Organised by National Radiation Protection Institute

under the auspices of the State Office for Nuclear Safety of the Czech Republic

SÚRO

EU-NORM 2

2014

June 17 – 19, 2014
Prague, Czech Republic

BOOK OF ABSTRACTS

www.eunorm-prague2014.cz

FOREWORD

It is a pleasure to introduce this book of abstracts to be presented during the EU NORM-2 Symposium in Prague.

The radioactivity naturally contained in industrial residues along with leaching aspects, water contamination or site remediation issues have raised radiation protection concerns that EU Member States have currently tried to solve but with few or poor regulatory means so far.

Many building materials contain naturally occurring radioactive material (NORM) as well and some of them may present radiation issues whether from natural origin such as granitoides, porphyries, tuff, pozzolana, lava, alum-shale or from those in which NORM residues have been incorporated. This topic along with NORM residue management may become new challenges for European regulatory bodies, industries and even retailers for the marketing of construction products.

Since 1996, the European Commission, along with the IAEA, has drafted several principles, guidance and specific recommendations dealing with NORM. The European Commission decided to harmonize, promote and consolidate these principles and recommendations, introducing them into a new EU directive laying down basic safety standards for the protection against the danger arising from exposure to ionising radiation (EU-BSS). This directive was published in January 2014 and Member States have four years to transpose it into national regulation.

In this context, this Symposium is a great opportunity for EU Member States and for the European Commission to start taking stock of experience feedback and difficulties in this new European regulatory framework. A questionnaire about the implementation of this new EU regulatory framework regarding NORM issues was filled in by participants and will help obtain a good overview of the main issues and challenges that the European Commission will have to be dealing with in the forthcoming years.

The symposium is a substantial opportunity to share interesting facts, results and approaches about building materials, radioecology, NORM sites, risk assessment and site remediation, water treatment, activity measurements and regulatory issues.

We wish you a pleasant stay in Prague and a successful meeting.

Steering committee of the EU-NORM 2 Symposium

COMMITTEES

Steering committee

- Stepháne Calpéna (EC DG ENER D4, Luxemburg)
- Rafael Garcia-Tenorio (University of Seville, Spain)
- Rainer Gellermann (FUGRO, Germany)
- Stéphane Pepin (FANC, Belgium)
- André Poffijn (University Gent, Belgium)
- Hildegarde Vandenhove (SCK-CEN, Belgium)
- Rob Wiegers (IBR, The Netherlands)

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SYMPOSIUM VENUE

Hotel DAP
Vítězné náměstí 4/684
160 00 Praha 6
Czech Republic

Metro station “Dejvická”, line A

SCIENTIFIC TOPICS

- New BSS
- Water works (including geothermal energy supply)
- Building materials
- Site remediation
- NORM radio ecology
- NORM waste and treatments
- NORM – alternative energy

Remark: radon is not a topic of the symposium, except when related directly to NORM

OFFICIAL SYMPOSIUM LANGUAGE

The official language is English, no simultaneous translation will be provided.

EXHIBITOR

Canberra Packard
CENTRAL EUROPE GMBH

ORAL PRESENTATIONS

PowerPoint presentations should be delivered at the latest during the session before your presentation in the Symposium room. Duration of oral presentation is 20 min (15 min + 5 min discussion).

POSTERS

Posters may be mounted starting Tuesday, June 17, 2014 from 8.00 a.m. and should be removed on Thursday, June 19, 2014 after 4.15 p.m. Posters can be available for all 3 days of the Symposium.
Topical poster session is scheduled at the end of each day of the Symposium offering time for short presentation 2 – 3 minutes for the presenters of the day to introduce his-her work and invite Symposium participants to the poster. The presenting authors are kindly requested to be available at their posters for questions and discussion.

REGISTRATION DESK

The registration desk will be located at the Symposium venue. Participants can pick up their personal Symposium material at the registration desk, during the opening hours:

- Monday, June 16, 2014 14.00 – 18.30
- Tuesday, June 17, 2014 8.00 – 18.00
- Wednesday, June 18, 2014 8.00 – 17.00
- Thursday, June, 2014 8.00 – 18.00

REGISTRATION FEES AND DEADLINES

	Early fee before February 28, 2014	**Late fee** from March 1, 2014
Regular fee	390 EUR	430 EUR
1 day ticket (MetroNORM, NORM4BUILDING)	100 EUR	100 EUR
Accompanying person	60 EUR	60 EUR
Site visit	60 EUR	60 EUR

Registration fee includes:

- Admission to the scientific programme
- Symposium materials
- Badge
- 5 Coffee breaks
- 3 Lunches
- Welcome drink on June 16, 2014 at Hotel DAP
- Symposium Dinner on June 18, 2014
- Wi-fi access
- Book of abstracts

Accompanying person fee includes:

- Badge
- Welcome drink on June 16, 2014
- Symposium Dinner on June 18, 2014
- Wi-fi access

Additional charges

- Site visit – June 20, 2014 60 EUR per person

SOCIAL PROGRAMME

Welcome Party

Monday, June 16, 2014, 19:00 – 21:00
Hotel DAP / Sympoiusm venue
Address: Vítězné náměstí 4/684, 160 00 Praha 6

(included in the registration fee for regular participants and accompanying persons)

Symposium Dinner

Wednesday, June 18, 2014, 19:30 – 22:00
Letenský chateau / Letenský zámeček
Address: Letenské sady 341, 170 00 Praha 7

(included in the registration fee for regular participants and accompanying persons)

Connection from the Symposium venue – Hotel DAP: by tram No. 8 or 26 from the tram-stop „Vítězné náměstí“ to „Letenské náměstí“
approx. 10 minutes

Site Visit

Friday, June 20, 2014
Stráž pod Ralskem – former uranium industry region

Departure from Hotel DAP, Prague at 7.30 a.m.
Estimated arrival back in Prague, hotel DAP at 8.00 p.m.

PROGRAMME

Monday 16. 6. 2014	
16:00	Registration
19:00	Welcome party

Tuesday 17. 6. 2014		
9:00	**Opening**	**Chairs: Stephane Pepin, Rafael García-Tenorio**
9:20	Stéphane Calpéna	European Regulatory Approach For NORM
9:50	Haridasan Pappinisseri Puthanveedu	Radiation protection issues in industries involving naturally occurring radioactive material – main findings of the NORM VII Symposium
10:10	Ivana Ženatá	NORM Workplaces – The Current Situation in the Czech Republic
10:30	Coffee break	
	Section	**Building materials**
11:00	Bernd Hoffmann	A simple dose assessment tool for construction products
11:20	Cristina Nuccetelli	Radiological characterization of an ancient Roman tuff-pozzolana cave in Orvieto (Italy)
11:40	Kees Oranje	Reuse of NORM-materials
12:00	Tibor Kovács	Utilization of Manganese clay industrial by-product in building material industry
12:20	Wouter Schroyers	The new European COST network 'NORM4Building'
12:40	Discussion	
13:00	Lunch break	
	Section	**Radioecology** **Chairs: Stephane Calpena, Andre Poffijn**
14:00	Hildegarde Vandenhove	Mobility and bioavailability parameter values for impact assessment for NORM sites: can they be predicted?
14:30	Barbara Mazzilli	Lixiviation of natural radionuclides in columns of tropical soil amended with phosphogypsum
14:50	Cristina Tanzi	NORM bulk and external radiation: a proof of the sum rule for point sources at site boundaries
15:10	Kallio Antti	Behaviour of radionuclides in sulphide-ore tailings in Rautuvaara, Finland
15:30	Wu Qifan	A case study of radiological impacts arising from coal mining and combustion
15:50	Discussion	
16:00	Coffee break	
16:30	Poster session	
17:00	Workshop I (Problem gathering)	
18:00	Close	

Wednesday 18. 6. 2014		
	Section	**NORM sites** **Chairs: Cristina Nuccetelli, Rainer Gellerman**
9:00	Horst Monken-Fernandes	The ENVIRONET and its support to Environmental Remediation Projects in the IAEA Member States
9:30	Matthew Kozak	Radiological Safety Assessment of the Zapadnoe Uranium Tailings Facility, Dnieprodzerzhinsk, Ukraine
9:50	Rafael García-Tenorio	Preliminary Steps in the Restoration of a Phosphogypsum Disposal Site: Radioactive Characterization of Leachates and Efflorescences Affecting the Surrounding Areas
10:10	Stéphane Pepin	Good and bad practices of decommissioning in the phosphate industry
10:30	Almudena Hierro Gutierrez	Radiological risk assessment to workers of a dicalcium phosphate industry
10:50	Discussion	
11:00	Coffee break	
11:30	Boguslaw Michalik	System of monitoring and control of the hazard caused by NORM in Polish coal mines
11:50	Wonchul Choi	Aerosols Containing Natural Radionuclides in Coal-Fired Power Plant
12:10	Jim Hondros	Practical Impacts of NORM Standards on Mining and Minerals Processing
12:30	André Poffijn	Norm aspects of shale gas extraction
12:50	Discussion	
13:00	Lunch break	
	Section	**NORM sites** **Chairs: Hildegarde Vandenhove, Horst Monken-Fernandes**
14:00	Talal Al Mahayni	Impact assessment of a generic disposal design for the legacy radium production site in Olen, Belgium
14:20	Katerina Navratilova Rovenska	Radiological analysis of natural gas pipeline pigging products – Preliminary results
14:40	Vanusa Maria Feliciano Jacomino	Remediation of NORM/TENORM Contaminated Sites in Brazil
15:00	Taavi Vaasma	Natural Radionuclides in the Combustion products of Oil Shale-Fired Power Plants in Estonia
15:20	Discussion	
15:30	Coffee break	

16:00	Gert Jonkers	Oily Sludge (Mixed Waste) from Cradle to Grave – a Usable Solution
16:20	Gert Jonkers	Slag Wool from Cradle to Grave – arriving at a practical solution
16:40	Boguslaw Michalik	Effects of remediation in mining industry: investigations in abandoned and reclaimed settling pond
17:00	Discussion	
17:10	Poster session	
18:00	Close	
19:30	Symposium dinner	

Thursday 19. 6. 2014		
	Section	**Water treatment** **Chairs: Rob Wiegers, Ivana Ženatá**
9:00	Martin Neznal	Water treatment plants and NORM - Czech experience
9:20	Jörg Dilling	Naturally occurring radionuclides in the geothermal facility in the North German Bassin
9:40	Antonio Nieto	Elimination and concentration of natural radionuclides in drinking water treatment plants
10:00	Sebastian Feige	Radiation monitoring– an element to promote effective and safe operation of geothermal power plants
10:30	Coffee break	
	Section	**Measurement of NORM**
11:00	Leo van Velzen	Intercomparison of the applicability of equipment and analyze methods for the assessment of NORM in daily routine
11:20	Gerti Xhixha	Performances of a lightweight collimated γ-ray spectrometer for in-situ surveys
11:40	Saroa Rozas	An analytical method to determine activity concentrations of uranium- and thorium-series in the inhaled air during arc welding
12:00	Discussion	
12:15	Poster session	
13:00	Lunch break	
14:00	Workshop II – Discussion on topics	
16:00	Invitation to EU-NORM3 and NORM 8	
16:15	Closure	

16:30	**MetroNORM workshop** **„Metrology for processing materials with high natural radioactivity“**
	Oral presentations ● EMRP JRP MetroNORM and impact on the EU Member States's implementation of the Council Directive 2013/59/Euratom of 5 December 2013 basic safety standards for radiation protection, Franz Josef Maringer ● Improvements of Decay Data in NORM materials, Marie-Martine. Bé et al. ● Development of in-situ systems and sampling methods for NORM, Simon Jerome et al. ● A method for determination of the total activity of inhomogeneously distributed radioactive waste in drums, Branko Vodenik ● Development of improved measurement methods and standardised procedures for NORM industries: Status of work and preliminary results, Andreas Baumgartner, Michael Stietka
	Poster presentations ● NORM in European Specific Industrial Branches, M. Mazanova, V. Zdychova, P. Kovar ● NORM in Portugal. The establishment of an E&T platform as a key element for the implementation of the best practices for NORM industries, M. Reis, I. Paiva, L. Portugal, C. Cruz and C. Oliveira ● NORM analyses by laboratories and industries: Some basic statistics on materials and methods, M. Stals, M. Hult, V. Pellens et al.
	Discussion Current and emerging needs of NORM industry and end – users in NORM measurement methods, instrumentation and reference materials
19:00	Closure of the workshop

Friday 20. 6. 2014	
	Site visit

BOOK OF ABSTRACTS

Texts of abstracts have not undergone neither linguistic nor editorial correction.

