VII. TERRESTRIAL RADIOISOTOPES IN ENVIRONMENT

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National Radon Action Plan in Hungary

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The work on the Hungarian National Radon Action Plan (RAP) was started in 2015 as collaboration between scientific radon laboratories operated by universities and the 'FJC' National Research Institute for Radiobiology and Radiohygiene (later NPHC). The RAP was already finalized in 2017, but was approved and published by the Government only in March 2019. The accepted RAP contains general objectives and requirements for the Hungarian radon program. The program covers the following issues: national representative radon survey, corrective and preventive actions, epidemiological study, communication strategy, governmental subsidy system, ministerial responsibilities. The work on the concept of the new national radon survey was started in 2017. The clarified, several modified document is standing before governmental approval. The planned survey involves the following types of measurements: indoor radon concentration and gamma radiation, soil gas concentration and permeability, soil radioactivity, fountain water test for radon. The concept includes detailed information about other programs required by the RAP: assessment of biological hazard attribute to radon exposure and communication strategy. According to our plan the preparation for the execution of the radon program will start in the middle of 2020 and in 2021 will begin the new national radon survey, which will be finished in 2023.

Radiological risk assessment of indoor radon concentration in a high natural background radiation area: a case study of Mahallat

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In this study, indoor radon concentrations present in thirty representative houses in Mahallat city, Iran, were determined in order to estimate lung cancer risk associated with residential radon exposure. Long-term passive method, using CR-39, was used to measure the radon concentration. The results showed an association between the age of the dwellings and the indoor radon concentration that was found, in that the concentration of radon tended to increase as the age of the dwelling also increased. The indoor radon concentrations were calculated to be within the range of 23±2 to 350±26 Bq/m^3, with an average of 158 Bq/m^3. The annual effective dose from inhaled radon and its decay products was calculated between 0.8±0.1 and 12.3±0.9 mSv/y, with an average of 5.5 mSv/y. By taking into consideration the EPA recommendation and ICRP statement, the average annual risk of lung cancer from inhaled radon was calculated as 0.09%, 0.06%, 0.01%, and 0.03% for current smokers (CS), those who had ever smoked (ES), never smokers (NS) and the general population, respectively.

Earthworm Species as in vivo sentinel organisms of NORM transder in soil ecosystems

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Earthworms (Oligochaete and Annelida species) are one of the most important bioindicators of soil services. This warrants measurements and data collection of at theri species for further matching of NORM effects on their organisms, measured in vivo, with transfer factor calculations from the in vitro data. Previously, in an in vivo earthworm model utilizing Positron Emission Tomography (PET) with ^{18}F- fluor-deoxy-glucose (FDG) tracer significant correlation was found between Cd exposure and kinetics of FDG uptake in the upper parts (above the clitellum) of earthworms. According to the literature, other toxic heavy metals may increase the deleterious effects of Cd. Our in vivo metabolism investigations targeted in vivo determination of NORM effects, such as U-235 in model earthworms (Eisenia fetida S.) kept in standardized soil spiked with over 100 Bq/kg soil of U-235. We also applied ^{99m}Tc-pertechnetate ion injection and subsequent SPECT quantitative imaging for Malpighi`s excretory organ function measurements. The purpose of this study was to map the correlation of environmental NORM content and the glucose uptake quantitative PET, with kinetic models established from image data and establishment of transfer constants. We found differences in FDG and ^{99m}Tc kinetics and uptake over time in NORM- treated earthworms. These are detailed in the presentation. Imaging based biomarkers like ^{99m}Tc SPECT and FDG-PET may provide previously unknown data about the physiological behaviour of NORM and heavy metals.

The new Austrian indoor radon survey – objectives, methodology, challenges and results

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In Austria, a representative population-weighted national indoor radon survey was carried out from 1994 to 2004 (ÖNRAP). As for that survey different measurement systems were used (including short term) and the number of radon measurements was low in most municipalities, it was decided - in the course of the implementation of the new EU-BSS - to conduct a new national survey. The main purpose of the new survey is to develop a data basis to delineate reliably radon priority areas. Therefore, a geographically-based survey with 6-months passive radon measurements in more than 25,000 dwellings was carried out from 2014 to 2019, province by province. The measurement points (dwellings) were selected according to defined rules (grid, geology, municipalities) among members of the voluntary fire brigade. In this contribution, we will present the methodology of the survey and evaluate the advantages and challenges. Furthermore, the measurements results and dependencies (geographic distribution, impact of e.g. building characteristics, geology) will be discussed. Although the survey was not designed to be representative for the Austrian population, we will test its representativeness and will compare the results with the population weighted national indoor radon survey (ÖNRAP).

Long-term measurements of radon and thoron exhalation rates from soil using the vertical distributions of their activity concentrations

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A long-term measurement technique of radon exhalation rate was developed using a passive-type radon and thoron discriminative monitor and a ventilation accumulation chamber by Zhuo et al. In the present study, this technique was applied to evaluate the thoron exhalation rate as well, and long-term measurements of radon and thoron exhalation rates were conducted for four years in Gifu Prefecture. The ventilation-type accumulation chamber (0.8 × 0.8 × 1.0 m) with an opened bottom was embedded 15 cm into the ground. The vertical distribution of radon and thoron activity concentrations from the ground were obtained using the passive type radon-thoron discriminative monitors (RADUET). The RADUETs were placed at 1, 3, 10, 30 and 80 cm from the ground inside the accumulation chamber. The measurements were conducted from Autumn, 2014 to Autumn, 2018. The long-term measured results were found to be in good agreement with the values obtained by an in-situ exhalation monitor. The exhalation rates of both radon and thoron from soil showed a clearly seasonal variation. Similar to the previous studies, radon exhalation rates from summer to autumn were relatively higher than those from winter to spring. In contrast, an opposite trend of thoron exhalation rate was found in this study due to the high precipitation in summer seasons.

Simple Technique for Measuring the Activity Size Distribution of Attached Radon and Thoron Progeny for Dose Assessments

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In this study, a portable cascade impactor was developed to determine the activity size distribution of radon and thoron progeny in a natural environment more efficiently. The developed impactor consists of 4 stages with a backup filter stage for collection of aerosol samples. The aerosol cut points were set for 10, 2.5, 1 and 0.5 μm at a sampling rate of 4 L min-1. Five CR-39 chips were used as alpha detectors for each stage. To separate alpha particles emitted from radon and thoron progeny, the CR-39 detectors are covered with aluminium-vaporized Mylar films. The thickness of each film was adjusted to allow alpha particles emitted from radon and thoron progeny to reach the active surface of the CR-39 detectors. The particle cut-off characteristics of each stage were determined by mono-dispersive aerosols with particle sizes ranging from 0.1-1.23 μm from the collection efficiency curve. The test results show that the cut-off size of stage 3 and 4 are close to the designed cut-point. Validation of the technique was performed with commercial devices and results confirmed that the developed technique can provide the necessary information to estimate the activity size distribution of attached radon and thoron progeny for dose assessment.

The analysis of results of radon/thoron measurements performed with the use of nuclear track detectors

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Radon has been identified as one of the most important hazards, causing lung cancer. The most important isotope of radon is ^{222}Rn (3.83 days), while thoron ^{220}Rn (55 s) is treated as the less important isotope due to its short half-life. The radon/thoron hazard for people is related to inhalation of their decay products, but usually, only measurements of radon gas are done in dwellings. For such a purpose nuclear track detectors are used in most of the cases. Since several years simultaneous measurements are done to estimate thoron contribution to indoor radon and thoron exposure with the use of track detectors, too. Typically, a set of two detectors are applied and thoron concentrations are calculated on the basis of discriminative calculations. Unfortunately, very often results of these surveys are not accurate due to underestimation of the Lower Limit of Detection (LLD) for thoron in the presence of elevated radon concentrations. Therefore an analysis of thoron LLDs in relationship to radon concentrations is presented.

Significance of Thoron Measurement in Indoor Environment

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Exposure to radon, ^{222}Rn, is the most significant source of natural radiation to human being. It is an establish fact that exposure of high radon is one of the causative factors of human lung cancer. Although thoron, ^{220}Rn, has been a traditional object of study in atmospheric science but it has received relatively less attention than radon. The presence of thoron was often neglected because it was considered that the quantity of thoron in the environment is less than that of radon. However, recent studies have shown that the dose due to exposure to thoron and its progeny can equal or several times exceed that of radon and its progeny. Many studies found that thoron can be a significant contributor to the radiation dose in residential buildings. The results of radon, thoron and their progeny measurements in the houses of normal and high background radiation areas (HBRA) of India using both active and passive techniques in different types of houses are presented here. A comparison between the results obtained with various techniques is also presented. The effectiveness of various thoron and progeny measurement techniques and their usefulness in estimating the dose to general public are discussed in details.

Simultaneous measurements of radon and thoron PAEC concentrations in air with use of TLD monitor

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The idea to use the device with thermo-luminescent detectors (TLD) for simultaneous measurements of radon (Rn-222) and thoron (Rn-220) decay products concentrations has been invented and developed in the Silesian Centre for Environmental Radioactivity in the Central Mining Institute, Katowice, Poland. The results of the preliminary analysis of the technical applicability, the required minimum period of air sampling and the optimized time schedule have been a proof that such measurements could give information of potential alpha energy concentrations (PAECs) of radon and thoron decay products. Afterwards, the preliminary measurements have been performed at several locations – in thoron chamber, in dwellings and even outdoors. In the paper results of these measurements are presented.

Seasonal indoor ^{222}Rn and ^{220}Rn measurements and inhalation dose assessment for inhabitants in Mashhad, Iran

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Although radon and its progenies are the main contributors in inhalation dose for the public, thoron has gained increasing attention among health physicists in recent years. The health risk associated with radon is due to lung tissue damage caused by α-particles from the decay of radon and its non-gaseous daughters suspended in the atmosphere [1, 2]. In this paper, we aimed to measure indoor radon/thoron to calculate the effective dose caused by the inhalation of radon and thoron in 78 dwellings of Mashhad city, Iran, over 90 day periods (Winter and Summer season) using a passive integrated radon–thoron discriminative detector, commercially named RADUET. After the exposure, the CR-39 plates were chemically etched for 3 hours in 6 M NaOH solution at 90 °C, and alpha tracks were counted using optical transmission microscope and image analyser software. The calibration factors were determined as a result of test exposure in separate radon and thoron calibration chambers, as described in [3]. The indoor radon concentrations in winter season varied from 75±11 Bq.m^{-3} to 376±24 Bq.m^{-3} with a mean value of 150±19 Bq.m^{-3} whereas thoron concentrations lied in the range from below the LLD to 166±10 Bq.m^{-3} with a mean value of 66±8 Bq.m^{-3}. In case of the summer season, indoor radon and thoron concentration were between 50±11 and 305±24 Bq.m^{-3} with a mean value of 115±18 Bq.m^{-3} and below the LLD to 122±10 Bq.m^{-3} with a mean value of 48±6 Bq.m^{-3}, respectively. The yearly average indoor radon and thoron were 132±19 Bq.m^{-3} and 58±7 Bq.m^{-3}, respectively. The corresponding annual average effective dose was 3.7±0.5 mSv.yr^{-1}. With a corresponding excess life cancer risk (×10^{-3}) calculated to be 14.13. Hence, the indoor radon exposure could be responsible for approximately 12% of lung cancer deaths in this city, which is close to the WHO estimates of the worldwide proportion of lung cancer due to radon (3-14%) [4]. Comparing the annual indoor effective dose rate from gamma exposure and annual effective dose from inhalation of radon and thoron, it could be concluded that most of the received dose in the indoor environment of dwellings in Mashhad are from radon and thoron inhalation (about 79% of the total dose). Based on the

Kolmogorov–Smirnov test, the normality distribution of radon and thoron concentrations in any of the following sub-factors is rejected. By applying the Kruskal–Wallis nonparametric test with Dunn's post-hoc analysis, the null hypothesis, the absence of statistically significant difference in the average gas concentration, is rejected; therefore, the season and type of gas affect the amount of gas concentration (P-value < 0.05).

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Inter-comparison on the measurement of the thoron exhalation rate from building materials

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Thoron (^{220}Rn) exhalation from building materials has become increasingly recognized as a potential source for radiation exposure in dwellings. However, contrary to radon (^{222}Rn), limited information on thoron exposure is available. As a result no harmonized test procedures for determining thoron exhalation from building materials are available at present. This study is a first interlaboratory comparison of different test methods to determine the thoron exhalation and a pre-step to a harmonized standard. The purpose of this study is to compare the experimental findings from a set of three building materials that are tested, and identify future challenges in the development of a harmonised standard.

Open problems in radon research

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For the last 2 decades, environmental radon has been given increasing attention in Europe, primarily due to its radiological significance, but also its potential as tracer of various ecological processes. Its radiological importance motivated stricter regulation, latest the European Basic Safety Standards (BSS) Directive in 2013. Among much other, it requires EU Member States to establish National Radon Action Plans whose objective is reduction of radon exposure. Also a number of non-EU countries have adopted the BSS or the similar BSS by the IAEA in original or modified form. During implementation of the BSS certain challenges have been recognized. The practice of fulfilling the action plan means, taking decisions about action aimed to establish, assure or verify compliance with law. A decision must be quality assured (QAed) in the sense that it should be reliable and legally defendable. This in turn entails that the steps in the procedure which lead to a decision must be QAed. In the realm of radon action plans, this concerns QA of measurement, i.e. classical metrology, and of models which underlie for example estimation of radon priority areas or of doses. Some of the challenges have been addressed in the Euramet / Empir project Metro Radon (2017-20). Among subjects included were precise determination of low indoor radon concentration, influence of thoron on radon measurement and estimation of radon priority areas and their respective scientific bases. However, issues remained open because of the limited capacity of that (already large) project, or emerged during work on it. Some topics shall be addressed.

• Metrological QA: Performance under lab vs. field conditions; Rn and Tn progeny measurement; new cheap semiconductor-based Rn monitors; particular QA challenges of Citizen Science.

• Characteristic of indoor environments: Rn levels in dwellings vs. workplaces; particular behaviour of "Big Buildings"; and consequent legal questions.

• Temporal variability of Rn concentrations in different environmental compartments: consequences for long-term estimates and for mapping.

• Mapping problems: Impact of urbanisation; accounting for Rn extremes; new estimation techniques (machine learning); the Rn hazard index.

