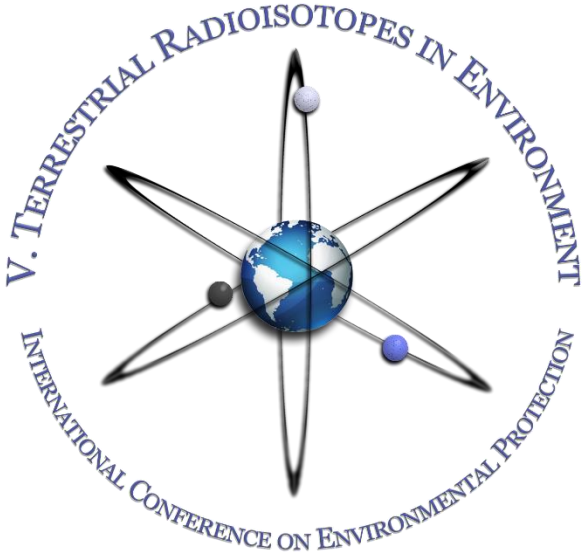
V. TERRESTRIAL RADIOISOTOPES IN ENVIRONMENT

International Conference on Environmental Protection



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International Conference on Environmental Protection

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Table of contents

RADON SURVEY IN HUNGARY

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Radon issue is well known for decades. From the ‘80s a lot of radon and thoron measurements were performed in Hungary, too. Research Institutes, Universities, Companies carried out these measurements in the framework of different survey projects with different, mainly scientific, purposes. First investigations based on indoor measurements, as elsewhere in other countries. Later in the ‘90s-2000s the source of indoor radon, the geogenic radon was highlighted. In Hungary geogenic radon measurements were performed with scientific and economical purposes, such as to study the dynamics of soil gas radon and make investigations associated with uranium mining. First geogenic radon mapping were performed in the early 2010s.

Hungary had law only for indoor radon concentration of workplaces (1000 Bq m^{-3} annual average) until January 2014 (16/2000. (VI. 8.) Ministry of Health Regulation). The new EU BSS (Council Directive 2013/59/Euratom) laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation, including radon. It is appropriate for this Directive that Member States should establish reference levels for indoor radon concentrations and establish national radon action plan addressing long-term risks from radon exposures in dwellings, buildings with public access and workplaces for any source of radon ingress, whether from soil, building materials or water. Member States shall identify areas where the radon concentration (as an annual average) in a significant number of buildings is expected to exceed the relevant national reference level. Accordingly, establishing national radon maps, both indoor and geogenic, are required.

REPRESENTATIVENESS OF THE FIRST NATIONAL INDOOR RADON SURVEY IN SERBIA

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As a first step in establishing the national radon action plan, the first national indoor radon survey in Serbia started in 2015. In the cooperation with IAEA, Serbian Radiation Protection and Nuclear Safety Agency (SRPNA) formed radon working group that made the design of the first national radon survey in Serbia. The project is supported by the IAEA through the technical cooperation, the national project: SRB9003 - Enhancing the Regulatory Infrastructure and Legislative System: expert mission on „National Radon Trial Survey and Raising Awareness of Key Stakeholders„ held in SRPNA, Belgrade, February 2 – 4 2015 and leasing of 6000 track-etched indoor radon detectors. The distribution of detectors across the Serbian territory is the responsibility of SRPNA and it is conducted in the cooperation with eminent institutions of Republic of Serbia. The distribution of the detectors started in October 2015, and exposure time is six months. The first preliminary results of national indoor radon survey are expected in the first half of 2016. In this work, the sampling design of the first national indoor radon survey is described in detail. Also, every radon survey needs to check the representativeness (e.g. compare certain parameters in the actual sample with corresponding values in the last census). A carefully designed survey can, in principle, meet the requirements and objectives of both types of surveys, population-weighted and geographically based survey. In the case of Serbia, we choose a stratified (target population is partitioned into separated groups - STRATA) sampling design. We defined STRATA according to the administrative divisions of Serbia into districts. A first check of the actual representativeness of the sample with respect to Serbian National Census Data is presented in this work.

PRELIMINARY RESULTS OF INDOOR RADON AND THORON SURVEY IN HUNGARIAN KINDERGARTENS

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The risk of radon became well known in the last decades, more than half part of the natural background radiation is from radon and its daughter elements and overall, radon is the second leading cause of lung cancer. Accordingly, the leading authorities take into account the current legislations (UNCEAR, EU-BSS).

It is appropriate for thr EU-BSS directive (2013/59/EURATOM) to establish national radon surveys in each EU member states. In this study two region (Veszprém and Gödöllő) as a survey area and 66 and 33 kindergartens were selected, respectively. One year indoor radon and thoron concentration measurement started in September 2015 to know whether the concentrations (as an annual average) exceeding the reference level.

To determine the radon and thoron discriminative SSNTD (Solid State Nuclear Track Decetors) were used. The detectors were placed near to the wall (15-20 cm), after 3 months exposure the detector were changed and evaluated.

According to the preliminary result (after the first and second 3 months periods) the radon concentration was under 300 Bq/m^3 which is the reference level recommended in the new EU-BSS.

A NEW RADON MAP FOR AUSTRIA – FIRST RESULTS FROM A PILOT SURVEY IN UPPER AUSTRIA

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According to the new EU BSS all member states have to identify areas where the radon concentration in a significant number of buildings is expected to exceed the relevant national reference level. Identifying such areas will be fundamental for establishing legislation and future strategies. The current radon map of Austria is based on about 20,000 indoor measurements normalized for a standard situation (radon potential), displayed on a municipality level in 3 classes. The map is mainly used for decision about preventive measures in new buildings. Although the map is based already on quite a large data basis, the uncertainty in the classification of municipalities according to their radon potential is still high and does not take into account geographical diversity within a municipality. To implement the requirements of the EU-BSS (e.g. radon measurement at workplaces in "radon areas") an improved, sound radon map is needed. Radon measurements in about 40.000 dwellings are planned in the next years to improve the Austrian radon map, funded by the Ministry of Environment. The measurement points are selected based on a regular 2x2 km grid, taking geology into account. In addition together with indoor radon, additional data should be included to characterize areas regarding radon. The availability of such data and the possibility to use them as input parameters to classify radon areas (e.g. aero-radiometry, geological information, soil permeability etc.) is assessed at the moment. As a pilot study radon measurements were carried out in about 5.000 dwellings in Upper Austria, the province with the highest radon potential according to geology (Bohemian massif). The measurements were carried out in the houses of selected members of the voluntary fire brigades. With the data set of the pilot study, the influence of house characteristics, living style and geology on the indoor radon concentration is tested and possible mapping methods for Austria are assessed. In this contribution, the first results of these evaluations will be presented and discussed, as well as the experience and lessons learned from the pilot study for improvement of the following measurement campaigns.

A BRIEF OVERVIEW ON RADON MEASUREMENTS IN DRINKING WATER

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Radon and especially its progenies pose radiation risk to humans not only via breathing but also due to water consumption. For this reason, the recent European Drinking Water Directive published in 2013 includes these radionuclides in the scope. For the accurate activity concentration determination of radon and its progenies in drinking waters reliable and robust methods are needed. Radon measurement is one of the most frequently used radioanalytical procedures which are applied widely in the field of radioecology, environmental monitoring and hydrology. The aim of this paper is to present information about currently used standard and routine methods for radon analysis in drinking waters. In the context preparing an interlaboratory comparison, an overview is given about the current situation and the performances of different measurement methods. These measurement methods are compared on the ground of literature data. The following parameters are compared and discussed: initial sample volume and sample preparation, detection systems, minimum detectable activity, counting efficiency, interferences, measurement uncertainty, sample capacity, typical counting time and overall turnaround time. Moreover, the reference levels for radon in drinking water from the different European countries` legislations and from the corresponding European Commission Directives on radon are presented and compared.

RADON ANOMALIES IN DRY CARBON DIOXIDE SPAS OF EASTERN TRANSYLVANIA, ROMANIA

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Dry carbon dioxide spas, established on mofettes, the final form of post-volcanic activity that contains mostly low temperature carbon dioxide, are often used for therapeutic treatments of patients suffering from vasoconstriction. Many dry CO_2 spas were built and operate to this day in the surroundings of Harghita and Csomád Mountains. Besides CO_2, radon may also flow into the pools, which is in many cases carried by mofette gases itself. In such cases radon is a good tracer, and can be used for the study of spatial and temporal variation of mofette gases. However, in the airspace of some mofettes (i.e. Bardócz, and Harghita-Băi) radon shows anomalous spatial and temporal changes, which raises doubts about its application as a tracer. It seems that CO_2 and radon enter into these pools at least partially independently following different pathways, and with various yields. The interpretation of these anomalies contributes to the better understanding of the flow pattern of pool-filling mofette gas, and the mixing process of medicinal gas with ambient air. With the information about flow and mixing patterns, there is an opportunity to plan the optimal design of the pool area, which facilitates to achieve high (90%) carbon dioxide concentration at the lower limbs while maintaining low concentration at mouth level of the patients. However, the anomalous behaviour of radon in individual mofettes draws the attention that this gas should also be examined from a health protection point of view. Especially reasonable for the staff accompanying the treatment, to wear personal radon dosimeters in order to determine the radon exposure, and to estimate effective dose of individual spa workers. Without personal radon dosimetry the uncertainty in the estimation of personal radon exposures may be as high as one order of magnitude.

SOME PRELIMINARY RESULTS OBTAINED WHEN INDOOR RADON MITIGATION METHODS ARE APPLIED

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University of Extremadura

Remedial actions are totally necessary in environment where high radon concentrations have been detected. In a survey about measurements of indoor radon concentration in working places performed in the region of Extremadura (Spain) several sites with high indoor radon concentrations were found. As these sites were generally placed in zones where the natural background radiation was also high, a deeper study was undertaken, performing surveillance and applying mitigation methods when necessary. Principal proposed actions included ventilation (when possible), architectonical actuations, or limiting the time of residence of the people working in the exposed areas (when no other actions can be performed). Several cases were studied, analyzing the effects that the proposed actions caused on the changes in the indoor radon concentrations. Studied sites included caves, cellars, historical buildings, hotels, museums and other interesting places. Seasonal variations, dose estimations, and the results obtained by the application of the proposed mitigation methods were studied in each case. Some chosen examples show the importance of studying each particular case because sometimes the solution to the problem is even simpler than expected.

TOWARDS A MULTIVARIATE GEOGENIC RADON HAZARD INDEX

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In most cases, the most important physical causes that control indoor Rn concentrations are geological and geophysical factors. This leads to the question of how to define a quantity which measures that "geogenic" control. As most natural candidates, different versions of a geogenic Rn potential (GRP) have been proposed, this quantity measuring, conceptually, "what Earth delivers" in terms of Rn. One of the Europe-wide maps which shall be part of the European Atlas of Natural Radiation, currently in the making at the JRC, is one of the GRP or a related quantity with similar informative value. The practical problem consists in the fact that GRP values are available only in few countries, and that their comparability is limited due to different definitions and sampling protocols. It has therefore been proposed to define a dimensionless geogenic Rn hazard index (RHI) out of "proxy" quantities which are related to sources of geogenic Rn and which are easily observable. Among these are uranium concentration in the ground (measured in samples or as eU by in situ- or aero-gamma spectrometric techniques), terrestrial gamma dose rate, Rn concentration in soil, Rn exhalation rate or the GRP itself. The basic idea is to calculate weighted means of these quantities after rescaling them. Weights are conceived to depend on the strength of association with the envisaged target quantity, which could again be the GRP itself, or on loadings resulting of PCA, or similar. Rescaling is done such that equal rescaled values of each quantity are equivalent with respect to their impact on the RHI. The method has the attractive feature that not all possible quantities are required as input to calculate the RHI. This is important, because we attempt to be able to calculate the RHI for locally available datasets, as the reality in Europe is that nearly every country (sometimes even every region) has different and differently complete datasets of Rn-related quantities. Calculating a harmonized GRP has therefore met considerable obstacles. The concept of RHI may be a tool to circumvent these difficulties. Certainly, the more datasets are available at a location, the more accurately the resulting RHI value would quantify what it is supposed to do according its concept. In this contribution, we introduce the RHI concept in more detail. We present datasets which are candidates for input data, and discuss the questions of weights and rescaling the raw quantities; these are the most difficult problems in implementing this otherwise intuitive and straight-forward idea. We show examples of how the concept could be realized, but since we are still in the phase of technical discussions, the results have to be regarded as preliminary.

UNCERTAINTY DUE TO OVERLAP CORRECTION IN RADON MEASUREMENT WITH SSNTD

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Radon detector with solid state nuclear track detector (SSNTD) was simply regarded to have approximate linear response to radon exposure by limiting the range of radon exposure and ignoring the track-overlap effect in most previous studies. With the development of SSNTD system and the extension of its application, some researchers attempted to operate SSNTD into track-overlap saturation regimes in current years. Several methods to correcting the overlap effect were proposed based on theoretical analysis, Monte-Carlo simulation and experiments. However, most of these works were focused on obtaining the non-linear response curve between the number of counted tracks and the number of real incident particles. Few of them provided a systematic discussion on the large uncertainty due to overlap correction and its influence on the radon detection. This article was aimed to investigate the influence of uncertainty due to overlap correction on radon measurement with SSNTD.

Monte Carlo simulation code was developed to investigate the track overlap. Each run of the simulation was ended only when counted tracks reached a specific number and the number of generated tracks was recorded. Overlap effect with different counted track densities and different track diameters were simulated. The verification experiments were conducted in standard radon chamber. At last, as an application, the relationship between track density and uncertainty due to overlap correction was applied to optimize the radon measurement.

From the simulation, equations of overlap correction factor and corresponding uncertainty for different track densities and track radiuses were obtained. It was found that relative uncertainty due to overlap correction exceeded 10% in high track density and increased rapidly with track density increasing. The verification experiments showed that the overlap correction curve obtained in this article was capable to correct the overlap effect correctly and extend the radon detector's linear response range. Based on the obtained uncertainty due to overlap correction, it was found that the uncertainty due to the overlap correction contributed significantly to total uncertainty in high radon exposure and that the track density should be between 9 tracks·mm^{-2} and 170 tracks·mm^{-2} to maintain a 5% combined uncertainty for the system used in this article.

In order to extent the linear detection range of this radon measurement method by overlap correction, the uncertainty due to the correction should be carefully estimated.

RADON ASSESSMENT IN WATER SAMPLES FROM THE ASPIRING BUZĂU LAND GEOPARK

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A study of radon gas concentration in groundwater throughout the aspiring Buzau Land Geopark was carried out between 2014 and 2015. More than 100 samples were collected from the most representative sources present in the area, such as wells, natural springs, boreholes and tap waters. Spring water samples were predominant. Due to their chemical characteristics, 90% of spring waters can be classified as mineral waters which can be used in medical treatments while some are even fit for bottling. Therefore, a comprehensive analysis of such waters is more than welcomed and in progress. The present paper investigates the radiological aspects, in terms of Rn content. Other sources of water were also analysed in order to assess the potential health risk posed for the local households. All measurements were performed using solid scintillation, and the LUK VR system. The radon activity concentration ranged between 2.9 Bq/L and 15.38 Bq/L with an average of 9.24 Bq/L. One fourth of the samples had radon concentration above the recommended value of 11.1 Bq/L (US EPA, 1999). Used for household and drinking, the latter may represent an additional risk to the population. Acknowledgements: The research leading to these results has received funding from EEA Financial Mechanism 2009 - 2014 under the project contract no 22 SEE/30.06.2014 GEOSUST/EEA-JRP-RO-NO-2013-1-0135, entitled „Applied research for sustainable development and economic growth following the principle of geoconservation: supporting the Buzau Land UNESCO Geopark initiative”.

RADON MEASUREMENTS AND DOSE ASSESSMENT OF UNDERGROUND MINERS. FOCUS ON NEW EU-BSS AND HUNGARIAN LEGISLATION

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It is known that in places under the ground (mines, caves) the radon level could be extremely high compared to the above ground. In the last 15 years at the Manganese Mine of Úrkút the radon levels measurements were monitored and successful mitigation techniques were applied to decrease the risk of radon. According to the previous surveys the radon levels without mitigation 1000-9000 Bq/m^3. Following the Hungarian legislation the radon level was mitigated under 1000 Bq/m^3 exactly 190-530 Bq/m^3. However, according to the new European Basic Safety Standard, the concentration of radon has been recommended to be below 300 Bq/m3 in workplaces and dwellings.

Focusing on the reducing of the risk of the miners the Manganese Mine begins the new monitoring and mitigation program to following the recommendations.
The aim of the comprehensive study were analysing the source of radon and monitoring of the radon level after mitigation and dose estimation of the miners.

10 water samples from the manganese mine and 20 different rocks sample radiological characterisation were carried out (gamma spectrometry, radon emanation, radon exhalation). The radon level were measured by different devices Alphaguard 2000, EQF 320, Rad 7, Tesla TSR2 and CR-39 passive detectors to get the clear overview.
Based on the results the mine water radon contribution to the mine air is negligible the main source is the manganese clay according to the relatively high radium content 62-87 Bq/kg and emanation factor 28 % and massic exhalation rate 81 Bq kg^{-1} h^{-1}

Optimizing of the ventilation in the tunnels the radon level was between 155-240 Bq/m^3 what is suitable eligible for the BSS recommendation the equilibrium factor measurements (0.32-0.41) and the unattached fraction measurements (0.15-0.22). Calculating with dose conversion factor from this study and radon concentration and equilibrium factor from previous studies in this manganese ore mine, the estimated dose originating from radon and its progeny was around three times higher than in results from former studies.

EXPERIENCES OF RADIOHYGIENE EXAMINATION OF BUILDINGS IN HUNGARY

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Radiohygiene examinations were carried out by NRDRR in 570 buildings between 1995 and 2015. Gamma dose rate and indoor radon were measured in 558 buildings and in 516 buildings respectively. Statistical analyse was made from the results generally and separately for special groups. Detailed information was collected about the indoor gamma dose rate levels and type of building materials for 189 buildings. The gamma dose rate levels were measured at different points of several rooms, namely on the floor, at 1 m height, near to the ceiling and near to the surface of walls. Using these results we determined the general measurable gamma dose rate levels by different structure elements (like floor, ceiling, walls). In 64% of the buildings sludge was built in. According to our results the average indoor gamma dose rate was 176 nSv/h for those buildings where sludge was built in and 120 nSv/h for those buildings where sludge was not built in. The gamma dose rate values were determined in environmental dose equivalent unit ($H^*(10)$). For comparison the average outdoor gamma radiation was also measured. The average value was103 nSv/h based on the results of 361 measuring point. The indoor radon concentration was measured in 415 buildings for at least 1 year period. Using these results we calculated the average radon concentration and the distribution of values. The average radon concentration was 108 Bq/m^3 and the highest measured value was 781 Bq/m^3. Furthermore, radon concentration was measured in 154 buildings for shorter period which were usually 1-5 days. We analysed the time dependence and variation of the radon level for these short periods. From the evaluation of the results it can be seen that usually the maximum value was 3 times higher than minimum.