EUROPEAN REGULATORY APPROACH FOR NORM

S. Calpéna

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Since 1996, the European Commission, along with the IAEA, has drafted several principles, guidance and specific recommendations dealing with naturally occurring radioactive material (NORM). The European Commission decided to harmonize, promote and consolidate these principles and recommendations, introducing them into the new EU directive laying down basic safety standards for the protection against the danger arising from exposure to ionising radiation (EU-BSS). This directive was published in January 2014 and from now on, Member States have four years to transpose it into national regulation. It should be added that this draft EU-BSS was made consistent with the existing EU regulation laying down harmonised conditions for the marketing of construction products (CPR n°305/2011). Both documents regulate building materials and NORM industries with their residues. These EU requirements should shortly be accompanied by guidance and EU harmonized standards to consolidate such a new regulatory framework. The European Commission mandated the European Committee for standardizations (CEN) to do so.
Regarding regulatory aspects, a conservative screening tool, providing a maximum gamma dose estimate for a given material, was established. This screening tool considers the activity concentrations of Radium-226, Thorium-228 and Potassium-40 and specific coefficients derived from a given model room (similar to a bunker of 4 m x 5 m x 2.8 m) with walls, ceiling and floor of 20 cm thick and with a density similar to concrete's (2350 kg m^{-3}):

$$\text{Index} = C^{226}\text{Ra}/300 + C^{232}\text{Th}/200 + C^{40}\text{K}/3000$$

C in Bq/kg (and the Index in mSv for a theoretical bunker as described above)

These three radionuclides and their progenies were considered to be the most common radioactive elements regarding natural radiation doses to the public in dwellings or buildings. It is now considered that building materials with an index less than 1 can be placed on the EU market without restrictions. If the index were to exceed 1, for a given building material, restrictions or specific conditions might be applied depending on the density, thickness and uses of the material. A national regulatory process and proper EU standards will be established to get harmonized technical specifications, coherent restriction policies and common product labelling in Europe prior placing building materials, containing NORM, on the EU market. The regulatory approach and its related EU standards are ongoing within mandated organizations in charge of the establishment of these EU technical standards. Two categories of materials (A and B) will be established depending on their gamma emission in an standardized dose model taking into account of density (ρ) and thickness (th). Such categories will be established along with a CE marking and a "declaration of performance" (instructions) about the material prior placing the construction product onto the EU market. The following dose modelling equation might be considered in the future to categorize building materials with a maximum reference level of 1mSv over a period of 7000 hours (less than 1 mSv → category A and more than 1 mSv → category B):

$$\text{Dose} = [C^{226}\text{Ra}.[2.81+1.63(\rho\text{th})-0.0161(\rho\text{th})^2] + C^{232}\text{Th}.[(3.19+1.85(\rho\text{th})-0.0178(\rho\text{th})^2] + \\ + C^{40}\text{K}.[0.223+0.128(\rho\text{th})-0.00114(\rho\text{th})^2]].10^{-4} - 0.245 \text{ mSv/y}$$

RADIATION PROTECTION ISSUES IN INDUSTRIES INVOLVING NATURALLY OCCURRING RADIOACTIVE MATERIAL – MAIN FINDINGS OF THE NORM VII SYMPOSIUM

P. P. Haridasan

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Keywords: NORM, industry, mining, raw materials

Exposures to NORM (Naturally Occurring Radioactive Material) have been a subject of concern among regulators, operators, workers and public at large. The NORM VII symposium was held in Beijing last year with wider participation from all geographical regions. The main findings of the symposium include the following.

Much progress had been made in addressing exposure to natural sources in national laws and regulations, but a consistent regulatory approach had still not been fully achieved. Inconsistencies in applying the requirements of the International Basic Safety Standards (the BSS) to natural sources were particularly prevalent with respect to the application of the graded approach, including the application of the concept of exemption. There were still some countries for which the regulatory framework did not provide a mechanism for exemption. However, there was now widespread acceptance in principle that regulatory control was unwarranted for materials with radionuclide activity concentrations below 1 Bq/g and for practices giving rise to doses less than 1 mSv/a.

It was further confirmed that an industry-specific approach to the regulation of NORM was the correct approach. The industry-specific information provided in the suite of five IAEA Safety Reports was proving to be useful to national authorities. A large amount of new information on exposures in NORM industries had become available and verified previous findings that the majority of workers received doses less than 1 mSv/a and that doses received by members of the public were very low or insignificant. However, the new information highlighted the potential for high radon levels in underground mines if they were not adequately ventilated.

There was still a lack of harmonization of national approaches to the management of NORM residues. However, acceptance of the need to minimize NORM waste by recycling NORM residues or using them as by-products (with dilution if necessary) continued to grow. Some national authorities were now actively promoting this approach instead of discouraging or prohibiting it as in the past. Although the use of NORM residues as components of building materials was a sensitive issue, national authorities were, actively pursuing this approach because of a growing recognition of the need to conserve raw materials and to reduce the amounts of NORM residues requiring disposal as waste.

More pragmatic approach in setting reference level for site remediation, considering societal and cost factors are needed. The importance of the involvement of all concerned parties is being recognized to an increasing extent in industrial activities involving NORM, as presented at the symposium.

NORM WORKPLACES – THE CURRENT SITUATION IN THE CZECH REPUBLIC

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Keywords: legislation, NORM, the Czech Republic

The State Office for Nuclear Safety ensures the state supervision of NORM workplaces since 2002. Act. No. 18/1997 Coll. (Atomic Act), as amended, and Regulation No. 307/2002 Coll., on Radiation Protection, as amended, form the currently applicable legislation for this purpose. Information about level of radiation protection at NORM workplaces is mainly obtained for control activities of the State Office for Nuclear Safety.
Disposal of filters from the underground water treatment, coal combustion products treatment including production of building materials from these products, titanium dioxide production, as well as uranium admixtures in glass and production of zirconium products for foundry industry, are the most common examples of NORM workplaces that occur in the Czech Republic.
Workers' exposure calculation is secured only by the holders of the State Office for Nuclear Safety license. The calculation methodology is standardized and developed under the SONS guidance and free to access on-line. NORM by-products, whose activity is higher than the clearance level, are most often present especially in water treatment plants. The license, according to the atomic law, is needed in these cases.
The State Office for Nuclear Safety is nowadays in the course of preparing a project of NORM wastes disposal and simultaneously started working on the implementation of the 2013/59/EUROATOM Directive.

A SIMPLE DOSE ASSESSMENT TOOL FOR CONSTRUCTION PRODUCTS

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Keywords: Building Products, Dose, EU-BSS, CPR

The “EU Council Directive laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation” (EU-BSS) includes regulations for indoor external exposure caused by building materials. The core of the regulations is the definition of a reference value of 1 mSv/a (in addition to the natural background). It is now up to the member states to find assessment tools to allow the relevant authorities as well as the producers to verify the compliance with the dose criterion for products missing the activity concentration index criterion used as a screening tool.
As part of the mandate under the Construction Product Regulation (CPR) to adopt standardized assessment methods with which information may be given in the CE marking on the release of dangerous substances, CEN TC351 “Construction products: Assessment of release of dangerous substances” WG3 “Radiation from construction products” will publish a technical report regarding i.a. possible ways for calculating the dose resulting from building products with known concentrations of natural radionuclides.
With boundary conditions defined by the WG3, a simple dose assessment tool can be proposed. To avoid the conservatism of the activity concentration index and – as recommended by the EU-BSS – to include the density and thickness of the material, the areal density (mass per unit area) can be used as a control parameter. For the intended purpose, it can be shown that a sum of quadratic polynomials in areal density, each multiplied with the activity concentrations of the relevant nuclides, is sufficiently exact.

The author wants to thank all members of the CEN TC351 WG3 for the productive discussions.

RADIOLOGICAL CHARACTERIZATION OF AN ANCIENT ROMAN TUFF-POZZOLANA CAVE IN ORVIETO (ITALY)

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Keywords: natural radioactivity, gamma dose rate, in situ measurements, radon decay products

A full characterization of a particular environment, an ancient Roman cave of tuff-pozzolana, was carried out in order to intercompare different measurement and dose assessment methods. Tuff and pozzolana are very rich in natural radioactivity and are interesting from the radiation protection point of view since they are still used as building materials [1]. The *in situ* experimental protocol consisted in measurements by:

- two different devices for *in situ* gamma spectroscopy
- gamma dose rate meter (scintillation detector)
- ionization chamber radon monitor
- two channel working level monitor

Moreover, samples of tuff and pozzolana stones were collected to be measured with gamma spectrometry in laboratory.
The part of the cave we characterized is a tunnel of about 10 meters length, 4 meters width and 3 meters height. The floor and the first 50 cm of the walls were of tuff, whereas the rest of walls and ceiling were in pozzolana. Due to the high content of U-238, Th-232, and K-40 of tuff and pozzolana (see Tab.1), elevated levels of exposure to natural radioactivity were found: indeed, with different instruments and approach, a gamma dose rate of about 1 mGy h^{-1} and an average radon concentration of about 10000 Bq m^{-3}, with a PAEC of 288 Mev cm^{-3}, were detected.

Table 1 Natural radionuclides activity concentration in tuff and pozzolana samples

	U-238 (Bq kg^{-1})	Th-232 (Bq kg^{-1})	K-40 (Bq kg^{-1})
Tuff	210	370	2040
Pozzolana	460	530	2490

The results of *in situ* and laboratory measurements were compared and validated. Furthermore, experimental results were used as input of modelling tools for the gamma dose rate evaluation [2].