• Integral indoor air hazard, as radon is only one of a number of hazardous indoor air pollutants.

• Politics & sociology: Low Rn awareness of the public is notorious. How to better involve stakeholders? Potential of Citizen Science?

• Radon as tracer: Time series analysis for seismic prediction; atmospheric transport studies.

By the way, we do not know whether Rn is "colourless, odourless, tasteless".

Radon in older single-family houses in localities with high geogenic radon potential

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In areas with a high content of radon in the soil air there is a high risk that radon will contaminate also the indoor air. Areas in which radon concentrations in residential areas are increased due to natural (geogenic) causes, i.e. due to a high concentration of radon in the subsoil, are also referred to as radon prone areas [Bosew, 2014]. The locality in the northern part of southern Slovakia in the vicinity of NPP Mochovce, which occupies an area of approximately 24x22 km^2, was in the past mapped in detail for the presence of natural radionuclides in the subsoil. The density of radon activity concentration measurements is ~0.6 point/km^2; the soil air sampling was performed at a depth of 0.8 m. Subsoil permeability data are also available for this site. Based on these data, radon potential maps for this site have been constructed according to Neznal et al. [2004]. After rescaling of these maps, several villages were identified as being located in the areas with high radon potential. Consequently, radon activity concentration (RAC) measurements were carried out in houses of these villages; most of these houses were built before 1990. In 53% of the monitored houses, the reference level of 300 Bq/m^3 was exceeded in the winter period; majority of these houses (94%) were built before 1970. The houses where the RAC exceeded the reference level were then monitored throughout the year using integral track detectors which were replaced every 3 months. RACs exhibited seasonal variations in all houses, with minimums in spring and summer and maximums in winter. The average annual RAC values in individual rooms of these monitored houses ranged from 420 to 780 Bq/m^3. These variations are presented in the paper in more detail.

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^{222}Rn in spring water close REE and Uranium mines in Middle and North of Vietnam

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In North and Middle of Vietnam, there are fifteen of Uranium and Rare-Earth-Element mines which are being explored and mined. Those mines can be the reasons of high radioactivity expose to environment, therein ^{222}Rn in spring water is one of the important target to access the impact of exposure near radioactivity mines. The ^{222}Rn concentration were determined by RAD-7 radon detector during 2019. The preliminary results showed that variation concentration of ^{222}Rn in spring waters varies from 70 Bq/m^3 to 35000 Bq/m^3 for areas, except for that of MH area, which is reached to 89900 Bq/m^3. The concentration of ^{222}Rn is higher in dry season and lower in rainy season. This result is explained because of ^{222}Rn in spring waters leaching from near radioactive mines. The low concentration of Radon in rainy season is due to dilution of ^{222}Rn by meoteric water. Based on the results, the natural radiological hazard was assessed also.

CFD based simulation of thoron concentration in a calibration chamber and radon distribution in a naturally ventilated room of a semi-detached house

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It is well known that the inhalation of radon, thoron and their decay products contribute the largest fraction (52%) of the natural background radiation dose to humans [1]. Most of the past studies have been focused on radon, neglecting ^{220}Rn contribution due to its shorter half-life [2]. The release of ^{220}Rn is an issue of concern from the radiological point of view for occupational environments for example pertaining to the thorium fuel cycle. Studies for understanding its release and developing systems to control it are crucial for exposure control research. The ^{220}Rn distribution and its state of mixing inside the calibration chamber, is simulated using ANSYS&FLUENT 2020 R1 software based on Computational Fluid dynamics (CFD). There exist studies wherein CFD has been used to study ^{220}Rn distribution in rooms and dwellings [3-4]. This work attempts to employ CFD technique to assess the ^{220}Rn distribution in confined volumes in the presence of a forced flow. Simulations have been carried out with a ^{220}Rn source in a cylindrical chamber of 0.2 m^3 volume. The study aims to obtain transmission factor of ^{220}Rn (i.e. Cout/Cin) for different configurations of inlet-outlet positions and flow rates in a thoron calibration chamber available in the Institute of Radiochemistry and Radioecology at the University of Pannonia and also simulate the distribution of indoor radon levels in a naturally ventilated room of a semi-detached house. The results show that the flow and the position of the inlet and outlet play an imperative role in the transportation, mixing and subsequent concentration distribution of thoron inside the chamber. A comparison has been made with the uniform mixing model and it is found that the results of simulation are close to the uniform mixing model at the tested flow regime. Our results clearly show the applicability of using the uniform mixing model to describe thoron distribution in a calibration chamber and highlight the need of CFD based predictions, especially for thoron which has a very short half-life. A three-dimensional room with size 3.0×2.8×4.0 m^3 was the basis of the study of the indoor distribution of radon. The room included one window in the middle of the right wall, which opens to the outer environment, and a door (2.2

m×1.0 m) on the left side of the front wall. The complete volume was meshed in the ANSYS mesher using 2,851,839 unstructured hexahedral cells with a minimum volume of 5.81×10-7 m^3. Hexahedral cells were chosen because the specified volume can be modelled with high accuracy. The results from analytical solution and numerical simulations showed that air change rate, indoor temperature and moisture had significant effects on indoor radon concentration.

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Analysis of climatic influences on indoor radon concentration with applicability in calculating temporal correction factors

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The estimation of the annual indoor radon concentration is most often based on passive measurements, that can last from 1 month to 1 year. Under these circumstances, temporal correction factor must be applied, in order to estimate the annual radon concentration. Significant variations in the temporal correction factors from one dwelling to another, within the same period of time, were observed in many studies. Using an averaged seasonal correction factor can increase the uncertainty associated with the estimated annual concentration and it may lead to inaccurate estimates of actual exposure. Therefore, it is recommended that either the passive detectors be installed for a longer period of time (6-12 months) or by reducing the uncertainties associated with the seasonal correction factor assessment. The increase of measurement period, however, is not often an option in the present age of speed. The necessity of accurate and more reliable seasonal correction factors is severely noted, therefore, this task became the aim of the present research study. In this sense, active radon measurements were continuously carried out for one full year in 80 residential buildings, located in 5 of the major cities of Romania. Indoor air quality monitoring systems (ICA), developed by the "Constantin Cosma" Radon Laboratory (LiRaCC) were used for this study. The annual radon concentration determined in the present study had a normal distribution, with an arithmetic mean of 192 Bq/m^3 and a standard deviation of 92 Bq/m^3. The ratio between the summer season' months and those of the winter season presents an average of 0.3 with a range of values between 0.07 and 1.44. These values indicate that bulk of buildings do not present a single profile, for which to apply the average value. It is, therefore, necessary to

identify a range of indoor/outdoor factors which could indicate the potential deviation of a house from the average value, respectively the quantification of the degree of deviation in relation to the average. The multivariate statistical analysis established that the difference of the inside-outside temperature represents one of the most important factor in this deviation, a determination coefficient of 0.5 ($p < 0.01$) was obtained for the relation between the temporal correction factor and the temperature differences. The obtained results could represent a reference point in the elaboration of new strategies for calculating the temporal correction factors and, consequently, the reduction of the uncertainties related to the estimation of the annual radon concentration.

Gamma dose rate levels and radon concentrations in Hungarian homes

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The biggest part of the natural radiation exposure of general population originates from the inhalation of radon daughter elements and exposition to indoor gamma-radiation. As it is well known, the two main sources of indoor radon are the soil gas infiltration and building material exhalation. The arithmetic mean value of long-term indoor radon concentrations is about 110 Bq/m^3 and the calculated annual doses from inhalation are 1.95 mSv/a and 5.21 mSv/a using the conversion factors of ICRP 65 and ICRP 137, respectively. The main contributors to indoor gamma-radiation exposure are the radioactive decays of natural radioisotopes of the building materials. This external dose originates from the elements of U-238, Th-232 decay chains and K-40, respectively. According to our results, the indoor gamma dose rate is about 1.6 times higher comparing to the outdoor gamma dose rate. The mean outdoor level is about 100 nSv/h, while the mean indoor level is 157 nSv/h. The annual dose rates originating from these exposures are 0.14 mSv/a and 0.63 mSv/a, respectively. The level of indoor gamma dose rate can be estimated, when the type of building materials and the building structure is known, since most of the building materials can be characterised by a certain range of radioactivity. The concrete, gypsum, Ytong, limestone shows the lowest radioactivity. Usually, the gas concrete blocks has a little bit higher radioactivity and normally the highest gamma radiation level can be measured at the surface of burned clay bricks. Furthermore, slag (and dross) was used as constructing materials from the end of 1800's until the end of 1980's. The radioactivity of slag can be much higher and consequently can contribute significantly to the indoor gamma dose rate and radon levels. During the survey of homes, the gamma dose rate level is measured by active detectors within the frequently used rooms at a few points and several heights. Additionally, radon concentration is detected by active detectors in one or two selected rooms for 3 – 7 days under minimalized ventilation. From the analysis of these short-term radon measurements it can be recognized that under closed conditions, the radon level follows mainly two main patterns: i) moves around a constant level or ii) increases at the beginning and saturating at a certain level. The median value of radon growth speed is 10 Bq/m^3 per hour, but sometimes it exceeds 30 Bq/m^3 per

hour. This later phenomena was recognized typically in buildings, where slag was built in into the floor spaces.

Radon-based atmospheric mixing classification: identifying uncertainties by application of machine learning methods

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The machine learning methods, linear regression (LR) and random forest (RF), are applied to predict the diurnal course of radon and selected urban pollutants under different atmospheric mixing states, as determined using a recently-developed radon-based classification technique. Data were collected during summer (June to August, 2018) in the Ljubljana Basin, and the radon concentrations were measured with an AlphaGUARD PQ2000 PRO (Bertin Instruments), operating in diffusion mode with a 60-minute integration time. The response time of the AlphaGUARD appeared to be a limiting factor of the technique's accuracy. We approximated a response time correction by first smoothing the hourly radon data with a 3-point running mean (to reduce noise in the low ambient radon conditions), then artificially increasing the sampling frequency to 30 minutes by linear interpolation. We then made duplicate radon time series with time shifts of 30 to 60 minutes. The LR and RF models were run on the observed and time-shifted radon data. In the modelled radon series without any time shift, the morning peak radon concentration was underestimated and the evening peak value was overestimated. Since the ambient radon concentration changes rapidly in the morning and evening, and the AlphaGUARD was operating in diffusion mode, this underestimation/overestimation of modelled radon concentration may be caused by a slow response time of the instrument. However, in the two modelled radon time series (shifted for 30 min and 60 min) the underestimation/overestimation radon peaks decreased, which is a good indication that AlphaGUARD approximately report with a 60-minute delay what is happening in the lower atmosphere. Since our results clearly demonstrate that deriving a better response time correction for the AlphaGUARD would be quite useful for the interpretation of their output when making continuous observations of near-surface atmospheric radon concentrations, this will be a topic for our future research.

Indoor radon concentration in 88 Hungarian kindergartens

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It is well known that children are one of the most sensitive to all kinds of harm, including ionizing radiation. Thus knowledge about the harmful radon in kindergartens, self- evident aim of us all. Accordingly, annual average indoor radon activity concentration was studied in 88 Hungarian kindergartens in 76 towns of 10 different counties. Targeted at kindergartens this is the first such survey in Hungary. None of the kindergartens has higher annual average indoor radon activity concentration than the recommended reference level, 300 Bq m^{-3}, not even in the seasons separately. Annual average indoor radon activity concentration in the kindergartens was 61 Bq m^{-3}, maximum was 160 Bq m^{-3}. In the kindergartens the seasonal variation of radon is not so strong like in dwellings, because of the permanent ventilation and the closed period during the summer break. Effect of building material, room type, window's type, year of construction and presence of cellar, insulation, and slag built-in were also studied.

IAEA technical support for environmental radiological monitoring and assessment

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The International Atomic Energy Agency's fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation. The IAEA Environment Laboratories are supporting its Member States (MSs) to improve capabilities in the field of environmental monitoring and dose assessment by means of:

- Strengthening capabilities and quality assurance for the measurement of radioactivity in the environment;
- Harmonization of approaches and parameter values for dose model predictions;
- Training activities and guidance for sampling approaches and dose assessments;
- Coordination and information exchange.

The reliability of the model's predictions depends on the quality of the data used to represent radionuclide transfer through the environment. The IAEA has for many years supported efforts to assemble sets of transfer parameter data for human food chain and wildlife for temperate regions and conditions. This work is currently extended also to non-temperate areas (arid and humid tropical areas) with different types of soils and vegetation, different climatic conditions which might potentially influence the transfer of radionuclides. Particular attention is also focusing on the sampling approaches and techniques used to derive the data within the radiological monitoring programme for different exposure situations.

Natural radioactivity concentration in thai medical herb plants

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Usage of herbal medicine has been promoted in Thailand as a popular alternative to the modern medicine. It is one of the radiation exposure pathways for the local population. In our study, the natural radioactivity concentration of ^{226}Ra, ^{228}Ra, ^{40}K and ^{210}Po in various herbs used in the Thai herbal medicine has been measured and compiled. The herb samples have been collected from the dry herb packed in medicinal capsules (99 kinds with 214 samples) and the fresh herb plants (5 kinds and 36 samples). The activity concentration of the ^{226}Ra, ^{228}Ra and ^{40}K was determined by gamma-ray spectrometry while that of ^{210}Po was determined by alpha spectrometry. The activity concentrations of the dry herbs were found to range from <0.20 to 89.92 Bq kg^{-1} for ^{226}Ra, from <0.10 to 39.62 Bq kg^{-1} for ^{228}Ra, from 4.83 to 2761.33 Bq kg^{-1} for ^{40}K and from 0.32 to 47.13 Bq kg^{-1} for ^{210}Po, while the activity concentration of the four isotopes in the fresh herbs were found in the range of <0.2-7.6, <1.2-67, 292-2339 and 0.98-27 Bq kg^{-1}, respectively. The highest activity concentration of ^{226}Ra was found in the houttuynia cordata, while the highest concentration of ^{228}Ra ^{40}K, and ^{210} Po was found in Elephantopus scaber. In order the quality control the sample preparation process of the fresh herbs, the cross-check measurement was conducted on similar samples prepared from multiple laboratories.