RADON INDUCED HYPERPLASIA MODULATES THE BASAL CELL DOSES IN THE BRONCHIAL EPITHELIUM

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There is experimental and histological evidence that chronic irritation and cell death may cause increase in progenitor cell number, i.e. hyperplasia in the exposed tissue. As the heterogeneous deposition of inhaled radon progeny results in high local doses and cell death rates at the peak of the bronchial bifurcations, it was proposed earlier that hyperplasia occurs in these deposition hot spots upon chronic radon exposure. The objective of the present study was to quantify how the induction of basal cell hyperplasia modulates the radiation burden of basal cells. For this purpose, numerical epithelium models were generated with spherical cell nuclei of six different cell types based on histological data. Basal cell hyperplasia was considered by epithelium models with additional basal cells and increased epithelium thickness. Microdosimetry for alpha-particles was performed by an own-developed Monte-Carlo code. Results show that the average hit number and dose of basal cells decrease by the increase of the measure of hyperplasia. Hit and dose distribution reveal that the induction of hyperplasia results in a basal cell pool which is shielded from alpha radiation. It points out that the exposure history affects the microdosimetric consequences of a present exposure, while the biological and health effects of a present exposure may also depend on previous exposures. If the location of radiosensitive target cells change due to previous exposures, dosimetry models considering the tissue geometry characteristic of normal conditions are inappropriate for dose estimation in case of protracted exposures. As internal exposures are frequently chronic, such changes in tissue geometry are highly relevant for other incorporated radionuclides.

This work was supported by the European Union and the State of Hungary, co-financed by the European Social Fund in the framework of TÁMOP 4.2.4. A/2-11-1-2012-0001 ‘National Excellence Program’ (A2-EPFK-13-0160) and by the National Research, Development and Innovation Office under the contract VKSZ_14-1-2015-0021.

COMPARISON OF EFFECTIVE DOSES BASED ON DIFFERENT RADON MONITORING APPROACHES

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In 43 buildings of high radon levels (23 schools, 3 kindergartens, 16 offices and one dwelling), radon was monitored using various techniques. In all the buildings, instantaneous radon concentration was obtained with Lucas-type α-scintillation cells; in 18 buildings, solid state nuclear track detectors were exposed for a month; and in 10 buildings the retro detectors were used (glass surfaces). In 14 buildings, the Sarad EQF devices gave us diurnal variations of radon and radon progeny concentrations. In 4 buildings, all the available techniques were applied. Annual effective doses were calculated based on the data obtained with all the methods, using either radon concentration and equilibrium factor of 0.4, or radon concentration and the measured values of the equilibrium factor. For the same place, they may vary by a factor of up to 2.

SPACE DISTRIBUTION OF AIR IONS, THORON AND RADON IN INDOOR AIR

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Air ions in indoor air are generated mostly by MeV-energy α-particles produced in radioactive transformations of radon (^{220}Rn and ^{222}Rn) and its short-lived descendants. Since the intensity of all other air ionizing sources is significantly lower and mostly constant in time, air ions may serve as confident indicator for spatial and temporal distribution ^{222}Rn and ^{220}Rn concentrations indoors. Example of vertical gradients of ^{220}Rn & ^{222}Rn activity concentrations measured above earthen floor in the basement at house in Sokobanja is presented.

Measurements were performed in Sokobanja region (Serbia), where ^{220}Rn concentration in soil and building materials is relatively high, and in Slovenia in villages Gorisnica and Rakitna, where ^{222}Rn concentrations are much higher than ^{220}Rn. Following equipment was used for the measurements: 2 x Rad7 (Durridge company, USA), RTM 1688-2 Radon/Thoron Monitor (Sarad, Germany) and three Gerdien-type air-ion CDI-06 detectors.

During the ^{220,222}Rn measurements, inlets of measuring devices were fixed at 1 cm, 20 cm and 40 cm above the floor while air ion detectors were positioned at 10 and 85 cm above the floor. During measurements, switching of the air ion detectors places was performed in order to test their quality of operation.

Air ion concentration at the height of 85 cm was 37% lower than at 10 cm while in the case of thoron reduction was 75% after 40 cm. At the same time, moderate but still clearly measurable decrease of air ions concentration with height (gradient) was measured. Thoron and radon gasses are decaying with similar energy of α-particle and thus creating similar number of air ion pairs. Gradient of air ion concentrations from the floor would be probably much higher if it is not “diluted” with ions generated by radon and its decay products. Also, life time of air ions in relatively clean air is about 100 s which is twice as Tn so that ions can move for longer distances from point of origin than thoron.

During the survey, measurements of the mentioned parameters were also carried out at different distances from walls and have shown either linear or exponential pattern depending on microclimatic ambient. Many measurements of air ions were impossible to conduct due to electrostatic field of the walls that strongly influenced on ions.

RADON CONCENTRATION IN THERMAL WATER OF KOSOVO'S SPAS

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The measurement of radon concentration in thermal water Kosovo's spas is the first scientific investigation of this kind. There are 5 thermal spas in Kosovo, the water from hot springs in these spas are used for therapy and drinking purposes. Three of them are outdoor spas and offer only daily services during the summer, but the others are indoor spas offering health service for customers during the whole year. The aim of the study was to measure the radon concentration in water (hot spring, individual bathtubs/public pools and drinking water). The water samples were taken on December 2015 from different places of treatment process, from thermal water hot spring up to individual bathtubs/public pools and drinking water. For this purpose we used alpha scintillation cells and PRM-145.The observed radon concentration values on hot spring, on individual bathtubs/public pools and in drinking water of spas ranges from 29 Bq L^{-1} to 280 Bq L^{-1}, from 5 Bq L^{-1} to 270 Bq L^{-1} and from 6 Bq L^{-1} to 45 Bq L^{-1}, respectively.

INTEGRATED RADON AND THORON MEASUREMENTS AT SNOLAB UNDERGROUND FACILITIES

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SNOLAB is an underground astroparticle laboratory specializing in neutrino and dark matter physics. Located 2 km below the surface in the Vale Creighton Mine near Sudbury, Ontario, Canada, SNOLAB is an expansion of the existing facilities constructed for the Sudbury Neutrino Observatory (SNO) solar neutrino experiment with 5,000 m^2 of clean space underground for experiments.

Raduet and NRPB type integrating detectors (using CR-39) were placed at ten different locations in the underground facilities of SNOLAB. The detectors were changed and evaluated in consecutive three months periods starting 9th July 2014. The aim was to gain information about the radon/thoron levels for a long-term (more than one year) and see the seasonal variations. In addition, the performance of these types of detectors under the special circumstances for the underground clean laboratory environment can be studied, where the air pressure is 25% (18.6 psig = 1.28 bar) higher than at surface and rapid pressure swings can occur (up to 5% change in air pressure over 3 minutes).

The results showed that average radon levels in the given periods measured with these method were under 200 Bq/m^3 at all the investigated spots and the thoron levels were negligible in the lab.

Considering the dosimetric aspect, the overall average radon level above mentioned implies less than 1.6 mSv/y dose contribution for the workers estimating 2000 working hours per year underground.

FUKUSHIMA IMPACT ON ENVIRONMENTAL RADIOACTIVITY: FIVE YEARS OF INVESTIGATIONS

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The Fukushima accident has had great impact on radionuclide concentrations in the terrestrial and marine environments. The paper is focusing mainly on radioiodine, radiocesium and radiostrontium, which have been important for delivery of radiation doses to humans and biota. The highest radionuclide releases to the atmosphere were due to ^{131}I (150 PBq) and ^{137}Cs (15 PBq), however, they were about 10-times lower than in the case of the Chernobyl accident. The terrestrial radiation effective doses to the population of the most affected Fukushima Prefecture were below 25 mSv/year. The marine doses from ingestion of radionuclides in seafood from coastal waters were lower than doses delivered from the consumption of natural ^{210}Po in seafood.

IMPACT OF FLY ASH INCORPORATED IN THE CLAY MATRIX

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Fly ash as naturally occurring radioactive material (NORM) can be successfully incorporated in clay matrix due to its characteristics: fine granulation, chemical and mineralogical composition. In this study, the fly ash, sampled from the thermal plant REK Bitola, and the clay brick material from the company TONDAH were used as raw materials for the preparation of mineral compacts. The both raw materials were characterised from physical, chemical, mineralogical and morphological aspect. Powder technology was employed for incorporation of fly ash into the clay matrix. The fly ash was pre–treated by mechanical activation in a ball mill and incorporated into the clay matrix in the content of: 10, 20 and 30 wt.%. The consolidation of the raw mixture was realized at P= 73 MPa and T=830, 900 and 9800C/1h by using the heating rate of 5, 7.5 and 100/min. The physical (density and porosity) and mechanical (bending strength and compressive strength) properties of the compacts were determined after the sintering process. The main process parameters were optimized through the application of a 3D surface model and Statographics Centurion™ software. The optimization process was conducted based on the influence of the main process parameters (fly ash content incorporated in the clay matrix, sintering temperature and heating rate) on the characteristics (porosity and bending strength) of the compacts.

DATA MINING TO SELECT AND VALIDATE RADIOLOGICAL DATA OF NORMS AND NORM CONTAINING CONSTRUCTION MATERIALS

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Scientific data on natural occurring radioactive materials (NORM) are collected in UNSCEAR reports [UNSCEAR 2008] which are basis for the ICRP recommendations. New IAEA Basic Safety Standards (BSS) and Euratom directives, simulated by the ICRP recommendations, will eventually be translated in national policies. Upon gathering scientific data a crucial scientific challenge is the validation and selection of data that will form the basis of legislation. For analysing huge amounts of text data, the development of hardware and software platforms for the web and social networks enables the rapid creation of large repositories of different kinds of data. Currently the COST Action Tu1301 'NORM4Building' (2014-2017) is creating a large database gathering radiological data on NORMs and construction materials in which NORM containing by-products are implemented. There arose several problems during the creation of database: (1) The reliability and representability of the data used needs to be verified, (2) verification of multiple selected data as new papers can be based on previous results, the latter can be reported in double or even multiple times in different sources. Since huge amounts of data were gathered there is a need for an automatizised approach to support the valorisation of data, and therefore data mining was employed. A dedicated data mining approach was developed as an analytical method to extract information regarding NORM materials, i.e. ores and by-products, and all kinds of NORM containing construction materials from publications. The data mining approach was modified to support the validation of new and current entries in the database. During the data mining process as a first step a selection of papers was performed on the basis of choosen keywords: a filter was created based on the selected keywords. Publications were read into the IBM SPSS Modeler™ software, to extract information by means of natural language processing (NLP). Text Link Analysis (TLA) was applied to define pattern rules and to compare these to relationships found in the text and finally collected data were structured. With this technique 68,000 publications have been processed from different electronic sources, such as Science Direct and Web of Science. The existing databases (Italian, Serbian) with information on more than 48,000 radiological samples are merged and expanded by means of an automated data mining approach.

The current paper uses data collected on NORMs in the phosphate industry as a case study to demonstrate the approach used for data validation and data selection.

RADIONUCLIDE CONCENTRATION VARIATIONS IN RESIDUES FROM POTENTIAL NORM INDUSTRIES IN ESTONIA: THE EXAMPLE OF OIL SHALE-FIRED POWER PLANTS

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The new and revised Council Directive 2013/59/EURATOM (adopted in 2013) foresees the integration of protection against natural radiation sources to the overall requirements instead of addressing it separately as in the previous Directive. This in turn obliges the member states to determine the exposure to workers and to the public in industries also processing naturally occurring radioactive material (NORM). A nationwide survey has been started in Estonia in order to determine the activity concentration levels of naturally occurring radionuclides in the ore, products and residues of the following industries: Oil shale industry (oil shale-fired power plants (PPs) as well as oil industry); water industry (drinking water purification); rare earth metal processing industry; mining activities; production of cement and building materials; maintenance of large combustion boilers; clinker ovens. Thorough information on the technological parameters of these industries is being gathered and combined with the data on the input (raw material, energy etc.) and output (products, waste). By analysing the activity concentration of natural radionuclides and their variability in the residues during different time periods, better assessments and recommendations can be made on the need for further monitoring in a longer time scale. The activity concentrations of natural radionuclides have been determined over multiple years in the ashes of oil shale-fired power plants. Oil shale, bottom and fly ash samples were collected from pulverized fuel (PF) boiler equipped with a novel integrated desulphurization (NID) system and bag filters. Secular equilibrium can be observed between ^{238}U, ^{226}Ra and ^{210}Pb in the oil shale samples and between ^{238}U and ^{226}Ra in the bottom ashes as well as in the fly ashes (with few exceptions). ^{210}Pb activity concentrations show clear depletion in the bottom ashes, but highest enrichment factors (the activity concentration ratio between the corresponding ash fraction and the value in oil shale) in the fly ash samples. ^{210}Pb activity concentrations reach up to 89 Bq kg^{-1}. For ^{226}Ra and ^{238}U, the values are up to 69 Bq kg^{-1} and 66 Bq kg^{-1}, respectively. The highest ^{40}K concentration values reach 1186 Bq kg^{-1}. Variations in the enrichment factor values were observable between the samples collected during different days. However, in most cases these variations were not statistically significant. The results indicate that even during complex combustion conditions, the radionuclide enrichment factors in various ashes do not fluctuate significantly. The results can be used to estimate radionuclide enrichment trends in the bottom and fly ashes of the combustion boilers during a certain operating regime and evaluating the PP's impact on producing residues that contain natural radionuclides in a longer time scale. Also this data can be used to estimate the radiological content of certain building materials (e.g. ash blocks) where the filter ash is used as an additional component.

VARIATION OF NATURAL RADIONUCLIDES IN NON-FERROUS FAYALITE SLAGS DURING A ONE-MONTH PRODUCTION PERIOD

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Metallurgical slags, a by-product from the metal producing industry, are replacing primary resources in cement based building materials. Furthermore, they can be used to produce a new type of building materials named inorganic polymers (IPs).
A new Council Directive, the so-called Euratom Basic Safety Standards (EU-BSS) establishes basic standards, applicable in EU member states, for the protection against possible exposure of ionising radiation for workers and the general public [1]. In the framework of the EU-BSS, building materials require a radiological characterization. Therefore the radiological characterizations of current and future alternative resources for building materials are very relevant in view of the design and development of new building materials. The screening tool activity concentration index described in de EU-BSS can be predicted based on these measurements and the production process.

In this paper, a radiological characterization is performed on non-ferrous fayalite slags (FS) produced during 31 consecutive days. The materials were by-products from a secondary smelter facility, corresponding to a one month-production output. The facility input consists of a range of by-products from industries listed by annex VI of the EU-BSS as industries with naturally occurring radioactive materials. The activity concentrations of radionuclides from the ^{238}U and ^{232}Th decay chains, as well as ^{235}U and ^{40}K were determined using gamma-ray spectrometry using High Purity Germanium detectors (HPGe). The output of this characterization and the calculated activity concentration index (ACI) for FS based IPs are compared with slag, cement and concrete data from a European database described by Nuccetelli et al. 2015.

During the month measurement period, the activity concentrations in FS varied up to a factor 6 depending on the radionuclide. Furthermore, all activity concentrations were well below the exemption limits described in annex VII of the EU-BSS. The variation in resulting ACI is discussed in the paper.

INTRODUCTION OF BY-BM (BY-PRODUCTS FOR BUILDING MATERIALS) H2020 MSCA-IF-2015 PROJECT

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The construction industry is critical to innovation and employment in the EU economy. The sector provides 20 million direct jobs and about 10 % of the EU's GDP. Existing EU policy initiatives in the area of environmental performance of buildings have mainly targeted energy efficiency. Apart from these initiatives, the revised Waste Framework Directive with its objective to reach 70% of preparation for reuse, recycling and other forms for material recovery represents the main European policy driver. The depletion of raw materials and development of low CO_2 emitting energy and material resources requires innovative solutions to develop new eco-innovative Building Materials (BM). Geopolymers can be alternative low-carbon binders (produced with the reuse of industrial wastes that are produced in large quantities e.g., Pulverised Fuel Ashes (PFA), Ground Granulated Blast-Furnace Slag (GGBS), Cement Kiln Dust (CKD), etc. These geopolymers can be formed at room temperature by using wastes or by-products e.g. PFA, GGBS and CKD as source materials to form a solid-binder that looks like and performs a similar function to OPC (Ordinary Portland Cement). Geopolymers can be used to fully or partially replace OPC with a lower carbon footprint (80 - 90% reduction in CO_2 emissions).

In some cases components of the raw materials remaining in the by-product may affect human health and environmental risks. In addition to the potentially toxic compounds the risk from Naturally Occurring Radioactive Materials (NORM) with elevated natural isotope content cannot be ignored. The EU's Council Directive (2013/59/Euratom) has laid down basic safety standards for protection against the dangers arising from exposure to ionizing radiation. In addition to direct gamma radiation an important pathway of radiation exposure comes from radon, originating from BMs.

The host institute (Queen's University Belfast [QUB]) has the experience, exceptional infrastructure and ongoing industrial projects to accomplish such research projects. The secondment institute (Nuclear Technological Centre [NuTeC], Hasselt University). The By-BM project focuses on geopolymers and builds on the promising experience of the Fellow gathered during his previous research activity (radiological characterization of BMs).

THE UNCERTAINTY IN THE RADON HAZARD CLASSIFICATION OF AREAS AS A FUNCTION OF THE NUMBER OF MEASUREMENTS

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As a result of radon surveys areas are usually characterized by mean or median radon concentrations or by a percentage of houses with indoor radon levels exceeding a certain limit or by a Radon Potential (RP) which should represent the geogenic radon hazard. Often these quantities are classified and areas are assigned class levels, e.g. low, medium, high radon risk. In nearly all cases such a classification is derived from radon measurements, which can show a wide variability over spatial units. It is of paramount importance to estimate the uncertainties (misclassification probabilities) of such a classification.

Radon indoor measurements in nearly all homes in three municipalities and its conversion into a Radon potential (RP) were used to determine the uncertainty of the mean Radon potential of an area as a function of the number of investigated homes. For that purpose repeated (10 000) random samples of 3, 6, 12, 24, 48 RP data were taken from all data of one municipality. From these samples, the arithmetic mean (AM) and the geometric mean (GM) were computed. As a result the frequency distributions for AM and GM values were determined, with the number of measurements as parameter. Out of this it is possible to estimate the standard deviations of AM and GM as a function of the number of measurements used to calculate AM and GM.

It could be shown that the relative uncertainty scales like $1/\sqrt{n}$ with n the number of measured dwellings.

The question how to deal with uncertainties when using a classification scheme for the Radon risk is discussed. It is always a compromise between the number of measurements and the probability for a wrong decision concerning the classification of an area to be a radon prone area or not. A general procedure is proposed which is based on a stepwise increase of the number of measurements, depending on uncertainty of the measurement result and the distance between the measurement result and the classification limit.

UPDATED DATABASE ON NATURAL RADIOACTIVITY IN BUILDING MATERIALS IN THE EUROPEAN UNION

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Building materials, due to their natural radionuclide content, can determine a significant exposure to gamma rays and contribute to the radon concentration indoors. A database of activity concentration measurements of natural radionuclides (^{226}Ra, ^{232}Th and ^{40}K) in building materials used in Europe has been set up.