[1] Trevisi R., Risica S., D'Alessandro M., Paradiso D., Nuccetelli C. (2012). Natural radioactivity in building materials in the European Union: a database and an estimate of radiological significance. *Journal of Environmental Radioactivity* 105, 11-20.
[2] Nuccetelli C., Risica S., D'Alessandro M., Trevisi R. (2012). Natural radioactivity in building material in the European Union: robustness of the activity concentration index I and comparison with a room model. *Journal of Radiological Protection* 32, 349–358

REUSE OF NORM-MATERIALS

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In the Netherlands, due to the decreasing quality of waste that is processed on landfills, there is a lack of stable material which is needed for the landfill exploitation (building paths, slopes, etc.). Where these essential aspects can't be realised by using existing waste materials, we decided to make them ourselves in order to avoid using primary materials. With an immobilisation plant on site we are able to create our own building materials from waste, like residues of soilwashing.
The landfill is also permitted for the dispose of lower radioactive NORM-materials, so the location is accustomed to handling NORM. From different points of view, responsibly using NORM-materials on this particular landfill is an option.
The immobilisation process is quite a basic and proven technology. The innovation is using NORM-material as a stabilizer, for which normally the primary material lime is used. Just one parameter in the existing process is different, which makes it easy to apply. The fact that the primary process is well known, allows keeping focus on the secondary and most important process: handling the NORM-material with care.
In the presentation we will address both the general approach (technology, permits and practical issues) as well as a case study on a recent full scale application: Where a 40 ft. container filled with NORM zircon sand was a big problem for the trader in de Harbour of Rotterdam, by using our new technology/application combination succeeded in offering an appropriate solution using proven technologies.
Where the trader focused on the radiation problem, the key to a solution lay in keeping focus on the fact that still the zircon sand was a usable material. It can easily be applied in a useful way as a stabilization material in our process of immobilisation.
After several projects, this activity is scaled up from pilot phase to a new business line of Van Gansewinkel Maasvlakte. In the meanwhile this technology has proven itself for NORM slag wool, NORM sludges from the gas exploring en production industry (off shore) and NORM residues of vacuum distillation.

UTILIZATION OF MANGANESE CLAY INDUSTRIAL BY-PRODUCT IN BUILDING MATERIAL INDUSTRY

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Keywords: NORM, manganese clay, I-index, heat-treatment

The depletion of the raw materials requires the development of new synthetic building materials. The most commonly used building materials in Hungary and in numerous country of the world are the bricks made from clays. However, due to the congenial internal structure features the clays can be mixed with other materials provides great possibility to use industrial by-products as additive material, the production and inbuilt of new types of synthetic building materials based on by-products is raising concerns among authorities, public and scientists.
The manganese clay is originated as a result of manganese mining and processing ~20 Mt of manganese clay have deposited, which can be used as add material in building material factories.
In recent study a comprehensive radiological survey is published deals, with radiological features of manganese clay and clay mixed Mn-clay samples.
The natural radionuclide (K-40; U-238; Th-232) content was determined with gamma spectrometry to classify the material on the basis of I-index. It was found, that the K-40 content 607 ± 34 Bq/kg, The Ra-226 was 52.3 ± 6.2 Bq/kg and the Th-232 was 40.3 ± 5.3 Bq/kg. The calculated I-index was 0.58, which clearly proves that the decorative bricks prepared from Manganese clay is suitable for bulk amount and superficially inbuilt building material production according to its BSS recommended I-index.
The radon emanation and exhalation features were determined in case of the starting material and the end product as well. It was found that in the function of the heat treatment the radon emanation and exhalation power reduced under 5 % of the initial, which clearly proves, that the heat treatment has a favorable side-effect on Manganese clay in radon exhalation point of view.

This work was supported by 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

THE NEW EUROPEAN COST NETWORK 'NORM4BUILDING'

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Keywords: NORM, new building materials, European network, reuse

There is an increasing environmental need to develop new, more sustainable production technologies to utilize residues to substitute for raw materials in different industrial areas. Special emphasis here falls upon the construction sector, which produces almost ten percent of global CO_2 emissions. A specific class of residues, for which the use in construction products can introduce more sustainability, originate from NORM (naturally occurring radioactive materials) processing industries. NORM residues, such as fly ash produced in large quantities from coal burning, slags from steelworks and metal recycling industries, phosphogypsum of the phosphate industry and red mud of the aluminium processing industry, were already studied for application in construction products. Current innovations in the construction industry, such as the emerging field of Alkali-Activated Materials (Geopolymers), can open up promising new reuse pathways for NORM residues.
The main objective of the new COST Action 'NORM4BUILDING' (Tu1301) is the exchange of multidisciplinary knowledge and experiences to stimulate the reuse of NORM residues in new tailor-made sustainable building materials while considering the impact on both external gamma exposure of building occupants and indoor air quality. By improving radiological impact assessment models for the reuse of NORM residues in building materials the new COST Action aims to further stimulate justified uses of NORM residues in different types of newly developed building materials.
In the presentation, the approach, structure (4 working groups + management committee) and new initiatives of the NORM4BUILDING network are presented. The COST action (01/01/2014 to 18/09/2017) involves 76 researchers from 21 different countries. For support of the working groups an 'advisory board' consisting mainly out of NORM processing and construction industries and regulators, is created.

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OPTIMIZATION OF THE PROCESS OF PRODUCTION OF GLASS-CERAMICS FROM COAL FLY ASH

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Keywords: optimization, consolidation, process parameters, fly ash, glass-ceramics

In the frames of this work, the 3D surface model was successfully applied to investigate the influence of the process parameters on the mechanical properties of the fly ash glass-ceramics. Glass-ceramics was produced from coal fly ash and waste glass. Fly ash is industrial by-product containing Technologically Enhanced Natural Occurring Radioactive Materials (TENORM) with the great potential for valorization where the concentrations of the natural radionuclides were: ^{266}Ra:59 ± 6 Bq/kg; ^{232}Th:76 ± 8 Bq/kg; ^{40}K:376 ± 29 Bq/kg. The raw material was taken from thermal power plant REK Bitola, Republic of Macedonia. Glass-ceramics was obtained through the process of consolidation. Compacts with different ratio of fly ash and waste glass were pressed at 45 MPa, sintered in the temperature interval from 950 to 1100 ^{0}C, and isothermal time at the final temperature from 1 h to 5 h. The process of optimization was conducted of the process parameters such, quantity of glass, sintering temperature and isothermal time. Also their interactions on the mechanical properties of obtained glass-ceramic were reported. According to the results of the process of optimization presented by the software package, a final model equation of the bending strength dependence is:

Bending strength = – 80.709 + 0.07755 *Temperature + 0.65075 *Glass-36.625 *Izothermal period + 0.03795 *Temperature*Izothermal period

Software package used for the process of optimization was “Statgraphics Centurion”.

THE INFLUENCE OF PRE-TREATMENT OF FLY ASH ON THE PROPERTIES OF FABRICATED CERAMICS

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Keywords: fly ash, mechanical activation, ceramics

Fly ash from REK Bitola, Republic of Macedonia was used in this investigation. This kind of fly ash can be classified as C class according to the CaO content. The phase compositions of the fly ash consisted of: quarts, albite, hematite, anorthite, anhydrite and an amorphous phase. Diatomite was evident from the morphology of the fly ash. The concentrations of the natural radionuclides in fly ash were: ^{266}Ra:59 ± 6 Bq/kg; ^{232}Th:76 ± 8 Bq/kg; ^{40}K:376 ± 29 Bq/kg. It was pre-treated by thermal treatment (600 ^{0}C/2h) and mechanically activated by vibro mill for short period of time 10, 20 and 30 min prior to consolidation. Ceramics compacts were formed by pressing (P = 30 MPa) and sintering in the temperature region from 1050 to 1200 ^{0}C. The shrinkage/temperature dependence was followed by dilatometer. The leaching tests were made in water, 0,1 mol/dm^3 HCl and Na_2CO_3 in duration of 1 day and 7 days. Ceramics fabricated from thermally treated and mechanically activated fly ash, sintered at 1130 ^{0}C showed the optimal mechanical properties i.e. E-modulus and bending strength of 41,17 GPa and 74, 30 MPa, respectively.

MOBILITY AND BIOAVAILABILITY PARAMETER VALUES FOR IMPACT ASSESSMENT FOR NORM SITES: CAN THEY BE PREDICTED?

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The solid-liquid distribution coefficient and the soil-to-plant transfer factor are two important parameters in the assessment of the dose to man through contamination of the food chain. The solid-liquid distribution coefficient (K_d, L kg^{-1}) determines the mobility of an element (acccumulation in versus leaching from soil) and the soil-to-plant transfer factor (TF) indicates to facility of uptake by crops. Both parameters depend on soil characteristics. There is a large variability in Kd and TF values (more than 4 orders of magnitude) with implications for impact assessment. Considering minimum or maximum Kd values for U in an irrigation scenario leads to a 2000 fold difference in equilibrium soil contamination levels. Considering low or high soil to crop TF values for the NOR U-238, Ra-226, Pb-210, Po-210 and Th-232 in a subsistence farming scenario, dose rates calculated differed 800-fold. Hence reducing the variability and uncertainty in these parameter values within a given assessment context will result in more realistic and robust impact assessments.

A possible way to reduce the variability in impact assessment predictions is the development of parameterized Kd and TF values: e.g. by quantifying the influence of soil parameters on radionuclide mobility and bioavailability. This is generally done through laboratory based studies. We found, for example, for uranium and soils for which pH < 6, significant correlation between the K_d and the organic matter content ($R^2 = 0.70$) and amorphous Fe content ($R^2 = 0.63$). Above pH $= 6$, $\log(K_d)$ was linearly related with pH [$\log(K_d) = -1.18\ pH + 10.8$]. Uranium soil-to-plant transfer factors (TF) ranged from 0.0003 to 0.0340 kg kg^{-1}. Improved correlations were obtained when relating the uranium TF with the summed soil solution concentrations of 3 uranium species, UO_2^{2+}, uranyl carbonate complexes and $UO_2PO_4^-$, featuring the importance of U speciation, linked with soil characteristics through geochemical modelling, on availability. The K_d for Ra-226 was linearly related to cation exchange capacity (CEC) and organic matter (OM) content. TF was significantly related to K_d, CEC, OM and the calcium concentration in the soil solution.

How strong the relation between Kd (TF) and soil characteristics may be in securely designed laboratory experiments, no such strong correlations were found when considering data compilations such as the one developed by IAEA. Kd predictions based on single or multiple parameters failed. Categorizing Kd in function of texture as is commonly done, is generally not statistically justified. For U, Th and Pb, Kd categorization or estimation is best done on the basis of pH. Also for TFs to specific crops no link with soil parameters could be derived. An important reason for this absence of relationship is the lack of systematic recording of an important array of soil characteristics. More information on factors influencing sorption and bioavailability such as pH, CEC, clay content, OM content and concentration of counter ions should be collated. Research is needed to increase the understanding in the mechanisms governing radionuclide-soil-plant interaction. Until we have acquired this increased understanding and improved database for developing parameterized models, the proposed best estimates (as e.g. derived by IAEA) are suitable for screening assessments, but site specific impact assessment will remain to rely on site specific investigations of Kd and TF instead of on site specific predictions of Kd and TF.