Evaluation of TENORM Concentrations (^{210}Po, ^{226}Ra, ^{232}Th, ^{40}K) and Trace Element Levels (Al, Fe, Mn, Ni, Zn, Pb, Cr) using Sea grass (Posidonia oceanica)

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Sea grasses are the important habitat forming organisms in marine environment. Mediterranean endemic seagrass, Posidonia oceanica (L.) Delile, 1813, recognized as key ecosystems in soft-bottom sediments. According to EU legislation (Habitat Directive), the Bern and Barcelona Conventions, P. oceanica is a protected species. P. oceanica is also included in UNEP-MAP-RAC/SPA-2009 for protected in the countries along the Mediterranean Sea. Moreover, P. oceanica meadows are under protection with the "Circular on sea and inland waters n°37/1" in Turkey (UNEP-MAP-RAC/SPA-2007). Generally sea grasses stabilize sediments, decelerates water movements, trap heavy metals, thus improving the water quality. Increasing urbanisation and industrial activities become a threat for marine environment. Especially industrial pollutants such as radionuclides and trace elements endanger the marine life. The objective of this study is to evaluate the marine ecological impacts of TENORM (Technologically Enhanced Naturally Occurring Radioactive Material) and trace elements. Trace elements are essential for organisms such as Fe, N and P. Also, some trace elements have toxic effects like Cu and Hg. In this study, ^{210}Po, ^{226}Ra, ^{232}Th and ^{40}K activity concentration levels in P. oceanica at five different stations (Foça, Gerence, Çökertme, Mersincik, Yediadalar) were determined. ^{210}Po activity concentration was determined by alpha spectrometry using PIPS detectors after radiochemical separation and spontaneous deposition of polonium on a copper disc. For gamma measurements, each samples were sealed and stored for 4 weeks for secular radioactive equilibrium between ^{226}Ra and ^{222}Rn. A gamma-ray spectrometer consisting of a 3"×3" NaI(Tl) scintillation detector coupled with a multichannel analyzer was used for the spectral measurements of naturally occurring radionuclides (^{226}Ra, ^{232}Th and ^{40}K). Trace elements were determined by energy dispersive x-ray fluoresence spectrometry

(EDXRF, Rigaku Nex CG). Concentrations of the radionuclides have compared with at each stations.

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Radium isotopes concentration in mineral and spring bottled waters as well as in natural medicinal waters: a survey in Poland

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In the last few years in Poland, the annual consumption of natural bottled mineral and spring waters is growing steadily. The source of those water is various. Very often they are taken from surface springs or shallow wells. On the other hand, highly mineralized waters used in medical treatment are extracted from deep-bored wells. Due to the origin of the water, it may contain naturally occurring radioactive isotopes. The most important radionuclides are ^{226}Ra, ^{228}Ra,^{238}U and ^{234}U as they could cause the highest doses due to consumption by people. In the frame of the work, radium isotopes were determined in natural mineral and spring waters which are easily accessible throughout Poland as well in medicinal water, directly sampled from health resorts. Concentration of radium isotopes was measured by means of liquid scintillation spectrometry prior to chemical separation.

Gross alpha and gross beta activities in various marine species in Vietnam

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Fish are a staple food in many diets, including the Vietnamese diet, and assuring public safety requires the radiological screening of foodstuff consumed in large quantities. Gross alpha and gross beta activities were measured in the edible muscle tissues of eleven selected marine species gathered along the coast of North Vietnam. The observed gross alpha and gross beta activity concentrations varied from 10.2 ± 1.5 to 73.2 ± 8.1 Bq/kg (wwt) and from 10.6 ± 0.4 to 68.8 ± 2.8 Bq/kg (wwt), respectively. Bigfin reef squid (Sepioteuthis lessoniana) had the lowest alpha activity which has a carnivorous diet while the highest alpha activity was recorded for blood cockle (Anadara granosa) which has an omnivorous diet. The gross beta activities were similar in both carnivorous and omnivorous species. The highest gross beta activities were observed for Narrow-barred Spanish mackerel (Scomberomorus commerson) and lowest values were observed for Bigfin reef squid & squid (Teuthida), respectively. All three species are carnivorous. The calculated annual committed effective dose resulting from the consumption of 25 kg of fish meat per year varied from 192 to 1375 μS with an average of 689 μS.

^{210}Po in Northern Vietnamese thermal water sources

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^{210}Po, is a natural alpha-emitter natural isotope, and it is responsible for a considerable amount of the internal radiation dose. There are eight famous thermal water sources, with medium temperature, natural pH, and high TDS values in North Vietnam, which are utilized as heat sources, as drinking water, and for spa activities. Investigation of the waters' characteristics both chemical and radiological is an important task to assure public health and safety. The major ions found were Na, K, Mg, Ca, Sr, while the trace amounts of rare earth elements (REE), Ag, As, Pb, Th, U were also present. The ^{210}Po activity concentration and the calculated annual committed effective doses were far less than the guidance levels of WHO which are 100 mBq/L and 0.1 mSv/y, respectively.

Radionuclide content of drinking water in Hungary - How can hydrogeological approach help to understand? A case study in the vicinity of a granitic complex

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Previous studies have already shown high natural radioactivity in the vicinity of Velence Hills. High uranium concentration values were measured related to the granitic rocks in Velence Hills and related to the carbonatic and organic-rich beds of the siliciclastic sediments in the foreland of Lake Velence. Until recently, no observations and measurements were made regarding the radioactivity of the groundwater. The natural radioactivity of groundwater, as a possible threat for human health, has been investigated for a few decades as groundwater is a very common drinking water source. In Hungary, following the Euratom Drinking Water Directive the radioactivity of drinking water is screened by gross alpha and gross beta activity measurements. Gross alpha activity values exceeding the limit were measured in drinking water in the foreland of Lake Velence. To identify the radionuclide which is responsible for the high activity values and to understand the spatial distribution of the elevated activity concentrations nuclide-specific measurements were carried out and were evaluated in a hydrogeological approach. A total of 53 samples were taken from surface water as well as from groundwater. Alpha spectrometry applied on Nucfilm discs was used to measure uranium (U-234, U-238) and radium (Ra-226) activity while radon (Rn-222) activity was determined by TriCarb 1000 TR liquid scintillation detection. In groundwater, the presence of the soluble members of the uranium decay chain (i.e. uranium, radium and radon) is affected by physicochemical properties such as pH, redox potential and chemical composition of the groundwater. These parameters vary along the groundwater flow paths and with regard to the change of regime characteristics. Therefore, those areas can be delineated where according to the flow conditions and the related geochemical environment the mobility of the uranium or radium and thus elevated activity concentration can be expected in groundwater. The results of the study have proved that the areal variability of the natural radioactivity of the groundwater is strongly affected

by the groundwater flow conditions along with geological features. This study proved that flow system approach and its methodology may facilitate the safe water management of drinking water supply systems.

This study was supported by the ÚNKP-17-4 and ÚNKP-18-3 New National Excellence Program of the Ministry of Human Capacities and it has also received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 810980. The conference participation is supported by the József and Erzsébet Tóth Hydrogeology Chair.

Geochemical characterization of monazite sands in placer deposit from Kanyakumari southern coast of Tamil Nadu, India: Implication of Uranium isotope ratios and high content of rare earth elements

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Kanyakumari region in southern coast of Tamil Nadu, India is a well-known natural high background radiation area due to the abundances of monazite in the beach placer deposits. Natural gamma dose rate measurements were carried out covering an area of 50 km along the coastal belt. The ambient dose rate varied from 65 nGy h^{-1} to 25.5 μGy h^{-1}. Based on the ambient dose rate 23 locations were selected for sand sample collection. The main aim of the study is to understand radiological as well as geochemical characterization of placer deposit. Monazite is an ore mineral for Th with relatively high concentration of Ce, Nd and U. The activity concentration of ^{226}Ra, ^{228}Ac and ^{40}K were measured by a High purity Gemanium (HPGe) gamma spectroscopy and associated radiological hazard parameters were estimated. The concentration of major oxides and U, Th and REEs were measured using XRF and ICP-MS respectively. TiO_2 and Fe_2O_3 concentrations are high compared to average upper continental crust. High TiO_2 could be attributed to the presence of ilmenite in the sands. Average ΣREE concentration in sand samples is about thirty times higher than the average crustal concentration. The LREE/HREE is greater than 1 with negative Eu anomaly, it could be either felsic or granitic source. On the other hand, Th/U ratio ranged from 8 to 24 which clearly indicates Th is the dominant radionuclide for the enhanced natural radioactivity in the environment. The concentration of U varied from 18 to 230 μg g^{-1}. The $^{234}U/^{238}U$ and $^{235}U/^{238}U$ isotope ratios were measured by multi-collector inductively coupled plasma mass spectrometry (MC-ICP-MS). However, the activity ratio of U ranged from 0.97 to 1.06 in the samples. The detail information will be discussed during presentation.

Semipalatinsk Test Site: current radioecologocal situation and prospects

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The Semipalatinsk Test Site (STS) was one of the world's largest nuclear weapons test sites. It covered an area of 18,300 km^2 and it was the site of 456 tests using 616 nuclear devices. The most varied of tests were performed at STS, both in terms of the nature of the tests themselves (land-based, atmospheric, in tunnels, in boreholes, excavated and so on) and in terms of the type of nuclear devices (nuclear, thermonuclear) and nature of energy release (very low, low, average and high capacity), which, combined with various conditions related to the landscape and the geology of the location of the testing, formed a most diverse picture of radioactive contamination. From the moment the Semipalatinsk Test Site was closed and to this day, Kazakh scientists, in cooperation with the international scientific community, have obtained a large volume of information on the current radiation situation at the test site and adjoining areas. All the significant sectors of radioactive contamination, the main routes and mechanisms of current and potential distribution of radioactive substances have been ascertained. A critical deliverable of this work was an understanding that part of the STS area is now "clean" and can be used for the good of the national economy. The existing boundaries of STS are clearly redundant and unjustified in terms of radiation security. The area of STS is rich in minerals, including deposits of coal, gold, nickel, iron and copper, among others. The large expanses of STS have long since been used for farming, including for cattle rearing, although further development of STS is held back, both because of its legal status and because of its negative image. Systematic study of STS began in 2008. Between 2008 and 2015, a comprehensive environmental survey was performed of an area of the site measuring 7,860 km^2 (42% of the entire area of the test site), including the following: 3,000 km^2 in the northern part of STS in 2009, 560 km^2 in the western part of STS in 2010, 850 km^2 in 2011, 850 km^2 in 2012 and 800 km^2 in 2013 in the south-eastern part of STS, 800 km^2 in the southern part of STS in 2014 and 1,000 km^2 in the south-western part of STS in 2015. A survey has begun of 1,350 km^2 in the south-western part (2015) and of 1,250

km^2 in the eastern part (2015). It is noteworthy that the nuclear testing also led to a spread of radioactive contamination over areas adjacent to the boundaries of the test site, forming trails tens of kilometres across. Preliminary studies of the area adjacent to STS have shown that the contamination of the soil layer with radionuclides ^{137}Cs, ^{90}Sr and $^{239+240}Pu$ are at the level of several hundred becquerels a kilogramme, which is significantly higher than the radionuclide content, detected in the soil of the northern and western parts of STS. Here, the content of artificial radionuclides in environmental factors (water, air, vegetation) in the studied areas is no higher than standard levels and does not pose a hazard to the general public. The comprehensive radioecological research helped obtain an understanding of the current radioecological state of the part of the areas that lay adjacent to STS. Irrespective of spots of radioactive contamination, the radiation situation in the studied area can be seen as normal. No special measures are currently required to reduce the collective radiation exposure of the public through reclamation of contaminated areas, restricting access to radiation-hazardous areas and optimising commercial activity.

Transfer of radionuclides from soil to acacia auriculiformis in North Vietnamese high radioactive background areas

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The Acacia auriculiformis is a tree commonly found in tropical Asian countries, growing in many different soils, and accordingly, it could have some potential for use in biomonitoring areas with naturally elevated radioisotope concentrations in that climate. The transfer factor (TF) of radionuclides from soil to acacia auriculiformis was investigated in eight North Viethnamese uranium and rare earth element mining areas. The activity concentrations of radionuclides were measured using HPGe. The activity concentration of the studied radionuclides (^{226}Ra, ^{238}U, ^{232}Th, ^{137}Cs, and ^{40}K) showed significant variation in both soil and plant samples. The transfer factors (TFs) of these radionuclides also had a wide range. In most of the studied areas, the largest TF was observed for ^{40}K, followed by ^{137}Cs and ^{232}Th while the TFs for ^{226}Ra and ^{238}U are lowest ($TF^{40}K > TF^{137}Cs > TF^{226}Ra > TF^{238}U$). In addition, the TF for radionuclides near REE mines is similar to the ones observed near the uranium mines. The TF for acacia auriculiformis tree is within the ranges of TF reported for other plants, except for ^{137}Cs.

Radioactivity assessment of drinking water - a case study from a mixed bank filtered and karst water supply system

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In Hungary the drinking water supply mainly relies upon groundwater resources from aquifers characterized by different lithology. Riverbank filtered systems represent 40 % of drinking water supply. Following the Euratom Drinking Water Directive, there are recent regulations in Hungary regarding the natural radioactivity of drinking water. It is monitored by gross alpha and gross beta activity measurements. When activity concentration exceeds the recommended level nuclide-specific measurements are required to be performed by the relevant waterworks because radiological exposure through drinking water may occur in the long run. Since the mobility of uranium and radium is strongly influenced by the geochemical conditions, knowledge on the geochemical parameters of water is required. Therefore, hydrogeology has a crucial role in revealing the origin of elevated activity concentrations. This research presents a case study in Hungary where the drinking water supply is provided by bank filtered and karst wells. In most of the wells of the research area the gross alpha values are above the limit, 0.1 Bq/l. The aim of this study is to determine which radionuclides may cause the elevated radioactivity and explain their occurrence based on hydrogeological research. All samples of the study were analysed for U-234+U-238, Ra-226, Rn-222. Alpha spectrometry applied on Nucfilm discs was used to measure the uranium and radium activity while radon activity was determined by liquid scintillation. The study revealed correlation between the water level fluctuation of the river and the uranium content of the wells. Among the investigated radionuclides, the uranium activity concentrations responded the most to the water level changes of the river and showed systematically higher values during low water conditions. This suggests that uranium is transported by the groundwater component into the wells, and the fluviatile sediments can be the possible source. The results of this study highlighted the transient nature of river bank filtered systems, which should be taken into account in the monitoring and water supply strategy. The results of this study can also

help waterworks to understand the hydrogeological cause of radioactivity and to develop a method to reduce the high radioactivity below the limit in the consumed drinking water.