The authors already set up a first database of the activity concentrations of ^{238}U, ^{232}Th and ^{40}K in building materials used in 10 of 15 European Union Member States (MS) by a wide review of the relevant literature, taking into account previous experiences and, in particular, the collection reported in the Radiation Protection 96 and a study on Italian building materials conducted in 1999.

The data collection activity intensively continued in the last years making the database much wider. Indeed, now it contains about 23000 radiological data from 26 of 28 MS and, for a subset, also radon emanation/exhalation information. All data have been carefully checked and validated mainly in order to avoid mis-classification and multiple counting of identical sets of sample data reported in different papers. The collection of data was extended also to 2 EU candidate countries and 2 non EU countries increasing of about 400 the number of considered samples.

The database considers both bulk and superficial materials, such as bricks, concrete, cement, aggregates, industrial by-products, natural raw materials, etc. In this paper a synthesis of this final collection activity is reported.

RADON AS A NATURAL TRACER OF ACTIVE CAVE FORMATION ZONES

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The Molnár János cave is one of the largest caves of the Buda Thermal Karst (Budapest, Hungary) and mainly characterized by water-filled passages. The major outflow point of the waters in the cave system is the Boltív-spring, which feeds the artificial Malom-lake. Previous radon measurements in the cave system and in the spring established the highest radon concentration (in average 44 Bq/L) in the springwater. The origin of radon was identified in the form of iron-hydroxide containing biofilms, which form by mixing of waters and adsorb efficiently radium from the thermal water component. Since mixing of waters is responsible for the formation of the cave as well, these iron-hydroxide containing biofilms and hence zones of high radon concentration mark the active cave forming zones. Based on previous radon measurements it is supposed that the active mixing and cave forming zone has to be close to the spring, since the highest radon concentration was measured there. Therefore, radon mapping was carried out with the help of divers in order to get a spatial distribution of radon in the cave passages close to the spring. Based on our measurements the highest radon concentration (83.68 Bq/L) ever was achieved in the springwater. Direct connection was established between the spring and the István-room of the cave, which was verified by artificial tracer as well. However, the distribution of radon in the cave passages shows lower concentrations (17.89-46.35 Bq/L) compared to the spring, therefore an addition deep inflow from a hitherto unknown cave passages is assumed, from which waters with high radon content arrive to the spring. These passages are supposed to be in the active cave formation zone.

RADON ASSESSMENT OF VOLCANIC BUILDING MATERIALS OF THE LAZIO REGION, ITALY

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In the context of the international recommendations about the radionuclide content on building materials, we present the radon exhalation rate measurements for two different volcanic tuff samples coming from Lazio region, where tuff is still widely used as a building material. The results have been obtained with the well-known closed chamber method.

The chamber built in our laboratory, is a Plexiglas cube, of about 125. The chamber is interfaced with different detectors (Lucas scintillation cells and solid state detector). The two samples analysed are commercial blocks of about 4.7 l, the samples were dried during 48 hours at 100°C in an electric oven. In this work we are focusing on the dependency of the result on the correct evaluation of the main parameters of the chamber and the related uncertainty. In particular we are concentrate on the contribute, due to the chamber background and the chamber leakage. The main contribute to the exhalation rate uncertainty came from the chamber leakage estimation and is typically 18% and is obtained with the fit over the data and vary between 10 to 18%. About the contribute due to the background uncertainty, we demonstrate with this work, that is more proper to evaluated it inside the chamber instead what is typically done, assuming that the background of the measurements is the laboratory background. These choose reduce the uncertainty about 50%. In conclusion this work proposes an improvement of the measurement of the radon exhalation rate with the closed chamber methodology reducing sensibly the total uncertainty.

VERTICAL MIGRATION OF RADIO-CAESIUM DERIVED FROM THE FUKUSHIMA DAI-ICHI NUCLEAR POWER PLANT ACCIDENT IN UNDISTURBED SOILS OF GRASS LAND AND FOREST

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The vertical distribution of radio-caesium (^{137}Cs and ^{134}Cs) in undisturbed soil profiles of grassland and forest soils, derived from the Fukushima-Daiichi Nuclear Power Plant (FDNPP) accident that occurred on 11 March 2011, were studied. Surface soil and depth profile soil samples were collected from six locations within the 20 km zone of FDNPP, during November 2012 and June 2013.The activity ratio for ^{137}Cs and ^{134}Cs was found to be almost constant within the soil profile as well as in the surface soil, indicative of FDNPP accident origin. From soil depth profile distribution of Cs activity, it is observed that Cs is strongly bound to soil materials, which slows Cs migration. More than 90% of the activity was found to retain within the upper 5 cm layer of soil except in one place, depending on soil characteristics. Different factors affecting the downward migration of Cs have been studied. Retardation of Cs movement has been quantified by measuring sorption of Cs in soil in terms of distribution coefficient (Kd) using the laboratory batch method. Faster migration has been observed in case of forest land soil compared to grass land soil. The empirical migration velocity of Cs radio isotope was estimated from the depth profile Cs concentration and found to vary from 1.1 to 1.7 and 0.85 to 3.5 cmy^{-1}in grassland and forest soil, respectively. The residential half life for Cs isotopes was found to be 1.03-7.75 y and 1.18-4.67 y for grassland and forest land respectively using a compartmental model. In addition to the empirical analysis of the profiles, analytical models were fitted to data that may help to elucidate the physical nature of the transport of trace elements.

RADIOACTIVITY LEVELS IN ANGOLAN ADOBE BUILDING MATERIAL – COMPARATIVE STUDY OF THREE AREAS

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Radioactivity in building materials is one of the most investigated issues in the field of radiation protection, given its potential as a source of external exposure to gamma radiation. Therefore, in our systematic study of Angolan adobes activity concentrations for ^{226}Ra, assumed in secular equilibrium with ^{238}U, and ^{232}Th as natural decay chain members and for ^{40}K have been determined by gamma spectrometry analysis. Sixty samples have been collected from three remote areas of the country with different geological background and climate. These were Cabinda in the North, Huambo in the central part and Menongue in the South. To achieve the measurement, a HPGe-detector-based acquisition system installed permanently in a low background chamber1 was used. The activity concentration results obtained for the separate areas are as follows (mean and sample range in Bq kg^{-1}): in Cabinda 26 (15 45) for ^{226}Ra, 36 (26 49) for ^{232}Th and 45 (28 92) for ^{40}K; in Huambo 87 (49 116) for ^{226}Ra, 81 (39 121) for ^{232}Th and 82 (50 104) for ^{40}K; in Menongue 27 (15 56) for ^{226}Ra, 30 (17 57) for ^{232}Th and 73 (21 155) for ^{40}K. According to the UNSCEAR 2000 Report2, the average values in soil for radionuclides ^{238}U, ^{232}Th and ^{40}K are 35, 30 and 400 Bq kg ^{1}, respectively. A comparison shows that the activity concentration of ^{226}Ra in Huambo is higher than the average; similarly, the value for ^{232}Th is also higher in both Huambo and Cabinda; whereas the value for ^{40}K is lower in all areas. As a first approach, we can say that this difference may be given to the respective geological background. For the classification of the material, international indexes like the radium equivalent activity, Raeq, the activity concentration index, I, the indoor absorbed dose rate, Da and the annual effective dose, De were evaluated. According to the results, it can reasonably be concluded that the studied materials are safe to be used for building.

INVESTIGATION OF THE LEACHING CHARACTERISTICS OF THE ^{232}Th AND ^{210}Po CONTENT OF RED MUD FORMED IN HUNGARY

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The valorization of industrial by-products such as red mud became an issue of great interest, but the safe utilization of these products requires understanding of the risks involved. One of these risks are the elevated levels of radionuclides in red mud that can have an effect on human health. There is no satisfactory answer for the utilization of red mud; the current solution is still almost exclusively deposition. The total amount of deposited red mud is expected to reach 4 billion tons around the world in 2015. For the safe deposition and utilization of red mud it is very important to investigate the leaching behaviour of radionuclides.

The leaching features of red mud were studied according to the MSZ-21470-50 Hungarian standard, the British CEN/TS 14429 standard and the Tessier sequential extraction method for ^{232}Th and ^{210}Po. The leached solutions were taken to radiochemical separation followed by electrodeposition for Th and spontaneous deposition for Po. Compared to previous study, where 262±19 Bq/kg ^{238}U was measured by total digestion from red mud, while the leached amount was HNO_3+H_2O_2 digestion 75%, distilled water 5 %, Lakanen-Erviö solution 25%; for Tessier: I. step ~3%, II. step ~1%, III. step ~30%, step IV. ~7%, the 332±33 Bq/kg ^{232}Th content proved less mobile. The leached values were HNO_3+H_2O_2 digestion 40%, distilled water 1 %, Lakanen-Erviö solution 6%; for Tessier: I. step ~2%, II. step below detection limit, III. step ~4%, while more than 85% remained in the residue. The ^{210}Po proved to be more mobile than ^{232}Th.

NORM CONTAMINATED AREA IDENTIFICATION BASED ON RADIONUCLIDES ACTIVITY CONCENTRATION PATTERN IN A SOIL PROFILE

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Natural radionuclides are ubiquitous in human environment. Reported activity concentration of natural radioactivity in primordial rocs varies from merely few up to hundreds Bq/kg. According to the state of the art radiation protection the exposure to ionizing radiation originating from environment not altered by human activity is not considered as a source of additional health risk. Moreover, the same attitude is applied towards non-human biota exposed under such condition. On the contrary, when the exposure is caused by the same natural radionuclides but under anthropogenically changed conditions, the derived risk to humans either to biota shall be managed based on the same rules as those had been elaborated for artificial radioactivity. Such situation creates the strong needs to have a reliable method to distinguish whether the particular case of natural radioactivity occurrence has resulted from human activity or it is pure natural phenomenon. In case of current activity of an NORM industry there are no doubts but in case of a legacy site, such question becomes crucial. One of the first warnings that a case of concern has resulted from human deliberate or accidental activity is the lack of secular equilibrium among radionuclides constituting natural decay series. In such situation, the rate of activity concentration of particular radionuclides also usually let one assess how long ago this disturbance happened. On the other hand natural radionuclides and artificial ones, deposited on the ground surface due to radioactive fallout (e.g. cesium and lead) create in long term perspective a specific pattern that remains characteristic for un undisturbed soil. It can be assumed that every observed change in it proves a human activity. One-meter-deep soil profiles taken at undisturbed area and around different NORM heaps were analyzed and compared. The distribution of natural as well as artificial radionuclides along a soil profile provided a possibility to anatomize any alternation of natural state, assess radionuclides migration and even investigate the history of a site of concern in the time horizon, usually long enough to identify any human activity.

ENVIRONMENTAL INVESTIGATIONS OF URANIUM AND THORIUM DETERMINATION IN GRANITIC ROCK SAMPLES BY ACTIVE AND PASSIVE DETECTORS

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The determination of both Uranium and Thorium contents in natural granite rocks was carried out without the need of standard sources. A combined technique of nuclear track density counting system and gamma spectroscopic analysis has proved to be an adequate and reliable technique for U and Th determination in natural crustal samples. Results of U and Th analysis showed that in the Gabal El-Massakat region, U content ranges from 78 to 588 ppm and Th content ranges from 15 to 130 ppm. In the El-Eradyia area U content varies from 55 to 94 ppm and Th from 10 to 230 ppm. Also, measurements of radon gas emanating from the studied samples were also included using a specially constructed chamber. An overall estimation of radon concentration using some of the studied samples show that Rn concentration in the Gabal El-Massakat area ranges from 645 to 1088 pCi /1 while for the samples collected from the Gabal El-Majal area ranges from 4 to 27 pCi/1. Results are discussed within the frame work of track formation mechanism and etching methodology in plastic nuclear track detectors and spectroscopic analysis.

FOSSILIZED BIOMATS AS THE POSSIBLE SOURCE OF HIGH RADIONUCLIDE CONTENT AT THE EARLY- JURASSIC ÚRKÚT MANGANESE ORE DEPOSIT

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The early Jurassic Úrkút manganese ore deposit (Úrkút Manganese Formation – ÚMF) located at the western part of the Carpathian Basin and the central part of the Transdanubian Range. The deposit embedded into diverse mixture of Mesozoic limestone and marlstone, and the first Mn - indications appeared at the toarcian Falciferum zone. The deposit shows the two typical appears of the manganese ores, one with high content of manganese oxides (manganite, pyrolusite, etc.) and the larger second, with high content of manganese carbonates (mainly rhodocrosite) and clay minerals. There are anomalously high enrichment of radioactive isotopes in the ÚMF, without continuous ventilation the Rn concentration could reach 2000-3000 Bq m-3 in the Úrkút mine during a few hours. In the course of examinations of 13 samples from the oxide ores with petrographical microscope and FTIR (Fourier-Transform Infrared Spectroscopy) we identified fossilized Fe-rich biomats. By the comparison of the data and observed things with the literature, we assume the source of the high radionuclide content could be partly the microbial activity. The source of the high radionuclides and Rn concentrations could be from the decay of the ^{238}U, ^{232}Th, ^{226}Ra and ^{40}K content. The enrichment of radionuclides shows characteristic presence in the different parts and types of the ÚMF. As Vigh et al. (2013) shows, there are high amount of ^{226}Ra (44,9 Bq/m-3) in the primary oxide ore, and relatively low ^{238}U ratio, so the parent U isotopes has leached out. By these source of the Rn could be the α-decay of ^{226}Ra, which can form strong binds with the inactive (dead) microbial biomass and EPS, but during the fast mineralization the U cannot be set in the minerals, it departed in a soluble form (Tsezos et al., 1987; Vigh et al., 2013). The Ra content could be derived from upwelling water current through the floor rocks as recent studies shows (Fujisawa and Tazaki, 2003; Tazaki, 2009; etc.). Unlike these in some specific area like the cherty Fe-rich Mn-ore at the Csárda-hegy has relatively high amount of U. By the microbially mediated mineralization the U selectively enriched in these parts and by the special geochemical conditions the U rich state can endure (Vigh et al., 2013).

ASSESSMENT OF RADIOLOGICAL SAFETY BY EXPERIMENT AND SIMULATION: CHARACTERIZATION OF BAUXITE RESIDUE (RED MUD) FOR ^{235}U, ^{238}U, ^{232}TH, AND ^{40}K USING NEUTRON ACTIVATION ANALYSIS AND THE RADIATION DOSE LEVEL AS MODELED BY MCNP

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This study employs thermal and epithermal neutron activation analysis (NAA) to quantitatively and specifically determine radiological safety parameters. Specifically, a case study of bauxite residue (red mud) from an industrial facility is used to demonstrate the feasibility of the NAA approach for radiological safety assessment, using small sample sizes to ascertain the activities of ^{238}U and ^{232}Th. This proof-of-concept is shown to produce the expected results, and a similar approach could be used for quantitative assessment of other samples with possible radiological significance. Furthermore, the work demonstrates MCNP simulation to estimate the radiation dose from the samples, to assure that humans and the surrounding environment would be protected. ^{235}U was determined knowing the isotopic ratio and thus activities of $^{238}U/^{235}U$. In addition to the decay chains of uranium and thorium, ^{40}K was also determined using epithermal neutron activation analysis to determine total potassium content and then subtracting out its isotopic contribution. To assess if disposal sites raise any questions with respect to radiation safety, now or after remediation, MCNP simulation was conducted which also serves as a validation tool and an important addition to in-situ and laboratory measurements. Furthermore, phantoms are employed to observe the dose distribution throughout the human body, demonstrating radiation effects on each individual organ.

Unified TENORM data survey

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According to the article 23 of Council Directive 2013/59/EURATOM Member States shall ensure the identification of classes or types of practice involving naturally-occurring radioactive material and leading to exposure of workers or members of the public which cannot be disregarded from a radiation protection point of view. The Decree No. 47/2003 ESzCsM determines the list of the above mentioned classes or types of practice, and lists industrial activities which can concentrate or accumulate in their co-products the radioisotopes appearing in the nature extending the exemption level significantly. The performer of the activity shall report to the County Government Offices if it performs any industrial activity listed in the Decree. Radiohygiene license is also necessary for the management, disposal, reutilization of the co-products of these activities. The operator shall survey the radiation protection significant features of the co-products disposed in the facility installed either in the environment or on its operation site, and shall assess – with the co-operation of the institute holding appropriate expert background – the radiation exposure originating from them. The data survey system which was created by our Institute performs the requirements of the Decree. A MS Access data acquisition program was created for implementation of the unified data survey which program sets up unified system of criteria to describe and register the different activities. This data acquisition program will be performed in our presentation.

MAPPING THE BASELINE OF TERRESTRIAL GAMMA RADIATION IN CHINA

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The baseline of terrestrial gamma radiation is indispensable for providing basic reference information that may be used in assessing the public exposure to natural radiation, evaluating the radiation impact on environment due to applications of nuclear energy and radiation technology, and so on. In this study, based on the field measurement results published in 1980s, a database with the level and the geographic coordinate on the terrestrial gamma radiation in China was recompiled first, and it was further extended by assuming that the same level occurred with the same soil classification within 10 km. For obtaining more data on the terrestrial gamma radiation, the spatial interpolation was done by the inverse distance weighting (IDW) method, and a total of more than 90000 data was finally built in a resolution of 10 km×10 km. For more intuitive understanding of its distribution, a digital maps of the terrestrial gamma radiation in China was created by using the software of ArcView GIS. The result shows that the distribution of terrestrial gamma radiation in China is identical, i.e., it is generally higher in south than that in north. The area-weighted and the population-weighted terrestrial gamma radiation in China are about 79 nGy/h and 75 nGy/h, respectively. It is about 20% higher than the worldwide average.

DETERMINATION OF ^{137}Cs IN SAMPLES OF URBAN SURFACE SOILS

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Cesium-137 is a fission product, with a half-life of about 30 years. Its production by nuclear weapon detonations has resulted in wide distribution through the biosphere, its mobility and physiological properties have led to detectable activity concentrations in essentially all organisms and is a potentially significant contributor of the radiation dose to man.

Fallout levels of ^{137}Cs in urban surface soil from Uzhgorod city, Ukraine have been measured using gamma-ray spectrometry. Activity ^{137}Cs from 37 sites was measured systematically for the first time in the surface soil layer (0–5 cm) and represented on a map. The soil samples were collected during 2006-2012 years. All samples were dried at the temperature of 60 ^{0}C during 48 h, sieved through the 2 mm strainer, weighted and placed/stored in the cylindrical polyethylene containers (0.5 dm3 volume) for the further measurements. All samples were measured with an identical geometry. The measurement time was equal to20,000 s for each sample.

Table 1. The activity concentration of ^{137}Cs in surface soil from Uzhgorod city

	2006	2007	2008	2009	2010	2011	2012
Activity concentration of ^{137}Cs (Bq kg^{-1})	4,8±0,4	6,1±0,6	6,6±0,5	5,2±0,5	4,3±0,4	6,7±0,5	6,2±0,6

Geostatistical technique was applied to interpolate the values of the specific activity of the ^{137}Cs in the sampling points.