LIXIVIATION OF NATURAL RADIONUCLIDES IN COLUMNS OF TROPICAL SOIL AMENDED WITH PHOSPHOGYPSUM

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Keywords: phosphogypsum, natural radionuclides availability, soil amendment

The main phosphate industries in Brazil are responsible for the annual production of 5.5 x 10^6 metric tons of a TENORM residue, phosphogypsum (PG), which is stored in stacks. The presence of radionuclides puts restrictions on the use of PG in building materials and in soil amendments. The Brazilian regulatory body (CNEN) ruled that PG would only be permitted for use in agriculture or in the cement industry if the concentration of Ra-226 and Ra-228 does not exceed 1 Bq g^{-1}. In Brazil, PG has been widely used as soil amendment, to improve the soil fertility. To assure a safe utilization in agriculture, it is important to estimate the lixiviation of the radionuclides in PG. For this purpose, an experiment was carried out, in which columns filled with sandy and clayish Brazilian typical soils and PG were percolated with water, to achieve a mild extraction of these elements. The results obtained for the activity concentrations of U-238, Th-232, Ra-226, Ra-228, Pb-210 and Po-210 in the claysh soil are approximately four times higher than the sandy soil. The results obtained for the radionuclides concentration in the PG varied from 144 ± 11 to 294 ± 5 Bq kg^{-1} for Ra-226, from 149 ± 4 to 352 ± 23 Bq kg^{-1} for Pb-210, from 155 ± 11 to 346 ± 7 Bq kg^{-1} for Po-210, from 86 ± 8 to 210 ± 6 Bq kg^{-1} for Th-232 and from 116 ± 1 to 228 ± 6 Bq kg^{-1} for Ra-228. The addition of PG to the soils studied did not represent any increase in the final activity concentrations, which were of the same order of magnitude of the values reported by UNSCEAR for the world soil average values. The maximum Ra-226 and Ra-228 activity concentration observed in the PG samples, 294 ± 5 Bq kg^{-1} and 228 ± 6 Bq kg^{-1}, are below the limits adopted by CNEN, therefore its use is allowed for agricultural purposes. The results obtained for the activity concentration of all the radionuclides in the leachate were close to the detection limits of the methodologies adopted, giving evidence that, although the radionuclides are present in the PG, they are not available for the intake by plants.

NORM BULK AND EXTERNAL RADIATION: A PROOF OF THE SUM RULE FOR POINT SOURCES AT SITE BOUNDARIES

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To guarantee that the limit of exposure from external sources does not exceed the EURATOM Bss level of 1 mSv/y, Dutch regulations determine 100 microSv/y at the site boundary as the absolute maximum level that can be granted in a permit. This is based on the assumption of 10 different sources as the maximum to which a member of the public can be exposed at any one time. In the South West of the Netherlands there is an industrial area which has been selected not only to host a number of nuclear installations, but is also home to industries dealing with NORM and where NDO activities (including storage of sources) are carried out.
This high geographical concentration of sources has led to some doubts being raised, that there might be locations where the distribution of sources within site boundaries is such that the cumulative exposure might exceed the simple sum of the point source fields. If this would be the case, this would invalidate the assumption made by the regulatory authority, thereby potentially exposing members of the public (outside the site boundaries) to more than 1 mSv/y, in the case that the maximum permissible level have been granted.
Our objective is to show that the simple assumption of the summation of different sources can be proven mathematically. So we offer here a rigorous proof that, on surface plane, for a point source (or for any field which decays with the inverse of distance or faster), the combination of sources is indeed not more than additive. Should the sources be located at different heights over the surface plane, (as might be the case for a spent fuel pool), we show that the proof holds again for point sources, for fields which decay with the inverse distance squared or faster.
The proof, an application of analytical function theory, will be illustrated with a practical problem of a complex cumulation of radiation sources.
We offer the formal proof that the assumption, which is used in Dutch regulations, of a simple addition of fields from a point source, is correct. There can be no peculiar spatial arrangement of point sources of radiation which leads to a cumulation, which might be higher than the simple sum of the given radiation fields.

BEHAVIOUR OF RADIONUCLIDES IN SULPHIDE-ORE TAILINGS IN RAUTUVAARA, FINLAND

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Rautuvaara mine tailings-area in Kolari, North Finland was used actively 1975 – 1996, since then it has been unused and partly uncovered. Parts of the tailings are constantly under water, but large areas are also exposed to the atmosphere. Rautuvaara tailings contain deposits from the processing of several different sulphide-ores (Au, Cu), piled on top of older tailings from the regional iron ores. One of the processed Au-ores had significant amounts of uranium, which has resulted in a specific layer of tailings which now contains ca. 5 Bq/g dw. of each uranium-series nuclide, still in secular equilibrium. There is evidence of oxidation in the northern part of the tailings, resulting in local acidification and mobilization of heavy metals. Rautuvaara surface waters drain via the Niesa-river into the Muonio- and Tornio-rivers, which are the most important breeding rivers for the Baltic Sea salmon. Hence the behavior of NORM in the tailings is of special importance. The local reindeer also intermittently occupy the dry parts of the tailings. So far significant releases of radionuclides to the environment outside the tailings area have not been observed.
We have analyzed surface water, seepage water, groundwater and tailings samples from Rautuvaara for radionuclides and heavy metals (gamma-spectrometry, radiochemistry, ICPMS). There is evidence of at least uranium mobilization in the low-pH seepage waters inside the tailings-area. We will examine in more detail the mobility and solubility of uranium and daughter nuclides (radium, radon, lead, polonium) in different parts of the tailings, as variable geochemical conditions are present naturally in different parts of the same deposit. This variability in conditions makes Rautuvaara tailings a good target for a detailed study on the behaviour of uranium-series isotopes in old sulphide-ore tailings in arctic conditions.

A CASE STUDY OF RADIOLOGICAL IMPACTS ARISING FROM COAL MINING AND COMBUSTION

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Most of coal in China is used to generate electricity power in coal-fired power plant. While some contains higher uranium and other metal element, and used as mineral materials for metal element extraction. In the research area, coal contains higher uranium when it contains higher rare metal elements. For example, the uranium concentration in the coal with higher rare metal elements contains 1346 to4960 Bq/kg.

Coal burning in the furnace generates bottom ash, fly ash and gases. Fly ash and gases are transported by draft fan to dust-collecting house, where dust was removed from bag filter as products of rare metal concentrates. Radioactivities in the bottom ash and fly ash enhance in some extend. Table I shows the activity concentrations of uranium and radium increase in bottom ash, about 1.3 times as many as that in coal; the enrichment in fly ash is about 4 times. Lead and polonium are volatile elements, depleted in bottom ash, while they are highly enriched in fly ash, about 21 times and 36 times respectively.

The activity concentrations of radionuclides from aerosol monitoring in the plant were 10 times higher than the background nearby the plant. Radioactivity concentration in water from rivers also rises from 1.4 to 61.0μg/L for grossU, 0.3 to 2.8μg/L for grossTh, 3.7 to 81.0 mBq/L for ^{226}Ra, 4.98 to 77.8 mBq/L for ^{210}Pb, 0.83 to 10.69 mBq/L for ^{210}Po comparing to the background.

Table I The activity concentrations of radionuclides and EF values in samples

Samples	Radionuclides(Bq/kg)					
	^{238}U	^{226}Ra	^{210}Pb	^{210}Po	^{232}Th	^{40}K
coal	1200	1140	1170	1140	35.3	307
Bottom ash	1580	1610	570	200	58.3	546
Fly ash	4810	4730	42900	24300	128	668

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ASSESSMENT OF RADIOLOGICAL PARAMETERS OF NATURAL STONES IN THE CONTEXT OF THEIR APPLICATION AS BUILDING MATERIALS

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Keywords: natural radioactivity, building materials, activity concentration index, gamma spectrometry

Forty three natural stones used as building materials and available on the Polish market have been investigated and assessed with regard to their content of naturally occurring radionuclides.
Radionuclides concentration (K in %, U in ppm, Th in ppm) and the absorbed gamma dose rate (ADR in $nGy \cdot h^{-1}$) have been measured by means of the portable gamma spectrometer RS 230 with a BGO detector. Radionuclides concentrations were recalculated into $Bq \cdot kg^{-1}$. Average activity concentrations of K, U and Th are 774.0, 58.9 and 44.1 $Bq \cdot kg^{-1}$, respectively (tab.1). These values are similar to typical activity concentrations in natural building stones in the EU which are 640, 60 and 60 $Bq \cdot kg^{-1}$, respectively [1]. However, maximum values equal to 1774.9, 399.7and 125.2 $Bq \cdot kg^{-1}$, respectively are lower than those for building stones in the EU which are 4000, 500 and 310 $Bq \cdot kg^{-1}$, respectively [1].
External and internal exposure due to investigated natural stones have been assessed using activity concentration indices f_1 and f_2 defined in Polish law [2]. For 30% of investigated stones f_1 was equal to or greater than the limit value for building materials used in buildings designed for people and the livestock (f_1=1). The maximum value is 2.1 (tab.1). According to the European Commission [1] this index should not be greater than 1 for materials used in bulk amount but for materials used superficially the limit value is 6 and none of the investigated stones exceeds this limit.
Index defined as f_2 should not exceed the limit value of 200 $Bq \cdot kg^{-1}$. In two of forty three cases this limit was exceeded, with the maximum value of 399.7 $Bq \cdot kg^{-1}$ (tab.1).
All of these limits are established with the assumption that the excess annual effective gamma dose from building materials should not be greater than 1 mSv to that received outdoors. Regarding this criterion, only one of the investigated natural stones may be considered as a material that cause enhanced exposure.

Table 1. Summary of the results.

	Activity concentrations [$Bq \cdot kg^{-1}$]			**Activity concentration indices**	
	K	**U**	**Th**	**f_1**	**f_2 [$Bq \cdot kg^{-1}$]**
Minimum	121.4	11.2	7.8	0.1	11.2
Maximum	1774.9	399.7	125.2	2.1	399.7
Average	774.0	58.9	44.1	0.7	58.9

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[1] Radiological protection principles concerning the natural radioactivity of building materials – Radiation Protection 112. European Commission 1999
[2] Rozporzadzenie Rady Ministrow z dnia 2 stycznia 2007 r. w sprawie wymagan dotyczacych zawartosci naturalnych izotopow promieniotworczych potasu K-40, radu Ra-226 i toru Th-228 w surowcach i materialach stosowanych w budynkach przeznaczonych na pobyt ludzi i inwentarza zywego, a takze w odpadach przemyslowych stosowanych w budownictwie; Dz. U. z 2007 r., nr 4, poz. 29 (in Polish)

NORM IN RAW MATERIALS USED IN BUILDING INDUSTRY

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Natural radioactivity is responsible for most of the total radiation dose to the human population. Geological materials used in building industry usually contaminated with naturally occurring radioactive materials. They are used as mixtures in building industry (kaolin, zircon, frit, feldspar), or mechanically processed and used for covering floors and walls of the rooms (granite). In the paper activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in kaolin, zircon, granite, marble, sand, perlit, feldspar, korund and frit samples imported in Serbia were determined by gamma-ray spectrometry. Activity concentration index, dose rate and annual effective dose were calculated for each investigated samples. All measured samples contain increased concentrations of ^{226}Ra, ^{232}Th or ^{40}K. Comparing the values of measured activity concentrations of ^{226}Ra, ^{232}Th or ^{40}K with values of activity concentrations of materials which can, in extreme conditions, cause an annual dose of 1 or 5 mSv for workers given in (Markkanen 1995), it can be concluded than the measured values are lower than that given in (Markkanen 1995) [1].
Measurements presented in this work confirm that radiation exposure and attributed risk could be reduced by careful choice of building material during construction.

