of Public Service, Budapest, Hungary
[4]Department of Radiochemistry and Radioecology, University of Pannonia, Veszprém, Hungary

The safe handling of radioactive wastes is a crucial part of responsibly operating nuclear power plants. Cementation is a common immobilization method used for low-and intermediate-level wastes to produce stable waste matrices with acceptable performance, however the successful immobilization needs to be verified. In order to improve verification protocols, an accelerated leach test method based on the ASTM C 1308-08 standard was tried out for low level waste forms in the Hungarian NPP Paks. Test cylinders were prepared using Hungarian cements from evaporator bottom residue, evaporator cleaning acid solution, spent ion exchange resin and decontamination solution containing various radionuclides, mainly ^{134}Cs, ^{137}Cs and ^{60}Co. A computer program (ILT15) and its updated version (ILT20) associated with the accelerated leach test were developed based on the ASTM C 1308-08 standard to assist in the evaluation of leaching test results. The diffusion leaching laboratory test method and the models associated with ILT15 allow for determining the effective diffusion coefficient according to ASTM C 1308-08, while the ILT20 includes two additional models to calculate the concentration distribution within the test sample and the time course and mechanism of release with high accuracy and for an arbitrary time period.

Research of radium sorption from mine water with the use of A-type zeolites and fly ash

K. Samolej, S. Chałupnik

Silesian Centre for Environmental Radioactivity
Central Mining Institute, Katowice, Poland

The occurrence of radium isotopes in groundwater is due to natural processes of interaction of water in the aquifer with matter: rocks, soil, or metal ores. The migration of radium from rocks to water occurs with varying efficiency, depending on the availability and solubility of rocks, the presence of oxygen, acidity, the concentration of radioisotopes in rocks, and their mobility under given conditions. The uranium mining and processing industry, oil, gas, metal ore, and coal mining are the main sources of waters with elevated radioactivity and, most often, also high salinity. The Upper Silesian Coal Basin located in Poland's Malopolska and Silesia provinces is characterized by the occurrence of radon-bearing brines with high radium concentrations.

The ion-exchange properties of zeolites are their main feature used, for example, in water softening, and removal of radionuclides or metal ions from industrial waters. A study was conducted to see if zeolites and fly ash could be used to treat water with very high electrolytic conductivity from radium isotopes.

Zeolites 3A and 5A in the form of granules with a fraction of 1.6-2.5 mm and a finely crystalline fraction of 0.125 - 0.180 mm were selected for the study to see if the fraction affects the efficiency of the purification process and the maximum capacity of the zeolite. The mineralogical composition and zeolite phase content of the samples were determined by XRD. Textural properties studies using nitrogen adsorption/desorption were carried out for both zeolite fractions.

The study of radium isotope water purification efficiency was carried out using two methods: sequential batch test (zeolites in fine crystalline form and fly ash) and sequential dynamic test (zeolites in granular form). The idea of the test was to use a small mass of zeolite/fly ash and a large volume of water to record the course of the yield decrease and maximally saturate the zeolite with radium. Measurements of the radium isotope concentration in the water were made by LSC liquid scintillation spectrometry.

Self-calibration of HPGe-detector by delayed gamma rays from a shielded isotope ^{138}Cs

I. Pylyphynets, A. Lengyel, O. Parlag, E. Oleynikov, V. Maslyuk, V. Holovey

Institute of Electron Physics, Ukrainian National Academy of Sciences, Uzhgorod, Ukraine

Radiation monitoring of nuclear facilities is a necessary condition for ensuring the radiation safety of the environment. Solving this problem requires reliable information on the isotopic and quantitative composition of nuclear materials (fertile, fissile) and their decay products which are usually in sealed containers. To identify the content of such containers, a method is widely used based on the use of experimentally obtained information on the ratio of the intensities of stimulated delayed gamma radiation from the actinide photofission products (light and heavy fragments). It should be noted that the accuracy of the analysis in this case will depend on the accuracy of measurements of the ratio of gamma radiation intensities of the studied samples, and, accordingly, on the accuracy of the detector calibration in terms of relative efficiency for individual energies. Therefore, the only way to determine the relative efficiency of the HPGe detector (or self-calibration) is to use information obtained from the delayed gamma radiation spectra of photofission products of nuclear materials. To stimulate delayed gamma radiation from the ^{138}Cs radioisotope (462.8; 1009.8; 1436; 2218; 2639.6 keV), as the product of the photofission reaction of the ^{238}U nucleus in steel container, we have used the bremsstrahlung with an energy of 12.5 MeV obtained at the M-30 electron accelerator microtron. Spectrometric measurements were carried out on an Ortec HPGe detector (150 cm3). The measurement error did not exceed 5%. It has been established that the delayed gamma radiation of the ^{138}Cs radioisotope (screened product of the ^{238}U nuclear fission reaction) can be used for self-calibration of HPGe detectors in terms of relative efficiency for energy ranges up to 2639.5 keV (standard commercial sources up to 1840 keV).

The application of the proposed procedure makes it possible to increase the accuracy and reliability of the analysis when identifying shielded fertile and fissile nuclear materials by their stimulated delayed gamma radiation, for cases where there is no reliable information about the technical parameters of packaging containers.

Distribution of natural and anthropogenic radionuclides and associated radiation indices in the western coastline of Corfu, Greece

A. Shahrokhi, G. Tóth, E. Tóth-Bodrogi, T. Kovács

Department of Radiochemistry and Radioecology, University of Pannonia, Veszprém, Hungary

A comprehensive radiological survey using multivariate statistical analysis was carried out to evaluate the distribution of ^{40}K, ^{232}Th, ^{226}Ra, ^{235}U, and ^{137}Cs, and associated radiation indices in beach sand samples of the coastal area of the Ionian Sea. The activity concentration of selected radionuclides was measured and no clue of recent migration of radiocaesium by not only precipitation but also through an indirect way, such as ocean runoff, was found. As part of radiological risk assessment, external radiation hazard index, effective dose, and absorbed dose rate were estimated. Pearson correlation, cluster, and PCA analysis were used by processing observed radiological parameters to determine the correlation between the radiological parameters and locations. A spatial distribution map was provided to a distinct visual representation of the distribution of radionuclide contents in the study area.

A baseline study to understand the fate of uranium in a natural background radiation area soil using uranium isotope ratios

[1,2,3]N. Veerasamy, [2]S. Kasar, [2]R. Murugan, [1]K. Inoue, [1,2]T. Natarajan, [1]M. Fukushi, [2]S. K. Sahoo, [4]R. Bhutani

[1]Tokyo Metropolitan University, Tokyo, Japan
[2]National Institute of Radiological Sciences, National Institutes for Quantum Science and Technology, Chiba, Japan
[3]Institute for Environmental Sciences, Aomori, Japan
[4]Pondicherry University, Puducherry, India

The Chhatrapur-Gopalpur coastal area in Odisha, India is a well-known natural high background radiation area due to the abundance of monazite (thorium bearing radioactive mineral) in beach sand and soils. The concentration of uranium (U) and thorium (Th) in the soils were ranging from 1 to 100 µg/g and 8 to 1180 µg/g, respectively. U is highly dynamic compared to Th. The mobility and stability of the U in the environment (soil, sediments, and aquatic systems) controlled by geological (chemical weathering and leaching) and biogeochemical processes. In 2020, the central groundwater board (CGWB) of India, has reported that the concentration of U in groundwaters of Chhatrapur (60 µg/L) is higher than the WHO permissible limit (30 µg/L). Therefore, the soils of Chhatrapur-Gopalpur area could be suspected as the sources of the high concentration of U in the groundwater. In order to address this problem, the U isotope ratios of $^{234}U/^{238}U$ and $^{235}U/^{238}U$ in soil samples were measured using multi-collector inductively coupled plasma mass spectrometry (MC-ICP-MS). The $^{235}U/^{238}U$ ratio was observed to be "normal terrestrial value". $^{234}U/^{238}U$ isotope ratio ranged from 5.38-5.95 (x 10^{-5}). Activity ratio ($^{234}U/^{238}U$) was calculated in soils to understand the secular equilibrium between ^{234}U and ^{238}U. The activity ratio in soils varied from 0.94 to 1.08. However, a few samples showed the leaching of ^{234}U trend from the soil. For a detailed understanding of this phenomenon, physico-chemical characteristics of soils has also been carried out and will be discussed during the presentation.

Evaluation of technologically enhanced natural radiation near the coal-fired power plant in the Salgótarján region of Hungary

[1]D. Tserendorj, [1,2]K. Zs. Szabó, [1,2]P. Völgyesi, [2]T. C. Nguyen, [3]I. G. Hatvani, [4]N. Buczkó, [1]G. Abbaszade, [1]N. Salazar, [1,5]Cs. Szabó

[1]*Lithosphere Fluid Research Laboratory, Institute of Geography and Earth Sciences, Eötvös Loránd University, Budapest, Hungary*
[2]*Nuclear Security Department, Centre for Energy Research, Budapest, Hungary*
[3]*Institute for Geological and Geochemical Research, Research Centre for Astronomy and Earth Sciences, Eötvös Loránd Research Network (ELKH), Budapest, Hungary*
[4]*Nuclear Analysis and Radiography Department, Centre for Energy Research, Budapest, Hungary*
[5]*Institute of Earth Physics and Space Science, Eötvös Loránd Research Network, Sopron, Hungary*
Centre for Ecological Research, Institute of Aquatic Ecology, Budapest, Hungary

Primordial radionuclides can be found in all environmental compartments. Coal-fired power plants can be a source of additional radionuclide contribution because coal contains natural radioactive isotopes such as ^{238}U, ^{232}Th. The study deals with assessment of potential exposure from ^{238}U, ^{232}Th, ^{40}K and ^{137}C in attic dust (n=36), urban soil (n=19), brown forest soil (n=1) and coal ash (n=1) samples from Salgótarján. In the bulk samples, the mean elemental concentrations (mg kg^{-1}) of U, Th, K and Cs in attic dust and urban soil were 2.4, 3.6, 0.6, 1.7 and 1.1, 4.4, 0.3,1.2, respectively, using ICP-MS at Bureau Veritas, Canada Ltd. Activity concentrations (Bq kg^{-1}) of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs in attic dust and urban soil samples were determined by low background iron chamber with a well-type HPGe and with an n-type coaxial HPGe detector, respectively in the Centre for Energy Research, Hungary. The mean values of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs activities for attic dust and urban soils are 43.3, 34.0, 534.4, 88.5 and 25.1, 32.8, 386.4, 5.2, respectively. The brown forest soil shown one of the lowest U, Th and K content and their studied radionuclides, except for ^{137}Cs. A significant difference of U, K and Cs elemental and activity concentrations was observed between attic dust and urban soil samples showing elevated radionuclide activities in attic dusts, which preserved past records of fingerprint and components of atmospheric deposition rather than urban soil.

New application of Thermal Ionization Mass Spectrometry: ^{90}Sr as well as ^{87}Sr/^{86}Sr ratios determination in Fukushima environmental samples

[1]S. K. Sahoo, [2]N. Kavasi, [3]K. Inoue, [1]T. Aono

[1]National Institute of Radiological Sciences, National Institutes for Quantum Sciences and Technology (QST), Chiba, Japan.
[2]Department of Radiological Sciences, Tokyo Metropolitan University, Tokyo, Japan.
[3]Jožef Stefan Institute, Slovenia

In recent years, significant developments are in progess for rapid measurement of ^{90}Sr using mass spectrometry instruments. Sample introduction, detector and interference removal techniques have been improved a lot. For this purpose, inductively coupled plasma mass spectrometry (ICP-MS) instruments with collision/reaction cells or triple quadrupole system have been primarily applied. Alternatively, thermal ionisation mass spectrometry (TIMS) is a robust technique for ^{87}Sr/^{86}Sr ratio measurement and could be used for ^{90}Sr determination.

The main advantages of the mass spectrometry method over the radiometric are the shorter analysis time, higher sample throughput and less sample intake. The low level Sr-90 detection in environmental samples with mass spectrometry instrument is a challenging task. The isobaric interference of ^{90}Zr is a challenge due to presence of significant amounts of Zr in the environment. Another important point for the application of mass spectrometry instruments for ^{90}Sr determination is the peak tailing on the higher mass side from ^{88}Sr.

Therefore, it was necessary to develop a rapid and precise ^{90}Sr determination after the Fukushima nuclear accident using the Phoenix X62 TIMS in the laboratory of the National Institutes for Quantum Science and Technology (QST), Japan. This was the first mass spectrometry method which was evaluated and confirmed by an independent proficiency test.

In this work, efforts were made to decrease the sample intake of stable strontium from µg to ng level, which can give the possibility of strontium isotope ratio analysis in low sample amount (mg level). Stable isotope ratio (^{87}Sr/^{86}Sr) in Fukushima plants and leaf samples will be presented.

Tritium concentration in natural water samples collected at Fukushima Prefecture after the FDNPP accident

[1]K. Kheamsiri, [2]N. Akata, [2]H. Tazoe, [3]K. Okada, [3]N. Otashiro, [1]H. Kuwata, [4]H. Kakiuchi, [1]M. Hosoda, [5]T. Kovács, [2]S. Tokonami

[1]Graduate School of Health Science, Hirosaki University, Japan
[2]Institute of Radiation Emergency Medicine, Hirosaki University, Japan
[3]School of Health Science, Hirosaki University, Japan
[4]Institute for Environmental Sciences, Japan
[5]Department of Radiochemistry and Radioecology, University of Pannonia, Hungary

A fuge amount of radionuclides was released from the Fukushima Dai-ichi Nuclear Power Plant (FDNPP) following the serious damage caused by aftermath of the 2011 Tohoku earthquake and tsunami. The many kind of paper already reported about ^{137}Cs concentration in environmental media and its inventory near the FDNPP. In this paper tritium concentration in natural water samples (rain/snow water, tap water, pond water, river water, well water, etc.) collected in Fukushima Prefectrure after FDNPP accident. Immediatry after accident, slightly high tritium concentrations were observed in natural water at not only seaside area but also inland area of Fukushima Prefecture. However, concentration level was almost return to background level after one month of accident. A committed effective dose equivalent of 3.5×10^{-3} mSv/y was estimated for an annual consumption of drinking water having the highest tritium concentration in natural water (snow water: 267.8±1.0 Bq/L) by using a dose conversion factor of 1.8×10^{-11} Sv/Bq and a daily water intake rate of 2.0 L. This value was negligibly small compared with 1 mSv, which is the index of the annual dose limit for the general public.

Evaluation of semi-automatically combustion system for organically bound tritium analysis using reference material of pine needles

[1,2]H. Kuwata, [1]K. Kheamsiri, [3]T. Tamari, [3]N. Shima, [2]N. Akata

[1]Graduate School of Health Sciences, Hirosaki University, Japan
[2]Institute of Radiation Emergency Medicine, Hirosaki University, Japan
[3]Kyushu Environmental Evaluation Association, Japan

Tritium is a radioisotope of hydrogen that easily exchange its atom in the general environment. A part of this radionuclide, ingested by animals and plants, is incorporated into organic substances such as carbohydrates and lipids and forms the organic molecules called organically bound tritium (OBT). It remains in the body longer than the water form of tritium (HTO). The Fukushima Dai-ichi Nuclear Power Plant (FDNPP) accident resulted in a large amount of contamination, and decommissioning work has been underway. The contaminated water has been treated by a multi-nuclide removal system (ALPS) and stored in the tanks on FDNPP as treated water. On 13 April 2021, the Japanese government approved a plan to release the treated water, which contains radionuclides including tritium as the majority part, from the site to the Pacific Ocean. Although the amount of tritium to be released is not large, environmental monitoring is essential because residents are concerned about internal exposure from tritium ingestion. Generally, OBT analysis is complex and time-consuming. Critically, skillful techniques are required since the combustion process also involves the risk of explosion. From the literature review, the monitoring data in this study field is still very scarce. Therefore, we developed a semi-automatically combustion system to make it possible to obtain OBT data with less effort. To improve the safety and accuracy, we optimized a temperature program and gas flow rate to prevent ignition during heating using a commercially available programmed tube furnace. A comparative test was carried out with other combustion equipment which generally used previously. The commercially available standard material pine needles (NIST 1575a) were analyzed by a semi-automatically combustion system. The results showed no difference in the analytical results between the two types of combustion equipment, indicating that the newly developed equipment is appropriate for the combustion process.