BIOMONITORING OF TERRESTRIAL RADIOISOTOPES BY TOBACCO IN THE VICINITY OF RADIOACTIVE WASTE DEPOSITORY SITES

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The low and intermediate level radioactive and nuclear waste is deposited mainly in the underground places. The monitoring of the natural radioisotopes could be a tool to understand the migration behavior of the isotopes (even artificial) for the emergency situation too.

In this study based on our previous results the tobacco plant was used as a biomonitors on vicinity of the Hungarian (Püspökszilágy and Bátaapáti) radioactive and nuclear waste depositories.

On the focus of this study was the measurements of radon progeny ^{210}Po(Pb) activity. Both depository 7-7 pieces of tobacco plants were planted and the soils and plants ^{210}Po(Pb) activity concentration were determined by alpha spectrometry and the outdoor radon concentration was measured using CR-39 track detectors.

The ^{210}Po(Pb) activity concentration of the tobacco samples were between 6.92 ± 1.11 – 19.40 ± 1.62 mBq g^{-1} and the soil samples 16.80 ± 1.49 – 77.23 ± 6.02 mBq g^{-1}. The ^{222}Rn concentration on 60 cm above the surface was between 13-76 Bq m^{-3}.

Based on the results obtained it can be stated that there has been no ^{210}Po(Pb) increase the mean values of measured result do not differ from grew tobacco on the similar soil samples.

The outdoor Rn concentration level also suit on average outdoor air concentration.

EFFECTS OF COVER LAYER ON THE RADON EXHALATION OF REMEDIATED COAL ASH DEPOSITORY WITH HIGH ^{226}Ra CONTENT

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Coal fired power plants play of a significant role in the production of electricity. The ^{226}Ra concentration in coals mined in the Ajka region can reach up to 3000 Bq/kg. This study is focused on the effects of Hungarian (Ajka) remediated coal ash depository on the environment and the effectiveness of the cover layer. During the remediation method patented in Hungary the upper layer of the depository, which has settled like concrete, was ploughed and mixed with wood chips followed by planting greenery. The gamma dose rate $\mathring{D}$ of the depository and its vicinity has been measured by Automess 6150AD-b at 32 points, surface ^{222}Rn exhalation at 19 points, air radon concentration at 34 points, and at 32 points soil gas radon content with ALPHAGuard and soil permeability with Radon Jok. The nuclide content of 9 sample has been determined by HPGe gamma-spectrometer and their ^{222}Rn exhalation has been measured by ALPHAGuard. $\mathring{D}$=120-525 nSv, C_{226Ra} was 1997 Bq/kg, 960 Bq/kg, 104 Bq/kg for ash, cover layer and background soil. The ratio of C_{210Pb}/C_{226Ra} was 0.8, 1.1-1.2 and 1.2-1.6 for ash, cover layer and background soil respectively. C_{222Rn} in soil was 22-90 kBq/m^3, soil gas permeability K was 1.80E-11 – 6.84E^{-12} m^2. The radon exhalation of the covered-uncovered depository was 259-648, 540-1100 mBq/m^{2}s. The emanation and exhalation of the samples were 0.05-0,32 mBq/kgs and 8-22%. The effects of vegetation on the migration of radon were examined too. The results show that the Ajka coal ash depository has higher radiological risk than the previously published depositories. The applied cover layer did not reduce radon exhalation significantly, however vegetation reduces the convective air-flow and with this the migration of Rn.

A NEW APPROACH FOR DISCRIMINATIVE MEASUREMENTS OF ENVIRONMENTAL RADIATIONS

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To develop an accurate approach for the measurements of the different components of environmental ionizing radiations with passive dosimeters and lead chamber, and evaluate the performance of the developed technique.

For discriminative measurements of both the hard and soft components of secondary cosmic rays, terrestrial gamma radiation, and gamma radiation originating from airborne radon and its progeny, the configuration of the lead chamber was dedicatedly designed based on the Monte Carlo simulations. A new monitoring post consisting of a 3-layer lead chamber and 4 pieces of passive dosimeters was designed in this study. Additionally, the relative responses of passive dosimeters to these radiation components were taken into consideration during the calculation of each radiation component. To testify the design and investigate its performance, *in-situ* measurements were carried out in three different places by four seasons throughout a year.

The results showed that the monitoring post could accurately measure the different components of environmental radiations. The deviation existing in the calculated dose rate of each radiation components were controlled within 5%. And the seasonal variation of environmental radiations could be distinguished with the method. Furthermore, it was also confirmed that by adding a passive radon monitor in the monitoring site, the monitoring post can also be used to monitor the low level of artificial gamma radiation around the monitoring site and the discrepancy between estimated and real value of the artificial radiation was less than 20%.

The new approach indicates good performance in the measurements of environmental radiations. It is expected that the new approach would be useful for monitoring of environmental radiations and discrimination of low-level radiation.

BIOACCESSIBILITY OF U, TH AND PB IN SOLID WASTE AND SOILS FROM AN ABANDONED URANIUM MINE

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Currently there are about 150 uranium mines in Europe at various stages of development, operation, decommissioning, restoration or abandonment (wise-uranium.com). Many harbour millions of tonnes of waste rock and mill tailings. This may pose a risk to human health through the ingestion of particulate uranium, and its decay products, which exposes people to the dual toxic effects of heavy metals and their radioactive emissions. Also, the bioaccessibility of the stable forms, $^{206;207;208}$Pb, may be different to the transient decay products, ^{214}Pb and ^{210}Pb, because of attachment to different binding sites within the soils. We investigated the bioaccessibility of U, Th, Pb and $^{214;210}$Pb in particulate samples taken from an abandoned uranium mine in South West England. Samples were collected from the mine shaft, adit and the dressing floor, as well as field soils. The contaminants were extracted using the in-vitro Unified Bioaccessibility Research Group of Europe Method (UBM) in order to mimic the digestion processes in the human stomach and the combined stomach and gastrointestinal tract. The concentrations of U, Th and Pb were determined by ICP-MS and the activity concentrations of ^{214}Pb and ^{210}Pb by gamma spectroscopy. 'Total' concentrations of U, Th and Pb across the whole site were in the range 16,200 to 57, 3.8 to 0.28 and 4750 to 69 mg kg-1, respectively. For U and Pb the concentrations in the stomach fraction were lower than the total and small intestine fractions were even lower. However, for Th the small intestine fractions were higher than the stomach due to the presence of Th carbonate species within the digestive fluid. Activity concentrations of ^{214}Pb and ^{210}Pb were in the range 180 to <1 Bq g-1 for the dressing floor and waste heap and 18 to <1 Bq g-1 for the field soils. Estimates of the mean bioaccessible fraction (BAF) of U at the mine site were about 5%, whereas the field soils had a mean of 24%. For stable Pb the mean BAF was 3% and 17% for the most contaminated samples and the field soils, respectively. The BAFs for ^{214}Pb and ^{210}Pb were the same as stable Pb indicating that isotopes of Pb were being retained on similar energy sites in the particles. The results are discussed in the context of the management of U mine wastes.

^{210}Po AND ^{210}Pb ATMOSPHERİC FLUXES İN İZMİR, TURKEY

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Nuclear techniques and measurement methods are widely used for environmental monitoring and research using natural and artificial radionuclides as indicators for atmospheric, terrestrial, and marine transport processes. ^{222}Rn and its progenies in the atmosphere have been widely utilized as powerful tracers to quantify atmospheric processes.

The annual atmospheric deposition rates of ^{210}Po and ^{210}Pb were determined at three sites in İzmir, Turkey. The first sampling point (Aliağa) is an industrial site with oil refineries, fertilizer factories, and three natural gas and oil fired thermic power plants. The second sampling point (Bornova) is a semi-industrial site at a highly populated area. The third sampling point is a reference point. The samples were collected from 1 November 2014 to 31 October 2015.

After collection, the samples were prepared for alpha spectroscopy analysis, because the ^{210}Pb-specific concentrations were determined using the radioactive equilibrium between ^{210}Pb and ^{210}Po by alpha spectrometry.

The highest fluxes have been observed in Aliağa station. It is thought that the industrial activities around Aliağa station had enriched the fluxes in that region. Similarly, there are some industrial activities around Bornova station. It is considered that this station is also under the effects of some anthropogenic activities. Dikili station has the lowest values.

TRACER APPLICATIONS OF TERRESTRIAL RADIONUCLIDES

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Radioisotope tracer method was discovered by George Hevesy when he attempted to separate lead from RaD, i.e. ^{210}Pb isotope in Rutherford's laboratory. In early tracer applications, terrestrial radionuclides, mainly the members of the natural decay series were used. These applications revealed many new scientific results in natural sciences. Moreover, the basic concepts of radiotracer applications were postulated using terrestrial radiotracers.

The radioactive isotopes can easily be measured in very small quantities. Depending on the decay constants, 10^{-16}-10^{-6} g of the radioactive isotopes can be detected. The application of the radioactive tracers/indicators is independent on the physical and chemical properties. Since the radioactive isotopes are chemically the same as the studied inactive isotopes, they do not change the studied system. They can be applied in dry analytical methods. If the radioactive indicator is chemically pure, no contaminants are added to the investigated system.

An important aspect of radiotracer applications is the chemistry of extremely low concentrations which becomes more and more important in other fields of chemistry as the analytical methods becomes more and more sensitive. In the range of extremely low concentrations, the Hahn's rules of (co)precipitation and adsorption are principal.

The distribution of the radioactive tracer is determined by the mixing entropy. The change of mixing entropy serves as the basic classification of the tracer methods.

Recently, mainly the artificial radionuclides are applied in tracer studies. Only a few terrestrial radionuclides are prepared and used as tracers in laboratory experiments. An example is ^{212}Pb isolated from the ^{232}Th decay series and used as a tracer of lead. The application of ^{212}Pb in the study of lead ion sorption on clay rock and clayey sediment will be shown.

GAMMA-RAY FIELDS OF SIZE-LIMITED URANIUM OBJECTS: MODELLING AND POSSIBILITIES OF LOCALIZATION BY GROUND GAMMA-RAY SURVEY

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This research is focused on localization of uranium mineralization by means of ground survey with portable radiometric instruments. The initial goal in uranium exploration is localization of radiometric anomalies. The aim of the research was to analyse and define localization possibilities of size-limited radioactive objects by ground gamma-ray survey in uranium prospection. This task was solved by theoretical considerations and by modelling of gamma ray fields of radioactive objects with variable size and radiation intensity. Possibilities of localization were studied with respect to the properties of radioactive anomalies (shape, size, intensity of radiation) and methodology of measurement (detector sensitivity, time of measurement, height of detector above ground surface). Modelling of gamma ray fields of size-limited radioactive objects was carried out by two mathematical methods; i) the deterministic method using summation of effects of point sources, and ii) the Monte Carlo simulations. The deterministic method for modelling of gamma ray fields of uranium anomalies was invented using gamma ray intensity of point sources in sufficiently dense matrix. Reliability of mathematical modelling was assessed by experimental gamma ray spectrometric measurements on known natural radioactive objects in the Czech Republic. Average difference in gamma ray intensity between experimental data and calculated models is about 10 %. Gamma ray fields of imaginary circular uranium objects of diameters from 2 m to 50 m were calculated for the detector position on the ground and at heights 0.5 m, 1 m and 2 m. Range in the ground from which gamma rays captured in detector originate was calculated for variable detector height above the ground surface, variable densities of rocks and variable definition of gamma rays penetration. Results of the research can be used for designing projects and optimizing settings of field ground gamma-ray survey.

INVESTIGATION OF SEDIMENTATION RATES AND SEDIMENT DYNAMICS IN DANUBE DELTA LAKE SYSTEM (ROMANIA) BY ^{210}Pb DATING METHOD

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The Danube Delta is the second largest river delta in Europe, having a surface of 5800 km^2. The water of the Danube River starts to spread in a fan-like distribution starting from the location Tulcea. The river is divided here from into three main branches, namely Chilia (forms the border between Romania and Ukraine), Sulina and Sf. Gheorghe, which mark the three main zones of the delta. Each of these is characterized by sub-branches, brooks and channels, which connect several inner lakes and swamps. The aim of this study is to apply the ^{210}Pb radiometric dating method on Danube Delta lake sediments for the first time in order to determine the sedimentation rates and sediment dynamics in the studied lakes and to identify and assess the anthropogenic influences of the man-made structures, especially the construction of the Iron Gate hydro-energetic power plant in 1972-1983.In order to assess the changes on the Danube Delta,seven lakes were analyzed: Merhei (6 cores), Cruhlig (5 cores), Iacob and Isac (4 cores each), Matita and Uzlina (3 cores each) and Cuibida (2 cores).Cores were sectioned into 1-2 cm slices, weighted and dried (72°C, 24 h). After determining the dry masses, porosity and water content was determined.Gamma spectrometric measurements using a GMX type HpGe detector were carried out for the determination of the in situ ^{210}Pb component by ^{226}Ra and the ^{137}Cs for the validation of the method. The total ^{210}Pb content of the sediment layers was determined via ^{210}Po, the alpha particle emitting progeny of ^{210}Pb. The subsamples were added ^{209}Po tracer for the determination of the chemical yield and put to acidic digestion. Samples were spontaneously deposited on stainless steel discs. And ^{210}Po activity concentrations were determined by PIPS detectors. Both porosity and water content vary in the 21.3-96.1% range, having higher concentrations in the upper layers. The maximum total ^{210}Pb values vary in the 42-210 Bq/kgrange, the highest values being accounted to the Cruhlig Lake, the lowest to the Matita Lake. The average supported ^{210}Pb content of the lakes was 19 Bq/kg. The building of the Iron Gates shows its effects on the three lakes (Cruhlig, Isac and Uzlina): the sedimentation rates decrease with 32% in 1973-1976. The other four lakes show an average increasing of 42%. 52% of the sediment cores show the flooding events of the last 14 years and 47% show the flood from 1980.

HISTORICAL RECORD OF ANTHROPOGENIC INPUTS IN SALT MARSH SEDIMENTS FROM UNITED KINGDOM USING A MULTIPROXY APPROACH

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Present work build and integrate geochronological, geochemical and granulometric approaches with river flow data and aspects related to land-use changes in a systematic and comprehensive way for the identification and quantification of historical source pollution in coastal regions. These corroborative data bring new insights on the mining pollution inputs and their response to catchment dynamics for a better protection of the great ecological value of the coastal sediment systems in compliance with the refined EU's Recommendations on Integrated Coastal Zone Management (2010) and the EU's Habitats Directive (92/43/EEC). The anthropogenic impact of the historical mining industry from eastern Cornwall, UK was studied in sediment cores from three saltmarshes, namely: Antony Marsh and Treluggan Marsh on the Lower Basin of River Lynher, and Port Eliot Marsh on the Lower Basin of River Tiddy. The temporal context of the study was provided through the well-established Pb-210 age depth model, coupled with bomb-derived Cs-137 and Am-241 data as independent chronological markers. Target elements that are normally associated with mining and smelting activities (e.g. Pb, Cu, Sn, Zn, Cr, Cd, etc.), and lithogenic elements (e.g. Fe, Al, Ti) were analysed by Q-ICP-MS and Q-ICP-OES techniques. Downcore trends in metal pollutants are discussed in the context of the chronological data, sediment composition and historic meteorological and river flow records. Acknowledgements: Andra-Rada Iurian acknowledges the support of a Marie Curie Fellowship (H2020-MSCA-IF-2014, Grant Agreement number: 658863) within the Horizon 2020.

226Ra – ^{238}U SECULAR EQUILIBRIUM AND ^{226}Ra ACTIVITY CONCENTRATION DETERMINATION OF HUNGARIAN COAL SLAG SAMPLES IN A LOW-BACKGROUND COUNTING CHAMBER

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The precise quantitative determination of ^{226}Ra is crucial for radiological evaluations. The use of the 186 keV peak is studied for speeding up the present time-consuming gamma-ray spectroscopic measurements. For this, the uranium isotopic abundance and the ^{238}U – ^{226}Ra secular equilibrium have to be ensured and hence, were determined in Hungarian coal slag samples. The measurements were performed in a low-background counting chamber on samples put into radon-leakage-free sample containers. The ^{226}Ra activity concentration was measured based on the radon decay products (Pb-214 and Bi-214) and also the ^{226}Ra peak at 186 keV. The isotopic abundance data agreed with the natural isotopic abundance of ^{235}U and ^{238}U. Secular equilibrium between ^{238}U and ^{226}Ra existed in 8 samples, whereas one sample showed a slight disequilibrium. The ^{226}Ra activity concentrations determined from the radon daughters and from the 186 keV peak are in good agreement. Therefore, the direct and fast measurement using only the 186 keV peak was validated which can be used after measuring the uranium isotopic ratio and verifying the ^{238}U – ^{226}Ra secular equilibrium. This method can be used to measure the ^{226}Ra content of high number of samples from the same geochemical background.

RADIOANALYTICAL INVESTIGATION OF DRINKING WATER

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The 2013/51/EUROATOM directive – requirements for the protection of health of the general public with regard to radioactive substances in water intended for human consumption – which is issued by the Council of the European Union determines expectations for the member states in terms of the activation concentration and indicative dose of radon and tritium in water. The hungarian regulation regarding to the radioactive contaminants of water intended for food production and consumption is comprised by 201/2001 (X.25) Government Regulation. In case of tritium it defines the limit of the activation concentration at 100 Bq/L and of the indicative dose at 0,1 mSv/year.

The activation concentration of the tritium can be obtained from direct measurements however the indicative dose can only be estimated by the results of different measurements. According to the EUROATOM directive the indicative dose can be defined as 'the committed effective dose of the natural and artificial radionuclides which can be found in the drinking water supply system except the tritium, potassium-40 and the short lived decay products of radon. There are different investigation startegies in order to estimate the aforementioned dose. One of the most popular is the determination of gross-alpha and gross-beta activation concentration. This parameter can be aquired quite easily though the uncertainity of the measurement is high because of the unknown composition of the radionuclides, thus it is recommended only for screening. Even so - according to the WHO as well as the recommendation of the EUROATOM directive - if either the gross-alpha or the gross-beta activation concentration is not above its assigned limit then it can be assumed that the indicative dose does not exceed its 0.1 mSv/year limit either in case of 730L/year water consumption.

Should the gross-alpha or the gross-beta activation concentartion exceed the abovementioned limit isotope specific measuremenet must be executed to determine the dose. The indicative dose can be computed from the results of the measurements, the dose conversion coefficients and the annually water consumption. The EUROATOM directive involves derived radioactive concentrations for the most common natural and artificial isotopes.

The investigation of the drinking water has been the part of the radioanalytical monitoring program for quite some time. It has initially meant the determination of the gross-alpha and –beta activation concentration as well as the activation concentration of gamma emitting nuclides. The investigation of the uranium- and polonium isotope content of the water used for food production started only a few years ago. The main purpose is to determine which isotope's activation concentration has to be monitored continuosly and which are the ones that occured only at a very low level in Hungary thus can be neglected during the calculation of the indicative dose. In our presentation our intention is to report the results up to now presented the estimation of the indicative dose.