This study was supported by the ÚNKP-19-3 New National Excellence Program of the Ministry of Human Capacities.

Transfer of ^{210}Po from soil to water spinach in Vietnam

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Water spinach is a part of the staple diet in Vietnam and a common vegetable. Partially due to its large leaf area it is well-known for the high absorption of lead, including the radioactive isotope Pb-210. Pb-210 decays to Po-210, which is an alpha decaying radionuclide, responsible for a large portion of the internal radiation dose from ingesting natural radionuclides. Currently data is lacking on the activity concentration and transfer parameters of water spinach grown in Vietnam in particular and tropical and subtropical climates in general. In this study, the Po-210 activity concentration in soils, water, roots, trunks, leafs of water spinach plants as well as air dust were determined by alpha spectrometry. Based on these results the transfer parameters, bioaccumulation factor and radiological risk of Po-210 were assessed.

Modern technologies for radium removal from water – Polish mining industry case study

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In the formation waters, occurring in coal mines in the Upper Silesian Coal Basin, Poland different pollutants are present which may cause damages to the environment, among them radium isotopes. In several collieries the radium removal from mine water was necessary to mitigate negative results of radium release with mine effluents. The most efficient method of radium removal is based on application of barium chloride, implemented in full technical scale in two of Polish collieries. Another possibility of removal radium isotopes from salty waters is an application of zeolites. In this paper a review of different techniques is given, showing possibilities of application of different methods of radium removal, its advantages and drawbacks.

Dispersion of air pollutants in the atmosphere

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Modeling of dispersion of toxic pollutants in the troposphere is one of the most important challenges. The effect of these chemical species (including radioactive substances) can have serious impacts on our environment and human health. Modeling the dispersion of air pollutants can predict this effect. Therefore, development of various model strategies is a key element for the governmental and scientific communities. This lecture will provide a brief review on the modeling of the dispersion of air pollutants in the atmosphere. We will discuss the advantages and drawbacks of several model tools and strategies, namely Gaussian, Lagrangian, and Eulerian.

Investigation of soil to plant transfer factors of ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs in Vietnamese crops

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Investigaton of staple food products is critical to assure public safety and provides input for predictive dose assessment models. There is a lack of available information on the various vegetables in Vietnam, which pose an important part of the local diet. In order to begin to fill this gap, the activity concentrations, transfer factors, and radiological hazards of ^{226}Ra, ^{232}Th, ^{40}K, and ^{137}Cs were studied for ten pairs of selected vegetables and soils in Tien Le near Hanoi in Vietnam. The ten most popular vegetables in Vietnamese diet were selected for this study, namely choy sum, kohlrabi, crown daisy, cabbage, Malabar spinach, lettuce, beans, sweet potato, potato, and carrot. The research results do not support the previously reported strong correlation between the activity concentrations observed in vegetable crops and those in soil. The ranges of TFs of ^{226}Ra, ^{232}Th, and ^{40}K were 4 ± 10^{-2} – 6.9 ± 10^{-1}, 8 ± 10^{-2} – 9.7 ± 10^{-1}; and 1.0 ± 10^{0} – 1.6 ± 10^{1}, respectively. Values for Th and K in tubers and leafy vegetables exceed previous world range figures. The radiological hazard indices calculated for the soil predict almost no risk to human health in the study area.

Multivariate Statistical Approach of Natural Radioactivity on the example of Common Building Materials used in Semnan Province, Iran

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Since a person spends 80% of their life inside buildings, determination of population exposure to radiation from building materials is of great importance. Different building materials contain various quantities of Naturally Occurring Radioactive Materials. For this reason, exposure to radiation from building materials has been worldwide legislated [1-3]. The purpose of controlling the radioactivity of the building materials is to limit the doses to the members of the public to as low as reasonably achievable. This paper aims to present a multivariate statistical method for the assessment of natural radioactivity in building materials on the example of ^{40}K, ^{232}Th, and ^{226}Ra activity concentrations measured in 29 samples of common building materials used in construction industry in Semnan Province in Iran, using high purity germanium gamma-ray spectrometry. The activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K in all samples varied from 6.7±1 to 54.1±9, 5.9±1 to 60±11 and 28.5±3 to 1085±113 Bq.kg^{-1} with an average of 27.2±5, 22.8±4, and 322.4±41 Bq.kg^{-1}, respectively. The radiological data were processed by multivariate statistical methods to determine the similarities and correlations among the various samples. Based on Pearson correlation, the relative distribution of ^{226}Ra and ^{232}Th is positively correlated with all of the calculated radiological parameters. This result may be due to the rich content of ^{226}Ra and ^{232}Th, which plays an important role in determining the hazardous nature in the building materials; in addition, a weaker relationships observed between these two nuclides and ^{40}K, however, still indicated statistically significant. The factor analysis yielded two factors with eigenvalues<1, explaining 95.58% of the total variance. From the rotation space of component 1 and 2, the first factor accounts for 59.83% of the total variance and is mainly characterized by high positive loading of concentrations of ^{232}Th and ^{226}Ra. Factor 2 accounts for 35.75% of the total variance and mainly corresponds to positive loading of ^{40}K. Therefore, it can be deduced that ^{232}Th and ^{226}Ra dominantly

increase the radioactivity in all the building materials. The results from the cluster analysis coincide well with the correlation analysis. In the derived dendrogram, all 29 building materials are grouped into four statistically significant clusters. As a result, the radiological data of the building materials primarily depends upon the concentrations of the natural radionuclides.

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Method of standard sets of the nuclides of U-Th series for nuclear dating of carpathian rocks and soil

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It is well known that the levels of terrestrial radiation are unevenly distributed over the Earth's surface and depend on the composition and concentration of radionuclides of the natural series U, Th, and Np in the Earth's crust. Rocks and soil, which determine the natural radiation background of the territory, are interesting objects. Today, the natural decay series and their isotopes are widely used as geochemical tracers, natural markers of various environmental processes. These isotopes are also the basis of nuclear dating methods. There is a correlation between the content of long-lived radionuclides in soils and soil-forming rocks. An essential factor in the content of radionuclides in the soil depends on the degree of change of the parent rock in soil formation. Then the measured age of soils increases from the upper horizons to the lower ones, due to the effect of gradual isolation of the lower horizons from the radionuclides' inflow. Typically, ^{238}U and ^{234}U uranium isotopes are studied in soil profile horizons, to assess weathering processes and estimate the age of formation using the non-equilibrium method between U isotopes. The data obtained were favorable for using available models to determine the age of soil horizons formed during the weathering of primary sandstone rocks. In this work, we present the new abilities of the method of standard sets of nuclides (MSSN) to determine the age of the test specimens, both rocks, and soils. This method considers all sets of gamma-active nuclides (GANs) of natural series ^{232}Th, ^{235,238}U, which are subject to experimental identification. The MSSN is based on the determination of the time dependencies of the nuclei for such GANs and their activities using the radioactive decay patterns of natural uranium and thorium series. The numerical results are obtained from the solutions of the linear differential equation system first considered by Bateman. The calculated data allow obtaining MSSN as a set of activities of daughter nuclides of series ^{238}U for arbitrary time intervals. Such spectra can be conveniently used to collate with experimental data to analyze the "closeness" of the nuclide system and the nuclear dating of the samples under study. The nuclear dating algorithm involves a series of gamma-spectrometric studies of specimens, identification, determination of the content/intensity of radionuclides on the instrumental spectra, and the

formation of an array of data of their activities. The results of a nuclear dating of the rocks and soils of the Carpathian Mountains using the MSSN of the series ^{238}U are presented. The dependence on the reliability of nuclear dating on the quality of the low background experiment is also discussed. It is shown to specify the accuracy of setting not only the nuclear dating value for this object but also the absolute error of its determination. Soil samples show some variation in activity values due to differences in the migration mobility of these elements.

^{226}Ra and ^{238}U in well waters from high-level natural radiation areas in northern Vietnam

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Assuring public health and the need for the estimation of the radiological hazards requires the determination of natural radionuclide concentrations in various media, especially in high level radiation areas. In this study, ^{226}Ra and ^{238}U concentrations were investigated in well waters surrounding eight of the Northern Vietnamese high-level natural radiation areas. The observed ^{226}Ra and ^{238}U concentrations vary from 0.39 to 1.11 and 0.40 to 1.96 Bq/L, respectively. ^{226}Ra and ^{238}U isotopes in most areas are in or near equilibrium, with the exception of the DT-Thai Nguyen area. The calculated radiological hazard indices are often higher than WHO recommendations. AED and ELCR values due to consuming well water range from 96.1 to 292 (μSv/year) and 0.0004 to 0.0012 respectively. The study contributes important data on the effects of mining on the local population in the study areas.

Lake sediments as live databases in quantification of the anthropogenic activities in forest ecosystems

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The lake sediments due the formations process of the annual depositions, represents a natural database which store annually the environmentally changes from the hydrographic basin. The changes in the environment has in many case two major sources, one in generated by the climate variations which can be represent as a natural factor and the anthropogenic influence. Scientific-based current state of knowledge on anthropogenic impact on forested areas in Chomad, Parang and Gutai mountains in Romania is limited. ^{210}Pb dating method is a valuable tool for studying the sedimentation rates of lakes over the last 150 years. The method was used successfully for dating peat bog accumulations. The peat bog accumulations are the perfect environments for climate reconstruction which grow rate are directly correlated with climate variations. Four peat bog deposits was chose for investigation from Gutiiului Mountain (Maramures County, Romania). Peat samples were taken and (Loss of Ignition) LOI investigation was done for separation the organic material from the inorganic part. Lake sediments from Red Lake were investigated in order to make visible the anthropogenic activities in the studied site. Radionuclide measurements (^{210}Pb, ^{226}Ra, ^{137}Cs, and ^{7}Be) were made by using gamma spectrometry with a HPGe Well-type detector. By using the ^{210}Pb chronology each layer from the peat bog and sediment column was dated. Date obtained from peat grow was used for subtract the naturally induced sediment deposition rate.

Accurate measurement of $^{234}U/^{238}U$ and $^{236}U/^{238}U$ isotope ratios in contaminated soil samples using thermal ionization mass spectrometry

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Environmental contamination with alpha-emitting nuclides of uranium and trans-uranium elements is possible during accidents involving nuclear devices or nuclear power plants. Since soil samples contain high concentration of inherent natural uranium, it is more difficult to detect small quantities of U from man-made nuclear sources. Therefore, accurate measurement of uranium isotopic composition in environmental samples is important to estimate the origin of nuclear materials and act as isotopic fingerprints. A new chemical separation scheme has been developed to isolate U from soil samples affected by Fukushima dai-ichi nuclear power plant (FDNPP) accident. This method is based on U/TEVA column separation twice where Fe interference is minimized with most of elements except U. A multi-collector thermal ionization mass spectrometer (TIMS) (Phoenix, IsotopX, UK) used has nine Faraday cups collectors and a Daly ion-counting system detector positioned behind axial Faraday and WARP (wide aperture retardation potential) energy filter. The WARP filter is designed to suppress the tailing effect. The limit of detection for $^{236}U/^{238}U$ measurements using Daly ion counting system with WARP is about $2x10^{-9}$ to $4x10^{-9}$. It was optimized for the determination of extremely low uranium isotope ratios and applied for the analysis of $^{236}U/^{238}U$ isotope ratios in the isotopic range of 10^{-7} in reference material and 10^{-8} in natural samples. In this study, we have selected eleven soil samples within 50 km from Fukushima dai-ichi nuclear power station (FDNPS) accident, and one soil sample from Chernobyl nuclear power plant (CNPP) accident with high ^{137}Cs activity and one soil from Kosovo in depleted uranium (DU) conflict area. We also measured uranium isotopes from two Japanese soil samples before FDNPS accident as global fallout and three geological standard materials. Radioactive dis-equilibrium of $^{234}U/^{238}U$, enrichment and depletion of $^{235}U/^{238}U$ were noticed in some soil samples in addition to significant evidence of $^{236}U/^{238}U$.

The role of natural radioisotopes in dose calculations of the NMX shutter pit of the European Spallation Source

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The NMX neutron macromolecular crystallography diffractometer is one of the experimental channels of the European Spallation Source (ESS) – currently under construction in Lund, Sweden. The aim of our research was to determine dose exposures from decay gamma rays of induced radioactivity via MCNP and Cinder simulations. Results show that a thin layer of Mirrobor effectively absorbs most of the incident neutrons (generated in the facility) leading to only minor neutron activation of the structures of the shutter pit. However, natural radioisotope content of the concrete walls had a high portion of dose contribution in the total calculated dose rates of the maintenance personnel. Evaluation of such results required a new mind-set and new indicators in order to draw correct conclusions. Reassessed KERMA values were assigned to the radioisotopes and activity concentration indices were calculated too.

Radiation-Induced Electron Spin Resonance Signal of Human Nails: Increase after irradiation

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The characteristics of the ESR signals in nail have been studied as they are possibly useful for retrospective dosimetry in radiation accidents. Previously, researches have reported that the radiation-induced signal (RIS) decays quickly after irradiation in several days [1][2][3]. However, in the present study, we found not only a decaying component but an increasing component of RIS. We prepared 40 nail samples, including fingers and toes from 3 donors and separated them into three groups, for X-ray and γ-ray irradiations, and for control. Firstly, all signals were erased by soaking in water for 12 hours before irradiation. After drying for four days, we observed the background ESR signals for several days. Then, X-rays irradiated one group with peak intensity at 60 keV and a maximum at 160 keV. γ-rays of ^{137}Cs irradiated another group. The added doses measured by glass dosimeters for the X-ray group were 23 Gy, 47 Gy, and 92 Gy. For the γ-ray group, 24 Gy, 48 Gy, 97 Gy. We stored all samples at 20℃ and with 11% humidity, where they were monitored for more than one month. ESR measurements were done for these samples just after the irradiation and several times during storage for two months. It was found that the ESR signal intensity increases by storing in both X-ray and γ-ray irradiated samples. The increase was proportional to the intensity of the RIS after irradiation and was 40 % for five days of storing. The present results are obviously contrary to the previous reports. According to reference [1], the decay rate depends on the humidity. We roughly estimated the decay rate under 11% humidity and performed the regression analysis with a model assuming two components, one increasing and the other decreasing with time After obtaining the increasing rate, we simulated the signal intensity change with different humidity values and found that the signal increase cannot be seen with more than 30 % humidity with which previous studies were done.