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INTERCOMPARISON ON STANDARDIZED METHODS FOR NATURAL RADIOACTIVITY DETERMINATION IN BUILDING MATERIALS

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In the last decades great attention has been devoted to the effects of the exposure of public to natural radiation sources, such as cosmic rays and radioactive isotopes in soils, rocks and water, mainly ^{40}K and radionuclides belonging to ^{232}Th and ^{238}U decay chains [1,2]. In particular, these radionuclides are present in building materials, and they may be considered partially responsible for the effective dose equivalent due to the natural sources of radiation [3,4]. Anthropogenic activities, such as high-altitude flights and living in buildings, have enhanced the people exposure to these sources and have led authorities in different European countries to develop specific regulations to guarantee the health of the public. A key point is the development of effective and reliable methods for the evaluation of the specific activity of natural radionuclides in building materials and of the consequent dose. This paper aims to provide a clear and comprehensive review on natural radioactivity measurement procedures in building materials for the evaluation of hazard parameters, such as the absorbed dose and the acceptability index [3,4]. An exhaustive analysis of the available standard national normatives (e.g.: Dutch NEN 5697, Italian UNI 10797, Polish ITB 455) was performed: all suggested gamma spectrometry as the most practical and reliable technique for the radiometric measurement of ^{40}K, ^{212}Pb and ^{214}Bi (the latter two for determining respectively ^{232}Th and ^{238}U). Moreover, some critical issues were identified, e.g. the homogenization of the sample and the waiting time required to obtain secular equilibrium between Radon and its decay products. Finally, two very promising alternatives have been considered: i) direct measurement of ^{238}U and ^{232}Th concentrations by ICP-MS spectrometry [5]; ii) extrapolation of the specific activities by carrying out two gamma spectrometry measurements, without waiting for secular equilibrium [6].

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ASSESSMENT OF RADIOLOGICAL HAZARDS OF CERAMIC TILES AS BUILDING MATERIALS IN DIFFERENT COUNTRIES

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Keywords: Natural Radioactivity, Building materials, Ceramic tiles, Radiological hazards

The ceramic industry encompasses a varied group of producers and products. One of the main subsectors is the production of ceramic tiles [1]. The consumption of ceramic tiles has experienced a considerable increment during the last decades, associated mainly to the development of the building sector. Ceramic tiles are considered building material as they are used as cover liner of floors and walls.
Measurements of ceramic tiles and raw materials used in them, show that natural radionuclides of uranium (^{238}U) and thorium (^{232}Th) series, together with the radioactive isotope of potassium (^{40}K) are present. Uranium series contain radium, which decays to radon (^{222}Rn), an inert gas that can be released from materials and inhaled by individuals. Limits of ^{226}Ra concentrations are established by different countries in order to control Radon levels (200 Bq/m^3 in European Union) for internal dose calculation. ^{40}K, ^{226}Ra and ^{232}Th descendents can cause an external dose.
Therefore, with the purpose that individual doses due to building materials do not exceed a certain level, recommendations or regulations have been established. In practice an easy way to avoid building materials provide doses to individuals over the reference level is to introduce an index depending on activities concentrations of ^{226}Ra, ^{232}Th and ^{40}K, defined so that the dose limits will never be exceeded. These limits and indexes present differences between countries. In this paper indexes are compared and differences are discussed [2, 3, 4, 5].
From the results exposed in this work, it is evident that certain ceramic tiles can or can not be used as building materials depending on the index applied. Consequently, manufacturers of ceramic tiles to be exported, should keep in mind these indexes as well as the concentrations of radioactive pollutants of their products to avoid problems in the customers. Related the presence of radioactive pollutants in the manufactured materials with the presence of the same ones in raw materials, in particular the zircon micronized and the zirconium oxide, care should be taken in the selection of these raw materials to keep the indexes of the manufactured materials far from their limits.

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RADIOLOGICAL ASSESSMENT OF ROCKS WITH POTENTIAL USE AS BUILDING MATERIALS: A CASE STUDY IN CENTRAL PORTUGAL

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Hercynian granites and pre-hercynian metasediments are the main lithologies outcropping in Central Portugal and both have been used as building materials. Locally, some granites were sometimes transformed by episienitization processes. The goal of this study is the radiological assessement of these materials, estimated from the activities of ^{226}Ra, ^{232}Th, ^{40}K and radon gas exhalation. A total of 78 samples were collected along a roughly N-S profile with around 200 km in extension.
Isotopic activities were measured with NaI gamma spectroscopic techniques and the radon exhalation from accumulation experiments using scintillation flasks and solid state track detectors. A set of parameters that have been proposed to evaluate the radiological hazard according to the potential use of building materials, namely the I-index, absorbed dose (D), annual effective dose equivalent (AEDE), radium equivalent activity (Raeq) and the external hazard risk (H) were calculated.
The ^{226}Ra isotope shows the highest variance with average ranging between 23.6 Bq.kg^{-1}, measured in the metasediments, and 241.7 Bq.kg^{-1} in the episienites. The I-index average ranges from 0.7 to 1.7, also higher in that last lithology. The other radiological parameters shown a similar trend, with the lowest averages observed in the metasediments and the highest in the episienites; more than 50 % of the biotite granites also show I-values higher than the unit. However, the results of the other referred parameters shows that, for the same geological unit, only about 10 % of the samples should be of concern with respect to the radiological hazard. So, from this finding it can be concluded the I-index is more conservative in the evaluation of the hazard risk than the other parameters. Radon exhalation, significant for all granite samples, shows a significant correlation with the ^{226}Ra activity, but the behavior of the emanation coefficient, ranging from 0.03 to 0.96, is more contrasted and sometimes opposite.

THE ENVIRONET AND ITS SUPPORT TO ENVIRONMENTAL REMEDIATION PROJECTS IN THE IAEA MEMBER STATES

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Several nuclear operations in the past gave rise to radiological environmental impacts of different proportions. The same has happened to NORM industries. Legacy sites have been created and now solutions need to be found and resources allocated to remediate these sites.
Progress has been made in some of the IAEA Member States (MS's) leading to the accumulation of a huge amount of experience and knowledge. The exchange of this experience and sharing of available information can undoubtedly contribute to improve the situation wherever remediation works are implemented at a slow pace or are virtually stagnant. Still, new solutions that favor a more dynamic flow of information are needed.
The support given by IAEA/Technical Cooperation Department to its MS's is of vital importance but room for improvement has been identified to expand this effort. Therefore, different networks have been created aiming at expediting and making even more efficient and effective the transfer of knowledge and sharing of experience amongst MS's.
One of these networks is the ENVIRONET – Network for Environmental Management and Remediation. It has been organizing thematic events on topics that are of common interest to the remediation and NORM communities including courses on Mathematical Modelling, Elaboration of Policy and Strategies on Environmental Remediation and Establishment of the Necessary Infrastructure for the Implementation of Remediation Projects; workshops such as Stakeholder Communication and Engagement in Remediation Projects and NORM Residues Management. The ENVIRONET maintains a discussion forum in LinkedIn that counts more than 1,100 participants, allowing for people from all over the world to post discussion topics and ask questions about a variety of issues pertaining to environmental remediation and NORM. With the participation of ENVIRONET in the IAEA CONNECT platform a series of e-learning materials, videos and a WIKI database will become available for the members of the network.

RADIOLOGICAL SAFETY ASSESSMENT OF THE ZAPADNOE URANIUM TAILINGS FACILITY, DNIEPRODZERZHINSK, UKRAINE

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Keywords: uranium tailings, safety assessment, remedial actions

The Zapadnoe uranium tailings facility is situated within the boundaries of the former Pridneprovsky Chemical Plant (PChP) site at Dnieprodzerzhinsk, Ukraine. The residual radioactivity at PCP has the potential to pose long-term risks to human and the environment; as a result a project has been undertaken to investigate remedial alternatives for contamination at the site.

As one of the first steps in the remedial alternatives process, a radiological safety assessment has been carried out for the Zapadnoe tailings facility. Zapadnoe is one of four tailings facilities at PChP, and the safety assessment is intended as a model to be extended to the other tailings facilities, and to evaluate the contribution of the tailings to the overall radiological risk from all sources of contamination at PChP.

The purpose of this paper is to present results of the application of a safety assessment methodology to Zapadnoe. The methodology is based upon the safety assessment methodology recommended by the International Atomic Energy Agency. The methodology is systematic and structured, and provides for continual improvement of the assessment through an iterative process. The result is a safety assessment that is transparent and defensible. Alternative scenarios have been identified and justified using formal scenario generation approaches. Consequence models have been identified and implemented for releases by various potential release mechanisms. Results will be presented for the alternative scenarios, and their implications for remedial decisions will be discussed.

PRELIMINARY STEPS IN THE RESTORATION OF A PHOSPHOGYPSUM DISPOSAL SITE: RADIOACTIVE CHARACTERIZATION OF LEACHATES AND EFFLORESCENCES AFFECTING THE SURROUNDING AREAS

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After the recent closing of some phosphoric acid plants located in the South-West of Spain, it has been decided to restore a big extension (more than sixty hectareas) of salt-marshes where historically it has been disposed some million tonnes of phosphogypsum, the main by-product generated by these plants. This PG is characterized for containing high activity concentrations of several radionuclides from the uranium series, mainly ^{226}Ra, ^{210}Pb and ^{210}Po and to a lesser extent U-isotopes.

The PG disposal area can be considered as a potential source or radionuclides to their nearby environment, through the waters which percolates from them and through the efflorescences formed in their surroundings. A detailed radioactive characterization of the mentioned waters and efflorescences has been considered essential for a proper planification of the restoration plan to be applied in the near future in the zone. With this end, U-isotopes, ^{234}Th, ^{230}Th, ^{226}Ra, ^{210}Pb and ^{210}Po activity concentrations have been determined by applying the alpha-particle and the gamma-ray spectrometric techniques to water and efflorescence aliquots collected in the area. .

The acidic waters discharging from the phosphogypsum piles to the surrounding environment contains very high concentrations of radionuclides from the uranium series (3 – 4 orders of magnitude higher than in a sea water) particularly of the U-isotopes, while the activity concentrations for the same radionuclides in the efflorescences, cover an ample range, with the activity concentrations of ^{210}Pb and ^{210}Po being very high and, in general, higher than ^{226}Ra and ^{238}U. These facts clearly highlight the different trend of the radionuclides from the uranium series in the different processes occurring in the area and affecting their behaviour: dissolution in the acidic waters, incorporation to the efflorescences during their formation, etc.

However, in spite of the general high activity concentrations determined in both draining waters and efflorescences, the relatively low weight of the outflows from the piles in comparison with the water flow in the estuary and the low density of existing efflorescences imply a moderate radioactive environmental impact of the disposal area in the estuary as a whole, although this impact is more important in their surrounding salt-marshes. As a consequence, in the planned restoration, and trying from the radioactive point of view to come back as much as possible to the situation existing before starting the disposal of PG in the estuary, two main actions should be taken: the outputs of acidic waters from the disposal area should be banned, and the existing efflorescences should be removed and properly managed.

GOOD AND BAD PRACTICES OF DECOMMISSIONING IN THE PHOSPHATE INDUSTRY

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Keywords: phosphate, decommissioning, decontamination

Phosphate minerals processing – e.g. for production of phosphoric acid – may lead to significant contamination in the installations: scalings inside pipes, contamination on filters, on the inner wall of tanks, … The nuclides involved and their concentration may differ from one component to the other: while radium may be the main contributor in some cases, significant concentration in uranium (without its progenies) may also be observed. U-238 activity concentrations up to more than 200 Bq/g have recently been measured on a phosphoric acid tank from the decommissioning of a former phosphoric acid plant in Belgium.

The decommissioning of these installations requires a well-structured approach including the following elements:

– an inventory and a characterization of the contaminated components of the installations,…
– health and safety procedures in order to ensure the radiation protection of the workers during decommissioning operations;
– an approach for the decontamination or disposal of the contaminated equipment (including a clearance procedure);

The presentation will review of few cases from Belgian phosphate industries and discuss the associated technical and regulatory challenges. It will underline the need to plan well in advance decommissioning activities in dialogue with regulatory authorities.