THE MAPPING OF ENVIRONMENTAL RADIOACTIVITY AND NEW PERSPECTIVES

FOR ECOLOGY STUDIES

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This report highlights the problem of natural radioactivity as a global factor for the formation and evolution of life quality of the human population. There are many questions as the life under/without radiation, the role of radiation in life processes and human evolution etc. for which we do not have enough answers. The study of this problem requires study of the structure of the natural activity and the α-, β-, γ- nuclides contents/ratio and determination their role in the formation of life indicators and statistics of the diseases population for studied areas. Actuality of radioecology investigations resides in abilities to obtain data about distribution and dynamics of radionuclide content/changes in environmental objects (geological rocks, soils, etc), especially for mountainous regions which are the sensitive indicators of human activity. Some data on geochemical composition of these objects still could be found in the scientific literature, but there is very limited information about the stability of their parameters to the factors of human activity and global geophysical processes on Earth.

Mapping of the environmental radon distributions is the first stage in such activities. Radon is a very important indicator of geophysical transmutation occurring in the earth's crust. Thus, isotopes of radon (^{222}Rn, ^{224}Rn) are the result of residual radioactive transformations U or Th, occurring in the depths of the earth. Ways of penetration of radon to the surface: through the water, especially in thermal source, with earthquakes and has intensified recently due to mining (oil, gas, ore) activities. Therefore, certification and monitoring of background concentrations of radon on the one hand are important to speak the intensity of these processes for the region, on the other – to protection from threats of diseases that cause internal exposure of the human body. Radon problems studying are attracting considerable attention but they remain topical due to the increasing global extraction of hydrocarbons using traditional methods and because shale gas revolution that is additional threats.

SEDIMENT DYNAMICS IN THE ST. ANNA LAKE (ROMANIA) PRELIMINARY RESULTS

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The St. Anna Lake is situated in the Ciomad Mountains (Eastern Carpathians, Romania) and it lies on the left side of the Olt River and it gains its sediment only from the soil and runoffs of its catchment area and the decomposition of its vegetation. The study of its evolution is of great importance since it is the only lake of volcanic origin in Central-Eastern Europe. Five sediment cores were taken using a gravity corer; these were sub-sectioned, wet and dry masses being measured. Physical parameters (water content, porosity, bulk density) were calculated and LOI measurements for organic matter and inorganic carbon content were carried out. The ^{210}Pb chronology was used to determine ages and sedimentation rates of each sub-section. Total ^{210}Pb content was measured using the alpha particle emitting progeny, ^{210}Po; therefore samples underwent acidic digestion using HNO_3, HCl and H_2O_2, spontaneous deposition on high nickel content stainless steel discs. Measurements were carried out using PIPS detectors. Supported ^{210}Pb content was measured via gamma spectrometry (HPGe detector) using the 295 keV 351 keV and 609 keV, using the short lived progenies of ^{226}Ra. The CRS model was used for the determination of ages and sedimentation rates. Result show that the average water content was 91% and the average porosity was 85%. Average bulk density was calculated to be 0.81 g/cm^3. LOI measurements show an average total carbon content of 46.39%. The inorganic carbon content has an average value of 4%, while the organic carbon content has an average of 39%. The average supported ^{210}Pb was measured to be 23±3 Bq/kg, while total ^{210}Pb decreases from an average maximum of 220±19 Bq/kg. The dating horizon was reached in the range of 15-21 cm. The dating of the sediment cores was made on average until the year 1820. Average mass sedimentation rates show two local maximum in all cores, one being registered in the 1974-1983 period when major floods were present over the entire territory of Romania (the 1975 flood), and the second in the 1918-1935 period (especially the great flood form 1932). In these periods values grew up to 12 times the values registered before the floods (from 0.001 ± 0.0002 g/cm^{2}y to 0.012 ± 0.004 g/cm^{2}y in case of one sampling area and from 0.019 ± 0.009 g/cm2y to 0.161 ± 0.025 g/cm^{2}y in case at the other). Linear sedimentation rate show maximums in the same periods, with average values varying in the 0.111 ± 0.021 - 0.120 ± 0.019 cm/y range.

SPATIAL DISTRIBUTION OF NATURAL RADIONUCLIDES OVER LARGE AREA - USE OF BIOMONITORS

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The activities of radionuclides were measured in samples of terrestrial mosses (197 moss samples) collected in Serbia. Measurements were performed by 9" x 9" NaI anti-Compton detector configured to be used as well counter. In all spectra measurable amount of airborne ^{7}Be and ^{210}Pb was observed. In number of them presence of ^{137}Cs is detected. Gamma lines of ^{214}Bi and ^{40}K can be seen in spectra too. In preliminary analysis of data is obtained that distribution of ^{7}Be activity in collected moss samples is far to be uniform. Measured activities of ^{7}Be are spread in the very large region - the highest activity concentration is almost 30 times higher than the lowest one. Good correlation between obtained specific activities of ^{214}Bi and ^{40}K were observed, indicating common source, probably dust and soil. Maps showing the spatial distribution of ^{7}Be, ^{214}Bi and ^{40}K were created using geostatistical methods. Spatial distributions of ^{214}Bi and ^{40}K indicate areas where higher concentration of ^{214}Bi (and ^{238}U as well) can be expected.

CHARACTERIZATION AND ^{10}Be CONTENT OF IRON CARBONATE CONCRETIONS FOR GENETIC ASPECTS - WEATHERING OR BURNING: RIM EFFECTS IN IRON CARBONATE CONCRETIONS

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Rocks exposed on the surface suffer changes which cause transformations of their surface and crust like as macro- and microtexture, mineralogy, geochemistry and isotopic composition. We overview all these changes in a multihierarchical comparative analyses in order to distinguish two different ways of weathering transformations: weathering or burning. In order to strengthen distinction by the exposition time we measured ^{10}Be, and ^{14}C content in addition. Two siderite concretions of exotic outlook were investigated, Nagykovácsi (Nk) and Úri, and also sedimentary siderite concretions and fragments from Délegyháza and Rezi, Hungary, to determine probable origin and faith of these objects. Why siderite? Thinking about the chance to recognize terrestrial originated "impact ejecta" on the surface, the possible existence of which are raised in the literature, siderite looks to be the best candidate. Siderite suffers degassing of th exposed surface on heat effect, and its color asks for macroscopic attention (shiny brown appearance), and the carbon isotopic and mineralogical changes can prove degassing. Among the aims of our study was the answering of that question whether the routinely used methodologies can distinguish siderite objects convincingly from each other, or not. Our results confirmed that the exposed surface is the result of considerable heat effect (310 - 800 °C) causing degassing. Also, the rim is basically different from terrestrial weathering crusts. The ^{14}C activity is (C-14 pMC abs) 1.01 (inner part) and 2.23 (exposed surface) for Úri, and 1.06 (inner part) and 11.96 (exposed surface) for NK. The ^{10}Be values are $1.28 \pm 0.05 \times 10^{\wedge}8$ atoms/g for NK and $(2.71 \pm 0.08 \times 10^{\wedge}8$ atoms/g) for Úri. Though the data are not conclusive at all to confirm impact ejecta of terrestrial origin in the case of our siderite data set, the data do not contradict with this scenario.

"THORON (^{220}Rn) INTERFERENCE ON RADON (^{222}Rn) DETECTING SYSTEM USING SOLID-STATE NUCLEAR TRACK DETECTORS AND ITS RESULTING ISSUES"

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Radon (^{222}Rn) is well known as the second cause of lung cancer after smoking. As radon is everywhere in the environment, WHO encourages general public to mitigate radon in their homes. Recently its radioisotope called thoron (^{220}Rn) is drawing attention as an additional risk on lung cancer from scientific communities on radiation protection because thoron can be detected by the advanced measurement technology.

Indoor radon surveys have been carried out in many countries. They provided an annual radon concentration in each country and are summarized in an international report such as UNSCEAR. Passive radon monitors using solid-state nuclear track detectors were commonly used in these surveys but they gave only radon concentrations. The passive radon monitor is originally designed to detect only radon effectively but several recent studies have revealed that some of them are sensitive to thoron though they are radon monitors. If the sensitivity is large than expected, thoron signals will be mixed into radon signals. As such studies have not sufficiently been done yet, radon concentrations might be overestimated even in major epidemiological studies supporting the recent radon risk assessment. This may imply underestimation of the radon risk and result in somehow exclusion of thoron risk.

This presentation addresses a review of passive radon monitors widely used in the world from the viewpoint of their performance in the environment such as thoron interference on radon measurements, and its resulting issues related to the radon risk assessment as well as the thoron risk itself.

SIMULATION OF DISPERSION OF RADIONUCLIDES IN THE ATMOSPHERE FROM REGIONAL TO GLOBAL SCALE

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Recent emissions of radioiodine and other radionuclides into the atmosphere have underlined the importance of continuous atmospheric dispersion model development. As a state-of-the-art approach of atmospheric transport modeling, the online integrated WRF-Chem (Weather Forecast and Research model coupled with Chemistry) has been adapted for regional scale simulation of radioiodine. WRF-Chem performs coupled simulation of weather conditions and tracer transport, providing better spatial resolution and a more detailed representation of transport processes. While the application of WRF-Chem is limited to regional scale due to the large computational cost, Lagrangian models are able to simulate the atmospheric pathway and dispersion of pollutants on continental and global scale. A Lagrangian dispersion model, called RAPTOR, developed at Eötvös Loránd University, is also presented in this study. Parallel application of the two models provides a tool to simulate the atmospheric dispersion of radionuclides from regional to global scale with good accuracy and a reasonable computational cost.

RADIOSTRONTIUM MONITORING IN THE REGION OF BAKONY MOUNTAINS

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^{90}Sr is present in surface soil around the world as a result of fallout from past atmospheric nuclear weapons tests. Monitoring the activity concentrations in both water, soil, plant and animal samples is vital because of the health concerns associated with the isotope. Thanks to the high chemical similarity of Ca and Sr, the isotope passing into the body of animals and humans readily infiltrates into the bone tissue, causing various illnesses like leukemia. During the development of the methods it was important to make it happen using the available standards. We already developed a method for the monitoring of water samples, in the present article we present a new method as a result of the development of the forementioned one, which is suitable for the monitoring of radiostrontium activity concentration in solid samples like soil and animal tissue.

44 samples were taken in the vicinity of the Bakony hills in Hungary. Sampling was committed based on the ISO 10381-2:2002 standard. As the beginning of sample preparation the samples were dried to calculate the dry matter content.

The following procedure was divided into two variants: In the first one the samples were cremated at 460 °C to remove of the organic content of the sample. Following this step the samples were dissolved in 6M HNO_3 solution, then desiccated to dryness. The dried samples were than dissolved in 6M HNO_3 solution and selectively extracted using a Sr-resin extraction column. The extracted radiostrontium was later analysed on an Quantulus 1220 (LSC).

The other used method involved in the research was the direct acidic digestion of the sample, where concentrated HNO_3 and HF were added to the sample, then the mix was digested with a microwave instrument. The dissolved sample was later separated with the extraction resin and analysed via LSC.

Both the aforesaid methods were heavily quality controlled, after determining the exact method the measurement were conducted in accordance to the ISO/IEC 17025:200, the calculations, detection limits and errors were calculated based on the ISO/IEC 11929:2010 standard.

Thanks to the high level of quality management we can assume that the given results are correct, and the fact that the results of the two different measurement types are basically the same, verifies that. As a result we concluded that both methods give the same results, but the microwave method gives us the opportunity to skip the extraction step, as the resulting clear liquid may be suitable for direct measurement using Cherenkov radiation.

RADIOACTIVITY CONCENTRATIONS AND ASSOCIATED GAMMA ABSORBED DOSE RATES IN COASTAL MARINE SEDIMENTS OF ARABIAN SEA, GULF OF OMAN

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Measurements were performed for the determination activity concentration in costal marine sediments were collected from the Gulf of Oman to provide a prospective on the relative contributions to enhanced radioactivity and associated radiation dose and health risks. MEight beach sand and and similar number of sea sediments samples were collected, dried and sealed off to attain equilibrium. Spectrometric measurements were performed using high-pure germanium gamma ray spectroscopy. Energy calibration, efficiency calibration and photo-peak to Compton ratio measurements were performed during the experiment using calibrated standard. The activity concentrations of ^{226}Ra, ^{232}Th and 40K radionuclides were: 16.3±0.2, 27.8±2.2 and 45.6±2.8 Bq kg−1, respectively (In beach sands) and 16.2 ±1.0, 34.5±2.3, and 54.7±3.2, respectively (In marine sediments). Activity concentrations (Bq kg−1) of 210P and artificial 137Cs radionuclides were: 29-159 and 0.05 to 0.2 varied, respectively. It was estimated that the outdoor absorbed doses rates from 22 to 46 nGyh-1 varied. Annual effective doses were in the range from 27 to 56 μSv.y−1 varied and were therefore, comparable to doses reported for areas of normal background radiation. The study thus provides the first marine radioactivity study in Oman and provides an important baseline data upon which future radioactivity levels in marine environment could be compared.

Inveatigation of radiation hazard in Northeast Vietnam underground coal mines

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People working in underground coal mines could be facing many natural hazards including radiation hazard. The radiation hazard is caused mostly by the presence of radon and thoron decay products in ventilation air. Two underground coal mines in the Vietnam northeastern coal field (Quang Ninh province) were investigated for radon and thoron concentrarions. The measurements were conducted by using alpha track detectors CR-39 technique. The results showed that radon and thoron concentrations in underground tunnels are 44±10 Bq m^{-3} and 80±35 Bq m^{-3} in one mine and 104±20 Bq m^{-3} and 93±29 Bq m^{-3} in the other mine. The radon levels in both mine are less than the radon action level of 200 Bq m^{-3} set by Vietnam and ICRP. Results of estimation of annual committed effective doses originated from the inhalation of radon and thoron showed that, comparing to the people working on the ground, people working in the underground tunnels may receive a small increased annual effective of 0.21 mSv yr^{-1} in one mine and 0.33 mSv yr^{-1} in the other mine. However, the increased annual effective doses are not higher than 1 mSv yr^{-1} recommended by ICRP.

RADIOLOGICAL INVESTIGATION OF SPILL WATERS ORIGINATED FROM ZINC, LEAD MINE OF GYÖNGYÖSOROSI (HUNGARY)

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The remediation work of former zinc, lead ore mine in Gyöngyösoroszi (Hungary) has been started in 2005. The abandoned galleries of the mine are being filled with slurry state ashes originated from Mátra Power Plant. The main aim of the remediation work to inhibit the acid producing oxidation – caused by interaction of oxygen, water and pyrite – of huge amount of remaining pyrite content can be found in lode-system of Mátraszentimre. As a result of the pyrite oxidation the spill water of the mine has low pH and due to that fact also has elevated heavy metal content but the natural radioisotope content has not been investigated before. During that study the activity concentration of ^{238}U, ^{234}U, ^{232}Th and ^{210}Po isotope of the mines spill water, deposited sludge with high $Fe(OH)_3$ content, and treated technological spill waters were determined simultaneously with alpha spectrometry. In the case of polonium isotopes spontaneous deposition, and for uranium and thorium isotopes electrodeposition source preparation method were applied. On the basis of the results of the uranium isotopes activity concentration it can be stated that the sludge with high $Fe(OH)_3$ content originated from the treatment of the spill water of the mine has low influence on migration of uranium isotopes. The results of the polonium measurements clearly proved that the polonium isotopes are stuck in the sludge with the precipitated heavy metals. In the case of high iron content the nitrate ions did not inhibit the deposition of polonium despite of the information can be found in scientific literature. It can be explained with the precipitated residue with unknown chemical form, which presumably contained all the iron and nitrate ions can inhibit the deposition process. The thorium isotopes were low or under detection limit in the investigated water and sludge samples as it were expected. On the basis of the obtained results it can be safely stated that the investigated radionuclides were found in normal or below activity concentration compared with environmental level in the case of examined technology.

DEVELOPMENT OF CALIBRATION PROTOCOL FOR CR-39 BASED SSNTDS USED FOR THORON CALIBRATION MEASUREMENTS

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Recently the accurate determination of thoron concentration came to the fore. During long-term surveys solid-state nuclear track detectors (SSNTDs) are commonly used. For the application of these integral (passive) devices it is important to solve that calibration. A thoron calibration chamber has been developed at the Institute of Radiochemistry and Radioecology at University of Pannonia (RRI) recently; however, examinations performed until now showed that its development is necessary for the more accurate operation. Furthermore, a protocol shall be given for the calibration process which contains parameters of the calibration chamber and the calibration and validation method as well. From the quality assurance aspect, important task of elaboration of calibration protocol is the specification of validation method.

During this work various gamma spectrometric and scintillation techniques capable for thoron measurement were tested in the interest of selection of reference method for validation of thoron calibration. From among scintillation devices PYLON AB-5 and NDI system with Lucas cells were tested with various counting techniques (two counts method, integral counting). In case of gamma spectrometry the thoron emanation was calculated from the remaining Pb-212 (after disrupting the secular equilibrium due to thoron exhalation) and Ra-224 activity. Between the suitable validation techniques and the available active devices (SARAD EQF 3220, SARAD RTM 2100, DURRIDGE RAD7) comparison measurements were performed in the calibration chamber.

Based on the results of the comparison measurements good correlation was found between the results of PYLON AB-5 and the active devices (the differences were less than 10 % in all cases). The values measured by NDI system are a bit lower, probably due to the inaccurate efficiency calibration of the applied Lucas cells for thoron. Emanation coefficients determined by gamma spectrometry were not accurate enough due to the properties of the applied thoron source. Therefore, PYLON AB-5 has been selected as reference device. The correction factors calculated for SARAD EQF 3220, SARAD RTM 2100 and DURRIDGE RAD 7 instruments to get the results of PYLON AB-5 (as a reference instrument) are 0.98; 1.09 and 0.95, respectively. Based on the results grab sampling with Lucas cells with ZnS(Ag) scintillator coating and counting according to TCM method are proposed for validation of thoron calibration measurements. In case of RRI chamber PYLON AB-5 monitor with 300A Lucas cell has been applied. Based on the literature and experimental data a proposal for the steps of an exact protocol for thoron calibration has been given.

DISTRUBUTION OF NATURAL RADIOACTIVITY AND ASSOCIATED GAMMA DOSE RATES IN RIVER SEDIMENTS FROM KHARTOUM STATE, SUDAN

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This study was performed with aims to determine concentration of natural radioactivity in shallow river Sediments in Khartoum state, Sudan. Totally, 30 samples were collected from three rivers, prepared in Beakers and sealed off to attain equilibrium. Activity concentrations of ^{238}U, ^{232}Th and ^{40}K were determined by using Na (TI) gamma spectrometry. For the determination of activity concentration of a certain radionuclide, Energy and efficiency calibrations were performed using reference standard radionuclides. Activity concentration of ^{238}U, ^{232}Th and ^{40}K were 21.3, 32.3 and 220.6 $Bq.kg^{-1}$, respectively (in White Nile sediments); 21.6, 32.9 and 365.2 $Bq.kg^{-1}$, respectively (in Blue Nile sediments); 18.7, 34.3 and 218.1 $Bq.kg^{-1}$, respectively (in River Nile sediments). It was estimated that the outdoor absorbed doses rates in White Nile sediments, Blue Nile sediments and River Nile sediments the range were 25.4 to 49.5 nGyh-1,39.6 to 58.1 nGyh-1 and 32.4 to 47.6 nGyh-1 varied, respectively. Annual effective doses were in White Nile sediments, Blue Nile sediments and River Nile sediments in the range were 31.1 to 60.7 $\mu Sv.y^{-1}$, 42.7 to 71.3 $\mu Sv.y^{-1}$ and 39.7 to 58.4 $\mu Sv.y^{-1}$ varied; respectively and were therefore, comparable to doses reported for areas of normal background radiation. The results obtained from the sediments were less than the recommended safe and criterion limits given by UNSCEAR.