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Study of $^{90}Sr/^{137}Cs$ and $^{239+240}Pu/^{241}Am$ ratios at plumes of radioactive fallout formed from aboveground nuclear tests conducted at Semipalatinsk Test Site

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The existing techniques for determining activities of ^{90}Sr and $^{239+240}Pu$, based on radiochemical preparation of samples followed by spectrometric measurements, are labor-intensive and costly. As an alternative approach that allowed to assess the activity of one radionuclide by the known activity of the other, one can use the ratios of $^{90}Sr/^{137}Cs$ and $^{239+240}Pu/^{241}Am$. With this approach for assessing ^{90}Sr and $^{239+240}Pu$ activities, it is sufficient to determine ^{241}Am and ^{137}Cs activities by gamma-spectrometry, which requires no much labor effort and it is comparatively cheap and accessible. The paper addresses distribution features of the ratio of 90Sr activity concentration to that of ^{137}Cs and that of $^{239+240}Pu$ to ^{241}Am in soil and particle-size soil fraction in plumes of radioactive fallout from two aboveground nuclear tests conducted on 'Experimental Field' – on September 24, 1951 (38 kt) and August 12, 1953 (400 kt, the first fusion test). The study methodology comprised sampling of surface soil (0-5 cm), particle-size fractionation and determination of radionuclides activity concentrations in samples using conventional techniques. Radionuclides activity concentrations in soil in plumes of interest vary in the following range of values: ^{137}Cs – <6 ÷ 1350 Bq/kg, ^{90}Sr – 63 ÷ 5600 Bq/kg, ^{241}Am – 1,0 ÷ 400 Bq/kg and $^{239+240}Pu$ – 6,7 ÷ 5240 Bq/kg. In both plumes levels of radioactive soil contamination with ^{137}Cs and ^{241}Am are commensurable. However, somewhat elevated values of $^{239+240}Pu$ activity concentration were found in the plume of 24.09.1951 test, whereas for ^{90}Sr – vice versa, in the plume of the 12.08.1953 test. $^{90}Sr/^{137}Cs$ ratios in plumes of 24.09.1951 and 12.08.1953 tests range as 0.4-1.7 and 1.1-5,4 respectively, $^{239+240}Pu/^{241}Am$ ratios – ranging 3.7 ÷ 19 and 6.4 ÷ 36 respectively. Higher-than-normal values of the $^{239+240}Pu/^{241}Am$ ratio (18 ÷ 36) are observed in both plumes, those of the $^{90}Sr/^{137}Cs$ ratio (4,4 ÷ 5,4) – only in the plume from the 12.08.1953 test. Along with that, the plume of the 24.09.1951 test revealed atypically low values of the $^{239+240}Pu/^{241}Am$ ratio (3,7). These values of the ratios are an exception to the general pattern, however these have to be taken into account. In particle-size soil fractions in the plume of the 12.08.1953 test, values of radionuclides ratios decrease as the fraction size decreases

(1000 to 40 μm). At the same time, higher values were mainly revealed in 250 to 1000 μm fractions. In these fractions maximum values of the $^{90}Sr/^{137}Cs$ ratio reach 6.2, for $^{239+240}Pu/^{241}Am$ – 61. In fine fractions, values drop as low as 2-5 times. In the plume of the 24.09.1951 test, there was not any reliable dependence revealed in the ratio variation of radionuclides of interest on the size of particle-size soil fractions. However, values found, particularly, for the $^{90}Sr/^{137}Cs$ ratios, are considerably lower, than for the other plume. Thus, the maximum value of the $^{90}Sr/^{137}Cs$ ratio in this plume does not exceed 3, and for fine fractions, it is far from 1. Results have proved the assumption that ratios of $^{90}Sr/^{137}Cs$ and $^{239+240}Pu/^{241}Am$ in plumes of radioactive fallout from aboveground nuclear tests will be characterized by individual values depending on the type of a nuclear test and contamination conditions formed. Thus, the suggested ratios technique makes it possible to give a rapid estimate of $^{239+240}Pu$ and ^{90}Sr activities by applying radiochemical analyses only to confirm findings.

Variability of ^{137}Cs activity concentration in urban environment studying attic dust from Salgótarján city (Hungary)

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The ^{137}Cs is a principal radioisotope introduced into the environment through the atmospheric bomb tests (from 40s) and the major nuclear accidents (Chernobyl, 1986 and Fukushima, 2011). From atmosphere, ^{137}Cs adsorbs to precipitation and returns to lithosphere by wet and dry deposition as radioactive fallout component. Due to the Chernobyl nuclear accident, the released contaminated air mass contained particles with attached Cs, largely propagated, deposited and distributed across northern and eastern European countries in the ambient environment (1). In case of Fukushima disaster, it also contributes to the increase of the ^{137}Cs activity concentration, but only in minor amount (2). The radiocesium-bearing particles could have reached the houses (e.g. through open windows, doors, fractures and vents) in urban environment and deposited inside resulting in the exposition of the habitants to ^{137}Cs. In areas that are not accessible for a regular cleaning (e.g., attics) physical state and chemical composition of attic dusts remain constant i.e. unchanged in time. Accordingly, undisturbed attic dust samples from Salgótarján (Hungary), a former heavy industrial city, were collected in 2016 and studied as past records of anthropogenic pollution, with intention of elucidating the pathways of radioactive contamination in urban environment. The specific activity of ^{137}Cs was studied in 36 attic dust samples. Homogenized (amount: 1.0-1.5 g, grain size: <0.125 mm) samples were measured by well-type HPGe detector placed in a low-background iron chamber at the laboratory of the Hungarian Centre for Energy Research. Construction ages of the selected houses range from 1880 to 1989, a selection criterion superimposed on the 1x1 km grid design. The obtained ^{137}Cs activity ranges from 5.51 ± 17.71 to 169.94 ± 1.71 Bq/kg^{-1}. Specific activity of radionuclide is higher than soil result

published in other regions of Hungary and neighboring countries. Consequently, attic environment archives the deposited ^{137}Cs which is an effective material for monitoring past fallouts of production from early fallout and nuclear catastrophe(s). Our results performed that high ^{137}Cs concentration is observed at year of house constructed from 1960-1965 and 1986. Due to the historical trends, it is likely correlated fallout occurring in 1963 and Chernobyl NPP accident in 1986. Therefore, 85% of attic dust samples were significantly associated (r=0.4, p-0.006) with elevation indicating that deposition of ^{137}Cs was strongly influenced by local landscape. Considering the regions, our hypothesis is northern part of Hungary can be noticed that the radioactive cloud had a NE to W movement direction.. Based on geostatistical analysis, interpolation was done with ordinary point kriging.. Adjusted variogram model shows a best fit (r^2=0.6) with spherical model. strategy. Therefore, it can be considered that attic dust remained undisturbed for decades and preserve past record of components of atmospheric pollution.

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Radiation protection in Polish coal mines - the system of monitoring and control of the hazard

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The radiation risk due to the exposure to natural radionuclides, especially to short-lived radon progeny, is a component of the radiation hazard, common in the natural environment and in the working environment. The effective dose, due to the exposure to radon decay products, exceeds 50% of the average dose for a man from all sources of the ionizing radiation. Under specific circumstances, for example as a result of working in confined space with a low ventilation rate, e.g. underground galleries in mines), the role of that particular hazard maybe even bigger. Another source of radiation hazard in coal mines is radium, present in brines and sediments, precipitated out from waters with elevated radium content.

In the Polish mining industry the radiation hazard, caused by natural radionuclides is stated as the natural hazard among many others. Investigation of that specific problem has been started in non-uranium underground mines in Poland in the early 1970s. At the end of the 1980's first regulations were published. Additionally, the national standard has been prepared, in which dose limits and requirements of the radiation monitoring have been established. In the following years, in the coal mining industry, internal regulations for monitoring and mitigation measures were developed on the basis of the Polish standard.

Due to implementation in the Polish legal system regulatory acts – The Atomic Law, Geological and Mining Law, Decree of the President of State Mining Authority and Decree of the Ministry of Economy – the monitoring and prevention against natural radiation became obligatory in all Polish underground mines since 1989. This duty is strictly supervised by local offices of State Mining Authority in co-operation with other governmental agencies (Polish Atomic Energy Agency). Monitoring and mitigation measures were obligatory not only in operating mines but also in mines, excluded from the exploitation, and used for other purposes as museums, balneotherapy, spas, etc. Such a solution was unique in non-uranium mining. Since 1989, particular acts were amended several times, especially after unification with EU and requirements to adopt Polish law to European Directives. Nonetheless, the monitoring and mitigation measures are being

continued, accordingly to the requirements of the radiation protection system in the Polish mining industry.

Valorisation of Al-containing mineral residues for sustainable inorganic binders

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There are huge amounts of Al-containing industrial residues (red mud, slags, fly and bottom ash, mineral deposits etc.) which presents the potential source of secondary raw materials. The actual industrial and mine waste and/or by-products in the Europe countries have the low recycling rate or are landfilled. There are many promising ways for their utilization in building sector mainly targeted on energy efficiency. Waste Framework Directive presents the main EU policy driver in relation to the preparation of waste for reusing, recycling and other forms of material recovering. Development of low-CO_2 and low-energy and material resources requires innovative solutions to develop new eco-innovative building materials. EIT Raw material Project: Al-rich mineral residues for minerals binders in ESEE region – RIS ALiCE present the promising way of recycling the industrial Al-containg by-products/waste by synthesis of mineral binders with high Al content. The obtained Al-rich mineral binder can be further used as innovative environmentally friendly construction material. High Al-content is the main pain for production of this type of mineral binders, due to the need of valuable natural bauxite. In RIS ALiCE Project the replacement of bauxite with Al-rich industrial and mine residues can be overcomed and the proposed approach will present an innovative recycling case study for the ESEE region. Also, in the frame of RIS ALiCE project the network among the relevant stakeholders in the area of currently unused and landfilled Al-rich industrial residues will be created contributing to the implementation of circular economy and zero-waste management for Al-rich waste. Thus, the base for innovation potential and competitiveness of the ESEE region will be made.

Changes of activity concentrations of radionuclides in Agricultural Soil based on model assessments

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We studied the long-term changes of activity concentrations of natural radionuclides (^{40}K, ^{210}Pb, ^{226}Ra, ^{232}Th, and ^{238}U) and artificial radionuclides (^{137}Cs, ^{90}Sr, and ^{131}I) in topsoils with plant cultivations and without plant cultivations. HYDRUS-1D model and CEMC model were used to assess the decreasing rates of radionuclides from the topsoils. For artificial radionuclides, we predicted the half-time values of ^{137}Cs, ^{90}Sr, and ^{131}I in the topsoil layer (0-20 cm) without plant cultivations. For natural radionuclides, we predicted the increasing/decreasing rates of radionuclides in the topsoils (0-20 cm) of the rice soil and other crop soils. The results showed that fertilization and irrigation were two potential processes that increased the activity concentrations of natural radionuclides in the agricultural soils. Under agricultural practices, plant uptake and water leaching were two potential processes that decreased the activity concentrations of natural radionuclides in the topsoils.

Study of the tritium distribution by the ecosystem components with an underground source of tritium

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In the framework of the presented work, tritium concentrations in various components of the ecosystem, including forest and meadow components, were studied. The source of tritium in this area is groundwater contaminated with tritium as a result of the leaking of an old radioactive waste storage facility located nearby (up to 1 km). The investigated area is located in the floodplain of the Protva River. The vegetation cover of the area is represented by: 1) a meadow with a predominance of Calamagrostis epigeos and the participation of Senecio fluviatilis and Agrimonia procera; 2) a forb meadow with a predominance of Bromopsis inermis, Elytrigia repens, Filipendula ulmaria and an appreciable participation of mesophilic and hygro-mesophilic forbs; 3) a polydominant short grass forb meadow with bushes and scattered low-growing trees on an artificial hill; 4) a meadow with a predominance of Phalaroides arundinacea, Filipendula ulmaria, Galium rivale and an appreciable participation of hygrophilic forbs among the thicket of Salix cinerea; 5) thicket of Alnus glutinosa, Salix cinerea, Padus avium combined with thicket of hydrophilic tall grass. Determination of tritium was carried out in prepared water samples using liquid scintillation spectrometer "Tri-Carb 4810TR", the detection limit of tritium in aqueous samples was about 7 Bq/l, in the form of organically bounded tritium about 25 Bq/kg. Determination of tritium in soils was carried out in free soil water obtained by distillation; in the air - in water obtained by freezing; in plants - in the fresh water of plants obtained by free or forced sublimation method. To determine organically bounded tritium, plant samples were decomposed by mineral acids in autoclaves, neutralized, and the resulting water was distilled. In the studied area there are zones of groundwater outlet to the surface, forming a small stream. It was determined that the concentration of tritium in the water of the stream is constant and is 3400 Bq/l. the Concentration of tritium in soils increases with depth, reaching a maximum (6000 Bq/l) at a depth of 1.5 m, while the type of dependence "tritium concentration in the soil-the depth of the soil" has a

specific form for each of the three studied points. The content of tritium in free water of plants reached values equal to about 0.5 of the maximum concentration of tritium in free water of soils. The ratio of OBT to tritium content in free water of plants lies in the range of 0.25-1.5, which is probably due to the variability of tritium concentration in free water of soils and different vegetative activity of plants. The content of tritium in water vapors of air reaches values of 0.03 of the maximum concentration of tritium in free water of soils. A significant dependence of tritium concentration in water vapors of air on the time of day was revealed. The curve "concentration of tritium in water vapor air – time" has a minimum at 12 a.m. and two peaks around 8 a.m. and 10 p.m., while the concentration of tritium in the maximum is higher than the concentration in minimum in 7 times. The conclusion is made about the significant influence of the biological activity of plants on the tritium content in the air for ecosystems of this type. The reported study was funded by RFBR according to the research project № 19-016-00146

On Using Neutron Activation Analysis to Determine ^{235,238}U, ^{40}K and ^{232}Th and Monitoring ^{137}Cs and ^{90}Sr Employing Stable Element Surrogates in Various Matrices with Sub-Gram Quantities of Material: A Review

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Neutron activation analysis (NAA) is primarily known as a technique to determine an array of elements in various types of matrices such as geological, biological, environmental and engineering (e.g. semiconductors, etc.). However, NAA can be effectively used to determine ^{238}U, ^{40}K and ^{232}Th in specimens that are used to determine dose measurements. As well, since the isotopic ratio of ^{238}U/^{235}U is universal with the exception of nuclear fuel, one can also mathematically determine the ^{235}U content. Furthermore, NAA can be used to determine stable cesium and strontium, which can then be used to investigate transfer factors for ^{137}Cs and ^{90}Sr from soil to vegetation to animal and humans. Over the last years, we have used NAA to investigate for dose measurements and radionuclide transfer factors. A detailed methodology of the NAA techniques developed in our laboratory will be given.