^{90}Sr contamination in the Fukushima exclusion zone

[1]N. Kavasi, [1]M. Štrok, [2]S. K. Sahoo

[1]Department of Environmental Sciences, Jožef Stefan Institute, Ljubljana, Slovenia
[2]Department of Radioecology and Fukushima Project, National Institute of Radiological Sciences, National Institutes for Quantum Science and Technology (QST), Chiba, Japan

Nuclear accidents and nuclear weapon tests have discharged ^{90}Sr, a radionuclide that emits pure beta radiation, into the environment. Because of its relatively long half-life (28.9 years) and biochemical similarities to calcium, ^{90}Sr monitoring in conjunction with ^{137}Cs monitoring after a nuclear disaster is crucial to prevent internal radiation dose increases for living things. Owing to its difficult analysis method as compared to ^{137}Cs, the database of ^{90}Sr released by the Fukushima accident is quite limited.

In this study, 76 soil samples from the Fukushima exclusion zone (soil, litter, rain gutter deposit, and roadside sediment samples) were used to determine the activity concentrations of ^{90}Sr and ^{137}Cs.

The activity concentration of ^{90}Sr and ^{137}Cs activity ranged from 3 to 1,050 Bq kg^{-1} (median 82 Bq kg 1) and 0.7 to 6,770 kBq kg^{-1} (median 890 kBq kg^{-1}), respectively. A moderately positive correlation between the ^{90}Sr and ^{137}Cs was found. The median of the ^{90}Sr/^{137}Cs activity ratio was 1.2×10^{-4}, thus the Japanese population's exposure to radiation from ^{90}Sr with Fukushima origin is negligible compared to ^{137}Cs.

Radiological assessment of natural and artificial radioactivity in sediments along the coastal area of Ghana

[1]E. O. Akuo-ko, [1]M. Adelikhah, [1]T. Ganbaatar, [2]E. Amponsem, [1]A. Csordás, [1]T. Kovács

[1]Department of Radiochemistry and Radioecology, University of Pannonia, Veszprém, Hungary
[2]GIS Department, Wallulel Ghana Limited, Accra, Ghana

Beach sediments are key environmental media for evaluating the health risks associated with gamma radiation exposure. The aim of this survey was to determine the radioactivity concentration of ^{226}Ra, ^{232}Th and ^{40}K and ^{137}Cs in sediment along the coast of Ghana. A total of 19 locations were sampled for this study. Samples were taken into Ziploc bags, air dried, oven dried at 105°C for 24 hours, homogenized and transferred into Marinelli beakers. After 4 weeks they were measured with gamma spectrometry at 80000 seconds and the spectra analyzed with the ORTEC GMX40-76 software. The mean activity concentrations of ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs were 42.8 Bq kg^{-1}, 22.1 Bqkg^{-1}, 391.5 Bq kg^{-1} and 8.4 Bq kg^{-1}, respectively. The high ^{137}Cs activity concentration 109.8 ± 0.3 Bq kg^{-1} measured at one of the locations ascertains that global atmospheric fallout of ^{137}Cs have impacted the coast of Ghana. It was observed that some sampled locations had activity concentrations of some radionuclides higher than the recommended world reference levels. The radiological risks associated with the sampled sediments were evaluated with indices such as Ra_{eq}, D, AED and AGDE. The average concentrations of these radiological variables were 104.6 Bqkg^{-1}, 50.1 nGy/h, 61.4 µSv/y and 347.6 µSv/y, respectively. Apart from AGDE, the evaluated radiological risks were below the world reference values.

Environmental radioisotopes in hydrogeological studies

[1]A. Erőss, [1]P. Baják, [1]K. Hegedűs-Csondor, [2]B. Izsák, [2]M. Vargha, [2]T. Pándics, [3]Á. Horváth, [4]V. Jobbágy, [4]K. Pelczar, [4]M. Hult

[1]József and Erzsébet Tóth Endowed Hydrogeology Chair, Department of Geology, Institute of Geography and Earth Sciences, Eötvös Loránd University, Budapest, Hungary
[2]Public Health Directorate, National Public Health Institute, Budapest, Hungary
[3]Department of Atomic Physics, Institute of Physics, Eötvös Loránd University, Budapest, Hungary
[4]European Commission, Joint Research Centre (JRC), Geel, Belgium

Groundwater may contain different natural alpha and beta emitters, but most often alpha-radiation–emitting uranium, radium and radon can be found in various concentrations. These radioisotopes can be used as natural tracers of groundwater flow systems, due to their different physical and chemical behaviour in the subsurface environment. Our studies show that elevated uranium values are associated with recharge regimes of groundwater flow and can be found in local flow systems, where oxidising conditions prevail. These systems are the most sensible for climate change and exaggerated water abstraction, which may cause both groundwater quantity and quality problems. Radium is mobile under reducing conditions; therefore, it can be often found in thermal waters, which are associated with regional flow systems. In their discharge areas iron- and manganese oxyhydroxides may develop due to the change in redox conditions, which efficiently adsorb radium and hence act as a source of radon. Besides the concentrations, the ratio of different isotopes (e.g. $^{234}U/^{238}U$) can further help to understand the transport processes. Depending on the measured activity concentrations, radiation exposure through drinking of groundwater-derived waters can have a significant impact on human health. To find the most appropriate risk management methods, understanding groundwater flow system is a key issue, as it helps to explain the origin of radioisotopes. Thanks to the mandatory measurements of gross alpha and beta and radon activity of drinking waters in Hungary, a basic knowledge on radioactivity of groundwater is available. These measurements highlight those areas where combined nuclide specific measurements and hydrogeological studies are essential further steps for safe drinking water supply.

The research was funded by the National Multidisciplinary Laboratory for Climate Change, RRF-2.3.1-21-2021 project. Some of the radioactivity measurements were supported by the European Commission's Joint Research Centre (JRC) – Research Infrastructure Access Agreement No. 36227-1 / 2021-1-RD-EUFRAT-RADMET.

Radioactivity Levels for Naturally sand Clays and Black Sand at the Source and Drain of the Nile River using NaI (Tl) and HPGe Spectrometers

[1]E. H. Ghanim, [2]M. S. Barakat, [3]M. Dawoud, [4]H. El-Samman, [4]A. Hussein

[1]Basic Sciences Department, Faculty of Technology and Education, Beni-Suef University, Beni-Suef, East of Nile, Egypt.
[2]Protection & Civil Defense Department, Nuclear Power Plants Authority, Al-Dabaa City, Mattrouh Government, Cairo, Egypt.
[3]Geology Department, Faculty of Science, Menoufia University, Shebin El-koom, Egypt.
[4]Physics Department, Faculty of Science, Menoufia University, Shebin El-koom, Egypt.

In the present work, the natural radioactivity levels in naturally occurring radioactive materials at Aswan and Rashid areas were measured using both scintillation detector and HPGE spectrometer. Regions, Aswan and Rashid areas were chosen to compare the radioactivity levels between the source and the drain of the River Nile sedimentation. The results throughout the present work, viz. the activity concentration of terrestrial radionuclides ^{226}Ra, ^{232}Th and ^{40}K were obtained. Gamma dose rate, effective dose rate in air, radium equivalent and radiation hazard index were extracted. A correlation study between different sample parameters and results of the measurements study were compared with some previously published related data according to radioactivity concentration levels.

The main important points extracted from the results of the present work Average activity concentration in sand samples using gamma ray spectrometer showed values of 702.79±26.51 Bq/kg for ^{40}K, 61.08±12.69 Bq/kg for ^{226}Ra and 77.09±8.78 Bq/kg for ^{232}Th for black sand samples collected from Rashid. Average activity concentration in soil samples using gamma ray spectrometer showed values of 902.0±30.03 Bq/kg for ^{40}K, 133.10±11.53 Bq/kg for ^{226}Ra and 49.82±7.06 Bq/kg for ^{232}Th for clay samples collected from Aswan. The absorbed dose rate and the average effective dose rate were found to be 134.28±11.59 nGy/h and 164.79±12.48 μ Sv/y for clay samples, while those of black sand samples are 157.29±11.74 nGy/h and 193.03±14 μ Sv/y, respectively. Radium equivalent (Ra_{eq}) was found to be 266.79±16.33 and 320.75±26.23 Bq/kg for clay and black sand samples respectively. The radiation hazard index was found to be 0.74±0.86 and 0.88±0.93 for clay and black sand samples respectively. The present data revealed more radioactivity concentrations in black sand samples than that of sand clay samples. Results are discussed within the frame work of γ-ray interaction mechanism and γ-ray spectroscopic analysis.

Assessment of ^{137}Cs, ^{90}Sr, ^{241}Am, $^{239+240}$Pu, ^{3}H (HTO, OBT) concentrations in the fish from nuclear shell craters and rivers of Semipalatinsk test site

[1]A.V. Panitsky, [2,3]Zh.A. Baigazinov, [1]T.N. Bayserkenova, [1]S.A. Baigazy, [1]I.A. Alexandrivich, [2]E. O. Akuo-ko, [2]E. Tóth-Bodrogi, [2]T. Kovács

[1]Institute of Radiation Safety and Ecology, Kurchatov, Kazakhstan
[2]Department of Radiochemistry and Radioecology, University of Pannonia, Veszprem, Hungay
[3]Alikhan Bokeikhan University, Semey, Kazakhstan

The purpose of this work is to estimate the activity concentration of artificial radionuclides in fish living in different types of reservoirs located on STS territory including those formed after a nuclear explosion. The objects of study were two species of fish of the cyprinid family - carp (Cyprinus carpio) and roach (Rutilus rutilus) and one species of fish of the loach family (Cobitididae) - Siberian char (Barbatula toni).

Fish were caught from crater "Atomic Lake" (explosion of 1965), Shagan Lake, the Shagan River (flowing along the trail of radioactive fallout), at the crater on the Sary-Uzen site (formed as a result of an emergency situation during the nuclear explosion) and from Uzynbulak and Karabulak streams (which comes from the where atomic bombs were tested underground).

The highest activity concentration of all studied radionuclides was found into fish organs from crater on the Sary-Uzen site (^{137}Cs – less than 15 Bk kg^{-1} (FW, muscle), ^{90}Sr – less than 3500 Bk kg^{-1} (FW, bone), $^{239+240}$Pu – less than 2 Bk kg^{-1} (FW, bone) and HTO – less than 65 kBk kg^{-1} (FW, muscle) and OBT – 25 kBk kg^{-1} (FW, muscle). In fish organs from other reservoirs, the activity concentration of radionuclides is essentially lower.

The high values of the activity concentration of radionuclides in fish organs in the Shell crater, the small area and isolation of this reservoir make it promising for conducting studies of the transfer parameters of radionuclides into the fish body and obtaining other parameters necessary for use in migration models and non-human biota to risk assessment models.

Assessment of natural radioactivity in rice and their associated population dose estimation in Hungary

T. Ganbaatar, G. Tóth, A. Shahrokhi, E. Tóth-Bodrogi

Department of Radiochemistry and Radioecology, University of Pannonia, Veszprém, Hungary

The concentration of natural radioactivity in rice is an important parameter for the determination of population exposure by the ingestion of natural radionuclides during habitual consumption of food. In this study, about 20 most common rice brands available at Hungarian market were investigated. Hence, studies on the evaluation of natural radioactivity in rice have been performed by gamma-ray spectrometry using High Purity Germanium (HPGe) detector in order to estimate associated population dose estimation in Hungary. The estimated effective doses for the respective radionuclides caused by the rice consumption were estimated, respectively compare with the UNSCEAR compiled value. The calculated excess lifetime cancer risk (ELCR) values via rice consumption were calculated and found below the acceptable limit of radiological risk.

Isotope pairs in targeted cancer therapy and diagnostics - Alpha Rising

[1,2,3]D. Máthé, [1,4]R. K. Bergmann

[1]*Department of Biophysics and Radiation Biology, Semmelweis University, Budapest, Hungary*
[2]*In Vivo Imaging ACF, Hungarian Center of Excellence for Molecular Medicine, Szeged, Hungary*
[3]*CROmed Ltd., Budapest, Hungary*
[4]*Helmholtz-Zentrum Dresden Rossendorf, Dresden, Germany*

The recent past has seen both an increase in cancer morbidity all over Europe and the US, and an icreased interest for targeted or „precision" therapeutics against cancer. Targeted isotope radionuclide therapy for cancer patients, despite its 80-years past, has not gained mainstream medical traction until the late 2010's. In what represents a leap in pharmaceutical industry terms, then major investments were done by Big Pharma to either technologies for appropriate medical ^{223}Ra production or to ^{177}Lu incorporation to peptide targeting moieties. These resulted in blockbuster (over 500 million USD per annum turnover) sales of ^{223}Ra dichloride and ^{177}Lu and ^{90}Y octreotate by two companies. Several dozen thousand patients have been treated since 2018, with very impressive results using intravenous targeted radionuclide cancer therapy.

In the quest for appropriate tumor absorbed dose deposition with a fair adverse effect profile, individual pre-therapy diagnostic tomography and dosimetric planning should be made. To this end, diagnostic counterparts of beta-emitting isotopes have been used, such as ^{68}Ga or low-activity ^{177}Lu for ^{177}Lu therapy. Other developmental stage or small scale applications include ^{88}Y for ^{90}Y, and ^{44}Sc for ^{47}Sc or ^{161}Tb. Usually selected and tailored macrocyclic chelators are used to link the radiometal isotope to the biologically active targeting peptide, protein or nanoparticle.

An exceptional dose-effect and microdosimetry profile exists for alpha emitting isotopes in targeted radionuclide cancer therapy, but biodistribution and profiling should be performed with care in the case of this application. Thus, for the currently clinically most applied alpha emitting isotopes ^{225}Ac, ^{212}Pb and ^{213}Bi, a diagnostic counterpart should be warranted. Production and in vivo applications of ^{203}Pb, the appropriate isotope for targeted ^{212}Pb cancer therapy, is reviewed in the presentation, along with current clinical trials pushing the therapy field forward.

The transfer of ^{137}Cs and heavy metals to the tissues of snails' organs

[1,2]Zh.A. Baigazinov, [3]S.N. Lukashenko, [2]B.M. Silybayeva, [2]Zh.T. Bukabaeva, [1]T. Ganbaatar, [1]T. Kovács

[1]Department of Radiochemistry and Radioecology, University of Pannonia, Veszprem, Hungay
[2]Alikhan Bokeikhan University, Semey, Kazakhstan
[3]Russian Institute of Radiology and Agroecology, Obninsk, Russia

Three main tasks were investigated in the experiment with using gastropods (*Lissachatina fulica)*: distribution and dynamics of the accumulation of radionuclides into the organs of snails; determining the concentration ratio (C_R) value; stading the influence of the age / weigh of the snail on the variability of the transfer parameters (C_R).

It is found that with prolonged intake of ^{137}Cs into the body, its concentration in the body of snails increases during the first 40 days of the experiment, after which there is a significant slowdown in the growth of the radionuclide's activity. Also, it was found that food is the main source of the contamination in the body of snails compering with a soil (tab.1); therefore, it is necessary to reconsider the issue of assessing the content of radionuclides in the body of wild animals, in particular gastropods.

The biological availability of the Pb and U when they have taken with forage is one order of magnitude higher than it is intake by the soil (Table 1). Nevertheless, based on the obtained results of the Pb and U content in the body of snails, it can be concluded that the soil will be the main factor that determines the body's contaminant levels.