A STUDY ON RADIOACTIVITY OF ENVIRONMENTAL SAMPLES FROM THE VICINITY OF THE OBRENOVAC POWER PLANT

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Measurements of radionuclide content in various environmental samples (soil, plants) have been performed. The samples were collected from three different sites in the broader vicinity of the coal-fired Obrenovac power plant (TENT) – close to the power plant and farther away from it, including previously flooded ground. Radioactivity in soil and plants taken from each site were measured and the obtained results have been analyzed.

ASSESSMENT OF NATURAL RADIOACTIVITY LEVELS IN BUILDING MATERIALS AND RESIDUES IMPORTED IN SERBIA

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The estimation of the radioactivity levels of materials utilized in construction sectors is crucial in the assessment of possible radiological hazards to human health. Different materials used as building materials were sampled and their natural radioactivity was measured by gamma-ray spectrometry. In order to assess the radiological impact from the investigated samples, the absorbed and the effective doses were determined.

Natural radioactivity is responsible for most of the total radiation dose received by human population. Building materials and residues can cause substantial radiation exposure if they contain elevated levels of naturally occurring radionuclides. Radiation practices comprise the production, trade in or handling of materials with elevated natural radioactivity causing significant excess exposure of workers or general public.

All investigated samples of imported building materials were taken in period 2006-2016 and measured by gamma-ray spectrometry. The database contain more than twenty thousand results of radioactivity concentrations of different NORM materials and residues used in building industry.

The investigated samples were crushed, homogenized to fine powder and transferred into containers for measurement. A typical sample weight was about 400 g. The radionuclide content of the samples was measured using the HPGe extended range ORTEC GMX type detector (10 keV–3 MeV) with nominal efficiency of 32 %. The detector was calibrated by means of a reference radioactive material in cylindrical geometry (NBS Standard Reference Material 4350B). Self-absorption effects due to different densities were taken into account using the ANGLE computer code based on the concept of the effective solid angle.

Results of activity concentration measurements of ^{226}Ra, ^{232}Th, ^{40}K, gamma index, dose rate and annual effective dose for different building materials and residues are presented.

Measurements presented in this work confirm that radiation exposure and attributed risk should be reduced by careful choice of building material during construction.

ESTIMATION OF INDOOR RADON, THORON & THEIR PROGENIES CONCENTRATION LEVELS ALONG WITH ANNUAL INHALATION DOSE IN DWELLINGS OF NE PUNJAB, INDIA

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A survey was conducted to determine radon and thoron concentrations, and their progeny concentrations in dwellings of north east region of Punjab state, India. Concentration level of radon and thoron gas has been estimated using pin hole based twin cup dosimeters with single entry face. Annual level of radon and thoron was found to vary from 11.22 ± 3.56 to 56.13 ± 10.97 Bq/m^3 and 12.21±4.05 to 101.53±20.76 Bq/m^3 with an average value of 32.98±5.54 & 51.81±8.66 Bq/m^3 respectively. However, deposition based progeny sensors have been utilized for direct estimation of radon and thoron progeny concentration in terms of equilibrium equivalent concentration (EEC). Results for average annual equilibrium equivalent concentrations have observed to be 15.55±3.42 & 1.22±0.35 Bq/m^3 for radon and thoron respectively. Annual dose due to inhalation of radon, thoron and their progenies has been found to be well within the reference level as recommended by the ICRP. In the present study, dose due to thoron and its progenies contributed about 28 percent in the total annual inhalation dose.

PHOTOCATALYTIC PROPERTIES OF THE SYSTEMS BASED ON URANYL-INCORPORATED SBA-15 MESOPOROUS SILICA

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Periodic mesoporous materials are extensively employed with a view to aiding in the dispersion of photocatalytically active species, since they possess very high surface areas, large pore volumes, and can be easily synthesized. They have remarkable features such as tunable structural and morphological properties, a large surface area (1000–1400 m^2/g) and uniform pores with well-defined and controlled sizes (2–10 nm). SBA-15 is a mesoporous silica sieve possessing uniform hexagonal pores with a narrow pore size distribution and a tunable pore diameter of between 5 and 15 nm. The present original laboratory-scale study fits into a currently active field with the aim of incorporating uranyl ions into solid porous matrices for long-term storage. The matrix synthesis consisted in a self-assembly process triblock by using as template a copolymer Pluronic 123(EO20PO70EO20) under acidic conditions. The uranyl ions were heterogenized onto the large ordered pores of SBA-15 mesoporous silica that served as ideal hosts for the encapsulation of uranyl species due to their high surface area, large pore size and high thermal stability. The uranyl ions incorporated within the mesopores of silica host matrices served as highly efficient heterogeneous photocatalysts for room-temperature photooxidation of Eosin Y as a reactant in the photocatalytic batch reactor. The results indicate the potential applicability of uranyl encapsulated onto the SBA-15 silica photocatalyst in applications related to wastewater processing under ambient conditions.

NEW URANIUM (VI) COMPLEX WITH 8-HYDROXYQUINOLINE

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Uranium (VI) is known to form coordinative compounds with numerous Schiff bases, showing a strong affinity for ligands with oxygen-and nitrogen-bearing ligands. The synthesis, structure and some properties of the uranium nitrate complex with 8-hydroxyquinoline in tautomeric form are presented. The coordinative compound has been studied by UV-Vis, IR, X-ray crystallography and thermal analysis. The theoretical properties have been calculated with Density Functional Theory (DFT) method and Gaussian 09 software package. The intramolecular hydrogen bonds and significant π-π stacking interactions are also observed in the packing and characterize the supramolecular three-dimensional network. The properties of the synthesized coordinative compound recommend their utilization for the purification of the residual waters, resulted from mining exploitations, containing the uranium VI.

The interest of this complex refers to the applications in metallic ion extractions from various solutions in which they occur in low concentrations, as well as in the spectrophotometric determination of the uranium traces in different samples, leading to the possible purification of residual waters containing uranium ions.

PRODUCTION OF COAL BOTTOM ASH CERAMICS AND INFLUENCE OF THE MAIN PROCESS PARAMETERS ON THE PHYSICAL AND MECHANICAL PROPERTIES

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Bottom ash as residue containing NORM (Naturally Occurring Radioactive Material) has been presented as a major problem of disposal throughout the world, since it is produced from the process of coal combustion in thermal power plants. However, its physical, chemical and radiological properties make the powdered ash an adequate potential construction material in variety of applications. The aim of the study which has been realized through a Short Term Scientific Mission supported by COST Action TU 1301, was to investigate the possibility of utilization of bottom ash for production of ceramics compacts and to analyse the influence of the main process parameters and their interaction on the physical and mechanical properties of the final product. Consolidation of the powders were conducted on two bottom ash samples with particle size (s) -0,250 mm and -0,500 mm, pressing pressure (P) of 100 and 150MPa and sintering temperature (T) of 900 and 1100 ^{o}C. The density and bending strength of the dense bottom ash compacts were the response function. The optimization was performed through implementation of main effect plots, Pareto charts and 3D surface method using "Statgraphics Centurion" software package. According to the results of the process of optimization, the final model equations of the density and bending strength dependence have been obtained and presented: ρ=-8.7055+0.00938T-0.02836P+23.556s+0.00026PT-0.02136Ts [g/cm^3] σ=260.268-0.2735T-5.3833P+507.38s+0.005208PT-0.9048Ps-0.3584Ts [N/(cm^3)] The obtained model equations of the density and bending strength dependence from the main process parameters are solid basic data for modelling the process of ceramic production.

RADIOCARBON LEVEL IN THE ATMOSPHERE OF RAMNICU VALCEA, ROMANIA

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The paper presents ^{14}C variation in the atmosphere of Ramnicu Valcea Romania. The samples were collected in the vicinity of the Experimental Pilot Plant for Tritium and Deuterium Separation (PESTD) from the Institute of the Cryogenics and Isotopic Technologies (ICSI) placed about 10 km south from the Ramnicu Valcea city (Romania), in the Govora industrial area. This facility is an experimental project in the national nuclear energy research program, which has the aim of developing technologies for tritium and deuterium separation. Until now, PESTD normal operation was with heavy water and tritiated water below exemption level approved by Romanian legislation. Foreseen experiments will be done with tritiated heavy water moderator from Cernavoda NPP (two CANDU-6 reactors), known to contain about half of the ^{14}C production of a Heavy Water Reactor. The largest contributor (>95%) to the production of ^{14}C in CANDU reactors is neutron activation of ^{17}O in the heavy-water moderator. Considering the fact that one of the important releases of PESTD is gaseous radioactive effluents, the baseline of atmospheric ^{14}C was a must for environmental program. It should be noted that in the Govora industrial area operates a 315 MW Coal-Fired Thermoelectric Power Plant and two chemical plants. A radiocarbon background level (250 Bq/g of carbon) was established by international regulatory bodies. Above this background level, other than the normal production of ^{14}C by cosmic radiation, will be considered pollution. In order to determine radiocarbon activity in the atmosphere, samples were collected monthly by absorption of CO_2 into sodium hydroxide (NaOH) at Ramnicu Valcea. In addition, control materials (tree leaves and wild vegetation), primary standards (Carbonate, IAEA-C2), and process blanks (marble) were analyzed. Radiocarbon measurements were performed using the direct absorption method. This consists in measuring ^{14}C contained in a known quantity of carbon, as carbon dioxide, obtained from a sample, standard or background material, counted in an ultra-low level liquid scintillation counter Quantulus 1220. ^{14}C results were normalized for deviation of the measured $\delta^{13}C$. The $^{13}C/^{12}C$ ratio was measured by isotope ratio mass spectrometry on a Delta V IRMS on small aliquots of sodium carbonate resulted from absorption of CO_2 into sodium hydroxide. Values are given relative to the VPDB standard, with overall precision typically ± 0.1 ‰. $\delta^{13}C$-corrected $\Delta^{14}C$ data are given relative to NBS oxalic acid activity, corrected for decay disintegration. The measured $\Delta^{14}C$ levels varied between -116.20 ‰ and 148.54 ‰. The results have a clear decreasing trend, but due to local influence caused by continuously production of fossil CO_2 we cannot observe $\Delta^{14}C$ seasonal variations.

DETERMINATION OF BIOGENIC FRACTION IN LIQUID FUELS BY ^{14}C LSC DIRECT METHOD

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The novel technique for determination of biogenic component in liquid fuels by direct measurement of the activity concentration of ^{14}C on Liquid Scintillation Counter, Quantulus 1220 has been developed in few laboratories worldwide and the results of the implementation were published recently. This paper presents first results of the development of this method and measurement calibration in the Nuclear Physics Laboratory Novi Sad, Serbia. The European Union develops common EU policy and strategy on biofuels and sustainable bio-economy through several documents. The encouragement of biofuel's consumption is therefore the obligation of each EU member state. According to the EU Directive 2009/28/EC liquid fuels have to contain at least 10% of bio-fuel by the year 2020. The fraction of biogenic component within various types of materials that can be used as fuels for energy production and transport can be determined by measuring ^{14}C activity. The direct LSC method is based on different ^{14}C signatures of the biogenic and the fossil components: while the biogenic component reflects the modern atmospheric ^{14}C activity, no ^{14}C is present in fossil fuels. For calibration purposes we used two different scintillation cocktails, both suitable for organic sample measurements, Opti Fluor O and Ultima Gold F. The calibration was done by different blank samples. Both, plastic and glass vials were tested in order to determine the measurement efficiency. The sample – scintillation cocktail ratio was also explored and the best FOM was found for ratio 10 ml of scintillation cocktail Ultima Gold F -10 ml of sample and 9 ml of scintillation cocktail Opti Fluor O – 11 ml of sample. According to the obtained results we concluded which scintillation cocktail gives better results and which vial is more suitable for use. The MDA values were determined for every blank sample which is used.

CONCENTRATIONS OF TRITIUM IN PRECIPITATION AND INLAND WATERS COLLECTED IN OKINAWA ISLAND, SOUTHWESTERN PART OF JAPAN

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In order to estimate the recent concentration of environmental tritium in Japan, water samples were taken in Okinawa Island every month from June 2014. Precipitation was collected at the rooftop of a building of University of the Ryukyus. Also inland water samples were taken from two springs, a well and a limestone cave. These samples were distilled to remove impurities. Then the distilled samples were electrolysis enriched, because the concentration of tritium in the environmental water is extremely low in the recent years. Analysis for the tritium concentration was performed by a liquid scintillation counter. So far, the analyses have been performed for the samples obtained from June 2014 to May 2015. The arithmetic means of tritium concentration for the precipitation and inland water samples were calculated to be 0.13 Bq/L and 0.16 Bq/L, respectively. The maximum value, 0.19 Bq/L, was observed on a dripping water sample obtained from the cave. The results indicate that there is no difference for the tritium concentrations between precipitation and inland water samples, and that the tritium concentration of environmental water in Okinawa Island is lower than that of the past data obtained in the mainland of Japan (approx. 0.35-2.7 Bq/L, Sugihara et al., 2008). This suggests that the latitude effect brings the low tritium concentration in Okinawa Island. In addition, it is considered that the decrease with physical half-life of tritium originated from the past atmospheric nuclear tests contributes the low tritium concentration in Okinawa Island. To view the recent seasonal and geographical variations of the environmental tritium concentrations, continuous study is requirements.

INVESTIGATION ON PREPARATION TECHNIQUE FOR ORGANICALLY BOUND TRITIUM ANALYSIS FROM SEDIMENT

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The measurement of total organically bound tritium (OBT) from sediment using liquid scintillation counting (LSC) implies first of all conversion of organic matter in liquid water. In order to convert organic matter from sediment to water a necessary step is the process of total oxidation, which most commonly was made through combustion using different type of tube catalytic furnaces (Cossonnet, 2009; Eyrolle-Boyer, 2014) or the devices called oxidizers (Kim, 2013). The objective of this study was to develop, optimise and verify a new method for analysis of OBT from sediments, using a Parr bomb type 1121, a versatile device needing limited financial resources, already available in our laboratory. The content of carbon and hydrogen in sediments are quite low, around 3% for carbon and 1% or less for hydrogen, and the combustion using a Parr bomb has limitations regarding minimum organic content, due to the explosion in oxygen atmosphere. In order to use this kind of device for sediment combustion we needed to mix the sample with a tritium free combustion promoter, in our case a dried heavy fuel oil. The preliminary experiments involved the use of two fossil tritium free combustion promoters, a heavy fuel oil (petroleum derivate) and a coal. Between the two promoters the heavy fuel oil was selected for its high viscosity, which ensures good homogeneity of the mixture and prevents the deposition of the sediment on the bottom of the combustion bomb capsule. Next step involved the optimization of the sediment: promoter ratio, in order to have complete combustion of the organic matter from sediment. The proper ratio sediment: heavy fuel oil in our experiments was between 1:3 and 1:2, sediments higher ratio conducting to unreliable results, due to incomplete combustion of the sample. The limitations of this method are the low levels of OBT and also low hydrogen content in sediment, due to the fact that mixing the sediment samples with dried heavy fuel oil conducts to dilutions of the OBT with tritium free water formed during the combustion. Due to tritium dilution during combustion, minimum measurable activity of the OBT can be around 10 Bq L^{-1} for a sediment with 1% hydrogen and around 15 Bq L^{-1} for a sediment with 0.5% hydrogen. This method was used to determine the OBT activity from estuarine sediment from the 2nd OBT Intercomparison Exercise. Acknowledgments This work was performed within the framework of the Experimental Pilot Plant for Tritium and Deuterium Separation from Institute for Cryogenics and Isotopic Technologies ICSI Rm. Valcea.

A POSSIBLE ALTERNATIVE GENETIC INTERPRETATION OF THE MN-P-U-BE-REE MINERALIZATION, BÜKKSZENTKERESZT, BÜKK MTS., HUNGARY

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The U-Be-REE-bearing phosphate bodies are associated with Mn-oxide ore of Triassic (Ladinian) age, found in fracture zones of rhyolite tuffs, near the village of Bükkszentkereszt. Geological, petrographical and tectonic details were elaborated by Szabó and Vincze (2013), and also detailed geochemistry was reported recently by Zajzon et al. (2014). The mineralization occurs in a slightly pressed, anchimetamorphic, mafic/acidic volcanic series, built from lavaflows and tuffs. Footwall and hanging wall and intercalated limestone beds belong to the series. Originally their main components could have been acidic, pyroclastite and pelitic sediments. The U-Be-REE-phosphatic and Mn–oxide-bearing tuffaceous rock-formed bodies have irregular thicknesses, they form bands, and lenses in the brecciated zones with sharp contact to the fracture walls. The acidic tuffaceous series has suffered significant hydrothermal metasomatic effects (e.g. silicification, K-Na-migrations, phosphatic and Mn-oxide mineralization). The geochemical evaluation clearly indicated a close correlation between P-U-Be-REE contents. The respective correlations between these elements with MnO_2 proved to be negative and very weak. The alpharadiographs of the U-contents (U-oxide ("U-black"), uranophane, bertrandite and/or berillonite) indicated dense and unequally dispersed alpha-tracks inside the phosphatic fields, but the Mn-oxide ones were shown to be barren (Szabó and Vincze, 2013). The maximum concentrations are the following: MnO-44.6 wt. %; P_2O_5-35.3 wt. %; Fe_2O_3-3.1 wt. %; U-998 ppm; Be-1550 ppm; ΣREE-500 ppm; As and Zn-1400 ppm (Szabó et al., 2013). Rejuvenation of the volcanism (owing to the tectonics) brought submarine, hydrothermal exhalations. The microbrecciated zones and their surroundings were first silicified, and then phosphatised, resulting in the formation of Mn-ore with U-Be-REE contents; this was due to metasomatic replacements (Szabó and Vincze, 2013).

Based on the element enrichments, the microtextural features (Zajzon et al., 2014) and the mineralogical composition, besides the hydrothermal origin (source) a further enrichment effect can be supposed. In the case of P, Mn, Fe, U, As, Zn and also the REE, the effect of microbial mediation can be raised. The correlation of elements and also the mineralogical composition, among which so called bioindicator minerals occur, like collophane, Mn-oxides, Fe-phosphate, Fe-oxide-hydroxide, pyrite and also the U-minerals support this scenario. As a summary, the rhyolite-hosted manganese ore mineralization bounded U-Be-phosphate enrichment can be proposed as a fossile mineralized microbially mediated deposit.