Activation method to Be-10 determine in nuclear reactor constructional materials

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Highly toxic Be-10 with a half-life of $T_{1/2}$ = 1.6x10^6 years is formed in reactor constructional materials. It decays with the emission of only electrons with the 555 keV boundary energy. Lengthy and expensive radiochemical procedures are required to detect and control it. We propose to use the activation method for determining the Be-9 and B-10 concentration in the constructional material samples with subsequent recalculation of the Be-10 activity in them. We offer to activate constructional material samples by irradiation of an electron accelerator and to study the reactions Be-9(γ, 2n)Be-7 and B-10(γ, 2np)Be-7, which lead to the formation of an easily detected by gamma spectrometer Be-7 with a half-life of $T_{1/2}$ = 53 days (477 keV gamma line). Constructional material samples, beryllium, and boron targets were irradiated bremsstrahlung γ-quanta with boundary energies of 20, 37, 40, and 55 MeV to implement the proposed method and determine the Be-10 contribution to the activities of constructional material samples. The activation technique for the Be-10 determination can simplify the procedures for its identification and control in reactor constructional materials and various types of radioactive waste. Taking into account the huge volume of radioactive waste generated at nuclear power plants, the proposed method is more operative than traditional radiochemical methods. The calculated error of the method is about 20%, the method sensitivity is 10^{-2} Bq/g.

^{14}C analysis to determine the sources of organic acids in oil industry

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Biodiesel is a vegetable-oil or fat based fuel, which can be used in compression-ignition engines without any modification. The blending of biodiesel provide higher octane rating, significant emission reduction, superior lubricity and less toxic emissions. The biodiesel is manufactured by esterification processes and the different Fatty Acid Methyl Esters (FAME) is processed simultaneously with intermediate petroleum distillates in existing petroleum refinery process units to produce finished fuels. In the European Union (EU) the biodiesel has been produced on industrial scale since 1992 and the rate of production is increasing constantly. The European Union has had a target for member states to source 10% of their transport fuel from renewable sources by 2020. Increasing the use of biomass fuel sources affects the integrity loss of the carbon steel in the refining plants. It was observed, that processing of mixtures containing high free fatty acids resulted in higher corrosion rates in hydrodesulphurisation unit of the refinery. Moreover, tests showed that, the corrosion rate of aluminium and copper metal was almost double in biodiesel than in diesel. On the other hand, the increased organic acid concentration in each unit of the refinery and therefore the higher corrosion rate are not always straightforward to associate with the processing of biomass fuel sources. In today's refining marketplace, the potential to process lower cost crude (opportunity crude). The organic acid-laden crudes are usually priced at a significant discount with respect to other opportunity crudes, however these crudes are extremely corrosive and can cause substantial damage to refinery equipment. In order to gain the most benefit from the use of high organic acid content feeds, new strategies and tactics are needed. In this study ^{14}C analytical method was developed for the assessment of suppliers. The organic acids were separated by individual laboratory technique and Liquid Scintillation Counters (LSC) was used for counting ^{14}C decay rate. The developed technique was validated by samples from Middle-European refinery.

Study on occurrence of chemical elements in bottom sediments of the uzynbulak creek at the Semipalatinsk test site

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There were 209 underground nuclear tests of medium and low yield were conducted at the "Degelen" testing site of the Semipalatinsk test site from 1961 to 1989. However, testing site is considered as a source of radiation hazard, without taking into account heavy metals (HM) and toxic elements (TE) effect, existence of which is reported in previous experiments data. The Uzynbulak, the longest creek, surface waters of which may be potential source of HM and TE export beyond the mountain ridge, was studied for elemental composition. Fresh water of the creek is used by locals as a watering place for stock. Thus, one of the tasks is to find out whether the concentration of HM and other TE in the creek is constant, are they bound or able to migrate through food chain. The work presents study results of occurrence variations of chemical elements in bottom sediments of the Uzynbulak creek. Sequential extraction method includes sequential fractionation of chemical elements from certain quantity of sample, at this starting from "weaker" extraction agent and finishing with stronger one. There were next forms distinguished based on generalizations of various techniques: water-soluble, exchangeable, specifically low sorbed, bound with organic matter, bound with oxide/hydroxide of ferrum and manganese, and residual form. Total concentration of studied chemical elements are on the level of bulk earth values of global soil, exception is only for Be and U. There were differences on some elements revealed, thus for water-phase extraction there was a quite high percentage of leaching (% of total concentration) for elements: Mn, Sr and Mo – from 2 to 19%. Sr (62 %), Ba (42 %) and Mn (23 %) concentrations increase was observed in exchangeable form. It should be noted that for Mn, Sr and Ba there was a maximal level of concentration in exchangeable form which indicates their great migration ability and bioavailability. Organic matter of bottom sediments contains such elements as Mn, Sr and Ba for relatively long time. The largest concentration for U (73 %) and Be (48 %) was preserved in stable bound forms which are bound with oxide/hydroxide of ferrum and manganese. Amount of extraction into residual form for Mo was more than 50%. This is the most inactive element which was transferred from matrix

latitude fractured crystallization of bottom sediments into solution. The assessment of Be, Mo and U migration ability in bottom sediments, sampled along the Uzynbulak creek was carried out. Study revealed exceeding of maximum permissible concentration (MPC) of abovementioned elements in surface waters of the creek: for Be was 30 MPC, for U – 4 MPC, and for Mo – 2 MPC (by spring well in spring). Be and U have the greatest ability to bind with the most stable components of bottom sediments (with oxide/hydroxide of Fe and Mn and residual form). The largest concentration of these elements in all studied forms was observed on section from 9 to 11 km. The significant concentration for Mo was registered in more active water-soluble form which was 38 % from total concentration. At that, it should be noted that maximal concentration of Mo in organically bound form was observed in estuarial part of the creek and reached 50 % from total concentration. Distribution of occurrence forms of studied chemical elements varies with significant nonuniformity with difference in several orders. In general, high concentration of studied elements in bottom sediments has natural occurrence and is caused by mineral composition of soil material of Degelen mountain massif.

Distribution of Sr-isotopes indicates industrial contamination in urban soil samples - A case study of Salgotarjan, Hungary

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Strontium is a useful element in characterization of urban areas since it works as a tracer of soil and atmospheric pollution (anthropogenic/industrial specially). It can be derived from the emissions of coal and gas combustion, coal fired power plant, iron, steel and steel alloys industries occurring in byproducts like slag and fly ash. The fossil fuels, particularly coal, has been one of the most feasible solution for the energetics needing of the world, during the last century, causing serious impact to the atmosphere, pedosphere and hydrosphere resources, principally, and then to the society and communities themselves. The main aim of this research was to identify the spatial distribution of Sr concentration and $^{87}Sr/^{86}Sr$ isotopic ratio in Salgótarján city, one of the former industrial cities of Hungary, from where 15 urban soil samples were studied. Our samples were grouped within four categories, according to their location: kindergarten (4), park (3), playground (4), roadside (4), and besides, a brown forest soil sample as geochemical background and two potential contamination sources, a slag and a coal sample, were also collected. Chemical compositions of the samples were determined in Canada at the Bureau Veritas laboratory, using ¬ICP-MS method after modified aqua regia digestion. The total concentration of Sr ranged between 17.5 (one of the park sample) to 51.3 ppm (another park sample, the closest one to the slag deposit). The slag and coal samples show the highest concentrations, with concentration of 113.6 ppm and 52.8 ppm, respectively. The $^{87}Sr/^{86}Sr$ isotopic ratios were determined at the Environmental Radionuclide Research Group in Japan, using Thermal Ionization Mass Spectrometry (TIMS) method. The results varied from 0.7103 (a playground sample) to a maximum of 0.7195 (a roadside sample). Even though the samples of slag and coal showed the highest Sr concentration, the isotopic ratios were

relatively lower than urban samples (0.7116 and 0.7128, respectively). In our study, it is found out that among the contamination sources, the slag is mainly responsible for the enrichment of Sr in total concentration meanwhile showing lower $^{87}Sr/^{86}Sr$ isotopic ratio

A Methodology to Ascertain if Secular Equilibrium Exists in Oil Scale

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Oil exploration results in higher concentrations of Ra-236 and Ra-228 and their daughter products within the scale and produced water. These decay products within a West Texas oil scale sample were determined not to be in decay-equilibrium. The activity concentrations of these radionuclides within the oil scale sample and a certified reference soil (Eckert and Ziegler) were obtained with an efficiency and self-attenuation curve using a Eu-152 standard point source. Additionally, the comparative method was used to verify the activities. Secular equilibrium was not seen across the decay chains of either Ra-226 or Ra-228. A comprehensive method of evaluating the activities in the decay chains using both passive counting and neutron activation analysis will be presented.

Distribution of ^{238}U by speciation depending on its degree of oxidation in water objects of «Degelen» site

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One of the main tasks of radioecology and radiological protection is to assess contamination of environment with ^{238}U as well as to assess the risks associated with effect of this contamination on humans and natural environment which is made by means of measurement of the total concentration of the radionuclide. However, without knowing the distribution regularities of ^{238}U, its speciation and possible transformations, affecting the dynamics of its migration in the ecosystem components, correct assessment of radiological situation or its forecasting become impossible. Speciation of radionuclides are determined according to their physical and chemical properties. Determination using applied methods of laboratory analysis consists of extraction, identification and quantitative determination of individual radionuclides in the environmental objects. Methodology of determination of ^{238}U speciation by their oxidation level was based on sedimentation methods. Stability of valence states of uranium in solutions can be described through the range as follows U (VI) > U (IV) > U (III) > U (V). The most stable state was registered for U (VI), which can have widely ranging pH from 1.0 to 12.0. U (IV) is less stable than U (VI). U (III) and U (V) are unstable, that is why were researched uranium in valent states as follows: U (VI) and U (VI). Each of uranium forms was determined individually. Total concentration of uranium was determined by sedimentation with fluorides, where all available uranium speciation are converted into valent U (VI). U (IV) was determined by means of oxidation with 8- hydroxyquinoline, and U (VI) was determined using pyrophosphate method. The main streamflows at the STS territory are the brooks of «Degelen» site, contamination of that was caused by radioactivity takeout from the tunnels with water. At this site, streamflows from the peri-portal area of the tunnels, genetically associated with the brooks running far beyond the former test site were studied. The brooks beyond the «Degelen» site become potential water objects with free access to water, that can be used by local population for watering cattle, drinking and household needs. For the research purpose, streamflows in the zone of impact of the tunnels 104, 503, 504, 609 were chosen. Upon the result of determining ^{238}U speciation by oxidation degree, up to 64% of the total content of uranium in

water of the tunnel 104 was found to be hexavalent and the rest 36% of it to be quadrivalent. Over 90% of ^{238}U in water of streamflows originating from the tunnels 503 and 504 as found to have the oxidation degree of + 6. Remaining part belongs to quadrivalent U. Distribution of ^{238}U in water of tunnel 609 between the speciation depending on oxidation degree shows, that 52% of the researched radionuclide is hexavalent U, 48% of U is quadrivalent. Such distribution ^{238}U between the speciation depending on oxidation level is affected by macrocomponent composition of the researched water and pH values. Obtained results will provide additional data in prediction estimate of radiological situation for the territories contaminated with ^{238}U.

Use of delayed gamma rays for detection and identification of nuclear materials in steel containers by photofission

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One of the important tasks of ecology investigations is the radiological monitoring of nuclear facilities to ensuring the radiological safety of the population of adjacent territories. Control at all stages of the nuclear cycle (for example nuclear fuel production, reprocessing and storage of nuclear waste) is necessary to prevent environmental pollution. Reliable information on the isotopic composition and activity of nuclear materials and their decay products, which are potential sources of radiation pollution, is necessary for the successful resolution of these problems. Also, this information is necessary for the successful elimination (neutralization) of the consequences of accidents of nuclear facilities (for example, nuclear power stations Chernobyl, Fukushima). The results of the detection and identification of nuclear fissile materials by the ratios of intensities of delayed gamma rays by the products of their photofission are presented. The isotopes of actinide nuclei ^{232}Th (weight – 1.0018 g), ^{235}U (0.514 g), ^{238}U (1.119 g), ^{239}Pu (0.400 g), which were packed in stainless steel containers, were used for analysis. All containers had the shape of a cylinder (diameter – 2.3 cm, height – 3 cm, weight – 70 g). The photofission reaction was induced on an electron accelerator (M-30 microtron) at bremsstrahlung energy of 12.5 MeV. Spectrometric measurements were carried out on an ORTEC HPGe detector (150 cm^3). The measurement error did not exceed 5%. The gamma-rays of the fission products ^{88}Kr (2392.1 keV), ^{89}Rb (1031.9; 1248.14; 2570.2; 2707.3), ^{138}Cs (1009.8; 1436; 2218; 2639.6) was used to differentiating of actinides. The optimal line pairs and time bins for the identification of fissile materials are established. The results of those studies may be useful for the control at all stages of the nuclear cycle necessary to prevent environmental pollution.

Radiological impact assessment of industrial by-products

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Natural radioactivity of building materials contributes in huge amount to to the annual radiation dose to population both in terms of external irradiation directly emitted from the material (Ra-226, Th-232, K-40) and of internal exposure related to the radon exhaled. Most of the population spends their time indoor, where the natural radiation of the building materials can increase their exposure for radiation. According to the 2013/59/Euratom Council Directive, raw materials and final products used in building constructions need to be tested for activity concentration, before using them. This preliminary study presents the radionuclide concentration and radon exhalation values in different by-product materials, what can be used like additions to different kind of building materials. The acticity concentration of Ra-226, Th-232 and K-40 was determined with HPGe gamma spectrometry, and the radon exhalation was determined by using accumulation chambers an an ionization detector. The Ra-226, Th-232 and K-40 activity concentration in the samples are between 13.4 ± 0.7 Bq/kg and 327.5 ± 13.1 Bq/kg, 20.82 ± 1.2 Bq/kg and 309.04 ± 18.54Bq/kg, 32.83 ± 1.77 Bq/kg and 718.12 ± 45.96 Bq/kg. The average rate of radon exhalation in the samples is 48.83 $mBqkg^{-1}h^{-1}$. Due to the measurement we can calculate absorbed dose rate, radium equivalent concentration and annual effective dose. With the obtained values, we can suggest that the measured by-product can be used by additional materials to different kind of building materials or not.