Table 1. C_R of ^{137}Cs and Pb and U into the body of snail

Radionuclide/ Element	A group of snails fed contaminated forage, ($C_{R\ organs/forage}$)	A group of snails fed contaminated forage and soil, ($C_{R\ organs/soil}$)	A group of snails fed contaminated Soil, ($C_{R\ organs/soil}$)
^{137}Cs	0.057±0.01	0.25±0.05	0.0040±0.001
Pb	0.083±0.002	0.0043±0.0008	0.0037±0.001
U	0.13±0.02	0.0086±0.002	0.014±0.003

Determination of naturally occurring radionuclides in attic dust samples from different industrialized Hungarian cities using inductively coupled plasma mass spectrometry and gamma-spectroscopy

[1,4]D. Tserendorj, [1,2]K. Zs. Szabó, [1,2]P. Völgyesi, [2]T. C. Nguyen, [1]G. Abbaszade, [1]N. Salazar, [1,3]Cs. Szabó

[1]Lithosphere Fluid Research Laboratory, Institute of Geography and Earth Sciences, Eötvös Loránd University, Budapest, Hungary
[2]Nuclear Security Department, Centre for Energy Research, Budapest, Hungary
[3]Institute of Earth Physics and Space Science, Eötvös Loránd Research Network, Sopron, Hungary
[4]Current address: Centre for Ecological Research, Institute of Aquatic Ecology, Budapest, Hungary

There is an increased interest in measuring naturally occurring radioactive materials (NORM) like urban soils, considering their health hazards. Inductively coupled plasma mass spectrometry (ICP-MS) has the potential to be an ideal tool for precise, accurate and rapid determination of Th and U. There have been extended efforts in environmental analytical chemistry to optimise multi-element ICP-MS technique. However, well-type detector is ideal for small amounts of environmental samples as it combines both low background limit and high detection efficiency due to the 4π solid angle and shorter counting times as well, which has been used in present study. Accordingly, identical amount (1 - 1.5 gr) of 71 undisturbed attic dust samples (from Salgótarján, Ózd and Ajka cities) were measured by γ-spectrometry (^{238}U, ^{232}Th, ^{40}K and ^{137}Cs) by low background iron chamber with a well-type HPGe in the Centre for energy Research. Also, elemental concentrations of U, Th, K and Cs for all studied attic dust samples, using ICP-MS at Bureau Veritas Minerals Canada Ltd., were performed. The sampled houses, built between 1890 and 1990, were considered as long-term attic dust accumulation(s) if there was no reconstruction. Results of activity concentrations (Bq kg^{-1}) of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs [Bq kg^{-1}] in attic dust varied between <dl to 145.6; 8.0 to 94.2; 309.2 to 1382.2 and 5.5 to 169.8 for Salgótarján; <dl to 29.5; 8.0 to 27.1; 80.5 to 1493.7 and 2.0 to 292.9 for Ózd; 64.2 to 587.7; 15.7 to 31.8; 190 to 1976.8 and 32 to 114 for Ajka, respectively. A good correlation was found for measurements of U and Th using both techniques for each studied city. There is no correlation of Cs vs. ^{137}Cs was observed between attic dust in studied cities. In order to sum up, well-type HPGe gamma spectrometry is an indirect method and based on the assumption that secular equilibrium exists for ^{238}U and ^{232}Th parent radionuclides and their decay products, especially if the attic dust stay undisturbedly for long periods of time.

Determine the feasibility of using brines discharged from mines for carbon dioxide sequestration

S. Chałupnik, N. Howaniec, M. Bonczyk, M. Wysocka

Silesian Centre for Environmental Radioactivity and Department of Air Protection
Central Mining Institute, Katowice, Poland

One of the priority thematic areas of investigation in the Central Mining Institute is the area of transformation of the coal mining sector, in the context of the green transition. The proposed work fits into this theme, as the research conducted therein is intended to provide an answer to the question of whether, and to what extent, mine waters discharged into the environment can be used for the chemical sequestration of carbon dioxide, at the same time causing the removal of radioactive contaminants from these waters. Bivalent ions of Group II elements, including calcium, strontium, barium or radium, present in saline mine waters can react with CO_2 introduced into these waters, resulting in the precipitation of carbonate deposits. This will also remove radium isotopes from these waters, co-precipitating with other Group II elements. Therefore, such action may additionally lead to a reduction in the cost of radium water treatment carried out at some mines. In addition, the subject matter of the work is in line with efforts to manage carbon dioxide from anthropogenic sources, including the power sector through carbon capture, utilization and storage (CCUS) technology.

Radon Monitoring for Earthquake Precursory Studies in Taiwan: Reference to Recent Seismic Events

[1]V. Walia, [1]A. Kumar, [2]C. C. Fu, [1]S. J. Lin

[1]National Center for Research on Earthquake Engineering, NARL, Taipei, Taiwan
[2]Iinstitute of Earth Sciences, Academia Sinica, Taiwan

Radon anomalies in soil gas and groundwater are commonly observed prior to the impending earthquake, attracting considerable attention in studies on precursory geochemical signals. The island of Taiwan is a product of the collision between the Philippine Sea plate and the Eurasian plate, which makes it a region of high seismicity. Active subduction zones occur south and east of Taiwan. Radon variations of soil-gas composition in the vicinity of the geologic fault zone of Northeastern and Southwestern parts of Taiwan have been studied in detail recently. To carry out the investigation, temporal soil-gases variations are measured at continuous earthquake monitoring stations established along different faults. In the present study, we have correlated observed soil-gas anomalies with some earthquakes magnitude ≥ 5 that occurred in the region during the observation. The data is processed using different kinds of filters to reduce the noise level. It helps us to filter out the high-frequency noise and daily variation caused by different parameters. However, radon anomalies in all cases are not only controlled by seismic activity but also by meteorological parameters which make isolation of earthquake precursory signals complicated. The radon variations exhibit dominant daily variations, which are controlled by atmospheric temperature inducted evaporation in surface water-saturated soil. To integrate our data with our working procedure, we use the popular and famous open source web application solution, AMP (Apache, MySQL, and PHP), creating a website that could effectively show and help us manage the real-time database. It is surmised that unless radon variations are corrected for meteorological/hydrological contamination, some precursory signals are masked on one hand while on the other hand some anomalies are falsely viewed as earthquake precursors. Based on the anomalous signatures from particular monitoring stations we are in a state to identify the area for impending earthquakes for the proposed tectonic-based model for earthquake forecasting in Taiwan.

Appraisal of public health hazards associated with uranium in drinking water of Doon Valley, India

[1]M. Prasad, [2]R. S. Aswal, [3]P. Bangotra, [4]A. Joshi, [4]P. Panwar, [4]R. C. Ramola

[1]Chitkara University School of Engineering and Technology, Himachal Pradesh, India
[2]Department of Environmental Sciences, H.N.B. Garhwal University, Badshahi Thaul Campus, Tehri Garhwal, India
[3]Atmospheric Research Laboratory, SSBSR, Sharda University, Greater Noida, India
[4]Department of Physics, H.N.B. Garhwal University, Badshahi Thaul Campus, Tehri Garhwal, India

The measurements of uranium concentrations were performed in the potable groundwater samples of Doon valley of Garhwal Himalaya using Inductively Coupled Plasma Mass Spectrometry (ICPMS). The experimentally measured values of uranium concentrations were used to estimate the associated radiological and chemical health risks for the public. The ICRP's age-specific Biokinetic model has been applied to estimate the retention of uranium in various organs of a human body. The measured values of uranium concentrations were found below the prescribed limits set by WHO, USEPA and AERB. The estimated risk assessment quntities indicate no siginifcant health risk through uranium in drinking water of the study area. The details of experimental techniques and results obtained are given in the paper.

Prussian Blue Nanoparticles as isotope-labeled and fluorescent contrast material

[1]L. Forgách, [1]N. Hegedűs, [1,2]Z. Varga, [1,3]N. Kovács, [1]I. Horváth, [1,3]D. Máthé, [1]K. Szigeti

[1]Dept. Biophysics and Radiation Biology, Semmelweis University, Budapest, Hungary
[2]Research Center for Natural Sciences, ELKH, Budapest, Hungary
[3]In Vivo Imaging ACF, Hungarian Center of Excellence for Molecular Medicine, Szeged, Hungary

The study presents the synthesis and development of a Prussian Blue based biocompatible and chemically stable T1 magnetic resonance imaging (MRI) contrast agent with near infrared (NIR) optical contrast for preclinical application.

The physical properties of the Prussian blue nanoparticles (PBNPs) (iron (II); iron (III); octadecacyanide) were characterized with dynamic light scattering (DLS), zeta potential measurement, atomic force microscopy (AFM), and transmission electron microscopy (TEM).

In vitro contrast enhancement properties of PBNPs were determined by MRI. In vivo T1-weighted contrast of the prepared PBNPs was investigated by MRI and optical imaging modality after intravenous administration to mice. PBNP-s doped with ^{201}Tl isotope have also been synthetised and biodistribution in mice was determined by using SPECT and MRI.

Activity concentrations (MBq/cm^3) were calculated from the SPECT scans for each dedicated volume of interest (VOI) of liver, kidneys, salivary glands, heart, lungs, and brain. Isotope-labeled citrate-coated PBNP accumulation peaked at 2 hours after injection in the kidneys and the liver followed by a gradual decrease in activity in later time points.

We synthetized, characterized, and radiolabeled a Prussian blue-based nanoparticle platform for contrast material applications. In vivo radiochemical stability and biodistribution open up the way for further diagnostic applications. The presence and detectability of PBNPs during initial biodistribution in the cardiovascular system indicates vascular contrast material applications, too.

Use of ^{64}Cu to radiolabel and track bacterial outer membrane vesicles in vivo with PET

[1,2]K. Das S., [2]D. Szöllősi, [2]P. Hajdrik, [2]Z. Varga, [2]H. Tordai, [2]K. Szigeti, [2]I. Horváth, [1]N. Kovács, [2,4]R. K. Bergmann, [1,2,3]D. Máthé

[1]CROMed Ltd, Budapest, Hungary,
[2]Department of Biophysics and Radiation Biology, Semmelweis University, Budapest, Hungary
[3]In Vivo Imaging ACF, Hungarian Center of Excellence for Molecular Medicine, Szeged, Hungary
[4]Helmholtz-Zentrum Dresden Rossendorf, Dresden, Germany

Bacterial outer membrane vesicles (OMVs) are nano-sized extracellular vesicles (EVs) released by Gram-negative bacteria into their environment. SpyCatcher (SpC) is a protein that forms a spontaneous isopeptide bond with the peptide tag SpyTag (SpT). A novel approach was established for the radiolabeling and quantitative molecular imaging of bacterial outer membrane vesicles (OMVs). SpyCatcher is anchored to the OMV surface using surface display systems based on bacterial autotransporters AIDA and Hbp that are expressed using a novel genetically engineered E. coli BL21(DE3) ΔnlpI, ΔlpxM strain. ^{64}Cu is an appropriate isotope for radiolabeling and tracking different protein, peptide or particulate systems in biological in vivo studies. Cu-64 half-life of 12.7 hours allows for flexible detection of the positron-emitting decay using appropriately sensitive imaging systems up to 5 days after injection. SpT was radiolabeled with Cu-64 through a macrocylic chelator, then purified and incubated along with OMV-s. After incubation and size exclusion based filtration, radiolabeled OMV-s were produced and ready for in vivo use. Biodistribution of radiolabeled OMVs in mice was measured using positron emission tomography (PET) following intravenous administration. The novel method can serve as a basis for a general OMV radiolabeling scheme and could be integrated into vaccine- and drug-carrier development based on bioengineered OMVs.

Actinide oxide nanoparticles

K. Popa

European Commission, Joint Research Centre, Karlsruhe, Germany

Actinide oxide nanoparticles are of interest for the nuclear fuel cycle and beyond. They can be formed by altering minerals containing uranium and thorium, but also due to the leaching of nuclear waste under repository conditions. Some organisms are able to convert soluble uranium species into UO_2 nanoparticles. From a technological point of view, actinide oxide nanoparticles can serve as precursors for dense oxide fuels. They may also be used as very active reagents in reactions taking place at relatively low temperatures. We summarize here the approaches employed for producing actinide oxide nanoparticles with a particular focus on the methods developed over the past decade. The advantages and disadvantages of such processes are highlighted. We focus the discussion on the hydrothermal decomposition of oxalate as a simple method to produce agglomerates of small AnO_2 nanoparticles (*An* = U, Th, Np, and Pu). Americium incorporation at concentrations relevant to the production of fuels for transmutation is reported. Finally, we give examples regarding their reactivity.

Investigation of radioactive fallout in soils in the remote period of a radiation accident

[1]M.V. Zheltonozhskaya, [1]N.V. Kuzmenkova, [1]I.E. Vlasova, [2]A.N. Nikitin, [1]T. Polyakova

[1]Lomonosov Moscow State University, Moscow, Russian Federation
[2]Institute of Radiobiology of the National Academy of Sciences of Belarus, Belarus, Gomel

Studying the territories contaminated due to radiation accidents is an urgent task since such soils still contain highly active micron-sized particles of irradiated nuclear fuel. These "hot" particles can rise with ascending convective air currents and reach the human breathing zone as a consequence of dry weather or forest fires.

The paper presents the results of studies of the behavior of anthropogenic radionuclides in vertical sections of soils of territories subjected to fallout as a result of the Chernobyl accident: Klintsovsky district of the Bryansk region (Russian Federation), Chernihiv district of the Chernihiv region (Ukraine), Braginsky district of the Gomel region and the Polessky state radiation-ecological reserve (Republic of Belarus).

The gamma spectra of radionuclides in soil samples were studied using Ortec and Canberra semiconductor spectrometers. The concentration of ^{90}Sr in soil samples was measured with the developed non-radiochemical technique. The main gamma spectroscopic studies of transuranium nuclides were carried out by measuring the L_X-radiation of uranium and neptunium U, Np, and γ 59 keV ^{241}Am. For some samples, studies of the alpha spectra of transuranium nuclides were performed after their radiochemical isolation.

The results show that anthropogenic radionuclides' vertical transfer occurs mainly in the form of fuel particles decreasing in size with time.

The data received indicate that ^{137}Cs is mostly accumulated in the upper 0–10 cm layer. We can note that ^{137}Cs mostly fell out of aerosol fallout, while the presence of ^{90}Sr and transuranium nuclides is due to the fuel component in studied soil cross-sections. The periods of half-cleaning of the upper *root-inhabited* 5-cm soil layer from anthropogenic radionuclides were calculated by the convective-diffusion model of radionuclide migration. They are equal to ~30–40 years. The results obtained are discussed.

The reported study was funded by RFBR, project number 19-05-50095.

Determination of nickel long-lived isotopes in structural materials of nuclear power plants

M.V. Zheltonozhskaya, D.A. Iusuk, A.A. Sherbakov

Lomonosov Moscow State University, Moscow, Russian Federation

A photoactivation method has been developed for determining the activity of long-lived nickel isotopes ^{59}Ni and ^{63}Ni in steel structural materials of nuclear power plants from the ^{60}Co activity. The proposed method makes it possible to significantly simplify their identification, control, and certification during nuclear power plant decommissioning.

A considerable mass of irradiated structural materials and radioactive waste generated at nuclear power plants make it impossible to use traditional radiochemical methods. Thus the developed way is more efficient. For the photoactivation approach, a sufficient mass of the measurement samples is several micrograms. Moreover, modern electron accelerators allow irradiating targets weighing 5–10 g. Thus, using the developed method, up to several hundred samples of structural materials or radioactive waste can be irradiated simultaneously. Such an approach significantly reduces the cost compared to traditional radiochemical methods.

The error of the method is 5-10%. Its sensitivity is 0.5 Bq/g (for using semiconductor gamma spectrometry).

This work is supported by the Russian Science Foundation under grant 22-29-01013.

Radiolabeling of different microorganisms using the medically relevant radioisotopes ^{177}Lu and ^{64}Cu

[1]P. Hajdrik, [1]D. Szöllősi, [1]I. Hegedűs, [2]Z. Varga, [1]K. Szigeti, [1]I. Horváth, [1,3]N. Kovács, [1,3]D. Máthé, [2,4]R. K. Bergmann

[1]Department of Biophysics and Radiation Biology, Semmelweis University, Budapest, Hungary
[2]Research Center for Natural Sciences, ELKH, Budapest, Hungary
[3]In Vivo Imaging ACF, Hungarian Center of Excellence for Molecular Medicine, Szeged, Hungary
[4]Helmholtz-Zentrum Dresden Rossendorf, Dresden, Germany

In vivo tracking of microorganisms in the body of hosts may be of interest in basic immunology, neuroscience, and microbiology, but it could reach out to human clinical practice, too. Our studies aimed at establishing different methods of radiolabeling intact living Gram-negative bacteria. Our primary interests being the gut-brain axis and bacterial communication to brain, we used *E. coli* as model systems. Quantitative isotopic tomographic imaging then allows for exact determination of microorganism presence in the body (of experimental animals e.g.). However, appropriate half-lived isotopes with a good compromise in imaging qualities vs. any biological effect or micro-dosimetry, should be chosen for these purposes.

For single photon emission computed tomography (SPECT) as a quantitative modality, coupled to MRI or CT (SPECT/MRI, SPECT/CT) we decided to use ^{177}Luwhich is a rather long half-life isotope in medical terms (6.65 days). For the use of positron emission tomography, ^{6}Cu was chosen (12.7 hour half-life). Both isotopes were bound to the bacterial cell wall using a macrocyclic chelator-based approach. After centrifugation radiolabeled bacteria were applied in vivo in mice, to determine in vivo biodistribution in different application routes.

A similar, chelator-based method was used to radiolabel inactivated SARS-CoV-2 particles using ^{64}Cu. After purification and intranasal application in the only available realistic animal model system (Syrian hamster), viral particles were detected in the pancreas, the adrenals, the brain using PET, along with severe lung inflammatory lesions as seen on MRI and CT imaging of these animals.