RADIOLOGICAL RISK ASSESSMENT TO WORKERS OF A DICALCIUM PHOSPHATE INDUSTRY

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The production of dicalcium phosphate (DCP) is considered a NORM industry and is regulated by the Spanish Royal Decree (RD 1439/2010) that obliges to perform a radiological characterization of the industrial process and the dose assessment to workers and public. Here we present the results of the dose assessment of a DCP production plant and the phosphate rock outdoor deposit located in the Port of Tarragona located in the northeastern Spain. We measured Rn concentrations in air and collected samples of aerosols, accumulated dust on the floor, and dry and wet deposition in both emplacements in order to determine the dose by inhalation received by workers. The external dose was measured in several plant locations by using an Eberline gamma detector. Results from the Port of Tarragona showed levels of ^{238}U in secular equilibrium with its daughters in all the measured samples, indicating that there is a dispersion of weathered phosphate rock that is accumulated preferentially close to the storage outdoor deposit. Outdoor Rn measurements ranged between 0 and 6 $Bq \cdot m^{-3}$, while maximum radiological doses of 0.24 to 0.32 $\mu Sv \cdot h^{-1}$ were obtained at 1 m distance of the phosphate rock storage area. At the production plant, doses reached values as high as 30 $\mu Sv \cdot h^{-1}$ at specific sites, mainly due to the high concentration of ^{226}Ra in the ebonite pipes. Measurements of the isotopes of the ^{238}U decay series showed disequilibrium amongst them due to the phosphate rock digestion with HCl. Then, ^{210}Pb and ^{210}Po measured in atmospheric dust ranged from 0.67 to 147 and 0.79 and 100 $mBq \cdot m^{-3}$, respectively, being particularly high in areas where DCP and phosphate rock are stored. Outdoor Rn measurements yielded up to 50 $Bq \cdot m^{-3}$ for most areas, but reached maximum values of 200 $Bq \cdot m^{-3}$ in indoor areas such as the phosphate rock storage warehouse and offices. The estimated annual dose received by workers in Port of Tarragona and the DCP production plant is much lower than 1 $mSv \cdot y^{-1}$.

SYSTEM OF MONITORING AND CONTROL OF THE HAZARD CAUSED BY NORM IN POLISH COAL MINES

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The radiation risk due to the exposure to natural radionuclides, especially to short-lived radon progeny, is a component of the radiation hazard, common in natural and working environment of people. Under specific circumstances, for example as a result of working in confined space with low ventilation rate (cellars, underground galleries, tunnels, mines), the risk caused by radon and its progeny can reach a significant level.
In Polish mining industry the radiation hazard, caused by natural radionuclides is one among many other natural hazards. It is worth being pointed out that besides radon another source of radiation hazard in coal mines is radium, present in formation water associated with coal seems. Sediments, precipitated out from such waters, have enhanced radium content and may cause substantial exposure to external gamma radiation as well as internal contamination due to inhalation or accidental ingestion.
Investigation of that specific problem started in hard coal underground mines in Poland in early 1970's. Due to being in force regulatory acts – Geological and Mining Law, Decree of the President of State Mining Authority and Decree of the Ministry of Environment – the monitoring and prevention against natural radiation is obligatory in all Polish underground mines since 1989. This duty is strictly supervised by local offices of State Mining Authority in co-operation with other governmental agencies. Monitoring and mitigation measures are obligatory not only for active mines but also for mines, excluded from the exploitation, and used for other purposes as museums, balneotherapy spas etc. Such solution is unique in non-uranium mining.
In the article the general principles of enforced monitoring system are described and statistical analysis of results gathered during the last decade is presented.

AEROSOLS CONTAINING NATURAL RADIONUCLIDES IN COAL-FIRED POWER PLANT

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Coal-fired power plants (hereafter "the plants") are one of general methods to generate electricity. The plants consume coals to make electricity but also produce the byproducts and wastes, including fly ash, bottom ash, and flue gas desulfurization (FDG) gypsum. According to International Atomic Energy Agency (IAEA), the coals contain natural radionuclides and might be regulated [1]. However, the health risks to workers in the industry resulting from chronic inhalation of radionuclide-containing aerosols have not been adequately addressed. Therefore, the Act to protect against ionizing radiation from naturally occurring radioactive materials (NORM) was recently enacted in Korea. Radiation dose due to the inhalation of aerosols containing natural radionuclides depends on aerosol properties, including aerosol size, concentration, shape, density, and radioactivity [2]. The objective of this study is to characterize the aerosols at the plants for internal dose assessment. Eight-stage cascade impactor was employed to sample aerosols at various processing areas in two coal-fired plants. The samples were used for characterization of aerosol concentration in the air, size distribution, and shape analysis. Aerodynamic diameters of airborne particulates ranged 0.03 – 100 μm with the highest concentration at the particle size range of 4.7 – 5.8 μm or 5.8 – 9.0 μm. Aerosol concentrations in the air varied widely depending on processing area, ranging 0.01 – 10 μg/L. The wide variations were observed for the same types of processing areas, up to one order of magnitude. The aerosols appeared as spheroids or rough spherical fragments across all sampling areas and sampled size intervals. Radioactivity concentration of Ra-226 and Ra-228 were 78 – 165 Bq/kg and 91 – 133 Bq/kg for fly ash, 75 – 113 Bq/kg and 85 – 109 Bq/kg for bottom ash, 5 – 8 Bq/kg and 1 – 3 Bq/kg for FDG gypsum. The database established in this study can be used for the accurate risk assessment of workers due to inhalation of aerosols containing NORM. In addition, the findings can be used as a basic data for development of safety standard and guide and for practical radiation safety management at the coal-fired power plants.

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PRACTICAL IMPACTS OF NORM STANDARDS ON MINING AND MINERALS PROCESSING

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Keywords: Mining, Minerals, Exemption

The international approach to the management of NORM for bulk raw metal concentrates remains complex and contradictory.
The IAEA provides a detailed framework for controlling material, containing elevated concentrations of NORM, which is based on a logically sound graded approach. This approach aims to ensure that the actual risks of radiation remain in perspective and that control is commensurate with the magnitude of risk. In addition, 1Bq/g is identified as the level below which regulation is unnecessary, and by implication, the level above which, control should be considered.
At a practical level, the application of the IAEA NORM standards in many countries is generally simplified resulting in 1Bq/g being established a de facto limit rather than a trigger for further consideration of graded control.
Mechanisms do generally exist in national regulation for consideration of materials above 1Bq/g, but these seldom appear to be used because accurate impact assessments can be complex and sometimes subjective. Usually “hard and fast” numbers are more desirable for decision making.
The non-uranium metals mining and processing industry is now being caught in the complex area of radiological impact assessment of its products and justifying the radiological safety of its products. This is simply because some raw materials exceed 1Bq/g.
The true intent of the IAEA standards is a graded approach to radiation protection based on actual risk. However, its simplification in practice has resulted in unnecessary business constraints that are not consistent with the actual risk.
This paper provides real examples of cases where the intent of the IAEA standard has been lost and argues that national authorities and companies should actively consider the real risks and impacts of materials that exceed the 1Bq/g before making decisions on control.

NORM ASPECTS OF SHALE GAS EXTRACTION

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Keywords: shale gas, Norm, geology

The only experience existing up to now in Belgium as to unconventional gas is through the test Coal bed methane (CBM) drilling performed in the period 1992 – 1994 in the Campine basin in the NE of the country.
In 2013 an expert group of geologists did analyze the huge amount of information available on shale in Belgium. Taking into account that layer thickness, organic fraction (TOC) and thermal maturity (VR) of the source rock are basic factors for the potential of shale gas extraction, they came to the conclusion that in Belgium the Namurian shale formations have the greatest potential for shale gas production. The complex geology and tectonic history of these formations and the important disturbance by former coal exploitations can be limiting factors for the success of future shale gas extractions.
One of the most promising sequences within the Namurian shale consist of black alum-shale rich in uranium and its decay products (Chokier Formation). Shale-gas extraction from this formation will probably imply the buildup of NORM at some phases of the process. Due to the lack of own data and based upon the geological analogy with the Bowland shale, the information gathered in the UK has been used to estimate the importance of NORM during the different stages of the extraction process in the potential shale gas region in Belgium.
Special attention is given to the wastewaters produced, as, although the natural radioactivity levels are not extremely high (most important is Ra-226 with concentrations of the order 10 – 20 Bq/l) and although Ra-226 is removed up to 90 % in the wastewater treatment, high concentrations of Ra-226 (540 – 8800 Bq/kg) have recently been observed in the sediments of the river near the discharge point of the treatment facility.

IMPACT ASSESSMENT OF A GENERIC DISPOSAL DESIGN FOR THE LEGACY RADIUM PRODUCTION SITE IN OLEN, BELGIUM

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Keywords: low level radium-bearing waste, biosphere model, performance assessment

Radium production in Belgium started in 1922 in the radium extraction plant at Olen. Within one year, Belgium dominated the world market until mid 1930's when comparable high grade ore was discovered in Canada. Due to the discovery of artificial isotopes, radium importance rapidly decreased, and the site in Olen was finally closed in 1960 and decommissioned in 1977.

Today, there is approximately a total of 217 000 m^3 radium bearing waste with an average contamination level of 7 Bq/g waiting to be disposed of at the historical radium production facility at Olen [1]. To inform the final design of the disposal concept, the long-term safety of a generic disposal concept was assessed through a combination of experimental and modelling investigations. The proposed generic disposal design consists of a multi-layered system where the NORM material is enclosed by low-permeability clay layers protect by a multi-layer cap. The function of the clay is to reduce the infiltration of meteoric water and subsequent leaching of the contaminated water into the underlying aquifer.

The performance of the disposal concept is assessed by testing various remediation scenarios. The scenarios considered are the effect of separating the waste into very low level radioactive and non-radioactive materials in addition to reducing rainwater infiltration and subsequent leaching by enclosing the waste by low permeability clay layers. To assess the effectiveness of the various disposal designs, radiological exposure (annual dose) due to leaching of ^{226}Ra, ^{210}Po and ^{210}Pb to a self-sustained farmer (representative person) utilising a hypothetical nearby well is taken as a performance indicator. A biosphere assessment model, BIOSPHERE [2], is used to assess the annual dose from potential exposure pathways (inhalation, ingestion, external irradiation).

The modelling results show that separating the waste into chemical non-radioactive and very low-level radioactive materials and using the non-radioactive material as an extra barrier resulted in a slightly enhanced radiological exposure. The isolation provided by the non-radioactive layer was abolished by the elevated radioactivity in the concentrated waste. Enclosing the waste by layers of low permeability clay reduced the annual dose from ^{226}Ra and its progeny significantly.