Assessment of soil-to-plant transfer factors for radionuclides near the phosphate industrial area in the north-western Morocco

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Transfer factors (TF) are important parameters to estimate the partition of radionuclides in the soil-plant system and their incorporation to the food chain. This work reports TFs of natural radionuclides (^{234}Th, ^{226}Ra, ^{214}Pb, ^{214}Bi, ^{210}Pb, ^{212}Pb, ^{212}Bi, ^{228}Ra, ^{235}U and ^{40}K as well as the anthropogenic radionuclide ^{137}Cs) from soil to a wide variety of vegetables grown in the surroundings of the phosphate industrial plants of El Jadida region in Morocco. Radionuclide activities measurements were carried out using a broad-range HPGe gamma ray spectrometer. Thirteen samples from the plant [pumpkin (Cucurbita moschata D.), Courgette (Cucurbita pepo L.), Bean (Vicia faba L. var major Harz), Fennel (Fœniculum vulgare), Potato (Solanum tuberosum L.), sunflower (Helianthus annuus L.), Broccoli (Brassica oleacera var. italica L.), Onion (Allium cepa L.), Carrot (Daucus carota L.), Cabbage (Brassica oleracea L.), Tomato (Lycopersicon lycopersicum L.), Turnip (Brassica rapa L.) and Mallow (Malva sylvestris)] and six samples from its soil were collected from six different locations. Radionuclide activities in soils showed wide ranges of variability for one location to another; ^{234}Th: from 25.8 ± 3.9 Bq/kg to 185 ± 12 Bq/kg, ^{226}Ra from 18 ± 1.0 Bq/kg to 80 ± 4 Bq/kg, ^{210}Pb from 49.7 ± 4.4 Bq/kg to 269 ± 16 Bq/kg. However, in the case of ^{228}Ra, ^{235}U, ^{137}Cs, and ^{40}K, the activities ranged from 6.0 ± 0.8 Bq/Kg to 19.6 ± 1.6 Bq/kg, from 1.2 ± 0.2 Bq/kg to 8.5 ± 0.5 Bq/kg, from 1.0 ± 0,1 Bq/kg to 6.5 ± 0.4 Bq/kg, respectively. Soil-to-plant Tfs were determined for all species and, in some cases, for different parts of the plant (fruits, leaves, roots and stems).

Animal dose measurements and biological impacts in the closed area around Fukushima

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After the Fukushima Daiichi Nuclear Power Plant accident in Japan, the surroundings became contaminated with radionuclides. Although the radiation dose rates are decreasing, people living in the affected areas are still concerned by possible adverse health effects. These effects in humans could be extrapolated by examining the effects of radioactivity in wild animals living in contaminated areas of Namie Town. We developed a methodology to measure the actual absorbed dose rate on the large Japanese field mice (Apodemus specious), by analyzing the absorbed dose rate measured with radiophotoluminescence glass dosimeters embedded in A. speciosus. The absorbed dose rate at Omaru and Ide areas exceeded the lower limit of the derived consideration reference level of 0.1−1.0 mGy day-1 for rodents as determined by the International Commission on Radiological Protection. Furthermore, after spleen extraction from A. speciosus, spleen cell culture was performed to obtain metaphase spreads. Chromosome aberrations were assessed on Giemsa-stained metaphase spreads. Although the mice in the contaminated areas were chronically exposed, there was no radiation-specific chromosome aberrations observed, such as dicentric chromosomes and rings. Some structural aberrations such as gaps and breaks were observed, and these frequencies decreased annually in mice from Namie Town.

Study of isotope ratios of the Chernobyl origin and explosive origin hot particles

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Various origin radioactive particles were studied: "Chernobyl" hot particles, sampled in the "Red Forest" soils at the Chernobyl Exclusion zone, and "explosive" hot particles, sampled at the experimental field of the Semipalatinsk Test Site. The radionuclide compositions of sampled hot particles were obtained by HPGe spectrometers and radiochemical methods. The maximum activity of investigated Chernobyl origin hot particles was 103 Bq/sample (by ^{137}Cs). The maximum activity of investigated explosive origin hot particles was 104 Bq/sample (by ^{239}Pu). Currently, radioactive particles of several varieties are found in the soils of the near the 4th Chernobyl NPP unit. The first type is characterized by the dominant ^{137}Cs and ^{90}Sr activities. The contribution of plutonium and ^{241}Am isotopes varies between 4-10% compared to ^{137}Cs activity in such hot particles. We can note the ^{90}Sr/^{137}Cs ratio currently is 3-4 in these hot particles, while it was 0.7-1 for the majority of hot particles sampled in the 2000s at the same places. After the building of the Chernobyl's New Safe Confinement, hot particles of a new type were found in the surrounding areas. They also contain dominant activities of ^{137}Cs and ^{90}Sr, however, the ^{241}Am contribution reaches to 20%. In addition, the ^{60}Co significant amount and the ^{94}Nb activity with a half-life of 2×10^4 years were found in such particles. This fact indicates the secondary contamination of the 4th Chernobyl NPP unit surrounding area with fragments of structural materials during the new confinement building. Also, Chernobyl hot particles of a completely new composition were studied for the first time. In these particles, the ^{241}Am activity is 5-6 times more than the ^{137}Cs activity. The activity of other gamma nuclides is the same as in hot particles of the first type. Studies of the dispersed composition of Chernobyl hot particles in soil were carried out by the radiographic method. We obtained that the size maximum distribution of hot particles has shifted by 1-1.5 microns compared with the distribution in the 2000s. It can be concluded that there are intensive processes of destruction of hot particles in the soils of the Chernobyl exclusion zone. The elemental and radionuclide composition of Semipalatinsk hot particles was studied. The explosive hot particles were sampled at the P-1 technical place of the Semipalatinsk Test Site (the place

of 1949-1953 two atomic and one thermonuclear explosions). These particles are characterized by the dominant ^{239}Pu activity. The ^{239}Pu activity was reliably detected in the gamma spectra of all these particles. The isotope ratios of the accident origin and explosive origin hot particles were calculated. The obtained results are discussed.

Uranium Isotope ratios and Sr-90 in Fukushima radiocaesium contaminated soil samples

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On 11th March 2011, the Fukushima Daiichi Nuclear Power Station (FDNPS) accident released a massive amount of highly volatile fission products such as ^{127m}Te, ^{132}Te, ^{131}I, ^{133}Xe, ^{134}Cs, ^{136}Cs, and ^{137}Cs caused serious contamination in the atmosphere (aerosol), water, and soils. However, radionuclides such as ^{90}Sr, U and Pu also have a serious concern, because they spread as a result of partial melt-down of the nuclear fuel core including the MOX fuel (mixed U and Pu oxide fuel) in the FDNPS. The chemical toxicity of U is likely to be much more important for human health compared to the risk of cancer from ionizing radiation. The Sr element has the potential to incorporate into the bone structure because its bio-chemically similarity to calcium, thus the ^{90}Sr isotope can cause long-term radiation dose. The principal modes of U and ^{90}Sr intake are from food and water for occupationally unexposed persons. The retention or mobility of U and Sr in soil is highly dependent on soil characteristics in the particular area, due to its large range of distribution coefficient values. The ^{235}U/^{238}U isotope ratio of the soil samples can give fingerprints about the spent fuel used in FDNPS and characterize the fuel melt down.

However, due to the relative difficulty of measuring actinide and pure beta particle emitter radionuclides, there is a little data available on U and ^{90}Sr isotopes in and around the Fukushima area. Therefore, studies on U isotope ratio and ^{90}Sr contamination of the contaminated soil samples are important. In the present study, highly radiocaesium contaminated (over 200 Bq g^{-1}) soil samples are used to check the ^{234}U/^{238}U and ^{235}U/^{238}U isotope ratios and ^{90}Sr activity concentration. Further results will be present and discuss in the presentation.

Concentrations of Rare-Earth Elements Thorium and other chemical elements in Solid Air Aerosols Particles of settlements (on the example of village Dolon)

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For the first time the research of elemental composition of particulate matter of air aerosols of small settlements of East Kazakhstan region was carried out on the example of Dolon village. In general, when modeling the processes of chemical pollution it is necessary to know not only the detailed composition of the main gas components of atmospheric air, but also the elemental composition of particulate matter of air aerosols. At the same time, geochemical properties of the environment, in which chemical elements get, play an important role. This kind of research provides information on possible processes of redistribution, migration and accumulation of chemical elements in various ecosystem components, in our case in the atmospheric air. Beyond the heating season some researched rare-earth elements and thorium were registered in higher concentrations comparing to heating season in the aerosol solid particles contained in the near-bottom atmospheric layer of Dolon village. The maximum peak in the dynamics of mean Pr and Nd concentration distribution belongs to April and June, for Sm- to April and August and for Th it belongs to June. Mean value (median values were used as mean values) for the Pr concentration in June is 3.7 ng/m^3 while for Nd, Sm and Th these values are – 13 ng/m^3 0.7 ng/m^3 , and 5.0 ng/m^3 respectively. This stable dynamics in distribution of praseodymium, neodymium, samarium and thorium speaks of natural source of their occurrence, that is soil erosion process. Concentration of light lanthanides in the environment is higher than that of heavy ones, at the same time, concentration of cerium in the environment is higher than that of lanthanum. There is a tendency observed for cerium to have 7-750 times higher concentration than lanthanum during the heating season, that speaks of its artificial origin. According to the bookish data, rare-earth elements can be found as an admixture to coals. These elements can enter the atmosphere when burning coals, i.e., the process of burning solid fuel can become a source of cerium entrance into the environment at the researched territory in the winter season. Concentration of cerium in coal samples we studied was twice higher than concentration of lanthanum there. The group of elements

with more stable dynamics of concentration distribution by seasons for the period under study was also revealed. Elements of this group - Cu, Ni, Co. A similar picture of distribution of average daily concentrations of copper and nickel in some months of heating and non-heating seasons has been determined. The difference between the average concentration values for heating and non-heating nickel seasons is 1.3 times, for copper - 1.4 times. Stability of dynamics of distribution of the cobalt content is observed practically on all months, except for months of March and December. Stability of dynamics of distribution of the contents of the given elements irrespective of the periods testifies to their different sources of receipt in atmospheric air of investigated territory. Probably, the presence of copper, nickel and zinc concentrations in the heating period is connected with the intensive process of solid fuel combustion, as in the ash samples increased concentrations of these elements were found. Thus, it has been revealed that soil erosion processes and solid fuel combustion factor are involved in formation of chemical composition of air aerosol particles in small settlements (in particular, Dolon village).

Radiation weather, radiation mapping/environmental identification as new trends for radioecology studies

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It is well known about the importance of all types of radiation of terrestrial, cosmic, and man-made origin as factors of its permanent impact on the life and evolution of biota. The life of biota takes place on the surface of a natural nuclear reactor such as Earth, and radiation itself is as important as other natural factors: terrestrial gravity, the composition of the atmosphere. Therefore, the characteristics of natural radiation: the ratio of its cosmic and terrestrial components, the alpha-, beta-, gamma- nuclides contents/ratio for terrestrial radiation are the parameters of the “radiation weather”. These parameters are important for studying the mechanisms of protection/adaptation of living organisms to the ionizing radiation and the role of radiation in the metabolism of living organisms. Moreover, terrestrial radiation standards allow the identification of territories by the ratio of chemical components of U : Th : K which are important for nuclear dating tasks, the establishment of temporal scales and the nature of global factors that may disturb the equilibrium of U, Th nuclides of natural series. In this presentation we consider the concepts and parameters of "radiation weather". The main points of the proposed talk are: • in situ nuclear metrology of low background measurements: substantiation of the choice of isotopes as markers of anthropogenic and natural or geochemical characteristics of the region to ensure the sufficiency and representativeness of the studies;

• The importance to establish the radioecological standards about of the contents and ratios of technogenic and U/Th/K isotopes as parameters of terrestrial radiation weather.

• The use of these standards for the estimation of geochemical indicators, in particular, the ratio of the chemical elements U/Th/K in the studied regions.

• The importance of radiation mapping, in particular, regarding the distribution of the U/Th/K component in the environment. Availability of

such maps is a prerequisite for establishing the parameters of the radiation weather for determination the geochemical indicators and estimating the distribution of the ^{220,222}Rn components. The preliminary data on radiation mapping of natural parks and protected areas as well as study of geochemical indicators in isolated mountain areas of Transcarpathia are presented.

Fate of Cs, Sr and U in soils affected by Fukushima Daiichi Nuclear Power Station Accident

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On March 11, 2011 a massive earthquake and ensuing tsunami severely damaged the Fukushima–Daiichi Nuclear Power Station (FDNPS) resulting in hydrogen explosions at nuclear reactors. Although it is believed that nuclear material such as plutonium and uranium isotopes must have remained largely inside reactor, the chances of their release in environment should be considered. Consequently, the study of fate of radionuclides that could be present due to FDNPP accident is of great importance from the viewpoint of radioecology. In order to understand migration behavior of Cs, Sr and U, determination of sorption-desorption characteristics in contaminated soils from exclusion zone in Okuma town has been carried out in present work. Kd (distribution coefficient) values were established using batch method with stable isotopes as tracers. To estimate the source of contamination in soils, isotope ratios of uranium were measured using TIMS. Analytical chemical separation of U from digested soils was carried out with AER (AG 1 x 8)-UTEVA resins. Characterization of different soil parameters like particle size distribution, pH, organic content, cation exchange capacity (CEC), $CaCO_3$, elemental and oxide composition of soil has been determined. Sorption coefficient, Kd(S) of Cs and Sr was found to be in the range of 65 to 2100 and 15 to 130 L/kg respectively. Kd(S) - U values varied from 30-36000 L/kg i.e. three orders of magnitude difference. High values of Kd(S) reflect more sorption capacity of soil for U and Cs than Sr. Values of desorption coefficient, Kd(D) for Cs and U were higher than values in the sorption process. This shows irreversibility of Cs and U sorption in soil as well as good retention capacity for actinides like U. The $^{235}U/^{238}U$ ratio did not show any enrichment of ^{235}U in Fukushima soils. The $^{236}U/^{238}U$ isotope ratio value of the order of 10^{-7} in Fukushima soil showed mixing effect of global fallout and FDNPS accident. Details of the work will be presented in the conference.