Carbon sinks or sources: assessing the impact of climate change and anthropic activities on peat development in SE-Europe over the last 150 year

[1,2]R-Cs. Begy, [1]C-F. Savin, [1,2]A. Avram

[1]Faculty of Environmental Science and Engineering, "Babeş-Bolyai" University, Cluj-Napoca, Romania
[2]Interdisciplinary Research Institute on Bio-Nano-Science, Babeş-Bolyai University, Cluj-Napoca, Romania

Greenhouse gasses, such as carbon dioxide, play a major role in climate change that is increasingly visible nowadays. Peatlands are terrestrial ecosystems crucial in the global carbon cycle, as they are storing by an order of magnitude more carbon than forests. Industrialization during the last 150 years has brought numerous anthropic factors that, in addition to natural ones, are damaging the development of peatlands. If the peat is degrading as a consequence of biochemical processes, these ecosystems are converting from carbon sinks to carbon sources, emitting greenhouse gases back into the atmosphere. Our study aims to investigate peatlands, as carbon reservoirs, by applying multi-proxy analyses ($\delta^{13}C$, $\delta^{15}N$, C/N ratio, humification, C loss, carbon accumulation Rates (CAR), X-ray fluorescence (XRF), inductively coupled plasma mass spectrometry (ICP-MS)) GC-MS gas chromatography). Their development throughout the mentioned period will be analyzed by ^{210}Pb dating method, and the degradation periods will be identified using stable carbon analyses. The causes leading to degradation, both natural and anthropic, will be determined and interpreted. In order to provide relevant information leading to a better understanding of these ecosystem functions in carbon sequestration processes, and the necessity of adequate management policies for their conservation, seven peat bogs located in Romania and South-Eastern Europe were chosen. The retrospective analysis of the depositional signatures provides indispensable knowledge, which facilitates highlighting the importance of peatlands in the global carbon cycle and their susceptibility to climate changes. Thus, the impact of anthropic influences and climatic changes on peatlands can be assessed, and the analytical tools required to determine carbon loss and carbon accumulation rates of peatlands in relation to changes in climatic factors can be further developed.

Evaluation of Outdoor Radon in Aomori Prefecture for Radiation Risk Awareness

[1]Y. Oda, [1]M. Kiso, [1]A. Sampei, [2]C. Kranrod, [3]T. Jin, [3]M. Jin, [1]H. Hashimoto, [2]Y. Omori, [2]H. Tazoe, [2]N. Akata, [1,2]M. Hosoda, [2]S. Tokonami

[1]Hirosaki University Graduate School of Health Sciences, Hirosaki, Japan
[2]Institute of Radiation Emergency Medicine, Hirosaki University, Hirosaki, Japan
[3]Aomori Prefectural Nuclear Power Safety Center, Rokkasho, Japan

In Aomori prefecture, there are power plants, spent fuel intermediate storage facilities, and reprocessing facilities. Understanding the level of natural radionuclides is important for improving radiation risk awareness and reducing excessive anxiety even in an emergency situation. The present study was carried out to measure the outdoor radon concentrations and consider the environmental factors that cause temporal and spatial variability in the concentration for 2 years in Aomori prefecture. Radon concentrations were measured using the passive ^{222}Rn and ^{220}Rn discriminative monitor (RADUET) at 41 locations and changed every three months. Moreover, the pulsed ionization chambers (AlphaGUARD, SAPHYMO, GmbH) were installed at two points, where the high radon concentrations were observed and measured continuously at 60-minute intervals for three months. As well, meteorological data such as temperature, humidity, rainfall, and atmospheric pressure, were observed in Mutsu City, Aomori prefecture for considering the environmental variation. The average outdoor radon concentration varied from < 2 to 9 ± 11 Bq m^{-3} measured by RADUET, and the results did not show any correlation between rainfall and atmospheric pressure to the radon concentrations. However, the radon concentrations recorded by AlphaGUARD show high concentrations from night to morning and low concentrations during the day. In addition, the outdoor radon concentration and humidity are correlated positively and in contrast with temperature (Figure 1).

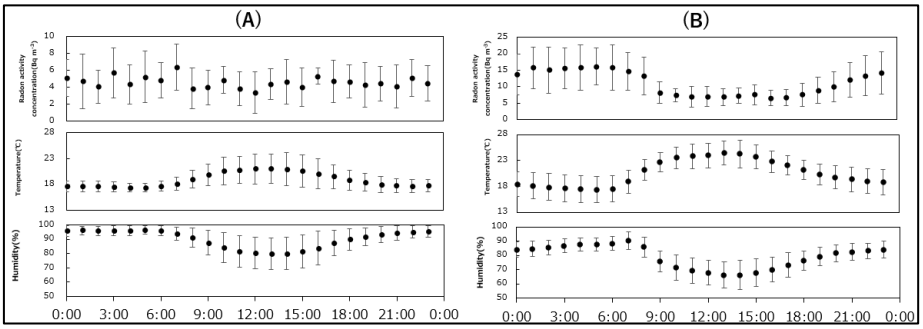

Figure 1: Variation of radon concentration, temperature and humidity measured using AlphaGUARD at (A) Chitosetai district and (B) Chikagawa district

Radiological properties of alumina containing industrial residues as potential secondary raw materials

[1]E. Fidanchevski, [2]K. Šter, [2]M. Mrak, [3]M. Rajacic, [4]B. D. Koszo, [5]A. Ipavec, [6]K. Teran, [6]G. Žibret, [7]N. S. Aluloska, [2]L. Žibret, [2]S. Dolenec

[1]Faculty of Technology and Metallurgy, Ss. Cyril and Methodius University in Skopje, Skopje, Republic of North Macedonia
[2]Slovenian National Building and Civil Engineering Institute, Ljubljana, Slovenia
[3]Radiation and Environment Protection Department, Vinca Institute for Nuclear Science, National Institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia
[4]Bay Zoltán Nonprofit Ltd. for Applied Research, Szeged, Hungary
[5]Salonit Anhovo d.d, Deskle, Slovenia
[6]Geological Survey of Slovenia, Ljubljana, Slovenia
[7]Cementarnica "USJE"AD Titan Group, Skopje, Republic of North Macedonia

Large quantities of industrial mineral residues have been produced in recent years that present global environmental problem. To reduce consumption of raw materials and CO_2 emmisions, recycling and reuse of mineral wastes have been promoted and supported by EU directives (Roadmap to a Resource Efficient Europe COM (2011) 571, Eco-Innovation Action Plan (Eco-AP) COM (2011) 899, Council Directive 2013/59/EUROATOM, 2013, Article 75,...). Based on the concept of circular economy most of the mineral wastes can be considered as secondary raw materials (SRM) that can be sucesfuly used in construction. Beside chemical and minerological composition, morphology of particles and the content of trace/heavy elements, the enriched concentrations of natural radionuclides (characteristic for naturally occurring radioactive materials – NORM like red mud, metalurgical slag, fly and bottom ashes) infuence on the behavior and potencial applications of SRM.

The actual study presesents the results obtained in the frame of RIS-ALiCE project (Al-rich industrial residues for mineral binders in ESEE region, EIT Raw Materials, H2020) for particular alumina containing industrial residues from some ESEE countries. Radiological assesmant was defined based on the results for ^{226}Ra, ^{232}Th and ^{40}K activity concentration of alumina containing industrial residues. The activity concentration index (I-index), used only as a screening tool to identifed raw materials, and the health efect estimated via radium equivalent activity (Raeq), external hazards index (Hex), the external absorbed dose rate (Ḋ) and annual efective dose rate (EDR) were deffined. Physical, chemical and minerological characterization of investigated samples support the actual study for defining the potencial usage of SRM in constuction. A specially tailored online registry of secondary mineral raw materials which serves as matchmaking tool that can connect mineral waste owners with potential end-users was also developed (avalible on: https://www.alice-registry.eu/).

Distribution of natural radionuclides in NORM Samples from North Abu Rusheid Area, EGYPT

[1,2]S. Sakr, [1]K. Inoue, [2]S. K. Sahoo

[1]Department of Radiological Sciences, Tokyo Metropolitan University, Tokyo, Japan
[2]National Institute of Radiological Science, National Institutes for Quantum Sciences and Technology (QST), Chiba, Japan

North Abu Rusheid Area was selected for my research since this is a well-known high background natural radiation area (HBNRA) due to the existence of cataclastic (mylonitic) rocks. In this study, twenty-seven rock samples were chosen for dose estimation studies. ^{238}U and ^{232}Th were measured using inductively coupled plasma mass spectrometry (ICP-MS) and ^{40}K was measured using a sodium iodide (Thallium) gamma-spectroscopy system. The range of activity concentrations of ^{238}U, ^{232}Th and ^{40}K in the samples varied from (270 to 2120 Bq kg^{-1}), (350 to 1840 Bq kg^{-1}) and (20 to 1390 Bq kg^{-1}) with mean values of 980, 770, 640 Bq kg^{-1} respectively. Associated radiological hazard parameters were estimated using UNSCEAR equations and the results were compared with other worldwide ranges. The absorbed dose rate in air (D) were ranged from 390 to 2090 with an average of 950 nGy h^{-1}. The Radium equivalent activity (Raeq) ranged from 870 to 4760 with average value 2140 Bq kg^{-1}. The annual external effective dose (AEDE) ranged from 0.5 to 3 with the average value of 1 mSv y^{-1}. The calculated values of external hazard index (Hex) and internal hazard index (Hin) ranged from 2 to 13 and from 3 to 19 with average values 6 and 8 respectively. Excess lifetime cancer risk (ELCR) ranged from 2 to 9 with average value 4. Finally, representative gamma index (Iγ) ranged from 6 to 33 with average value 15. On the other hand, U/Th ratio ranged from 0.7 to 3 which indicates U rich in a few samples that could be attributed to presence of zircon, uraninite, uranothorite, ishikawaite and xenotime minerals. These rocks from North Abu Rusheid area needs detailed radiological studies prior to use in construction materials.

Radiological risk assessment of ^{226}Ra, ^{232}Th and ^{40}K in beach placer deposits of Tamil Nadu (India)

[1,2]T. Natarajan, [2]S. K. Sahoo, [2]T. Nakajima, [3]N. Veerasamy, [1]K. Inoue, [4]R. C. Ramola

[1]Tokyo Metropolitan University, Tokyo, Japan.
[2]National Institutes for Quantum Sciences and Technology (QST), Chiba, Japan.
[3]Institute for Environmental Sciences, Aomori, Japan.
[4]H.N.B. Garhwal University, Tehri Garhwal, India.

Distribution of ^{226}Ra, ^{232}Th and ^{40}K were studied along the coastal region of Kanyakumari (Tamil Nadu), a high background natural radiation area (HBNRA). In this study, a total of 35 sampling stations were selected along the 70 km coastal area of Kanyakumari. The activity concentrations of three natural radionuclides e.g. ^{226}Ra, ^{232}Th and ^{40}K were measured using a gamma spectroscopy equipped with a high purity germanium (HPGe) detector. Based on the radioactivity results of ^{226}Ra, ^{232}Th and ^{40}K, the radiological risk parameters have been estimated. The average specific activities of ^{226}Ra, ^{232}Th and ^{40}K were 535 Bq kg^{-1}, 9000 Bq kg^{-1} and 580 Bq kg^{-1}, respectively. The absorbed gamma dose rate ranged from 30 to 44960 nGy h^{-1} with a mean value of 6200 nGy h^{-1} which was approximately 100 times higher than the world average 57 nGy h^{-1}. A large variation was noticed in activity ratio of $^{232}Th/^{226}Ra$ which could be attributed to the enrichment of thorium rich mineral monazite in the study area. The radiation hazard parameters are much higher than the UNSCEAR recommended values. These results suggest that people using sands for construction purposes needs more radiological monitoring.

Distribution of radionuclides in Niška Banja, Serbia soils and assessment of radiation hazard parameters

[1]Z.S. Zunic, [1]N. Veselinovic, [2]S. K. Sahoo, [2]N. Veerasamy, [2]T. Natarajan, [3]P. Jovanovic, [4]M. Zhukovski, [4]A. Onishchenko, [4]I. Yarmoshenko, [5]R.C. Ramola

[1]University of Belgrade, Belgrade, Serbia.
[2]National Institutes for Quantum Sciences and Technology (QST), Chiba, Japan.
[3]Institute of Occupational Safety (ZVD), Ljubljana, Slovenia.
[4]Institute of Industrial Ecology UB RAS, Ekaterinburg, Russia.
[5]H.N.B. Garhwal University, Tehri Garhwal, India.

The mountains and hills around Niška Banja, a spa town located in a radon-prone area in southern parts of Serbia, have been selected to study the distribution of natural radionuclides in surface soil. The activity concentration of natural radionuclides such as ^{226}Ra, ^{232}Th and ^{40}K were determined in 55 soil samples using HPGe gamma spectroscopy. The concentration of ^{226}Ra, ^{232}Th and ^{40}K in soil varied from 10 to 750, 7 to 48 and 96 to 583 Bq kg^{-1}, respectively. Based on the natural radionuclide activity concentration, radiological risk parameters were estimated. The total absorbed dose rate varied from 26 to 387 nGy h^{-1} with a mean of 70 nGy h^{-1} which was a litlle higher than the worldwide value given by UNSCEAR. In this area, ^{226}Ra was the dominant radionuclide in most of the soils. The external hazard index, radium equivalent and annual effective dose were lower than the permissible level. ^{226}Ra concentration > 370 Bq/kg at some sites can be associated with local geological conditions. Generally, these results indicate that there is no significant radiological health hazard to the local population.

Presence of terrestrial radionuclides in vicinity of Somló hill, Hungary

P. György, A. Csordás, D. Hanis, T. Kovács, E. Tóth-Bodrogi

Department of Radiochemistry and Radioecology, University of Pannonia, Veszprém, Hungary

A one year complex radioecological study is being carried out at the Somló area, Hungary, covering multiple environmental compartments (soil, water and moss) in order to establish the current baseline of activity concentrations. Somló is an eroded volcanic hill, the smallest Hungarian Wine Districts, home to multiple smaller settlements and a 585 ha landscape protection area with special basalt forms housing rare plants and wildlife. This kind of radioecological assessment is important to assure public safety and to provide a point of reference for further investigations into the environmental behaviour of natural and artificial radionuclides. Mosses were selected as an indicator species for the atmospheric deposition according to international recommendations, since they can bind or fix radionuclides from their environment during their life cycle, but they lack developed root and vascular systems.

Repeated sampling is being carried out at multiple selected locations over a one-year period in the study area to determine the activity concentrations of the major naturally occurring radionuclides using HPGe semiconductor detector gamma spectrometry and to their check their temporal variations. In addition, the concentration of artificial radionuclides of concern was also determined if any were present in sufficiently high concentrations.

Results show that the activity concentration in the area sometimes exceed world and national averages, but can't be considered exceptionally high. Activity concentration in water ranges from 0 to 17.5 Bq/l for ^{226}Ra and from 0 to 1.5 Bq/l for ^{232}Th. The activity concentration of the soil samples ranged from 13.9 to 71.4 Bq/kg for ^{226}Ra, from 9.3 to 39.1 Bq/kg for ^{232}Th and from 70.0 to 416.6 Bq/kg for ^{40}K. The activity concentrations of the moss samples ranged from 9.7 to 92.3 Bq/kg for ^{226}Ra, from 3.2 to 82.2 Bq/kg for ^{232}Th and from 78.9 to 368.9 Bq/kg for ^{40}K. ^{137}Cs has also been detected in some soil samples, probably originating from the Chernobyl nuclear power plant disaster.

The presence of terrestrial radionuclides along the hiking trails in Mecsek

M. Fehérvári, A. Csordás, D. Hanis, T. Kovács, E. Tóth-Bodrogi

Department of Radiochemistry and Radioecology, University of Pannonia, Veszprém, Hungary

Humans are naturally exposed to radioactivity during our lives. One of the main sources is the Earth itself and the natural elements around us. Today, bioindication and biomonitoring studies to assess the state of the environment and its changes are becoming increasingly important. Plants are in constant dynamic interaction with soil, air and water, making them suitable for biomonitoring studies. The use of pre-organisms to study environmental quality is widely supported in many countries. Mosses play a very important role in plant communities. They have a significant biomass mass even under unfavourable climatic conditions and are well suited to assess a wide range of pollution.

Our research is based on a survey of the main terrestrial radionuclides' presence in case of two hiking trails in Mecsek. The environmental samples taken on the hiking trails was analysed by gamma spectrometry using an HPGe semiconductor detector and Quantum GIS geospatial software was used to prescribed the measured values. During the research soil, water and moss samples were taken.