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RADIOLOGICAL ANALYSIS OF NATURAL GAS PIPELINE PIGGING PRODUCTS – PRELIMINARY RESULTS

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On the territory of the Czech Republic two pipeline systems were built. The first, transit pipelines, are used for the international transportation of natural gas to foreign partners and for the transmission of natural gas to supply the Czech Republic and consists of pipelines of length of 3,600 km in total. The second system, system of national pipelines is connected to the transit pipelines by national transfer stations. In addition, the territory of the Czech Republic has several underground gas storage facilities and natural gas is also produced but in relatively small quantities.
The pipelines are periodically cleaned to remove dirt, deposits and debris by means cleaning. The impurities collected by the cleaning pigs are according to the Czech legislation subject of radiological analysis as a product with possible presence of NORM before they are disposed. The workplaces where the pig receiver chambers and/or compressor stations are present are considered as a potential NORM workplaces requiring also radiological assessment to follow the radiation protection ordinance.
Extensive monitoring of such workplaces was carried out last year and are still ongoing. The impurities released by pigging are being measured directly in-situ by field portable device and the samples are subsequently analyzed in the laboratory by means of gamma spectrometry with HPGe detector. Collected samples showed high variability of consistency (powder to sludge), content of oily phase and content of other impurities. The performed measurements showed low content of radium, uranium and thorium at level of Bq/kg but relatively high content of Pb-210 and Po-210 at levels of tens of Bq/kg up to tens of kBq/kg. The radionuclide content in oily phase was usually lower than in powder. Mass activity concentration of Pb-210 in samples formed by powder is exceeding the clearance levels given in the Czech legislation. The former interest in the assessment of effective doses to the workers in contact with the pigging waste was then extended to the problem of disposal of the pigging waste to comply the requirements of Atomic law.

REMEDIATION OF NORM/TENORM CONTAMINATED SITES IN BRAZIL

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Naturally Occurring Radioactive Materials (NORM) and Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM) consist of materials enriched with radioactive elements found in the environment, such as uranium, thorium and potassium and any of their decay products, such as radium and radon. NORM occurs in geological formations and TENORM can be created by industrial activity. Examples of industries that may be of concern include oil, gas, niobium, rare earth elements, and phosphate fertilizer production, among others. The amount of waste generated by these industries usually is very large. Generally, they are stored on land near the mine site, which can contribute for soil and groundwater contamination.

Until now, decision about clean-up Brazilian sites contaminated with NORM/TENORM residues is addressed on a case-by-case basis, since there is no general guidance to support actions in early phases of the problem identification. The Brazilian Environmental Agency established background values prevention and intervention as the first step to implement remediation actions based on human risk assessment, which are only applied to sites contaminated with chemicals elements. The development of these values were based on the Soil Screening Guidance (SSG), which is a framework for developing risk-based, soil screening levels (SSLs) for protection of human health.

This paper describes the methodology used for developing the Soil Screening Guidance for radionuclides, which has been applied as preliminary remediation goals in Brazilian NORM/TENORM contaminated sites. Background values for Unat, Thnat, ^{226}Ra, ^{228}Ra and ^{210}Pb were determined through the analysis of different types of soil representative of the Southeast region of Brazil. Intervention and action values were estimated using typical exposure scenarios that could represent possible future uses of the soil after the remediation action. They included residential, agricultural and industrial possible uses. The dose factors, as well as the soil-plant transfer coefficients showed to be the most sensitive parameters of the proposed model.

NATURAL RADIONUCLIDES IN THE COMBUSTION PRODUCTS OF OIL SHALE-FIRED POWER PLANTS IN ESTONIA

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The dominant share of energy produced in Estonia originates from two large oil shale-fired power plants. Due to the high mineral content (over 50 %), burning this fossil fuel creates large quantities of residual ash. The fossil fuel contains natural radionuclides bound during its formation, and these radionuclides are concentrated in the combustion products. Research done in the 1990's [1] revealed significant differences in radionuclide concentrations between various ash fractions and an atmospheric emission of ^{210}Pb (around 30 % of its total activity).

Due to the large amounts of oil shale used annually for electricity production, a noticeable radiological impact on the environment and on the population near the power plants could be presumed. In the light of the new European Council Directive 2013/59/EURATOM, it is important to determine and quantify the additional doses to the public from the energy sector. The annual radiation doses to the population are expected to be caused primarily by the two volatile radionuclides ^{210}Pb and ^{210}Po, as well as by ^{226}Ra (according to recent studies [2]).

The technology used in the power plants has changed significantly during the past twenty years – four older types of pulverized fuel (PF) boilers have been replaced with the newer circulating fluidized bed (CFB) boilers and advanced filter systems have been implemented. Most recently, novel integrated desulphurization technology (NID) was put in place for the efficient removal of fly ash and SO_2 from flue gases. These technological changes, combined with the differences in the composition and volume of the oil shale being burned, have had a recognizable effect on the radionuclide concentration processes in various ash fractions as well as on the radionuclide atmospheric emission.

Collected ash samples were analyzed with gamma spectrometry to determine the activity concentrations of ^{238}U and ^{232}Th series radionuclides as well as ^{40}K. The results revealed an increasing trend of radionuclide enrichments (up to 4.5) in ash fractions along the flue gas duct. The highest radionuclide activity concentrations were found in the filter ashes, where the temperature was lower, particle size the smallest and specific surface area the largest (for the CFB boiler) [2]. It was also found that around 20 % of the total activity of ^{210}Pb and ^{226}Ra is released to the environment via small ash particles and flue gases. Based on calculations of mass activity balance, the annual emission of radionuclides per unit power output has been estimated. Preparations to implement the analysis method for ^{210}Po have been started.

Oil shale power plants have various effects on the surrounding environment and population. The comprehensive and accurate identification of the radiological effects is important in the context of the new European BSS directive. The radiological impact of the combustion products and the possible use of oil shale ash as a building material require further evaluation.

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OILY SLUDGE (MIXED WASTE) FROM CRADLE TO GRAVE – A USABLE SOLUTION

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During Oil Production also oily sludge may be produced. Due to the solids contained oily sludge – next to its hydrocarbon and other smelly contents – may be contaminated with heavy metals (*e.g.* mercury – Hg) and Naturally Occurring Radionuclide's (NOR's – ^{228}Ra, ^{226}Ra & ^{210}Pb). In this sense the oily sludge is a mixed waste, for which an safe and environmentally final solution should be found.
At first a contractor should be located, that is capable of processing oily sludge in such a way that clearly defined products or waste are obtained. Here the product may be reused, whereas any (NORM) waste has to be disposed of. The locations of such a contractor outside the Netherlands requires buy in of and well-defined mutual agreements between the competent authority and the companies of the nations involved.
This presentation describes the usable solution found for oily sludge processing and the path towards implementation of this solution.

SLAG WOOL FROM CRADLE TO GRAVE – ARRIVING AT A PRACTICAL SOLUTION

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Till the end of the seventies of the former century sensible applications for slag from metals industry were sought. One of the applications involved the spinning of heat insulation wool from molten slag. This so-called slag wool was applied for heat insulation in many furnaces and plants operating at high temperatures. However, at the time of application it was not realized that slag wool does contain relatively enhanced concentrations of Naturally Occurring Radionuclide's, thereby classifying this material nowadays as NORM. Only since the last ten to twenty years when the installations, in which slag wool was applied, were scheduled for replacement at scrap brokers portal monitors the scrap was flagged to be radioactive, *i.c.* NORM.
Since this issue was discovered at SNR, we have been looking for a practical solution to reuse or dispose of slag wool. Close collaboration with the Dutch competent authority was required in order to find a practical and environmental friendly solution. This presentation tells the ups and downs encountered in finding such a practical solution and the ultimate solution found.

EFFECTS OF REMEDIATION IN MINING INDUSTRY: INVESTIGATIONS IN ABANDONED AND RECLAIMED SETTLING POND

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Keywords: land reclamation, radium, brines, bottom sediment, radium transfer, radon

Problem which may appear at post-mining areas during ground reclamation of a surface settling pond, which had been used for mine water treatment, is huge amount of radium isotopes collected in bottom sediments. Such sediments in dependence of activity concentration can create substantial contamination of natural environment and additional radiation risk to inhabitants of neighbouring areas.
Investigations of natural radiation background alternation in the area of abandoned and dried settling pond used by a Polish coal mine, were performed at the different stages of its reclamation: starting from an initial step when bottom sediments were left to dry, then during the process of covering deposits with isolation layers and soil, and finally when agro-technical measures were applied. Within the frame of the work different sources of radiation exposure were observed. Radium concentration was measured in bottom sediments of the pond and in all types of waste material and soil used as isolation layers. In waters collected from drainage wells radium concentration was measured as well. Twice, at different stages of reclamation of the pond, gamma dose rates were measured at about 20 points. To assess possible radium transfer from soil to plants – radium in different plant species was measured. Additionally, observation of radon gas emission was performed. Besides radon exhalation from ground, its concentration in soil gas and in drainage wells was measured. The obtained results have shown that, radon risk caused by radon exhalation from bottom sediments has been reduced significantly due to reclamation. However, long term (3 month) measurements of radon gas concentration in drainage wells shown elevated values – the highest reached 4000 Bqm^{-3}. It means that any damage of the isolation layers may lead to the significant increase of radon emission from confined sediments. In our opinion, the assessment of radon emission level from the bottom sediments is the essential information pointing to the way the post-settling pond areas can be reclaimed. In the case of increased radon exhalation the sediments sealing should be planned so as to avoid migration and penetration of that gas into the future buildings that might be built in the areas of settling ponds.

COMPARISON OF TWO SEQUENTIAL EXTRACTION PROCEDURES FOR URANIUM FRACTIONATION IN CONTAMINATED SOILS

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Keywords: fractionation, sequential extraction procedure, soil-to-plant transfer, uranium

Two sequential extraction procedures were carried out on six soils with different chemical properties and contamination history to estimate the partitioning of uranium (U) between different soil fractions. The first standard method (method of Schultz) was specifically developed for actinides, while the second one (method of Rauret) was initially established for heavy metals. Reproducibility of both methods was compared by means of the coefficient of variation (CV). The part of U recovered in equivalent fractions for both methods was compared. A soil-plant transfer experiment was also carried out with ryegrass to verify if one of the extracted fractions efficiently predicted plant uptake.
The reproducibility of both methods was very good compared to the literature. In artificially contaminated soils, most of the U was retrieved from the exchangeable and the carbonates fractions. In soils with high natural levels of U or contaminated by industrial activity, most of the U was found in the less available fractions. Different U concentrations were found in the fractions which were supposed to be comparable for the two methods. Extracted fractions differentiated more strongly between the tested soils for the method of Schultz but no relationships with soil parameters could be established.
As expected, the highest U transfer factors (TF) were observed for ryegrass grown on artificially contaminated soils and the lowest on soils with high natural concentrations or industrial contamination, in agreement with the extraction procedures. Nevertheless, no good relation was found between root and shoot TFs and the extracted fractions. U concentrations in the roots and shoots on the other hand seemed to be correlated to the more exchangeable fractions extracted by the method of Schultz.
We concluded that the extraction method according to Schultz should be preferably used for U, and that the more exchangeable fractions can be used as an indicator to evaluate plant uptake in soils.

RADIATION AND ABRASIVES – A CHALLENGE FOR TRADE AND COMMUNICATION

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Keywords: Abrasives, minerals, radioactive, exemption level, trade

Kuhmichel Abrasives is the largest European supplier for abrasives. Abrasives are high-quality products, often from minerals, that are used in many industrial sectors. The overwhelming number of minerals or other materials used for production of abrasives contain radionuclides at the general background level or even lower. But a few of the minerals, in particular from heavy minerals, may contain natural radionuclides in higher concentrations than the general background.
The European Directive 96/29Euratom (E-BSS-96) did not yet cover the radioactivity of consumer goods or commodities from naturally occurring radionuclides. The requirements of Article 40 E-BSS-96 included work activities with NORM causing a significant increase in the exposure of workers and, residues causing a significant increase in the exposure of members of the public. By the implementation of these requirements in national legislation abrasives have been included radiation protection regulations of European member states mainly as part of zircon and zirconia-industry.
Kuhmichel has been dealing with the challenges of radioactivity in products since many years. All products containing zircon, zirconia, or are produced from bauxite (corundum) are checked regarding the activity concentration of naturally occurring radionuclides. Nevertheless, the requirements of customers result in some serious obstructions for trade of abrasives. The implementation of the new EU BSS (EU 2013) opens possibilities for improvements due to the exemption level of 1 Bq/g U-238sec and Th-232sec but also contains risks because working activities with NORM has to be considered as a practice. The poster / presentation will address the expectations of a supplier to the implementation on mineral products as abrasives are from both sides: a reasonable radiation protection and a barrier free trading environment.