NATURAL RADIONUCLIDES IN SOIL IN THE REGION OF PRIZREN

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Soil samples were taken in the Sharr-Korabi zone, in the south of Kosovo in order to contribute on establishing appropriate environmental radiation safety criteria for regulatory body in Kosovo. Twenty-one soil samples were analyzed for ^{238}U, ^{226}Ra, ^{232}Th,and ^{40}K using gamma spectrometry. The following ranges of activity concentration (Bq kg^{-1}) were obtained: 250-710 for ^{40}K, 30-70 for ^{232}Th, 21-53 for ^{226}Ra and 22-160 for ^{238}U.

With respect to lithology the naturally occurring radionuclides showed variation. The highest mean for ^{238}U and ^{226}Ra were found at terra rossa and for ^{232}Th and ^{40}K were found on metamorphic rocks. Total terrestrial gamma dose rate, calculated on the basis of measured activity of radionuclides, ranged from 27-60 nGy h^{-1}, being the highest over terra rossa.

INVESTIGATION OF THE POSSIBILITIES FOR APPLICATION OF NORM INTO POLYMER MATERIALS

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There is growing trend towards the development of composites with low environmental impact and good commercial viability. Over the last few years different kinds of waste materials have been successfully utilized as filler in polymer composites with various applications. This not only reduces the production costs but also offers an opportunity for utilization of waste materials thereby reducing environmental pollution. Due to the environmental concerns and disposal difficulties, the utilization of fly ash (FA) as NORM material has become of great importance. Fly ash is promising for fabricating composites which can be widely used in various important fields especially for buildings. The granulometry of fly ash filler and filler blends are reported to be attractive as filler material in polymer composites. The main aim of this work was to perform estimate the possibilities for preparing of the composites based on fly ash as NORM material and polymers.

INDOOR RADON DOSE ASSESSMENT FOR BUZĂU DWELLERS

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Indoor radon measurements in 62 homes randomly selected within the aspiring Buzau Land Geopark have been carried out, using CR-39 based detection. The annual indoor activity concentration of radon ranged between 13 Bqm^{-3} and 630 Bqm^{-3} with an average of 169 Bqm^{-3}. In half the dwellings were identified concentrations higher than the national average with 6.8% of the homes having indoor radon values above 300 Bqm^{-3}, the reference level requested through the Council Directive 2013/59/Euratom. The annual effective dose, associated with radon exposure, received by the inhabitants varied from 0.3 mSv to 14.5 mSv, with an average of 3.9 mSv. However, hardly 3% of the calculated doses were above 10 mSv per year, the upper value of the dosimetric reference level for radon exposure in the condition of exposure of a dwelling, as laid out in ICRP 65. Acknowledgements: The research leading to these results has received funding from EEA Financial Mechanism 2009 - 2014 under the project contract no 22 SEE/30.06.2014 GEOSUST/EEA-JRP-RO-NO-2013-1-0135, entitled „Applied research for sustainable development and economic growth following the principle of geoconserv ation: supporting the Buzau Land UNESCO Geopark initiative".

POSSIBILITIES AND LIMITATIONS OF RAPID 90SR SCREENING TEST IN MILK SAMPLES

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Radiostrontium ^{90}Sr is one of the most biologically hazardous radionuclides because of its long physical and biological half-life, high-energy beta radiation of ^{90}Y and its chemical analogy with calcium. Therefore, ^{90}Sr follows the paths of calcium in the food chain and is being deposited in the human skeleton, and is of major concern in environmental contamination, especially for samples related to the food chain. This paper summarizes results of experiments performed in order to test preparation procedure of milk samples through microwave digestion followed by Cherenkov radiation detection on Ultra Low Level Liquid Scintillation Spectrometer Wallac Quantulus 1220TM. Calibration of instrument was carried out for various milk samples with different percentage of milk fat spiked with referential ^{90}Sr/^{90}Y standard. Since milk fat influences on its density, results of experiments enabled investigation of efficiency detection correlation with density of milk. Optimization of method assumed selection of sample's vials, sample's volume, measurement time, instrument's protocol and optimal window selection based on highest figure of merit. The sample channel ratio (SCR) method has been applied to correct color quench effect. In order to investigate suitability of this method, minimal detectable activity achieved, accuracy and precision of determined ^{90}Sr activity were estimated. Validation parameters of method such as linearity, repeatability, reproducibility, sensitivity and recovery factor were also evaluated. Verification of method's accuracy and precision was performed on few real milk samples and few spiked milk samples. Obtained results indicate that this method is only screening test applicable in emergency situations (uncontrolled nuclear waste discharges/nuclear power plant accidents). Presented method is therefore, ultra fast, cheap and simple screening technique for a quick and reliable estimate whether milk samples contain increased ^{90}Sr activity or not.

RADIOLOGICAL CHARACTERIZATION OF HIGH VOLUME BAUXITE RED MUD ALKALI ACTIVATED CEMENTS AND CONCRETES

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Bauxite residue can be used as cementitious materials and as an aggregate in concrete products. The current study involves radiological characterization of different types of bauxite containing construction materials using gamma-ray spectrometry. The studied bauxite residue can, from a radiological point of view using ACI (Activity Concentration Index) defined by the EU-BSS, be used for dwellings, even in percentages reaching 90%. The disequilibrium between ^{238}U and ^{226}Ra can, however, result in the ACI not being a conservative screening tool. In order to keep the actual dose safely below the reference level (gamma-dose of less than 1 mSv/a) we recommend to incorporate less than 75% (by mass) of bauxite residue in the building materials for dwellings.

THE ORIGIN OF EXTREMELY HIGH RADON CONCENTRATION IN THE SOPRONBÁNFALVA GEODYNAMIC OBSERVATORY, HUNGARY

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The Sopronbánfalva Geodynamic Observatory is located on the border of City Sopron in the Sopron Mountains, Hungary. The observatory is an artificial gallery at a depth of about 60 m driven horizontally into an outcrop of the bedrock formed by orthogneiss at the so called Nandormagaslat Quarry. In the observatory, the radon concentration is extremely high, 100-600 kBq m3 in summer and some kBq m^3 in winter, which has been monitored since 2009 by an AlphaGuard radon monitor [Mentes, 2012; 2015]. The aim of this study was to search for the potential petrographic source of the high radon concentration. Radium activity concentration and radon exhalation measurements were carried out on thirty-seven rock samples from the 20 meter vicinity of the observatory. We investigated the original orthogneiss around the observatory and also the different altered rocks, which were created during rock-fluids interaction events during the Alpine high-pressure and retrograde metamorphism of the orthogneisses [Török, 1998; 2001; 2003]. These retrograde processes are Mg-metasomatism and argillitic-limonitic alteration with different degree of phosphate mineralisation. A couple of thin layers of weathered gneiss with argillitic-limonitic alteration were identified at the observatory. The average radium activity concentration was as high as 252±6 Bq kg^{-1} (range: 131–726 Bq kg^{-1}) in the material in the layers and the average radon exhalation was 46±3 Bq kg^{-1}. This is the highest measured radium activity concentration in the Sopron Mountains so far (average 226Ra activity concentration and radon exhalation of orthogneisses was 35±3 Bq kg^{-1} and 4±1 Bq kg^{-1}). The mineralogical composition and the radium bearing minerals were studied by scanning electron microscope and microPIXE equipment at the MTA Nuclear Phisics Institute. Most of the radium bearing minerals are phosphates which accumulate in the smallest, <64 μm particle size fraction, according to the results of the wet sieving - the ^{226}Ra activity concentration and radon exhalation of this fraction can reach even 2680±110 Bq kg^{-1} and 8630±610 Bq kg^{-1}. This layer with high radium activity concentration cuts the tunnel of the Geodynamic Observatory at several points. Our results indicate that the weathering and the argillitic-limonitic alteration with phosphate mineralisation changes both the activity and the chemistry of the rock. Presumably this layer is the source of the extremely high radon concentration in the observatory.

GAMMA AND NEUTRON RADIATION EFFECTS ON BUTTERFLIES

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Unintended radiation may have serious impact on the flora and fauna. Russian entomologists (Datchenko et al., 1995) observed an unusual population of the arthropod family Lycaenidae in Semipalatinsk. This area has been previously exposed to radionuclide contamination caused by Soviet nuclear activity. In a particular habitat 60% of the female individuals of the butterfly Meleageria daphnis population has become partially or fully gynandromorph (displaying both male and female characteristics), which is an extremely rare natural phenomenon. Following the catastrophic nuclear disaster in Chernobyl the effects of exposure to low levels of radiation on invertebrate population numbers have been investigated (Moller et al., 2009). This study notes that currently the highest levels of radiation pollution in Chernobyl is located in the top levels of the soil, in one of the most important invertebrate habitats. In the area this causes a significant reduction in the individual numbers of insect populations and also leads to malformations. Following the Fukushima Daichii nuclear disaster Japanese scientists (Hiyama et al., 2012) have observed the butterfly Zizeeria maha, another Lycaenidae species, showing several significant mutations which have increased in further generations. Despite these observations it is problematic to unequivocally determine whether these anomalies have been exclusively caused by ionising radiation as the genetic development of these butterflies – from the stages of egg to imago – is particularly sensitive to various environmental factors such as humidity and temperature. Therefore we thought to determine whether these anomalies are only caused by the radioactive pollution in the environment. Furthermore, it is a question whether these diurnal butterflies are utilisable for environmental biodosimetry. For this reason we have started pre-experimentations at the Centre for Energy Research, Hungarian Academy of Sciences. During the experiments we have exposed to gamma and neutron radiation in varying doses of 30 fully developed individuals of the species Plebejus argus and Polyommatus icarus collected in natural habitats; and 30 identical individuals of the Polyommatus icarus species reared in our laboratories from caterpillar stages and about half of them served as a control group. The results of the gamma radiation show that the mortality amongst the individuals exposed to 250 mGy gamma dose increased by 40% and there was a 75% reduction in the number of eggs laid by these individuals. The neutron radiation caused a more dramatic impact as after one day amongst the exposed individuals a significant mortality rate could be observed. Regarding mortality, our results are in accordance with those achieved by Hiyama et al. (2012) who investigated the radiation effects on Lycaenidae butterflies in the vicinity of Fukushima after the nuclear accident.

ORIGIN ASSESSMENT OF NUCLEAR MATERIALS FOR NUCLEAR FORENSIC PURPOSES

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Nuclear and radioactive materials were smuggled across Europe following the break-up of the Soviet Union. Nuclear forensic science was born to examine these materials, and combines techniques of nuclear and material sciences. The most important aim of these investigations is to determine the specific "signatures", which characterize the given material, and reveal the possible origin of the sample. The Nuclear Security Department at the Hungarian Academy of Sciences, Centre for Energy Research specialized its activity to the analysis of nuclear and other radioactive materials which have been seized in Hungary. The laboratory work, carried out mostly on uranium pellets, consists of physical, radiological, isotope-, elemental, and traditional forensic analysis methods.

Macro- and microscopic examinations are usually performed by optical and scanning electron microscopy (SEM). These methods provide information about the surface, chemical composition, specific features and grain size of the samples which are effective indicators of the production technology. Gamma-spectrometry, as a non-destructive radiological method, helps to determine the activity, gamma-emitter nuclide composition, enrichment and age of the samples.

Besides, several atomic spectroscopic and elemental analytical techniques are also used for forensics purposes like ICP-MS, XRF, PIXE, XRD or ESCA.

Mass spectrometric methods are basic methodologies to identify the origin of the samples. Rare-earth elemental profiles, and other elemental impurities, as well as stable isotope ratios (Pb, Nd, O. Sr) are also high confidence signatures.

In our work several analytical data of origin assessment of the seized nuclear materials and also results from inter-laboratory comparison exercises will be shown. New methods and techniques are also under development to find the relevant signatures.

DIFFERENT POTENTIAL SYSTEMATIC UNCERTAINTIES INVOLVED IN ^{210}Pb DATING METHOD

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The aim of this work was to analyse two potential systematic uncertainties associated with the ^{210}Pb dating method that may occur in the dating of lacustrine sediment samples. The sediment cores from nine lakes were collected, situated in four different locations in Romania. In one part of this study, the values of systematic uncertainties derived in applications of four types of chemical digestion methods were calculated, that have been used to determine the total ^{210}Pb content by ^{210}Po. The effects of the residue content to the ^{210}Pb method were also successfully investigated after application of leaching processes. The ^{210}Po activity concentrationsof the residue quantity for the samples, were also calculated and were compared to the initial values. Finally, the effects of the residue material to the ^{210}Pb method were determined. The mineral identification and quantification both the initial and the remainingsediment content were carried out by powder X-ray diffraction (XRD) technique. The second objective of this work was to apply corrections for the photo-peak efficiency, due to the differences between the sediment layers which are essential in the accurate determination of the supported ^{210}Pb, via gamma spectrometry. The attenuation of gamma ray (at e.g. 46.5 keV) was analysed experimentally using both the transmission and the relative methods, as well as the theoretical Monte Carlo computation technique. The absorption correction was determined for 3 sediment cores, collected from two lakes located in Danube Delta, Romania. Each layer was separately compared to IAEA 385 standard sample with considering the geometries and matrices to the analysed sediment samples. Additionally, the global errors were determined for each layer and were compared to those obtained by the ^{210}Pb method. The preliminary results show, the ages of the sediment layers tend to be up to 19% younger because of the ^{210}Po restrained in the silicate crystals. In the case of gamma ray absorption phenomenon, the maximum deviation to the reference sample was 2.3 ± 0.05 g/cm^2.

VARIATIONS IN SEDIMENTATION RATES AND DYNAMICS IN THE LAKE SYSTEM BETWEEN THE CHILIA AND SULINA BRANCHES OF THE DANUBE (DANUBE DELTA, ROMANIA)

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The aim of the present study is to describe the changes in the sedimentation rates and sediment dynamic patterns attributed to the northern Danube-deltaic lake system, the Matita-Merhei lake complex, lying between the Chilia (accounted for 65% of the total water transport of the Danube) and Sulina branches of the Danube, in the Danube Delta. Although the lakes are connected to the main branches through channels of 10-15 km lengths, they still represent the main source of suspended sediment income. The water circulation is mainly accomplished from the direction of the Chilia branch, but this can change in seasons of drought. This area is characterized by sub-branches, brooks and channels, which connect several inner lakes and swamps and it is assumed to be the most active part of the delta. Numerous human interventions are made to normalize the upstream river; however, the most important constructions are the two Iron Gate dams in 1970 and 1983 between Romania and Serbia. A total of eight sediment cores were taken with a gravity corer from this lake complex: three from the Matita Lake and five from the Merhei Lake. Each sediment core has been sub-sectioned into 1-2 cm substrate; wet and dry masses were measured (sediments were dried in a drying oven at 75°C for 24h) and porosity, content and wet and dry bulk density were calculated. LOI measurements were carried out in six of the cores for organic matter and inorganic carbon compounds. Gamma spectrometric measurements have been made in order to determine the ^{210}Pb and ^{226}Ra content of each sediment core using high resolution gamma spectrometry (HPGe type ORTEC GMX detector with FWHM of 1.92 keV at 1.33 MeV and a Be window of 0.5 mm) The ^{210}Po content of each sediment sample was determined by adding ^{209}Po tracer to dried samples, followed by acidic digestion, and spontaneous deposition on high nickel content stainless steel discs. The obtained alpha sources have been measured by ORTEC SOLOIST PIPS detectors (19 KeV resolution and ASPEC-92 data acquisition system). Ages and sedimentation rates were calculated using the CRS model. On average data was obtained until 1900, cores having an average supported ^{210}Pb concentration of 18±Bq/kg, while he supported ^{210}Pb decreased from the maximum of 160 ± 8 Bq/kg. Mass sedimentation rates show that the average value is 0.262 g cm^{-2}y^{-1} in case of Merhei Lake, while the Matita Lake shows higher average values (0.919 g cm^{-2}y^{-1}). Most cores show local maximums after 2000 and in the 1994-1998 period (values increasing up to 6 times in both cases). Similar trends are identified in the linear sedimentation rates, but average values are comparable: 0.912 cm y^{-1} in Merhei Lake and 0.987 0.912 cm y^{-1} in Matita Lake.

RADON CONCENTRATION MEASUREMENT AND DOSE EVALUATION IN SOME DWELLINGS AT MENOUFIYA DISTRICT IN EGYPT USING MAKROFOL DE_{1-1} NUCLEAR TRACK DETECTORS

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In this work, etching and spectrometric properties of Makrofol DE_{1-1} track detectors were investigated. PEW etchant solution (15gm KOH+40gm C_2H_5OH+45gm H_2O) at different etching temperature were used. Bulk- etch rate, V_B, track-etch rate, V_T and detector sensitivity, V, were determined. The response of etched track detector to alpha particle energy registration and radon-concentration measurement was also studied. Makrofol DE_{1-1} detectors showed a Bragg peak around 1.8 MeV using PEW solution at 65°C and for t_e = 30 and 45 minutes. The use of the studied detector as an alpha spectrometer was carried out at energies of 0.9, 1.5, 1.8, 2.7, 3.4 and 3.9 MeV

Radon calibration factor (K) and equilibrium factor (F) were determined using a home-made radon chamber. Values of K=0.149 track cm^{-2} d^{-1} sper Bq m^{-3} and F=0.346 were found. Radon-dose estimation in 18 dwellings in Menoufiya Governorate Zone was found to be 0.621 mSv/y and 0.43 mSv/y in case of closed and open respectively. Results of this study are discussed within the frame work of nuclear track formation theories and etching mechanism in nuclear plastic detectors.

NATURAL RADIOACTIVITY AND EXTERNAL DOSE IN THE HANOI AREA, VIETNAM

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Detailed natural radiation background for the Hanoi area was surveyed. External gamma dose rate in air at 1 m height were measured at 3360 points and 446 soil samples were collected in 345 wards and towns of the city. All soil samples were processed and measured by low background gamma spectrometers. Results showed that average gamma dose rate in air at 1 m height is 0.068 ± 0.015 μGy/h, average ^{238}U, ^{232}Th and ^{40}K concentrations are 39.96 ± 8.84 Bq/kg, 60.37 ± 14.97 Bq/kg and 557.53 ± 244.49 Bq/kg, respectively. The collected database of the natural radiation background with densely and evenly distributed throughout the Hanoi area, combined with the results of data processing by statistical techniques and digital mapping, showed that the inner city area has higher radiation background than the suburban area. Results also showed the correlations of the natural radioactivity with geological formations, as well as the contribution of fertilizer to the ^{40}K data.

RADIOLOGICAL INVESTIGATION OF PHOSPHATE FERTILIZERS: LEACHING STUDIES

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The raw materials of the phosphate fertilizer industry are the various apatite minerals. Some of these have high levels of natural radionuclides, thus phosphate fertilizers contain significant amounts of ^{238}U, ^{40}K and ^{226}Ra. These can leach out from the fertilizers used in wast quantities for resupplying essential nutrients in the soil, and they can get into the food chain trough the plants thus increasing the internal dose of the affected population. During the current study a high purity germanium semi-conductor detector was used to investigate the radionuclide content and activity concentration of several different phosphorous fertilizer (superphosphate, NPK, PK). By total digestion method the total ^{238}U, ^{234}U content of the sample and the very low ^{235}U concentrations have been determined. The leaching characteristics of the samples were investigated by the MSZ 21470-50 (Hungarian standard) procedure and the Tessier 5-step sequential extraction method.