Based on the measured and calculated values, the average values for K-40 isotope in the soil samples from Óbánya is 486.55 Bq/kg, for ^{232}Th is 55.52 Bq/kg and for ^{226} Rais 35.46 Bq/kg, while the values for ^{40}K isotope in the soil sample from Kővágószőlős is 869.33 Bq/kg, for ^{232}Th is 55.56 Bq/kg and for ^{226}Ra is 35.06 Bq/kg.

For moss samples, the activity concentration values for 40K isotope are 218.85 Bq/kg and 671.31 Bq/kg, for ^{232}Th are 291.38 Bq/kg and 101.72 Bq/kg, and for ^{226}Ra are 60.07 Bq/kg and 42.77 Bq/kg, respectively.

Determination of ^{210}Po activity concentration in mushrooms from the vicinity of Mátra and Őrség hill

M. Novák, A. Csordás, E. Tóth-Bodrogi, T. Kovács

Department of Radiochemistry and Radioecology, University of Pannonia, Veszprém, Hungary

Certain types of mushrooms, which are included the Dakarya fungi subdomain have the ability to bind metals, mainly through their widely branched underground fungal filaments (mycelia). Some specific mushrooms can accumulate various radionuclides of crustal origin, including the isotope polonium-210. The health effects of this isotope make it important to test the concentrations of edible species. ^{210}Po is an alpha-emitting radioisotope which has serious health damaging effects due to the short range but high destructive power of alpha radiation on cells. The ^{210}Po activity concentrations were measured in 34 mushroom samples, of which 16 species were consumable in some form. ^{210}Po was determined by alpha spectrometry using a PIPS detector after chemical leaching and spontaneous deposition of ^{210}Po on a high nickel-content (25%) stainless steel disk. The effective radiation dose from ingestion was estimated for edible species with higher concentration values. The samples were collected from two different Hungarian regions: 8 from Őrség and 26 from Mátra. The obtained results were also compared based on the collection site of the mushrooms. In the case of non-edible species, only activity concentrations were measured, and the results of these samples were used for taxonomic comparative analysis with the edible mushrooms also included.

Radioecological studies of bottom sediments of the Tisza River (Transcarpathia): from mountain to lowland areas

[1]V. Maslyuk, [2]T. Kovács, [1]N. Svatiuk, [3]O. Symkanich, [1]O. Pop, [1]Z. Torich, [4]V. Zeltonozsku, [1]V. Roman

[1]Institute of Electron Physics, Nat. Acad. Sci. of Ukraine, Uzhhorod
[2]Department of Radiochemistry and Radioecology, University of Pannonia, Veszprém, Hungary
[3]Uzhhorod National University, Uzhhorod, Ukraine
[4]Institute of Nuclear Research, National Academy of Sciences of Ukraine Ukrainian, Kyiv, Ukraine

The Tisza River is one of the largest rivers in Eastern and Central Europe. It is a crucial component of the water resources of Ukraine, Romania, Slovakia, Hungary, and Serbia. In Ukraine, almost the entire territory of Transcarpathia is the basin of its catchment area. However, this is only 25.6% of its total runoff; other catchment volumes are formed in Romania (51%), Slovakia (13.4%), and Hungary (10%). The main part of Transcarpathian water resources is river runoff, which plays an essential role in the accumulation and movement of chemical components and the formation of the isotopic composition of the surface layers of mountain slopes. Mudstones of mountain rivers are a dynamic accumulating environment, the isotopic and microelement composition of which is formed and renewed under the influence of factors of different nature. They capture the features of both regional - geochemical, economic, and global factors. The latter is due to the intensive interaction of mountains with air currents, which carry long-distance products of tectonic, climatic, and man-made activity. The microelement and isotopic composition of silt provide valuable information about the ecological condition of the surrounding and more remote areas. This report presents the results of low-background gamma-spectrometric studies of the natural radioactivity of bottom sediment samples from 27 points along the Tisza riverbed. Samples were taken in the mountains near the source of the Tisza, and other points were selected downstream where there are factors of anthropogenic and transboundary activity. The research subject was the content and ratio of radionuclides of natural U/Th series, ^{40}K, and technogenic label ^{137}Cs, which can be used for "radiation marks" and setting standards for the studied areas. Regulations of low-background gamma spectrometry conditions are discussed; the spatial variation of the ratio of radionuclides of U/Th series along the Tisza riverbed in mountainous and lowland regions Transcarpathia are analyzed. The degree of statistical proximity of sampling points is studied by factor and cluster analysis methods, and the nature of latent factors influencing their statistical clustering is discussed. The obtained data of the study of the structure of terrestrial radioactivity in the bottom sediments of the Tisza River allow us to identify patterns of their migration and accumulation in the environment. The importance of continuing such research along the entire riverbed in cross-border collaboration is discussed.

Gamma and neutron activation analysis of silt samples from the sources of the Tysa River

[1]V. Maslyuk, [1]N. Svatiuk, [1]V. Roman, [2]O. Symkanich, [1]O. Pop, [1]Z. Torich, [3]V. Zeltonozsku, [1]P. Ganych

[1]Institute of Electron Physics, Nat. Acad. Sci. of Ukraine, Uzhhorod, Ukraine
[2]Uzhhorod National University, Uzhhorod, Ukraine
[3]Institute of Nuclear Research, Nat. Acad. Sci. of Ukraine, Kyiv, Ukraine

The Carpathians play an important role in shaping the water and air regimes of Eastern and Central Europe, the place where the largest rivers in Europe originate. Tisza River is one of the largest waterways in Europe and the source of its water supply. It originates near the city of Rakhiv, Ukraine, the length of the river is 265 km in Transcarpathia. Monitoring its environmental performance is important for the countries of the Eurocarpathian region. Such information can be provided by the control of microelement and isotopic composition of silts of Tisza River, as they are formed under the influence of natural and anthropogenic factors of large adjacent areas. This study presents the results of nuclear activation experiments on silt samples of Tisza River performed on the microtron M-30 of the Institute of Electron Physics of the National Academy of Sciences of Ukraine. Sampling of siltstones (summer 2021) was performed at 27 fixed points along the riverbed, the structure of their natural radioactivity was determined by low-background gamma spectrometry, as well as using gamma- and neutron-activation techniques on the microtron M-30 at 12.5 MeV. Samples of silt were studied below Rakhiv, point №10, (altitude 429 m, GPS coordinates 48 ° 04'46.9 "N 24 ° 14'63.9" E) and after the confluence of the Iza River from Romanian territory, above Tyachiv, point 15, (altitude 189 m, GPS coordinates 48 ° 02'12.8 "N 23 ° 28'.7" E). Samples of silt were irradiated on the microtron M-30 with fluxes of both inhibitory gamma- and photoneutron irradiation, and the gamma spectra of secondary radiation of radionuclides formed in reactions (γ,n) and (n,γ), as well as their half-lives $T_{1/2}$ were studied. Analytical nuclear physics techniques allow multi-element analysis in one experiment, their high selectivity and high sensitivity are known. It is known that of the 84 chemical elements that are stable or with a large $T_{1/2}$ (U, Th), 74 elements can be determined by neutron activation analysis. The following scheme of irradiation of the samples was chosen: maximum energy of accelerated electrons - 12.5 MeV, duration of irradiation - 30 minutes, average electron acceleration current Isr = 3 μA, cooling time varied from 3 min. up to 24 hours. To irradiate photoneutrons from accelerated electrons, a Ta - Be convector was used, which was surrounded in 4π geometry by a polyethylene moderator. Measurements of gamma activity of irradiated silt samples were performed on a semiconductor γ-spectrometric complex of HP(Ge)-detector. The obtained hardware gamma spectra of activated samples are analyzed for the identification of chemical isotopes taking into account their nuclear-physical constants.

Strontium isotopes as tracers of urban soil pollution, a case study of Salgótarján, Hungary

[1]M. Maghsoudlou, [1]D. Tserendorj, [1]Y. López Marín, [1]G. Abbaszade, [2,3]N. Kavasi, [2]S.K. Sahoo, [3]M. Štrok, [4]K. Inoue, [5]P. Völgyesi, [6]E. Tóth-Bodrogi, [6]T. Kovács, [1]Cs. Szabó

[1]Lithosphere Fluid Research Laboratory, Eötvös Loránd University, Budapest, Hungary
[2]Department of Radioecology and Fukushima Project, National Institute of Radiological Sciences, National Institute for Quantum and Radiological Science and Technology, Chiba, Japan
[3]Department of Environmental Sciences, Jožef Stefan Institute, Ljubljana, Slovenia
[4]Department of Radiological Sciences, Tokyo Metropolitan University, Tokyo, Japan
[5]Nuclear Security Department, Centre for Energy Research, Budapest, Hungary
[6]Department of Radiochemistry and Radioecology, University of Pannonia, Veszprém, Hungary

Coal-fired power plants produce a large amount of coal ash, which contaminates the whole environment globally. Here we report the $^{87}Sr/^{86}Sr$ for tracing the contaminants in different environments from Salgótarján. Fifteen selected urban soil samples were studied collecting them at kindergartens, parks, playgrounds, and roadside, as well as, a brown forest soil sample as geochemical background (GB), and two potential contamination sources, local coal ash, and local coal sample were also investigated. $^{87}Sr/^{86}Sr$ shows negative correlation with Sr concentration in most samples. In contrast to the others, coal ash has a very low $^{87}Sr/^{86}Sr$ and a very high Sr content. Three samples (from a kindergarten, a playground, and a roadside) with high coal ash content have low $^{87}Sr/^{86}Sr$. A different roadside sample indicates the highest Sr-isotopic ratio proving the presence of many natural components. $^{87}Sr/^{86}Sr$ in more than 50% of samples show positive correlation with distance from the coal-fired power station. We conclude that the coal ash had a remarkable effect on the distribution of Sr and its isotopes however, natural chemical weathering also regulates isotopic fractionation.

Seasonal changes in the ^{222}Rn activity concentration in spring water in North Vietnam adjacent to rare earth element and uranium mining areas

[1]V-H. Duong, [1]T-T. Chu, [1]T-X. Pham, [1]H-D. Vu, [2]T-D. Nguyen, [3]L. Thanh Pham, [4]M. S. Musthafa, [5]E.O. Akuo-ko, [5]M. Hegedűs, [5]T. Kovács

[1]Hanoi University of Mining and Geology, Hanoi, Vietnam.
[2]Institute of Engineering Technology, Hanoi, Vietnam
[3]Faculty of Physics, VNU University of Science, Hanoi, Vietnam
[4]Unit of Research in Radiation Biology & Environmental Radioactivity (URRBER), P.G. & Research Department of Zoology, The New College (Autonomous), Affiliated to University of Madras, Tamilnadu, India
[5]Department of Radiochemistry and Radioecology, University of Pannonia, Veszprem, Hungary

^{222}Rn and its daughter elements are large contributors to the annual effective dose received by the public. The vicinity of rare-earth-element and uranium mines have an increased probability of risk, and are likely radon prone areas, however radiological risks in North Vietnam are just beginning to be explored. To assess the radiological impact of the rare earth element and uranium mining activity in the area and assure public safety, ^{222}Rn activity was determined by RAD-7 at seven water sources. The average activity concentrations ranged from 1270±60 in Binh Duong to 66400±2630 Bq m^{-3} in Muong Hum. These are spring waters, utilized as the main water resource by local residents, thus any possible contamination can have high local significance. The vicinity of REE mines tended to have a higher activity concentration, while the lowest value was observed near a uranium mine, however there are differences in cultivation methods and the lack of weathered ore on the surface. The dry season tended to have a higher ^{222}Rn activity concentration at every location, while the rainy season had increased precipitation, reducing the observed ^{222}Rn activity. A strong correlation was observed between ^{222}Rn activity concentrations in the dry and wet seasons for all locations. The ^{222}Rn activity concentrations were lower than the internationally recommended upper limits, indicating no significant health hazard from radon in the observed time period in the area.

Applications of radon measurements in finding a geodynamically active location with possible deep fluid upwelling

[1,2]Á. Kővágó, [1,2,3]T. P. Lange, [1]O. Gelencsér, [1,2]Cs. Szabó, [1,2,3]I. J. Kovács

1 Lithosphere Fluid Research Lab (LRG), Eötvös Loránd University (ELTE), Budapest, Hungary
2 MTA FI Pannon LitH_2Oscope Lendület Research Group, Sopron
3 Institute of Earth Physics and Space Science, ELKH, Sopron, Hungary

In this study, we carried out radon (Rn) measurements in the area of the Balaton – Balaton-Highland volcanic field in order to find a suitable location for the installation of an Integrated Geodynamic Station (IGS). The major goal of the IGS is to monitor diffuse CO_2-rich fluid upwellings and correlate its geochemical variations with seismic activity and electromagnetic signals occurring in its vicinity. For this purpose, a location is needed where a potential connection between the deeper geological spheres of the Earth and the surface is expected. To find such location, we selected a suitable wide area (in 10 km scale) based on the previous geological, particularly tectonic and structural information. However, to find the best location for the IGS inside this area, monthly measurements were conducted regarding the activity concentration for Rd and concentration of CO_2 and some other gases. The correlating concentrations of both gases refer to a possible deep CO_2-rich fluid component migrating through deep seated faults presumably from the upper mantle, which facilitates the transportation of the heavy Rn gas produced in the shallow crust to the surface. In this poster, we will introduce a protocol for such field work and results of the Rn measurements.

Assessment of the natural radiological hazards in surface soil at high-level background natural radiation areas, Northern Vietnam

[1]V-D. Nguyen, [1]T-D. Nguyen, [2]G. Tóth, [2]A. Csordás, [2]M. Hegedűs, [2]T. Kovács

[1]Hanoi University of Mining and Geology. Hanoi, Vietnam
[2]Department of Radiochemistry and Radioecology, University of Pannonia, Veszprem, Hungary

^{226}Ra, ^{238}U, ^{232}Th, and ^{40}K radionuclides in the environment need to be measured to estimate the associated radiological hazard indexs for human health, epsecically in high-level natural radition areas. In this study, the those radionuclides in surface soil in 88 soil samples from total of eight different locations in rare earth element (REE), metallic, and uranium mines in the Northern Vietnam will be measured using a high-resolution detector HPGe. The ^{226}Ra, ^{238}U, ^{232}Th, and ^{40}K concentration in study samples varied from 60.4 to 655, 59.3 to 643, 71.2 to 886, and 252 to 745 Bq/kg respectively. The highest total conentration of studied radionuclides was found in REE mine, followed by uranium and metallic mine. The result showed that the concentrations of ^{238}U and ^{226}Ra were almost equilibrium with the concentration ratios of ^{238}U/^{226}Ra of 1.01. Regarding the radiation hazard assessment, the radiation hazard indices for radionuclides in soil samples in the study areas were higher than the average and the range value in the world. The average excess life cancer risk (ELCR) was about 6 times higher than the wordwide average value.

Application of machine learning method for prediction of radon release from copper ore mining at Sin Quyen deposit, Lao Cai, Vietnam

[1a]D-B. Tran, [2]T. Vu, [3a,b]D-Q. Tran, [3a,b]T-T. Nguyen, [4]R. Katona, [4]T. Kovács, [4]M. Hegedűs, [1a,b]V-H. Duong

[1a]Hanoi University of Mining and Geology (HUMG), Hanoi, Vietnam
[1b]VNU School of Interdisciplinary Studies, Vietnam National University Hanoi, Hanoi, Vietnam
[2]Faculty of Mining and Construction, Quang Ninh University of Industry, Quang Ninh, Vietnam
[3a]Key Laboratory of Geoenvironment and Climate Change Response, University of Science, Vietnam National University, Hanoi, Vietnam
[3b]Faculty of Geology, University of Science, Vietnam National University, Hanoi, Vietnam
[4]Department of Radiochemistry and Radioecology, University of Pannonia, Veszprem, Hungary

Radon is one of the most toxic natural radionuclides, which occupy more than 50% of natural radiation exposure anywhere. The Sin Quyen is the biggest natural radioactive-bearing copper deposit in the North of Vietnam. The uranium is a dominant radionuclide in this deposit, which is the principal source release radon to the surrounding when this mine has been exploiting with millions of tons of copper ore yearly since 2006. The prediction and assessment of the radon released from the such kind of this mine which are essential targets for reducing the impact of the radiation risk, protecting human health, and sustainable social-economic development during mining and mineral processing of natural resources. Machine learning has been applied in radon prediction still rare and limited. In this paper, the radon and six input variables, including coordinates X, Y, gamma dose, distance (m), direction (degree), and uranium concentration (ppm) data were used as input data variables for the machine learning method. It was designed by a simple one-hidden layer artificial neural network (ANN) that requires low computation cost to train, reference and get the effectiveness. With considerable input data collected, the model was found to have a superior prediction accuracy, with low values of error (RMSE = 2.793 (Bq/m^3), *MAPE* = 1.121 (%), *MABE* = 2.102 (%), r = 0.997, R^2 = 0.995 for the training part and *RMSE* = 2.791 (Bq/m^3), *MAPE* = 1.117 (%), *MABE* = 2.094 (%), r = 0.997, R^2 = 0.995 for the testing part). The comparison results suggested that the proposed model outperformed other benchmark methods such as two-hidden-layer ANN, Support Vector Machine (SVM) and Random Forest (RF). The results also revealed that gamma dose and distance (X, Y) factors had a more significant effect on the radon prediction than coordinate, direction, and uranium concentration values.