Sr-90 analysis in Fukushima water samples

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The main contaminants released from the Fukushima Daiichi Nuclear Power Station accident is the volatile radioisotopes of caesium (^{137}Cs ~15 PBq, ^{134}Cs ~15 PBq) with the non-volatile ^{90}Sr (~0.14 PBq). The ^{90}Sr ($T_{1/2}$ = 28.8 y) is a pure beta particle emitter artificial radionuclide, produced by the fission of U and Pu isotopes. Low level (some Bq kg-1 or mBq kg-1) ^{90}Sr contamination exists in different environmental matrices as a result of nuclear weapon tests and nuclear accidents. For the public, radiation dose resulted from external beta particles exposure is not relevant because the low penetration efficiency of beta particles and limited radionuclide deposition on human skin. However, radiation dose due to beta emitter radionuclide incorporation via ingestion and inhalation into human body must be considered in case of a nuclear accident. Basically, Sr element has no biological role in the human body, however it is an alkaline earth metal with similar bio-chemical properties of calcium thus can attach into the bone structure causing long-term radiation dose. From the view point of public health and natural radiation protection, ^{90}Sr monitoring in various environmental, samples is essential. In this work ^{90}Sr contamination was determined in well and ground water samples collected from the Fukushima exclusion zone using a multi-collector thermal ionization mass spectrometry instrument equipped with wide aperture retardation potential (WARP) energy filter and Daly ion-counter. ^{90}Sr could not detected in the water samples since the concentration of the ^{90}Sr was below 30 mBq kg^{-1} (minimum detectable activity concentration). Considering the radiation protection of the population, the radiation dose from ^{90}Sr ingestion is negligible.

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

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Reconstruction of the irradiation dose of population living in regions adjacent to Semipalatinsk test site, which has been functioning for more than 40 years, arouses huge interest to the present day. The paper addresses results of the regional background frequency of stable translocations using a fluorescent hybridization in situ technique for different age groups that varies between 1.42±0.3 and 4.9±0.5 per 1,000 cells. 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. The effect of bad habits such as smoking is the most studied habit because it affects translocation level. There is a correlation between the level of stable chromosome damages and this bad habit for age groups of interest. The background frequency of stable chromosome damages 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.

Disaster Response in Japan: Fukushima Nuclear Regulator Probe Delays in the Wake of Covid-19, Torrential Rains and M4+ Earthquakes

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Japan had its fair share of disasters in the past decade, the 2011 earthquake that triggered a tsunami and the Fukushima Daichi meltdown being the most serious. Today, as the country struggles to deal with the coronavirus, disaster response experts have encouraged governments nationwide to improve emergency measures so they can better respond in the event of natural and other disasters. Evacuation centres capable of handling Covid-19 patients need to adopt stricter ventilation and disinfection strategies to prevent infections. In addition to that, torrential rains are becoming increasingly frequent in Japan and vast parts of the country saw floods that caused landslides in recent years. Earthquakes, as well as strong typhoons, hit western Japan in 2018 and exposed further shortcomings in the state's disaster-preparedness strategy. The Japan Academic Network for Disaster Reduction emphasized the need to use more classrooms in addition to gymnasiums to ensure evacuees maintain a safe social distance from one another and stated that it is essential to rethink evacuation methods. Following the state of emergency declaration last month, the central government issued a notice to local governments recommending they set up new evacuation centres. Further to the above, this paper is to look into how the probe by the Nuclear Regulation Authority (NRA) into the causes of the March 2011 Fukushima crisis has been hampered by the coronavirus pandemic. The NRA originally intended to send its staff to the Fukushima Daiichi plant every one or two weeks in April and May, but the plan came to a halt following the government's declaration of a state of emergency over the coronavirus on April 7 for Tokyo and six other prefectures, which was expanded nationwide on April 16. The nuclear watchdog was compelled to cancel the scheduled dispatch of its staff because any coronavirus infection among the employees at the plant could hamper their decommissioning work.

^{238}U and ^{234}U concentrations in groundwater of the Thu Duc region in Ho Chi Minh City, Vietnam

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The results of ^{238}U and ^{234}U activity measurements in groundwater of the Thu Duc region in Ho Chi Minh City, Vietnam, are presented in this paper. The measurements were performed using PIPS alpha detector manufactured by Canberra Company, Inc. Mean concentrations of ^{222}Rn and ^{226}Ra were found to be 40.51± 3,68 mBq l^{-1} and 61.31±4.73 mBq l^{-1} in 15 groundwater samples. We used K_2FeO_4 (potassium ferrate) to remove uranium in the these samples. Through precipitation produced in the chemical reaction with K_2FeO_4, uranium is removed from the solution attached to the product after the reaction is iron oxide (Fe_2O_3) - a non-toxic, non-mutant substance. The results showed that the percentage of radioactive substances was lower than the original by more than 80%. The results have created a chance for research K_2FeO_4 to expand and the possibility of future application.

Study of ratios of $^{90}Sr/^{137}Cs$ in conventionally-background territories of Semipalatinsk Test Site

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Comprehensive radioecological surveys of Semipalatinsk Test Site are being carried out, aimed at establishing the level of radioactive contamination of environmental objects and establishing the boundaries of radioactive contamination. The area of the test site is 18.3 thousand km^2. To obtain complete information on the content of radionuclides in environmental objects, it is necessary to carry out a great number of in vitro analyzes, results of which are used to construct maps of the radiological situation. These schematic maps are the basis for graphical representation of the spatial distribution of radionuclides in the area of interest. Taking into account the area of territories under study and the number of samples, the determination of such radionuclides as ^{90}Sr using radiochemical analysis is rather labor-consuming and costly. Research in the field of alternative techniques for determining radionuclides, for example, through the $^{90}Sr/^{137}Cs$ ratio, becomes relevant. This approach is based on the similarity of the nuclear-physical characteristics of ^{90}Sr and ^{137}Cs production during a nuclear explosion as well as on the assumption that the distribution of ^{90}Sr in the environment after the test in environmental objects will be similar to that of ^{137}Cs. Thus, to assess the activity of ^{90}Sr, it is sufficient to determine the activity of ^{137}Cs using a gamma-spectrometric technique, which is comparatively cheap and accessible. The paper addresses features of the distribution of ^{90}Sr to ^{137}Cs concentration ratio in topsoil in the territory of the test site beyond its testing areas and fallout plumes – in conventionally background areas. No nuclear tests were carried out in conventionally background STS territories, radioactive contamination there can only be caused by local and global fallout. There is a lot of information in the scientific literature on concentrations of ^{90}Sr and ^{137}Cs in the global fallout, typical of the Northern Hemisphere. The range of ^{90}Sr and ^{137}Cs content in soil due to the global fallout is rather short: ^{137}Cs - 4 ÷ 29 Bq / kg, ^{90}Sr - 1 ÷ 19 Bq / kg. According to literature data, the ^{90}Sr / ^{137}Cs ratio in the global fallout is 0.6. The research methodology included sampling of topsoil (0-5 cm), determination of activity concentrations of ^{90}Sr and ^{137}Cs in samples using conventional techniques followed by calculating ^{90}Sr / ^{137}Cs ratios, statistical data processing and mapping. Study findings showed that the

$^{90}Sr/^{137}Cs$ ratio varies from 0.01 to 1.5. $^{90}Sr/^{137}Cs$ values exceeding the level of global fallout are typical of those survey area that are located near testing areas and fallout plumes. The range of ratios obtained for conventionally background territories differs from ratios of fission products in soil of epicentral zones of the "Experimental field" testing area, in which the $^{90}Sr/^{137}Cs$ ratio is in the range of 0.6 ÷ 4.8 depending on the composition of a nuclear charge used during an aboveground test and on the extent of fallout plumes after nuclear tests conducted on September 24, 1951 and August 12, 1953 with ratios lying in the range of 0.4 ÷ 1.4 and 1.1 ÷ 5.5. Thus, at this point of research, there are prerequisites to apply the mean value of ^{90}Sr / ^{137}Cs for conventionally background STS territories, to assess ^{90}Sr concentration in topsoil rapidly using radiochemical analyzes only to confirm findings. Nevertheless, this work requires further research in order to improve the statistical reliability of data obtained. Research undertaken has also shown prospects of the comprehensive approach when studying ratios in topsoil in conventionally background areas and the necessity to include the process of radioecological mapping in the methodology for a better understanding of the radiological situation.

Radiological properties of fly ash as a raw material for low-carbon cements

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Recently, in order to protect the environment, fly ash and other secondary raw materials have been increasingly used in construction sector. In the area of building materials research, one of the potential comprehensive solutions to the problem is the synthesis of alternative mineral binders such as belite-sulfoaluminate (BCSA) cement clinkers, which are considered as low-carbon and low-energy, allowing the substitution of natural raw materials with secondary ones. In this study, five different types of fly ash from Thermal power plant Nikola Tesla A and B, (TENT A and TENT B, Serbia) were assessed with respect to their use in BCSA clinker production. For that purpose, physico-chemical characterization of the fly ashes were investigated. Radiological measurements of fly ashes was performed by gamma spectroscopy. Activity concentration of ^{40}K and radionuclides from the ^{238}U and ^{232}Th decay series in fly ash was determined, as well as the absorbed dose rate (D) and the annual effective dose rate (E), calculated in accordance with the UNSCEAR 2000 report. The synthesis of cement clinker is planned, in order to determine its radiological properties as a potential binder in the cement industry.

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Radiological assessment of red mud as Al-containing precursor in inorganic binder for building industry

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Secondary raw materials with high alkalinity, such as red mud, represent a major environmental problem. Red mud (RM) is a waste product obtained from the Bayer process in aluminum industry mainly made up of oxides of iron, aluminum, silicon, and titanium. Due to potential leaking in the soil or ground waters, it can be one of the most urgent environmental issues. The potential re-use of RM in the brick industry, the industry of building materials or road construction has been the subject of research by a lot of scientists. The presented research is a contribution to the potential solution of this environmental issue through the synthesis of potential construction materials based on RM. The content of naturally occurring radionuclides in manufactured material products with potential application in building and construction industry is important from the stand point of radiation protection. Gamma radiation of the primordial radionuclides, ^{40}K and members of the uranium and thorium series, increases the external gamma dose rate. However, more and more precedence is being given to limiting the radiological dose of building materials on the population these days. Since red mud contains radioactive elements like ^{226}Ra and ^{232}Th, this may be another key problem for the further utilization of red mud. The aim of this research was to investigate the radiology characterizations of red mud ("BOKSIT" a.d. Milići, Zvornik) and their chemical composition by X-ray fluorescence spectroscopy (XRF), particle size distribution with laser granulometry and BET specific surface area by gas sorption. Fourier-transform infrared spectroscopy (FTIR) and X-ray powder diffraction analysis were used to monitor chemical bonds and crystal or amorphous phases of investigated red mud samples, respectively. Specific activities of natural radionuclides (^{226}Ra, ^{232}Th, and ^{40}K) of red mud samples were

determined by gamma spectrometry measurements. In further research, processes studies of alkaline activation-polymerization of red mud as precursors containing Al are planned and also determination of natural radioactivity of alkaline activated materials (AAMs) synthesized by red mud.

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External and internal radiation risks in Angolan adobe houses focusing on thoron contribution

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Thoron contribution to the inhalation dose is now a known phenomenon proved by many studies mostly focusing on houses made of unburned earthen building materials like adobe (Szabó et al., 2014, Gierl et al. 2014; Shang 2005; Reddy et al., 2004; Guo et al., 1992). With the aim of evaluating the external and internal exposure of the Angolan population living in adobe houses, 1) 60 building material samples have been collected for the determination of Ra-226, Th-232 and K-40 activity concentrations by gamma-ray spectrometry and, 2) a year long survey (divided in rainy and dry seasons) was made in 45 dwellings in 3 different areas in Angola (Cabinda, Huambo and Menongue at the North, central and South parts of the country, respectively) for radon and thoron activity concentrations detected with etched track detectors. From these data, the radiation risks, and the external and internal doses of residents were estimated. The results show a spatial distribution: most of the values from Huambo are significantly the highest compared to the other studied areas, which is explained by its geological background composed mostly of granitic rocks (Salupeto-Dembo et al. 2020a; Salupeto-Dembo et al. 2020b). A seasonal variation of indoor radon activity concentrations was also detected (Salupeto-Dembo et al. 2020b). The external radiation from adobe building material in Angola is shown to be not hazardous for the local population (Salupeto-Dembo et al. 2020a), however, it was confirmed that radon and thoron may cause a non-negligible contribution to the internal radiation exposure (Salupeto-Dembo et al. 2020b). The presently best available estimation shows that thoron contribution to the inhalation dose is significant, around 50% in average (Salupeto-Dembo et al. 2020b).

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Post-volcanic activities reflected in radionuclide content of spring waters from Romania

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The volcanic activity brings to the surface rocks with higher radionuclide content. Naturally occurred radionuclide are dominant in magmatic rocks, and the water in touched with this rocks can dissolve a part of it radionuclide content, especially from U-238,235 and Ra-226,228. Thorium isotopes water solubility is relative low, and they are not present in the water. In Romania are two small groups of volcanically formed mountains, one in northern part of the country OAS-GUTII-TIBLES, and another in south CALIMAN-GURGHIU-HARGHITA, in each zones are present numerous springs denote the post-volcanic activity. In present study was investigated the radionuclide content of spring water from post volcanic zones in order to find correlations between the sites and isotopes. For investigations, three different types of measurements techniques were used. For Rn-222, Ra-226 Liquid Scintillation Counting (LSC), Lucas cell and Rad7 was used. For Pb-210 beta spectrometry (LSC), Po-210, U-238,235, by alpha spectrometry and K-40 was measured by gamma spectrometric techniques. An spectrum analyzer software was developed for TricCarb LSC with whose help, the calculation of Rn-222 and Pb-210 becomes fast and easy. The obtained results show strong correlation with the geological bedrock of the study sites.