Based on the evaluation of the gamma-spectra the level of ^{232}Th in the samples is low, near the limit of detection, the average ^{226}Ra activity concentration was 309Bq/kg (maximum 570Bq/kg), while the ^{40}K concentrations could be as high as 7050Bq/kg. The high 40K can be explained by the composition of the investigated fertilizers (NPK, PK). These values are significantly higher than the average activity concentrations for soil ^{238}U=33Bq/kg, ^{232}Th=45Bq/kg, ^{40}K=420Bq/kg.

The leaching studies revealed that the the mobility of the fertilizers uranium content is greatly influenced by the parameters of the leaching methods (pH, temperature, time, etc.). The values measured using Lakanen-Erviö solution for ^{238}U and ^{234}U were around 11% of the total content of the samples, while in the third step of the Tessier method the leached amount could be as high as 49%.

RESULTS OF LABORATORY INTERCOMPARISON OF ^{226}Ra MEASUREMENTS IN DRINKING WATER

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The natural radioactivity level of drinking waters even the Ra-226 sometimes high According to this reason the international agencies developed the reference levels of drinking waters. Due to the quality assurance aspects the laboratory intercomparisons are required due to a different national and laboratory standards.

The aim of this study to present the results of the intercomparison 8 laboratory participated in the intercomparison 3 previously surveyed water sample were selected.

The 3 different water drinking water sample (W1, W2, W3) (Budapest well water, Pécs spring water, Oradea thermal water) have difference chemical matrix and according to the previous survey different Ra-226 concentration). From each sample 200 L sample were taken and bottled into a 1 L PET bottles and homogenity test was carried out according to the ISO 13528:2005 standard.

The Na and K ions concentration wre determined and to check the homogenity. The homogenity criteria was determined by the Cochran's maximum variance test and samples were homogenous ($F = 0.25 < F_{crit} = 2.39$)

In the intercomparison 8 laboratories participated with different protocols and devices: alpha spectrometry, radon emanation, liquid scintillation, gamma spectrometry.

According to the results the Ra-226 concentration of the W1, W2 and W3 W1: 0.88 ± 0.62 Bq L-1; K=2 [0-2.13] W2: 0.57 ± 0.56 Bq L-1;[0-1.73] W3: 1.48 ± 0.71 Bq L-1.[0.07-2.89] was respectively. The Cocran's test values are W1 F= 0.47 (F crit:= 2.14) ; W2, F=0.32 F crit= 2.10; W3 F=0.47 F crit= 2.09

Summarizing of the results the collected samples suitable for secondary reference material for Ra-226 determinations the homogenity of the samples were really good and the deviation of the laboratory results were appropriate.

TRITIUM CONCENTRATION AND δD･δ^{18}O COMPOSITION OF MONTHLY PRECIPITATION COLLECTED AT TOKI, JAPAN

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The deuterium plasma experiment is being planned to produce higher performance plasma using the Large Helical Device (LHD) of the National Institute for Fusion Science (NIFS). In the experiments, a small amount of tritium will be produced by the D(d, p)T reaction in D plasma. Therefore, it is important to understand the background tritium concentration in environmental samples for radiation safety and environmental assessment. The aim of this study to understand the characteristics of δD･δ^{18}O, chemical composition and tritium concentration to understand the regional precipitation chemistry.

Monthly precipitation samples were collected from November 2013 to November 2015 (and continues to this day). After sample collection, we measured the sample weight, pH and Electro Conductivity (EC). Later the sample waters were filtered, anions (Cl^-, NO_3^-, SO_4^{2-}), cations (Na^+, Mg^{2+}, Ca^{2+}, K^+, NH_4^+), δD and δ^{18}O were analyzed.

Tritium concentration in the precipitation ranged from 0.15 to 0.61 Bq/L and higher tritium concentrations were observed in spring than the other seasons. This range is similar to other reported values in Japan. This regional background concentration range will be used to evaluate environmental assessments after the initiation of the deuterium plasma experiment in LHD.

CONCENTRATIONS OF RADIONUCLIDES IN SOIL AND ASSESSMENT OF THE ENVIRONMENTAL GAMMA DOSE

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The main objective of this study was to identify and determine natural and artificial radionuclide activity concentrations in soil samples collected from several locations in Serbia and asssessment of the enviromental gamma dose.

Two different techniques for the assessment of environmental gamma dose are compared: environmental thermoluminiscent dosimeters and dose evaluation from the activity concentration of radionuclides in soil.

Soil samples were grinded and sealed in appropriate geometry to achieve a radioactive equilibrium. The samples were measured by gamma spectrometry using two HP Ge detection systems. ^{137}Cs and naturraly occurring radionuclides ^{226}Ra, ^{232}Th, ^{40}K, ^{235}U, and ^{238}U were detected in the samples.

The obtained results for absorbed gamma dose rate ($\dot{D}$) were in range 16.5–89.5 nGy/h for uncultivated soil samples for two different depths (0-5 cm and 5-15 cm), and in range 30.1–88.5 nGy/h for cultivated soil samples for one depth (0-20 cm). Appropriate annual effective dose (D_E) was in range 0.020–0.110 mSv/year for uncultivated soil samples and in range 0.037–0.109 mSv/year for cultivated soil samples. These results relating to period 2014-2015.

For environmental monitoring, Harshaw 6600 Plus automatic reader and thermoluminescent dosimeters TLD-700H were used. The minimum value of the intensity of ambient equivalent dose for 2014. was measured at the meteorological station Palić (76 nSv/h), while the maximum value was measured in Kraljevo (Watertower) (111 nSv/h). For 2015. the minimum value was measured at the meteorological station in Institute Vinča (69 nSv/h), while the maximum value was measured in Obrenovac (100 nSv/h).

DELINEATING THE RADIOMETRY OF THE QUATERNARY AQUIFER BASED ON ITS HYDROLOGICAL AND HYDROCHEMICAL CHARACTERISTICS IN LUXOR AREA, UPPER EGYPT

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The Quaternary aquifer comprises a semi-confined silt clay layer underlain by gravels, sand and clay which is extensive and highly productive aquifer through the Nile River course. The movement of groundwater is eastward from desert fringes to the Nile River. Spatial distributions of ^{40}K, ^{232}Th and ^{226}Ra as well as the physical properties and the chemical constitutions of ground water using GIS is used to deduce the relation between radiometry and other geological, hydrological and hydrochemical parameters .The results showed that measurements range from 5.98 to 18.65 Bq/l for ^{40}K, from 0.11 to 0.45 for ^{232}Th and from 0.24 to 1.95 for ^{226}Ra. The Spatial distributions of ^{40}K, ^{232}Th and ^{226}Ra show that the activity decrease coincide with the groundwater movements from the desert fringes to the cultivated lands and the Nile course indicating that geology and hydrogeology is significant factors rather than the human activity in the cultivated area. Moreover, The Spatial distributions of ^{40}K, ^{232}Th and ^{226}Ra show a positive relation with hydrochemical properties of groundwater including pH, TDS, EC, anion and cation concentrations.

IMPACT OF SOIL COMPOSITION ON THE NATURAL RADIONUCLIDES LEVEL IN TWO FARMING MANAGEMENT SYSTEMS

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In this study, consideration and estimation of the natural radioactivity distribution in two farming management systems are presented. Organic farming is a method of agricultural production where each phase from production to consumption is controlled in order to certify that the products are free of synthetic pesticides, hormones and chemical fertilizers. Sustainable farming system is a newer system of agricultural production presents an integrated system that introduced to preserve the environment through favoring alternative farming systems (combined and cover crops) and the conservation of biodiversity. Primordial radionuclides present in the rocks and minerals of the earth's crust are naturally occurring source of radiation that has important impact on human health. The knowledge of radionuclide distribution levels in the agroecosystem is important in assessing the effects of radiation exposure due to natural sources.

The natural radioactivity of soil and alternative types of winter wheat in organic and sustainable farming is determined. For this reason, agricultural soil and genotypes of the winter wheat (Durumko - *Triticum durum L.* and Rapsodija - *Triticum aestivum ssp. vulgare*) that belong to varietes for human consumption, were collected at the experimental field "Radmilovac", a property of the Faculty of Agriculture in Belgrade (Republic of Serbia).

The study represents the results of influence of mechanical composition and basic chemical properties (pH, humus and content of C) of agricultural soil on the distribution and mobility of natural radionuclides ^{210}Pb, ^{235}U, ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K in two profiles of leached chernozem soil type. The studied leached chernozem in two farming management systems, showed that the specific activities of radionuclides (Bq kg^{-1}) ^{210}Pb, ^{235}U, ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K are ranged from 50 to 76, 2.5-3.7, 48-67, 39-53, 54-60 and from 558 to 665, respectively. The obtained values are compatible with recommended values of the background gamma radiation for soils all over the world. The study showed that the highest impact on the distribution of natural radionuclides in leached chernozem had clay size mineral fraction and organic matter, which is confirmed by the correlation coefficients. Beside that, the distribution of natural radionuclides in the winter wheat varieties is examined, also. The specific activities of radionuclides (Bq kg^{-1} dry matter) in the roots of plants are ranged from 12 to 29 for ^{226}Ra, 20-31 for ^{232}Th and from 196 to 305 for ^{40}K, while in the rest of plants are ranged from 1.9 to 2.3 for ^{226}Ra and from 259 to 412 for ^{40}K.

GROSS ALPHA AND BETA ACTIVITY AND ANNUAL COMMITTED EFFECTIVE DOSE DUE TO NATURAL RADIONUCLIDES IN SOME IMPOMOEA AQUATICA SAMPLES IN HO CHI MINH CITY

Le Cong Hao

The results of gross alpha and beta radioactivity measurement in ipomoea aquatica (water spinach) samples from some districts in Ho Chi Minh City, Vietnam are presented in this paper. The measurements were performed using a low-background proportional counters LB4200 manufactured by Canberra Company, Inc. Gross alpha radioactivity (with a self-absorption correction) was found to range from 0.07 to 3.28 Bq kg^{-1} and from 0.22 to 3.45 Bq kg^{-1} for dry ashing and wet digestion procedures, respectively. For dry ashing, gross beta radioactivity was found in range from 25.63 to 125.93 Bq kg^{-1} while they are range from 34.43 to 222.40 Bq kg^{-1} for wet digestion. This demonstrates that the results deriving from wet digestion procedure are more reliable for radiation risk assessment. Annual committed effective dose due to natural radionuclides in these samples was found to range from 0.12 to 0.75 mSv/year. Six samples analyzed have dose levels in excess of the World Health Organization (WHO) recommended maximum dose level of 0.3 mSv/year. The estimated soil-to-plant transfer factors for gross alpha for water spinach are lower than that for gross beta.

MEASUREMENT TECHNIQUES OF RADON AND THORON EXHALATION RATE FROM BUILDING MATERIALS AND THE EXHALATION RATES AFFECTING PARAMETERS

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More than half part of the natural background radiation is from the radon isotopes and their daughter elements. The radon gas can escape from solid phase and it can accumulate in the closed places (dwellings, workplaces, etc.). The main sources are in the buildings the soil and building materials. For this reason it is very important to qualify the building materials from radiological aspect.

One of these radiological parameters is the radon and thoron exhalation rate. It means how much part of the generated radon/thoron in the solid material can escape from that. This rate depends on a lot of parameters, for example the radium activity concentration in the material, the humidity, air pressure, etc.

One part of the measurement techniques based on a small accumulation chamber, in which the radon/thoron concentration is measured by active or passive devices. Both of them are some example in the literature. These devices measure the radon/thoron concentration directly.

The other part of the applied methods based on the gamma radiation of daughter elements. These elements are from the decay of the non-escaped radon isotopes.

The measurement is difficult because the radon/thoron exhalation rate depends on a lot of parameters, but for this reason there are some methods which can reduce the exhalation rates and indirectly the radon and thoron concentration in the closed places.

IDENTIFICATION OF SOURCES OF INDOOR THORON BY MEASUREMENTS OF ITS SPATIAL DISTRIBUTION

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Thoron and its decay products in air usually connote much less threatens to the public than radon because of their lower concentrations due to the short half-life of thoron. However, there have been found many places, especially underground workplaces, cellars and even houses, where thoron is also a problem. Due to its short half-life, thoron itself occurs usually in high concentration only in the close vicinity of its entry regions. Therefore, measurements of spatial distribution of thoron activity concentration in the air provides clear indication of thoron entry points. In this work we have used etched track type radon-thoron detectors to map the distribution of thoron spatially with high resolution around regions assumed to be possible sources of thoron. We have found that thoron distributes in highly unevenly in space, and found it possible to identify entry points, cracks and surfaces. Among these we have found that major entry points of thoron in a house are the electric power outlets. This study also demonstrates that careful selection of measurement points of thoron activity concentration is critical in estimating thoron risk in workplaces and houses.

EXPOSURE TO INDOOR RADON IN ARCHAEOLOGICAL UNDERGROUND ENVIRONMENTS

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In archaeological underground environments (for example, catacombs, tourist caves, etc.) visitors and workers - such as technicians, archaeologists and tour guides- inhale radon and thoron gas and their decay products during their occupancy time. Daily and seasonal variations of radon concentration, ambient parameters as humidity and ventilation rate, and a branched tunnel structure characterize the archeological underground sites and, thus, make the evaluation of radon exposure of workers more difficult than the evaluation performed in "conventional" buildings. In this study the radon concentration and microclimatic parameters have been monitored in some Roman catacombs to register time variations of these parameters. The measurement results showed high levels of radon concentration (in the order of thousands of Bq/m^3) with a strong daily and yearly variability. In particular, the daytime and the warmer seasons (summer-autumn) showed the highest levels of radon because of greater pressure-temperature gradient, driving force of radon emanation from the rock (tuff): the experimental results also showed a large inhomogeneity of radon concentration along the touristic route of archeological sites and in the same catacombs different branches has variable levels of radon. These evidences can be a problem in the assessment of the exposure of workers to radon. Moreover, in such particular workplaces, such as archeological underground, is not possible to assess the radon exposure of workers by performing a radon environmental monitoring, neither it is possible to control radon exposure of workers and member of the public by introducing remedial actions. Consequently, a different approach has been adopted: in the present work different approaches are described and compared.

MODELLING AND MAPPING OF RADIONUCLIDE DISTRIBUTION AND MOBILITY ALONG VERTICAL AND HORIZONTAL TRANSPORT ROUTES IN THE VELENCE MOUNTAIN

Gulcan Top

Natural radioactivity is a source of environmental and health risk especially where accumulated radionuclides artificially or naturally distribute to the sensitive receptors such as human settlements, aquifers, food producing agricultural areas or protected habitats. This project fundamentally contributes to our understanding of natural geogenic radioactivity, its spatial distribution, its radionuclide sources and their mobility in the environment.

Specifically, the project contributes to our understanding of natural radioactivity and the dispersion of natural radionuclides in the Velence Mountain. Despite the numerous studies on geogenic radioactivity there is only limited understanding of the extremely complex behaviour of radionuclides and the controlling physical and geochemical properties in terrestrial and aquatic environments. This project offers a unique detailed radiological and geochemical investigation using state-of-the-art field, laboratory and modelling techniques in order to link the geochemical and mineralogical controlling factors to the distribution of environmental radioactivity. This is achieved by detailed radiological measurement and geochemical sampling, laboratory analysis of the chemical, mineralogical composition of samples in vertical section along a regular grid, laboratory mobility tests, laboratory mobility tests and modells using these data for geochemical reaction modelling, soil erosion and sediment transport modelling and for spatial analysis.

COMPARISON OF ACTIVE AND PASSIVE BIOMONITORING METHOD USING MOSS PLEUROZIUM SCHREBERI (BRID.) MITT. AS A BIOINDICATOR OF RADIONUCLIDES POLLUTION OF A HEAVILY INDUSTRIALIZED AREA IN UPPER SILESIA (POLAND)

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The aim of this study was to analyze of contamination of Upper Silesia area by radionuclides with using of two biomonitoring methods: native mosses (passive biomonitoring) and transplanted mosses (active biomonitoring) and finally to determine their usefulness in detecting of contamination by radionuclides. Transplants are often used because of an absence of native mosses. In this research we compared bioaccumulation of radionuclides in moss Pleurozium schreberi transplanted from relatively clean places to contaminated area of Upper Silesia with bioaccumulation of native mosses growing naturally on this area. Both methods have been used but active and passive biomonitoring have not been compared in case of radionuclides. We choosed the terrestrial moss Pleurozium schreberi for this study. This species occurs widely in northern Europe and has been used successfully used in contamination biomonitoring during recent decades and is also available in the areas of research. Study area - Upper Silesia is one of the most polluted urban region of Poland, where are many industries emitting radioactive isotopes are placed. In this investigation, the hypotheses tested are: - bioindication value of native and transplanted P. schreberi is dependent on the level of radionuclide pollution of the investigated area, - atmospheric deposition is the main contribution to the levels of radionuclides in native and transplanted P. schreberi, - radionuclides level in P. schreberi transplanted from an unpolluted control site to an industrial area reflect the level of deposited radionuclides more closely than the same parameters in native P. schreberi. For the measurement of radioactive isotopes we used stationary semiconductor spectrometer gamma made by Canberra, equipped with a germanium coaxial detector with high resolution capacity. The spectrum analysis is performed with the use of the software package Genie-2000 (Gamma Analysis Option model S501C). The preliminary measurements at the study sites was conducted using portable InSpector1000 scintillation spectrometer made by Canberra.

HOW TO PURIFY PHOPSPHOGYPSUM FROM RA-226?

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Phosphogypsum is a waste product of the phosphate fertilizer industry. Because mainly of ^{226}Ra and heavy metals the use of phosphogypsum in construction is impractical, and 85% of PG produced worldwide is dumped in stacks, where it poses environmental and human health hazards.

The known purification approaches have failed to produce a breakthrough in the industry, and have remained confined to the laboratory, largely due to cost considerations.
The method suggested at the Technion is based on mixing hot phosphogypsum suspension containing special chemical reagents to extract the impurities. It was found that the main contaminant of phosphogypsum is radium sulfate, the salt of extremely low solubility (2□10-4). The approach suggested by the joint team from the Technion (Israel) and Vanderbilt University (USA) is based on the transition of insoluble radium salt to a soluble compound, which is successfully filtered out from the suspension (Kovler, K. et al, 2015. System and Methods for Removing Impurities from Phosphogypsum and Manufacturing Gypsum Binders and Products, WO2015153873). The best results achieved demonstrated reduction of ^{226}Ra content by an order of magnitude.

The author, together with his colleagues from the new COST TU1301 Action NORM4BUILDING seeks a cooperation with academic and industrial partners in order to compare the given approach with alternative purification methods for further implementation in a larger scale. An important step would be to estimate an economic efficiency of the process.

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