Characteristics and annual effective dose of ^{210}Po activity due to popular freshwater fish ingestion in Vietnam

[1]V-H. Duong, [1]T-T. Chu, [2]T. Ganbaatar, [2]E. Tóth-Bodrogi, [2]M. Hegedűs, [2]T. Kovács

[1]Hanoi University of Mining and Geology, Hanoi, Vietnam
[2]Department of Radiochemistry and Radioecology, University of Pannonia, Veszprem, Hungary

^{210}Po was a popular natural radionuclide in fish species and consumption of freshwater could be contributed to significant internal dose by ^{210}Po activity. The ^{210}Po is considered to be one of the most toxic naturally occurring radionuclides. The ^{210}Po activities and their characteristics in freshwater fishes will provide as baseline data for radiological hazard assessment and supplement knowledge for this radionuclide's behavior in radioecology from each country. In this study, the ^{210}Po activity and their characteristics were determined in 17 popular fish species with different living behavior (pelagic, demersal), feeding types (herbivores, carnivores, omnivorous) and mass in Dong Thai Lake, Hanoi, Vietnam by alpha spectrometry. The min, max and average of the ^{210}Po concentration were observed at 0.80, 12.7 and 3.54 Bq.Kg^{-1} respectively. Regarding the living behavior, feeding types and mass, the ^{210}Po accumulation in study freshwater fish species have relation with their type of different living behavior, feeding types and mass. The ^{210}Po activity behavior show the trend of $^{210}Po_{pelagic}$ > $^{210}Po_{demersal}$; $^{210}Po_{herbivores}$ < $^{210}Po_{carnivores}$ < $^{210}Po_{omnivorous}$ and $^{210}Po_{<0.2Kg}$ > $^{210}Po_{0.2\text{-}1Kg}$ > $^{210}Po_{>1Kg}$, respectively. The fish species with small mass may be more able to incorporate ^{210}Po into muscle tissue than fish with larger mass. In addition, the results showed an uneven distribution of 210Po activities in different aerosol, surface soil, freshwater, and sedimentary objects surrounding of study area. Therein the main ^{210}Po source could be come from aerosol and surface soil into study aquatic system. The ^{210}Po annual effective dose has been calculated with a range from 20 to 400 μSv.y^{-1} and 111 μSv.y^{-1} in average and all within the allowable limits.

Radon monitoring for volcanic and mud volcanic studies in Taiwan

[1]A. Kumar, [1]V. Walia, [1]S.-J. Lin, [2]C.-C. Fu

[1]National Centre for Research on Earthquake Engineering, National Applied Research Laboratories, Taipei, Taiwan
[2] Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan

In the present study solid state nuclear track detectors (SSNTDs) technique has been used for the measurement of radon-thoron concentrations in soil gas for volcanic and seismic study in Taiwan. The semiautomatic track count using a Nikon digital camera coupled to a PC and employing software "SCION" has been checked and tested by comparing the results with manual counting. In order to study radon-thoron in volcanic areas, pre-calibrated radon-thoron discriminators with LR films has been installed in Hsiaoyoukeng (SYK), Dayoukeng (DYK), Bayen (BY), and Gungtzeping (GTP) of Tatun Volcanic area in a hole (about 50 cm depths) having different temperatures for a defined period (bi-weekly to monthly). The observations have shown potential precursory signals for some earthquakes that occurred during the observation period having an epicenter in and around the TVG. Our monitoring stations in TVG area are sensitive to the events within a distance of 60 km.

On the other hand, radon monitoring in the artesian wells of Mato-san areas of south Taiwan were carried out to know the working of the mud eruption and the dependence of the eruption cycle with radon changes. Radon monitoring in water was carried out by using RAD7. Water samples were collected at different depths from different wells for the period of two weeks to one month. This study shows that anomalous radon value has been observed before and after to some eruptions during the study periods. The opposite radon behaviors at well No. 2 and well No. 3(B) were observed during the eruption. Noted behavior of these wells may be due to the movement of gas fluxes during the eruption period.

Environmental radioactivity in soil measured by inductively coupled plasma mass spectrometry and gamma spectrometry in Cameroon

[1,2,3]O. B. Modibo, [4]G. Yang, [2]Saïdou, [1]H. Tazoe, [1]N. Akata, [1]C. Kranrod, [1,2]M. Hosoda, [1]S. Tokonami

[1]Institute of Radiation Emergency Medicine, Hirosaki University, Aomori, Japan
[2]Research Centre for Nuclear Science and Technology, Institute of Geological and Mining Research, Cameroon, Yaoundé, Cameroon
[3]Graduate School of Health Sciences, Hirosaki University, Aomori, Japan
[4]National Institutes for Quantum Science and Technology, Chiba, Japan

In this study, data of the first measurement of ^{236}U in surface soil samples in Cameroon are reported, with the primary objective of establishing a baseline data for the Country in the case of accidental release of nuclear waste fuel in the environment in the future. A total of fifteen surface soil samples were collected from seaside, gold mining, volcanic, uranium and thorium bearing areas, for radionuclide analysis using inductively coupled plasma mass spectrometry and gamma spectrometry. The ^{234}U, ^{235}U, ^{236}U, ^{238}U, ^{232}Th, ^{226}Ra, ^{40}K, and ^{137}C activity concentrations of the samples were measured. For the first time in Cameroon, atom ratios of $^{236}U/^{238}U$ were determined, which ranged from 2.31 $\times 10^{-8}$ to 4.95 $\times 10^{-8}$, indicating that ^{236}U was predominately from the global fallout. Apart from two samples collected at Kitongo (1.22 and 1.58), all $^{234}U/^{238}U$ activity ratios were around 1 (secular equilibrium) ranging from 0.97 to 1.11 with the average (± SD) of 1.02 ± 0.04. Furthermore, secular equilibrium between ^{238}U and ^{226}Ra in the sampled soils was studied, activity ratios of $^{226}Ra/^{238}U$ were out of unity for all the samples analyzed, ranging from 1.06 to 3.78, with the average (± SD) of 2.23 ± 0.74 showing radioactive disequilibrium between these two radionuclides. The activity concentrations of ^{232}Th and ^{40}K were above and lower the global averages, respectively, and ^{137}C activity concentrations were found to be trace, ranging from below 0.1 to 6.7 Bq kg^{-1}.

Determination of the regional background frequency of stable translocations in population living in the territory adjacent to Semipalatinsk test site

[1]L.B. Kenzhina, [2]Zh.A. Baigazinov, [3]S.N. Lukashenko, [1]A.N. Mamyrbaeva, [2]A. Csordás, [2]T. Kovács

[1]Insitute of Radiation Safety and Ecology, Kurchatov, Kazakhstan
[2]Department of Radiochemistry and Radioecology, University of Pannonia, Veszprem, Hungay
[3]Russian Institute of Radiology and Agroecology, Obninsk, Russia

Reconstruction of the irradiation dose of population living in regions adjacent to Semipalatinsk test site, which has been functioning for more than 40 years, attracted huge interest nowadays.

This study provides results on the regional background frequency of stable translocations using a fluorescent hybridization in situ technique for different age groups that varies between 1.4±0.3 and 4.9±0.5 per 1,000 cells (tab. 1). It was found that frequency of stable chromosome aberrations identified by FISH-technique increases with age. This is because with age stability of genome is progressively reduced, DNA reparation and regeneration processes are slowed down.

Table 1. Translocation frequency per 1000 cells of the population living in the territory adjacent to STS

Age interval	Number of people	Number of cells analyzed	Number of translocations	Translocation frequency per 1000 cells
20-29	7	12711	22	1.73±0.4
30-39	9	12635	18	1.42±0.3
40-49	10	8599	27	3.14±0.6
50-59	5	5535	27	4.9±0.9
60-69	6	7781	33	4.2±0.7
Total	37	47261	127	-

The effect of smoking on background level of translocations is well known. As there is a clear correlation between the level of stable chromosome damage and smoking for age groups of interest. In this study, the background frequency of stable chromosome damage was calculated by means of the equipment of automated cytogenetic platform based on AxioImager Z2 “Carl Zeiss” electronic fluorescent microscope, automatic metaphase analytical search system called Metafer 4/M Search, ISIS (MetaSystems, Germany) and commercial whole chromosome DNA probes for chromosomes 1, 4, 12.

Uranium speciation and spatial distribution in the bottom sediments along the Uzynbulak creek at the Semipalatinsk Test Site

[1]N.Zh. Mukhamediyarov, [2]S.V. Makarychev, [1]M.A. Umarov, [1]M.T. Dyuisembaeva, [1]Ye.Z. Shakenov, [1]V.V. Kolbin, [1]G.M. Yesilkanov, [1]A.Ye. Temirzhanova, [1]A.Zh. Tashekova, [1]F.F. Zhamaldinov, [1]A.N. Nurekenova, [1]A.K. Sapakova, [3]Zh.A Baigazinov, [3]T. Kovács

[1]Insitute of Radiation Safety and Ecology, Kurchatov, Kazakhstan
[2]Altai State Agrarian University, Barnaul, Russia
[3]Department of Radiochemistry and Radioecology University of Pannonia, Veszprem, Hungary

The purpose of this work is to assess the spatial uranium variation in the studied forms of the bottom sediments along the Uzynbulak creek located ant STS and determine the isotopes ratio of ^{235}U and ^{238}U.

As a result of the study, a number of points exceeding the minimum significant activity at the creek source and in the distance from 9 to 11 km were identified. Analysis of the obtained research results allows us to conclude that the various uranium speciation content is characterized by heterogeneity in the Uzynbulak creek bottom sediments. According to the value of the absolute and relative associated with the environmental compartments of the studied uranium compounds (with insignificant deviations) were in the following order: CEexc < CEwater = CEorg < CEsp.sorb < CEres < CEox/hydr Fe & Mn. It should be noted that uranium practically did not convert into water-soluble and exchangeable forms easily accessible for plants. However, the gross content of this element exceeds the Clarke level of the world soils by a factor of 4.8. The greatest U accumulation (73 %) occurred in forms of compounds expected to be stable in the area - in the form connected with iron and manganese oxides and hydroxides.

Based on the results of the gross uranium content and its isotopic ratio we can conclude about its probable natural origin. Signs of the presence or migration of man-made uranium in the studied water body were not observed.

Estimation of radon exhalation from soil and accumulation of radon gas in indoor environment

[1]P. Panwar, [1]A. Joshi, [2]K. Pal N., [3]M. Prasad, [4]R. Mehra, [1]R.C.Ramola

[1]Department of Physics, HNB Garhwal University, BadshahiThaul Campus, Tehri Garhwal, India
[2]Department of Physics, Kumaun University, Govt. P. G. College, Ramnagar, Nainital, India
[3]Chitkara University School of Engineering and Technology, Himachal Pradesh, India
[4]Department of Physics, Dr B R Ambedkar National Institute of Technology Jalandhar, Punjab, India

Radon is a nobal gas generated from radium, a by product of uranium. Radium and uranium naturally present in the soil, and rock. Radon gas is produced and emanates from radium containing soil grain into the soil porous medium. Infiltration of emanated radon from soil to indoor environment may be influenced by ventilation rate, diffusion coefficient, radium content, and effective entrance area. This study was performed at test village soundkoti, Tehri Garhwal, India. In the present study, radium content, active measurement of indoor radon concentration and surface exhalation rate were performed by the gamma ray spectrometer, and Smart RnDuo, respectively. The aim of present study is to calculate ventilation rate and diffusion coefficient to predict the accumulation of radon gas in the indoor environment. The calculated value of ventilation of the room were ranges from 0.00 to 0.95 with an average of 0.30 h^{-1}. The value of mesured indoor radon concentration found to be between 31 to 177 Bq/m^3 with an average of 69 Bq/m^3. The value of predicted indoor radon concentration were ranges from 48 to 272 Bq/m^3 with an average of 108 Bq/m^3.

Variation of radon and thoron exhalation due to the dewatering of the underground coal mine

M. Bonczyk, S. Chałupnik, M. Wysocka

Silesian Centre for Environmental Radioactivity
Central Mining Institute, Katowice, Poland

Routine monitoring of radon decay products concentrations in the experimental mine (in Upper Silesia, Poland) showed, that in galleries potential alpha energy concentrations (PAECs) were enhanced, reaching almost 7.5 $\mu J \cdot m^{-3}$. Due to that fact, measurements of radon concentrations were performed and a very high level of radon ^{222}Rn, up to 43 $kBq \cdot m^{-3}$ has been found. The goal of the work was to find the reason, influencing radon and thoron emission variations in the underground mine. The measurements of the exhalation rate of radon and thoron were done. It was found that the measured values of radon and thoron exhalation rates ranged from 3.0 up to 38 $Bq \cdot m^{-2} \cdot h^{-1}$ for radon and from 500 up to 2000 $Bq \cdot m^{-2} \cdot h^{-1}$ for thoron. The simultaneous measurements of radon/thoron concentration and air pressure, temperature, ventilation rate in galleries as well as dewatering rate were performed. The investigation revealed that intensive dewatering of the mine caused the so-called 'piston effect' which subsequently caused increased radon and thoron emission into underground workings. In our opinion, such an effect was related to the presence of the former underground coal gasification reactor (UCG).

Radon and thoron emanation of adobes from Angola and the influence of its structural and compositional properties on the emanation fraction

[1]J. Salupeto-Dembo, [1]P. Völgyesi, [2,3]Zs. Szabó-Krausz, [4]F. Kristály, [2]Cs. Szabó

[1]Nuclear Security Department, Centre for Energy Research, Budapest, Hungary
[2]Lithosphere Fluid Research Lab, Department of Petrology and Geochemistry, Institute of Geography and Earth Sciences, Eötvös University, Budapest, Hungary
[3]Centre of Environmental Sciences, Eötvös University, Budapest, Hungary
[4]Institute of Mineralogy and Geology, University of Miskolc, Miskolc, Hungary

Previous studies on adobe building materials from Angola gave different results on the levels of indoor radon and thoron activity concentrations, as well as the activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K (Salupeto-Dembo et al. 2020b) from three geologically and climatically different areas: Cabinda in the North part of the country, Huambo in the central part and Menongue in the south part. The results from the mentioned studies led to a further investigation focusing on the radon and thoron emanation of adobe while investigating structural properties of adobes that could influence their emanation fraction. For this purpose, 10 adobe samples per study area, 30 samples in total were selected. The radon and thoron emanations were determined using a RAD7 detector. Grain size distribution measurements were carried out by laser diffraction analysis. The mineralogical composition of adobes was also determined by XRD measurement. Results show that samples from Huambo have the lowest radon and thoron emanation fractions (12±4 and 8±2 %, respectively) and Menongue samples show the highest values (28±9 % and 14±5 %, respectively). For the grain size fractions of sand, silt and clay, the results are, respectively, 44-74 %, 20-36% and 6-20 % in Cabinda, 4-75 %, 12-57 %, 8-83 % in Huambo and 5-58 %, 21-42 % 17-53 % in Menongue. Identified minerals from the three areas in variable amounts are quartz, kaolinite, goethite, illite, hematite, and cristobalite, whereas some minerals like gibbsite, anatase, rutile, andradite, and zircon are only found in samples from Huambo. Our results proved that the grain size distribution and the mineralogical composition have an important role in the radon and thoron emanation of adobes. Therefore, when considering the emanation of adobes, the mentioned parameters have to be taken into account.

A Japanese respiratory airway model to refine inhalation exposure dose assessment

[1]A. Sampei, [1]M. Kiso, [1]H. Hashimoto, [2]Y. Omori, [3]T. Morita, [1]M. Osanai, [1,2]M. Hosoda, [1]Y. Saito, [4]S. Kakeda, [2]S. Tokonami

[1] Hirosaki University Graduate School of Health Science, Hirosaki, Japan
[2] Institute of Radiation Emergency Medicine, Hirosaki University, Hirosaki, Japan
[3]Hirosaki University Hospital Department of Radiology, Hirosaki, Japan
[4]Hirosaki University School of Medicine, Hirosaki, Japan

The International Committee on Radiological Protection (ICRP) had developed the Human Respiratory Tract Model (HRTM) for dose assessment due to inhalation of airborne radioactive aerosols in Publication 66. The morphological characteristics of the respiratory tract in the HRTM are based on Caucasian males, which was reported in only 22 cases. There is a study simulating depositions of aerosol on respiratory airways for the Japanese and Caucasians using the HRTM assigning their biometric parameters such as height, weight, lung capacity, and breathing rate. However, it is required to examine whether the HRTM is applicable to the Japanese and other Asian populations because their morphological characteristics of the respiratory tract may be different from those of the Caucasians. Nowadays, morphological information can be easily obtained using X-ray computed tomography (X-CT) (Discovery CT750 HD, GE Healthcare, Chicago, IL, USA). This study provides a method to obtain morphological information on Japanese from X-CT scanning images in order to produce a respiratory airway model of Japanese populations. The analysis of bronchial structures was conducted using a computer software program (Thoracic VCAR software, GE Healthcare Japan). At present, 24 adult cases have been analyzed. The results indicated the cross-sectional area of the trachea decreased as each generation progressed, but there were differences in the length of the trachea in different bronchi even in the same generation.

Indoor radon measurements and its inhalation dose assessment in residences within Greater Accra, Ghana

[1]E. O. Akuo-ko, [1]M. Adelikhah, [1]T. Ganbaatar, [2]E. Amponsem, [1]A. Csordás, [1]T. Kovács

[1]Department of Radiochemistry and Radioecology, Veszprém, Hungary
[2]GIS Department, Wallulel Ghana Limited, Accra, Ghana

Radon and its progenies are known to accumulate in buildings leading to increased risks to lung cancer when found in high concentrations as stated by the WHO. For this survey, the objective was to measure the indoor radon concentrations in residences within Greater Accra, Ghana, and to evaluate the associated risks as a result of the inhalation of indoor radon. The NRBP radon dosimeter with CR-39 detectors were placed in 95 residences for a period of 90 days. The exposed detectors were then chemically etched in 6.0 M NaOH solution at 90 °C for 9 hours. The densities of the radon tracks were counted using a high-resolution image scanner and analysis software. The calculated indoor radon concentrations for the surveyed dwellings ranged from 36.1 to 92.0 Bqm^{-3} with an annual mean of 50.8 Bqm^{-3} and all the measured indoor radon concentrations were below the WHO reference level of 100 Bqm^{-3}. The average annual indoor radon level of 50.8 Bqm^{-3} corresponded to an annual effective dose of 1.3 $mSvyr^{-1}$. The average ELCR was found to be 4.9 and the LCC was 23.1. It was estimated that approximately 5% of lung cancer deaths would be recorded annually due to indoor radon concentrations. Indoor radon maps were created and the inverse distance weighting technique proved to be the most appropriate in predicting indoor radon concentrations for the study area.

Estimation of Attached and Unattached Fractions of Airborne Radon and Thoron Progeny in Indoor Environment

R. C. Ramola

Department of Physics, H.N.B. Garhwal UniversityBadshahi Thaul Campus, Tehri Garhwal, India

Radiation exposure from natural sources has become an important issue in radiological protection. The health risk associated with radon and thoron progeny exposure is significantly related to deposition of radon and thoron progeny in the lungs. It is believed that the unattached fraction carries a higher risk. Accurate estimations of the radiation dose to the lungs need information of the size and concentration of the attached and unattached fractions. This paper presents techniques for measuring airborne radon and thoron progeny, as well as their attached and unattached fractions using solid state nuclear track detector. These methods are based on passive measurement using LR-115 Type II plastic track detectors. The devices are employed in the dwellings of Garhwal Himalaya to measure the attached and unattached radon and thoron progeny concentrations. The methods and the resulting dose due to radon and thoron progeny concentrations in the dwellings are described in details.

The possibility of using CFD modelling as a supplementary tool for internal indoor radon mitigation

A. Shahrokhi, E. O. Akuo-ko, M. Adelikhah, E. Tóth-Bodrogi, T. Kovács

Department of Radiochemistry and Radioecology, University of Pannonia, Veszprém, Hungary

Radon, as a radioactive gas, occurs naturally in significant amounts in the ground by the radioactive decay of Ra-226 and easily migrates from ground to the indoor. Radon is one of the leading causes of lung cancer, after smoking. Therefore, it is frequently necessary to monitor the indoor radon level and in most of the case in the early stage, the best course of action can be to apply a mitigate system for radon concentration reduction. But beside the relatively high price of these systems, sometimes their efficiency and effectiveness are not as expected or not compatible with the targeted environment, especially in case of specific area mitigation. Therefore, a complementary tool is needed to be able to increase the efficiency and effectiveness of the system mitigation for each specific area in specific cases, as well as reduce start-up costs. In this study the possibility of using CFD model, as a supplementary tool for specific area mitigation system, investigated to evaluate the hypothesis of using this tool to find how environmental factors, e.g. air pressure, ventilation etc., will affect the mitigation system before designing and installing. In this study, the CFD model was used to investigate changes in radon concentrations in residential environments. In this room, radon gas was exhlated from the floor and wall surfaces with different rate and ventilation path. 4 Rad7 (Radon monitoring instrument) were used for accurate radon measurement several points of the rooms. The results from active measurements were compared with the results of CFD simulation of the corresponding conditions and times. Proper matching of the simulated results and experimental data with the results of the analytical solution determines the accuracy of the modeling performed. Thus, CFD could identify the distribution of radon concentration in different location of an area which could be used as an indoor radon map to identify where radon is high and where exactly the mitigation has to be applied.

Exhalation Rates and Emanation Coefficients of $^{220, 222}$Rn at Aswan and Rashid Areas of Nile River in Egypt using NTDs

[1]E. H. Ghanim, [2]M. S. Barakat, [3]M. Dawoud, [4]A. Hussein, [4]H. El-Samman

[1]Basic Sciences Department, Faculty of Technology and Education, Beni-Suef University, Beni-Suef, East of Nile, Egypt.
[2]Protection & Civil Defense Department, Nuclear Power Plants Authority, Al-Dabaa City, Mattrouh Government, Cairo, Egypt.
[3]Geology Department, Faculty of Science, Menoufia University, Shebin El-koom, Egypt.
[4]Physics Department, Faculty of Science, Menoufia University, Shebin El-koom, Egypt.

In the present study, radon and thoron levels of some selected samples from both investigated areas were measured. These measurements were carried out using the cup-technique with nuclear track detectors (NTDs).

Also, the exhalation rates and the emanation coefficients of radon (^{222}Rn) and thoron (^{220}Rn) were included. The free exhalation rates for radon and thoron were found to be $(5.3\times10^{-2}\pm0.23)$ and $(1.7\pm1.3)\times10^{2}$ Bq.m^{-2}.h^{-1} for clay samples respectively. In case of sand sample's free exhalation rates of radon and thoron were found to be $(6.4\times10^{-2}\pm0.25)$ and $(4.1\pm2)\times10^{2}$ Bq.m^{-2}.h^{-1} for sand samples respectively. The emanation coefficients for radon were found to be (6.13) % and (4.48) % for clay and black sand samples respectively. While those for thoron were found to be (8.52) % and (11.70) % for clay and black sand samples, respectively. Results of this study are discussed within the frame work of nuclear track formation theories and etching mechanism in nuclear track detectors.

Radon and carbon dioxide as indicators of ventilation efficiency in selected public buildings

[1]M. Dovjak, [2]J. Vaupotič

[1]Chair of Buildings and Constructional Complexes, Faculty of Civil and Geodetic Engineering, University of Ljubljana, Ljubljana, Slovenia
[2]Department of Environmental Sciences, Jožef Stefan Institute, Ljubljana, Slovenia

Energy renovations with the increased tightness of the building envelope and decreased ventilation lead to poor indoor air quality. The requirements and recommendations for design ventilation rates (DVRs) are often insufficient, resulting in the accumulation of pollutants in the indoor air. In our study, the efficiency of ventilation was checked in some selected public buildings (kindergarten, primary school, hospital, dental clinic, elderly home) by using Rn in CO_2. Firstly, concentrations of Rn and CO_2 were continuously measured over several weeks in winter and summer periods by Radon Scout Professional devices (Sarad) and simulated in the CONTAM 3.2 program (National Institute of Standards and Technology, 2021). After, concentrations of Rn and CO_2 were assessed by varying the DVRs within six scenarios according to the legal requirements and recommendations. It was found that concentrations of Rn and CO_2 often exceed national and international limits, especially in small rooms with higher occupancy (e.g. playrooms, classrooms, offices). Energy-efficient buildings should not only be aimed at cost benefits but also at ensuring adequate DVRs to prevent the accumulation of pollutants above the limits.

The Hungarian Radon Action Plan is going on

[1,2]Zs. Homoki, [1]Á. Szigeti, [2]A. Csordás, [2]G. Tóth, [2]T. Kovács

[1]National Public Health Center, Department of Radiobiology and Radiohygiene, Budapest, Hungary
[2]Department of Radiochemistry and Radioecology, University of Pannonia, Veszprém, Hungary

The implementation of the Hungarian Radon Action Plan (HUN RAP) started in 2021. New nationwide radon surveys are in the main focus of the HUN RAP which are organised by National Public Health Center (NPHC) using governmental financial support. The year of 2021 spent with preparation work. During this time, the main achievements were the followings: setting up a radon working group, determination and purchase of the required instruments and sampling equipment, initiate the type test and authentication of radon measuring instruments. Additionally, it was needed to educate the new staff and develop the environment. We worked out a time schedule and working plan for the radon project and determination of the main element of the communication strategy. The main objectives of the HUN RAP are the long-term indoor radon measurements using SSNTDs and the determination of geogenic radon potential by the measurement of soil gas radon concentration and soil gas permeability on the whole territory of Hungary. It was obvious that amount of the tasks exceeds the capacity of the NPHC therefore the NPHC and University of Pannonia entered into a contract to divide up the planned examinations. The NPHC could start the effective organisation of the measurements in May of 2022, when all the ordered instruments were delivered. The University of Pannonia has already started the work in 2021. The organisation and execution of the examinations were made independently by the two institutions but applying the same concept. The European Union's grid cells map (10×10 km) was used to demonstrate the advancement in the examinations. Until September of 2022, at 829 sampling sites were examined the geogenic radon potential which cover 196 map cells from the 1036. We have got long-term radon results from 1.512 location points together with the results of former studies and measurement is in progress in 1224 buildings. These sampling points are located in 934 settlements from the 3176 and cover 630 map cells. The measurements will be continued in 2023 and results will be evaluated in 2024. The geogenic information will be used by the categorisation and evaluation of the geogenic radon result. The characteristic of the examined buildings and population of the settlements will be taken into account by evaluation of the indoor radon results.

Activity-weighted Particle Size distributions of radon and thoron progeny aerosols in the atmosphere

[1]M. Kiso, [1]A. Sampei, [2]C. Kranrod, [3]E. Djatnika N., [4]O. B. Modibo, [1]H. Hashimoto, [1]Y. Oda, [2]Y. Omori, [1,2]M. Hosoda, [2]S. Tokonami

[1]Hirosaki University Graduate School of Health Sciences, Hirosaki, Japan
[2]Institute of Radiation Emergency Medicine, Hirosaki University, Hirosaki, Japan
[3]Research Center for Safety, Metrology, and Nuclear Quality Technology- The National Research and Innovation Agency of Indonesia, Jakarta, Indonesia
[4]Research Center for Nuclear Science and Technology, Institute of Geological and Mining Research, Yaoundé, Cameroon

Radon progeny (^{218}Po, ^{214}Pb, ^{214}Bi, ^{214}Po) and thoron progeny (^{212}Pb, ^{212}Bi, ^{212}Po) attach to ambient aerosols in the atmosphere. These aerosols become radioactive, their size distribution governs the location of their deposition on the bronchus. Therefore, measurement of aerosol particle size distribution is important to evaluate internal exposure due to the inhalation of radon and thoron progeny. The activity median diameter (AMD) can be estimated by measuring particle size distributions of radioactive aerosols. After classification of the aerosols in particle size using a Micro-Orifice Uniform Deposit Impactor (MOUDI, Model 110, MSP, USA), activities of radon and thoron progeny in the classified radioactive aerosols were measured using ZnS(Ag) scintillation counters. Only, the radioactivities of thoron progeny were also measured after radon progeny completely decayed. Measurements were made on the roof of the Hirosaki University building in Japan. The results showed that the AMDs based on their mixed radioactivity in radon and thoron progeny ranged from 0.15 - 0.28 μm. Further, the geometric standard deviation (GSD) values were approximately 1.9 - 2.8 for the mixed radon and thoron progeny. In addition, the AMDs derived from only thoron progeny ranged from 0.17 - 0.30 μm with the GSDs of 1.7 - 5.7, which are similar to the range provided by mixture of both progenies.

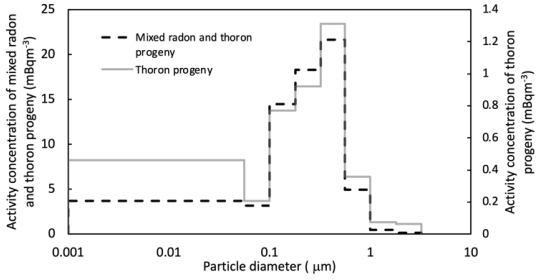

Fig. The activity size distributions of the mixed radon and thoron progeny and thoron progeny

Spatial and temporal variations of radon in the Szemlő-hegyi Cave, Budapest, Hungary

[1,2]I. Csige

[1]*Institute for Nuclear Research, Debrecen, Hungary*
[2]*University of Debrecen – ATOMKI, Department of Environmental Physics, Debrecen, Hungary*

The Szemlő-hegyi Cave in Budapest is open for tourists and is also used as therapeutic cave for children suffrenig from asthmatic diseases. Although toursits and patients spend rather limited period in the cave, staff, both of tour guides and medical staff are exposed to cave environment for elongated times. Therfore estimation of their exposure to radon should be a concern when planning working hour schedule underground. In this work we present the results of spatial and temporal variations of ^{222}Rn activity concentration measurements carried out from 1985 to 2020. Etched track detectors were placed at 20 different locations all along the cave path and were changed regularly montly and quarterly. Dataqua type semiconductor based radon monitors were also used to measure short term variations. Results show, that ^{222}Rn activity concentration shows a very regular seasonal variation with winter minimum and summer maximum, a pattern that can be explained by reversing the flow direction of natural ventilation of the cave. Even winter minima ^{222}Rn activity concentrations are relatively high, varying between 5 to 10 kBq/m^3, due to tight isolation of cave passagaes from outdoor environment. Rooms in the reception building, closely connected to the cave system, also show relatively high ^{222}Rn activity concentration, especially in summer times, reaching up to about 5 kBq/m^3. Regular long term variation and its correlation withsolar cycle was also observed.

Experimental verification of the areas with predicted increased radon potential based on integral measurements of indoor RAC

A. Brandýsová, K. Holý, M. Bulko, M. Müllerová, J. Masarik

Faculty of Mathematics, Physics and Informatics, Comenius University, Bratislava, Slovakia

Searching for localities with increased indoor radon exposure, the so-called „radon-prone areas", is an internationally recognized issue. There are many scientific studies that propose innovative approaches for identification of those localities using measured characterictics of the soil. Based on created radon potential (RP) maps of the Slovak Republic, the integral measurements of indoor radon activity concentration (RAC) were performed in several municipalities. An approximately linear relationship between predicted and measured indoor RAC was found. The results from measurements were used as an experimental verification of the RP predicton, while in one municipality located in the area with medium-high RP prediction, indoor RAC exceeding the reference level (300 Bq/m^3) was found also in houses built after year 2008. Since the emphasis is now on stricter standards for building materials (as one of the sources of indoor radon), this indicates that high content of radon in the soil has a significant influence on indoor RAC. In addition, the mentioned municipality is located in an area with ore and mineralogical uranium deposits.Radon potential predictions were also compared with standardized lung and bronchial cancer mortality data averaged over the period of 22 years (from 1996 to 2018) for individual districts of the Slovak Republic.

This work was supported by the Scientific Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic and the Slovak Academy of Science (VEGA project No. 1/0213/18, No. 1/0019/22 and No. 1/0086/22), Research and Development Support Agency (project No. APVV-21-0356) and Grant of CU for the Young Researches (grant No.G-22-30-00).

A conceptual model for radon transport in mofettes of Covasna area, Romania

[1]E. Sóki, [2]S. Gyila, [1,3]I. Csige

[1]Atomki - Isotope Climatology and Environmental Research Centre, Debrecen, Hungary
[2]Dr. Géza Benedek Hospital of Cardiology, Covasna, Romania
[3]University of Debrecen – Atomki, Department of Environmental Physics, Debrecen, Hungary

In this work we have measured the spatial variation of radon activity concentration in the the airspace of Cardiology Hospital, and in the air and water phase of Hell-Mud using etched track type radon detectors. We have developed a conceptual geological and physical-mathematical model describing the transport of mofette gases surrounding Covasna, with which the spatial and temporal behaviour of radon gas concentrations measured in the two mofettes could be successfully interpreted. The hydro- and gas dynamics model resulting from the conceptual model was also quantitatively compared with the measurement results. In order to find the most appropriate fit of model calculation results to measurement data we used the "trial and error" method during modelling. We have found that the relatively low radon concentrations at the bottom of these pools can be explained by the reduction of radon content of water by intense degassing of carbonated waters.

An intercomparison of thoron measurement for RAD7 devices in thoron calibration chamber at RRI

M. Adelikhah, A. Csordás, E. Tóth-Bodrogi, T. Kovács

Department of Radiochemistry and Radioecology, University of Pannonia, Veszprém, Hungary

Researchers around the world had already established that radon and thoron are a hazard to the human health. In several areas of the world, elevated radon and thoron concentrations have been found, and therefore concern about health risks from radon/thoron has been intensified. Several radon and thoron surveys have been initiated, but they have used many different measurement passive monitors (etch track detectors, activated charcoal and electret) and active instruments (ionization chambers, scintillation cells and solid-state detectors). Although the working principles are similar, it is difficult in practice to maintain a reasonable and accurate standard of measurement and quality. In addition, new laboratories and companies continually enter the field of radon and radon isotopes measurements and new measurement techniques and devices are still being developed. Consequently, it is necessary to improve and standardize technical methods of measurements and to ensure that radon and thoron testing devices and laboratories provide accurate and reliable data on radon and thoron levels.

An intercomparison of RAD7 radon/thoron monitoring detectors manufactured by DURRIDGE, USA was also conducted at the calibration chamber of RRI facility. The chamber contains ports to insert thoron gas from an external source. The detectors were exposed to thoron gases Two by Two in the thoron calibration chamber under well controlled conditions of temperature and relative humidity as well as thoron concentrations. The relative humidity inside the RAD7 is maintained at < 10% whilst the relative humidity in the chamber remains between 45 and 55%.

The thoron intercomparison have been carried out in 2 different exposure conditions of 1-3 kBq h m^{-3} (as lower concentration) and around 10 kBq h m^{-3} (as middle concentration) and one more reference RAD7 monitor device (calibrated by DURRIDGE) was used as a reference one. The range of relative deviation during intercomparison of RAD7 devices was found to be from 7% for higher thoron concertation to maximum of 22% for lower thoron concentration condition. In addition, regarding comparing the results to other international institutes, the Japanese National Institute of Radiological Sciences (NIRS) has reported that the calibration factor of the RAD7 for thoron is roughly 1.3 for their chamber. It is clear that this ratio is near to the value in this intercomparison experiment. Finally, it could reveal that the necessity of improvement on monitor calibration, thoron source makes and the necessity of more international intercomparisons.

The use of radon as a tracer for air pollution assessment: a case study in Bratislava, Slovakia

M. A. Sultani, M. Bulko, K. Holý, J. Masarik, M. Müllerová

Department of Nuclear Physics and Biophysics, FMFI UK, Bratislava, Slovakia

Being a noble and radioactive gas makes the radon (^{222}Rn) a useful tracer element for climatology and atmospheric research. In this work, boundary layer height (BLH) was determined based on radon activity concentration (RAC) continuously measured in Bratislava, Slovakia during 2020. BLH is the lowest part of the troposphere, which plays an important role influencing the behavior of atmospheric compounds. The BLH data have been used to investigate its influence on the surface concentration of pollutants (i.e., PM_{10}, $PM_{2.5}$, and O_3). For correlation analysis, the Sturges classification method was applied on BLH data to minimize the effect of factors such as emission rate, wind speed and chemical reactions on the pollutant concentration. Strong correlations were observed between BLH and air pollutant concentration, with correlation coefficients -0.71 for PM2.5, -0.75 for PM10 and 0.75 for O_3, respectively. As a result, the BLH has a considerable impact on the concentration of ground pollutants, which should be considered when evaluating the urban air quality.

This work was supported by the Scientific Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic and the Slovak Academy of Science (VEGA project No. 1/0213/18, No. 1/0019/22 and No. 1/0086/22), Research and Development Support Agency (project No. APVV-21-0356) and the scholarship of the Faculty of Mathematics, Physcis and Informatics.

Comparison of different spatial evaluation techniques in Geogenic Radon Potential mapping

[1]G. Tóth, [1]M. Hegedűs, [2]P. Tóth, [1]A. Shahrokhi, [1]A. Csordás, [1]T. Kovács

[1]Department of Radiochemistry and Radioecology, University of Pannonia, Veszprém, Hungary
[2]Bio-, Environmental and Chemical Engineering Development Centre, University of Pannonia

Radon and its daughter elements are usually the most significant contributors to the radiation exposure for the public from natural sources. Soil, in addition to building material is one of the most significant sources of radon. Geogenic Radon Potential (GRP) based on soil permeability and soil gas radon concentration is an index representing the potential indoor radon risk hazard from the surface soil independent from the influence of any building related or living habit factors. Radon risk maps based on GRP offer a chance to identify areas with a higher risk of developing indoor radon hazards, which may have implications with significant monetary consequences for home owners, the construction industry and local authorities. Soil permeability and soil gas radon concentration values were measured at 600 locations in multiple counties in the Northern Trans-Danubian region of Hungary. Mostly low and medium GRP characterizes the study area, with a sprinkling of high values. The data was processed into a raster map using 10×10 km grid cells according to the current European Union radon survey concept using 5 measurement locations per cell preferably located near settlements. Geogenic Radon Potential maps were generated using GIS software over the 10 km×10 km grid and multiple spatial interpolation techniques have been tested to determine which is the most suitable method for visually interpreting the measured data. Displaying only processed aggregate data in a raster or interpolation format may hide local outliers and worsens spatial resolution.

^{210}Pb dating as a tool for the investigation of environmental processes: From anthropic effects to climate changes

[1,2]R-Cs. Begy

[1]*Faculty of Environmental Science and Engineering, "Babes-Bolyai" University, Cluj-Napoca, Romania*
[2]*Interdisciplinary research institute on Bio-Nano-Sciences, "Babes-Bolyai" University, Cluj-Napoca, Romania*

Numerous environmental processes are influenced by anthropic interventions and climatic changes. The problems of soil degradation are all contributing to the destabilization of ecosystems. ^{210}Pb dating is an indispensable tool for the retrospective analysis of the last 150 years depositional signatures of various ecosystems such as peatlands and lake catchment areas, and allows for the assessment of the factors responsible for recent past changes within the studied area, by constructing high-resolution chronologies and correlating the obtained ages with other relevant proxies. Besides ^{210}Pb, ^{137}Cs proves to be an important alternative marker that validates the chronology. The last two decades are of the greatest importance, as climatic changes and most intense human interventions have manifested in this time-frame. To investigate the correlations between the land-use policies and erosional processes in catchment areas, the ^{210}Pb method was applied on Pănăzii watershed area, in Romania. Three distinct periods could be observed in the evolution of the sedimentation rate. The average deposition rate was 9.2 tons/year (1880-1958), followed by a high deposition period (1960–1991) of 29.6 tons/year and a third period (the last 30 years) of 15.7 tons/year. These sedimentation rates fluctuated depending on the main land use activity, and the highest were associated with agricultural practices. Sedimentation processes were also studied in four more lakes located in Romania. All the lakes are situated in protected natural areas, in which human activities are reduced or missing in the catchment. For Latoriței lake (Parâng), three periods can be identified with high sediment depositions peaks, in 1860 (0.25±0.02 g/cm^2), 1975 (0.3±0.02 g/cm^2) and 2000 (0.3±0.02 g/cm^2). In Zănoaga (Retezat) lake, the highest mass sedimentation corresponds to the 1977-1986 period, and to the year 1989 for Bâlea (Făgăraș) lake. The ^{210}Pb method was applied on six peatlands from Romania and Bosnia-Hercegovina. The periods of growth and degradation registered within the peat can be correlated, and are in agreement with local and regional drought events and variations in precipitation levels reported in the literature. The decadal temperature rise values corresponding to the 1980-2019 period were calculated. We obtained 0.28 ^{o}C/decade for peat bog Bijambar, 0.15 ^{o}C/decade for Vranica, 0.20 ^{o}C/decade for Violeta peat bog, for Hotenilor 0.19 ^{o}C/decade, for Iezerul Mare 0.19 ^{o}C/decade and for Vlasinescu 0.16 ^{o}C/decade. The average calculated values were 0.19^{o}C/decade, with only an 8.3% difference from the value of 0.18^{o}C/decade calculated by NASA.

Investigation of the radionuclides' vertical migration in the fallout at the bottom of the ChNPP cooling pond

D.E. Myznikov, V.A. Zheltonozhsky, V.I. Slisenko

Institute for Nuclear Research of National Academy of Science of Ukraine, Kyiv

This paper studies the isotopic composition and vertical distribution of radionuclides in the sediments found at the bottom of the cooling pond. The main radionuclides' activity was recorded at the pond depth of 10-20 cm. Analysis of the ratios of samples shows that these fallouts are associated with the first explosion of the 4th power unit of the Chornobyl nuclear power plant. Precipitation at a depth of 0-10 cm is mainly associated with the deposition of aerosol fallout during subsequent years. The isotope ratios of transuranium nuclides obtained by alpha-spectroscopic studies of the samples are close to the isotopic ratios in fuel rods of the 4th power unit of the Chornobyl nuclear power plant.

Why are gross activity measurements in water still used? Brief overview, current status and „replaceability" options

[1,2]V. Jobbágy

[1]Freelance researcher
[2]European Commission-Joint Research Centre, Geel (until 30 April 2022)

The presentation will give a brief overview on the gross alpha/beta activity determination in drinking water by introducing its past, current status and possible future applications. The current representative situation will be concluded from the results of two European wide proficiency tests (PT) organised for the European environmental radioactivity monitoring laboratories in 2012 and 2020. Both PTs yielded mainly not satisfactory performances. Sample preparation and measurement methods used by the approximately 180 participating laboratories were reviewed focusing on method-dependency of the measurement results. It was also an important goal to confirm if any of the gross-counting methods deliver more accurate measurement results than others or best practices could be identified. It will be briefly presented how to improve the situation in this field but the speaker would like to initiate discussions whether the current place of gross activity measurements in the analytical world is correct.

Since gross methods are just referred to as screening methods it may suggest that they can just be considered as qualitative analytical technique in a sense that indicating whether an activity concentration threshold is exceeded (see new Eurachem/CITAC guide, 2021). Then the whole interpretation of the gross alpha/beta activity analytical results should be revised fundamentally.

As it was identified, the majority of gross-counting methods suffer from trueness and repeatability issues. Furthermore, gross-counting methods without supporting radionuclide specific measurements of water samples can not provide true quantitative analytical results or even qualitative information (except liquid scintillation counting). Radionuclide specific methods have undisputable advantages over gross-activity counting: 1) clear identification of analytes, 2) metrological traceability can be established, 3) calculation of indicative dose from the individually determined radionuclides. Therefore, the inaccurate gross activity measurement methods should be replaced by rapid radionuclide specific screening procedures where qualitative and quantitative analytical data can be obtained with turnaround times comparable to the gross-counting methods.

What are building material indices and how are they related to each other?

M. Hegedűs, A. Csordás, E. Tóth-Bodrogi, T. Kovács

Department of Radiochemistry and Radioecology, University of Pannonia, Veszprém, Hungary

Most people spend a significant time indoors, and accordingly, they receive a significant part of their radiation exposure indoors. Currently the use of recycled materials and industrial by-products is viewed as a possibly lucrative opportunity, but it also carries the risk of increasing radiation exposure. There are many radiation indices used as screening intended for assuring that the building materials used in the construction industry do not pose a significant health risk for residents or workers, including radium equivalent concentration, external hazard index, internal hazard index, alpha index, representative level index, gamma-index, and more. These indices are based on the activity concentrations of gamma emitters in the ^{238}U, ^{232}Th decay chains, and ^{40}K. They have somewhat different underlying dose models, and with a few exceptions are not directly convertible to each other, even if they use the same input parameters, however many of them are closely related. Furthermore, these indices are in some cases used for evaluating implausible material and exposure scenarios, which may lead to erroneous conclusions. The types of commonly used indices will be presented together with their underlying assumptions and discussion about their comparison and their relative strictness.

^{210}Pb chronology applications in retrospective analysis of recent carbon accumulation rates in Romanian peatlands

[1,2]R-Cs. Begy, [1]C-F. Savin, [1,2]A. Avram

[1]Faculty of Environmental Science and Engineering, "Babeş-Bolyai" University, Cluj-Napoca, Romania
[2]Interdisciplinary Research Institute on Bio-Nano-Science, Babeş-Bolyai University, Cluj-Napoca, Romania

Peatlands are distinctive terrestrial ecosystems characterized by the accumulation of partially decayed organic matter, a particularity of peatlands is represented by their interaction with climate through the uptake and release of greenhouse gases, forming carbon pools. Although covering only ca. 3% of the total global land area, peatbogs play a major role in the global carbon inventory, storing about 30% of the terrestrial soil carbon. As peatlands are vulnerable to variations in precipitation and temperature, their carbon-storage capacity is threatened by a fast-changing environment, and for this reason these ecosystems constitute valuable archives of climate history. Considering the anthropic influences and accelerated industrialization of the last 150 years, the climate has undergone rapid changes, and the atmospheric carbon dioxide concentration increased with more than 47%. The retrospective analysis of recent carbon accumulation rates and carbon stocks of peatlands, and their variability in the last 150 years timeframe can prove to be an important tool in the assessment of the past and present state of these ecosystems, as well as their future role in the context of climate change. ^{210}Pb can be successfully used to construct high-resolution chronologies of peatbogs, covering the last two centuries period. For the present study, four ombrotrophic, sphagnum-dominated peatbogs from Romania, central Europe, were analyzed for their organic carbon content (C_{org}) and carbon accumulation rates (CARs) as well as the carbon stock contained in the investigated peatbogs layers. The results varied between 47.19 % and 57.42 % C_{org} and between 0.010 kg/m^{2}yr and 0.098 kg/m^{2}yr for CARs. Recently formed peat layers generally showed higher carbon accumulation rates, while organic carbon content was high throughout the whole investigated columns, with a small variance between the values. Our findings highlight the significance of peatlands for C sequestration and suggest that greater consideration should be given to peat C stores in national greenhouse gas inventories and conservation policies.

Determination of gross alpha and beta activities in soil samples

A. Csordás, E. Tóth-Bodrogi, T. Kovács

Department of Radiochemistry and Radioecology, University of Pannonia, Veszprém, Hungary

Some of the isotopes in the crust are incorporated into the food chain, increasing the internal radiation exposure. Depending on their physico-chemical properties, individual nuclides may be incorporated into certain critical organs for extended periods. From this point of view, the effects of gamma radiation are practically irrelevant, and it is mainly the damage caused by alpha and beta particles that may cause health risks. Plants are able to absorb radionuclides through two pathways: from the soil through their root system or from the atmosphere through their leaf litter. Uptake from the soil is strongly influenced by soil structure, composition, physical and chemical parameters, etc. The ability of individual nuclides to migrate also depends partly on these factors. Therefore, it is important to determine the relationship between the activity concentration of alpha and beta radiative isotopes in the soil and the soil parameters. In the area of nuclear metrology, the determination of alpha and beta emitting radionuclides is a very complicated, long-term and material-intensive chemical preparation. To simplify this, international recommendations often recommend the gross alpha and beta activity determination. The aim of the project is to determine the gross alpha and beta activities of the collected soil samples from Transdanubia and to compare the values obtained with the physical chemical parameters of the soils.

„SUPPORTED BY THE ÚNKP-22-4 NEW NATIONAL EXCELLENCE PROGRAM OF THE MINISTRY FOR CULTURE AND INNOVATION FROM THE SOURCE OF THE NATIONAL RESEARCH, DEVELOPMENT AND INNOVATION FUND."