ARC WELDING RESIDUES MANAGEMENT IN ACCORDANCE WITH THE CRITERIA ESTABLISHED IN THE SPANISH REGULATION

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Keywords: arc welding, NORM, residues management

As a consequence of using thoriated electrodes and rutile consumables in arc welding, a significant amount of residues containing natural radionuclides are produced. Subsequently, in Spain, their management must be accomplished according to the Order IET/1946/2013 [1], which in its Article 3 requires the radiological characterization of residues to verify if activity concentration is under established threshold values, and hence, if conventional management is needed.
Residues produced by the use of thoriated electrodes are worn rods. Using rutile consumables residues are pieces of rutile-covered electrodes, rutile slag and filters for the welding fume extraction. Following the criteria of Article 3, activity concentrations determined – 0.15 and 0.05 Bq g^{-1} for U and Th series in rutile-covered electrodes, 0.11 and 0.06 Bq g^{-1} for ^{230}Th and ^{228}Th in rutile slag and 3.33 Bq g^{-1} for ^{210}Pb in filters – are below thresholds, but in the case of thoriated rods, their activity concentrations being 65 Bq g^{-1} for ^{232}Th and 22 Bq g^{-1} for ^{228}Th are above them. Therefore, according to the Article 4 of the same Order, dose assessment in thoriated worn rods management is required.
Considering the most conservative situation, at a disposal site that receives all the thoriated electrodes used in Spain (3600 Mg yr^{-1}), effective dose will not exceed the reference level of 1 mSv yr^{-1}, it being around 0.1 mSv yr^{-1}. In conclusion, thoriated rods must be managed conventionally, as any other residues.
Rods, covered electrodes and slag are thus considered inert industrial residues and their European Waste Catalogue Code [2] is 120113; however, used filters are considered as hazardous and their code is 150202*. In both cases, after segregation, storage and transport, residues are eliminated or recycled. In this work, some of their recycling alternatives, as electrodes melting, use of slag as replacement for sand in concrete [3] and recovery of some valuable minerals [4], are analyzed.

This work was supported by the University of the Basque County under the grant of the Spanish Nuclear Safety Council.

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NATURAL RADIONUCLIDES IN METALURGICAL PRODUCTION OF UKRAINIAN ENTERPRISES

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At present the problem of NORM and TENORM at metallurgical enterprises in Ukraine is poorly investigated. In the article we present results of several radiation surveys in Ukrainian metallurgical enterprises. These are such enterprises as Nikopol Ferroalloy Plant, Volnogorsk Mining and Metallurgical Combine and Dniprodzerzhynsk Metallurgical Combine. The levels of radioactivity in raw materials and products of these enterprises have been measured. As known from literature, the process of technological concentration of lead-210 and polonium-210 was confirmed in the sludge of gas cleaning system. From these results we determined the levels of radiation exposure at selected workplaces at these enterprises.

NORM STUDIES IN AN OFFSHORE OIL PRODUCTION FIELD LOCATED IN THE COAST OF GHANA

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Since the middle of 2012, under the umbrella of the International Atomic Energy Agency, a collaboration between the Spanish Applied Nuclear Physics Research Group located in Sevilla and the Ghana Atomic Energy Commission (GAEC) has been running, devoted mostly to the training of a staff of the GAEC in the performance of up-to date radiometric and dosimetric determinations associated to the activities of NORM industries. The final objective is to have in the near future a consolidated national group in Ghana, with enough knowledge and skill to better manage occupational and public radiological assessments associated to the different NORM activities which can be found in the country.
The collaboration is now ongoing, and the training of the GAEC personnel initially involved so advanced, that a first study to evaluate the occupational radiological impact in a typical NORM facility (an offshore oil production field located in the coast of Ghana) is being developed. With this end, several samples of crude oil, produced waters, sludges and scales from the facility have been collected, properly pre-treated , and their radioactive content determined by applying the alpha-particle and the gamma-ray spectrometric techniques. In addition, an external gamma dose rate map of the field has been performed. U-isotopes, Th-isotopes and ^{210}Po activity concentrations by alpha-spectrometry, and ^{210}Pb, ^{234}Th, ^{226}Ra, ^{228}Ra, ^{228}Th and ^{40}K by gamma-ray spectrometry were the nuclides determined, taking into account particularly in the gamma-ray determinations, self-absorption corrections.
In this communication the experimental radiometric and radiological determinations performed will be shown and discussed, and the main conclusions from the radiological point of view highlighted. In view of the radionuclide content found in the analyzed sludges, some recommendations for the proper management of this waste will be done.

**submitted for poster session etc.*

RECYCLING OF NORM – AND MERCURY CONTAMINATED METALLIC RESIDUES – GERMAN EXPERIENCE FROM DECOMMISSIONING PROJECTS OF THE OIL AND GAS INDUSTRY

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A lot of branches dealing with raw material generate NORM contaminated scrap from the decommissioning of their facilities. The naturally occurring radioactivity results from the decay of the trace elements uranium and thorium in the earth crust. Scale is formed in oil field equipment due to the precipitation of alkaline earth metal sulphates and carbonates, particularly $CaCO_3$ and $Sr/BaSO_4$ which also contain Radium in $RaSO_4$ and $RaCO_3$. In gas processing facilities a thin layer of Lead-210 and Polonium-210 is formed on interior surface. Depending on the region of the oil and gas field, specific activity is amounting to some hundred Bq/g, often cross-contaminated by mercury and hydrocarbons.
In order to avoid radioactivity input in the steel and non-ferrous metal cycle, scrap yards and steel mills are equipped with gate detectors for measuring scrap. Scrap loads with radiation levels above background are rejected at the entrance. Most detections result from NORM contamination in the scrap. Siempelkamp offers the service to decontaminate this NORM-contaminated scrap in a special melting plant, licensed according to the federal law on protection against environmental pollution (BImSchG). In accordance with the European Basic Safety Standard and the German Radiation Protection Ordinance, neither licensing nor radiation surveillance, nor protection is required, if the annual dose exposure to workers does not exceed 1 mSv/a in the plant. Authorized recycling and disposal is assured for the waste resulting from the melting process, like slag and dust, in which radioactivity is accumulated. The poster will present experiences and results from different melting projects.

R&D ACTIVITIES ON SAFETY CONTROL OF NORM WASTE DISPOSAL IN KOREA

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Keywords: disposal of NORM wastes, radiological safety, landfill disposal, health effect

In 2012, Korean government promulgated an Act on safety control of NORM (Naturally Occurring Radioactive Materials) around living environment to protect human health and the environment. According to this Act, NORM wastes have to be disposed in landfill sites and other disposal sites. Several R&D works are being performed to setup foundation for the safety control of NORM and NORM wastes. One of them is to establish technical bases for securing radiological safety for the disposal of NORM wastes.
We investigated sources of NORM wastes. The representative NORM wastes in Korea are fly ash, phosphogypsum, and bauxite redmud. The radionuclide concentration of the fly ash is 26.4, 16.6, and 14.9 Bq/kg for K-40, Ra-226, and Th-232, respectively. The concentrations of the phosphogypsum are 17.0, 0.8, and 1.4 Bq/kg for K-40, Ra-226, and U-238, respectively, whereas those of the bauxite redmud are 0.3 and 0.2 Bq/kg for Th-232 and U-238, respectively [1]. And we investigated characteristics of methods for the disposal of NORM wastes including land spreading, landfill disposal, underground disposal, and so on. Based on these literature survey results, we suggest conceptual design of landfill disposal for NORM waste.
We estimated health effects such as exposure dose and excess cancer risk resulting from the disposal of representative NORM wastes using RESRAD-OFFSITE code [2]. The exposure doses are 4.0E-04, 2.0E-04, and 3.62E-07 mSv/yr for fly ash, phosphogypsum, and bauxite redmud, respectively. The excess cancer risks are 9.63E-07, 5.21E-07, and 8.13E-10 for fly ash, phosphogypsum, and bauxite redmud, respectively. The exposure doses are much lower than those from natural background radiation, and excess cancer risk is lower than the safety goals for the nuclear power plants in Korea.

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ROMANIAN EXPERIENCE ON NORM (URANIUM ORE) – *WASTE TREATMENT AND SITE REMEDIATION*

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The Safety and Security, radiological consequences during the uranium mining operations, tailings management, uranium processing, transport and disposal of waste in conventional landfill sites are matters of great importance.
The Uranium National Company (CNU) from Romania is responsible for all aspects belonging to the management within uranium industry – the uranium ore extraction, transport and processing of uranium ore, concentrates processing, as well as disposal of sterile ore and waste.
The paper presents specific problems related to the identification and evaluation of potential environmental risks, potential radiological consequences, by using computer codes as ***[1]RADTRAN6 and [2]INTERTRAN2***, associated with the transport of uranium ore -by road and by rail- the disposal of sterile and the uranium processing waste.

Some aspects related to the disposal and its management of uranium mill tailings and uranium sterile landfill, evaluation of the environmental aspects, dispersion factors, there will be also presented.

The paper is a layout of the result of the IAEA Romanian Scientific Research Contract ***–"Risk and Safety Evaluation in the Transportation and Disposal of Naturally Occurring Material-uranium ore, in Romania"***, part of the IAEA CRP-Coordinated Research Project***-"The Appropriate Level of Regulatory Control for the Safe Transport of Naturally Occurring Radioactive Material (NORM)"*** where the main author is ***CSI-Chief Scientific Investigator***, for the above mentioned IAEA – Romanian Scientific Research Contract.

Note:
[1] Computer code developed by SANDIA NATIONAL LABORATORY (SNL) – USA;
[2] Computer code developed by IAEA Vienna

WATER TREATMENT PLANTS AND NORM – CZECH EXPERIENCE

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Keywords: water treatment plant, NORM, Czech Republic

According to Czech legislation, water treatment plants where water from underground water sources is treated are classified as workplaces where exposure of workers to natural ionising radiation sources or exposure of individuals living within the vicinity of such a defined workplace may increase significantly. A release of natural radionuclides from such workpaces into the environment is permitted only in the scope not exceeding clearance levels laid down in an implementing legal regulation or in the scope and under the terms specified in a licence issued by the State Office for Nuclear Safety.
During the last years, it has managed to gather a lot of experience in this field. The experience is based on results of inspection activities, on analyses carried out in research projects, as well as on the solution of specific practical problems.
Authorities and stakeholders are intensively looking for other suitable handling of NORM from water treatment plants. Used ion exchagers with higher content of uranium are processed in the chemical treatment of uranium ores, managed by DIAMO, state enterprise. Some used sand filters may also serve as remediation materials – for example during the remediation of tailing ponds.

NATURALLY OCCURRING RADIONUCLIDES AT A GEOTHERMAL FACILITY AT A NORTH GERMAN BASSIN

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Keywords: NORM, geothermal facilities, salinity

A well known observation from wells of the oil and gas industry is the occurrence of NORM (natural occurring radioactive materials) with elevated specific activities in mineral precipitates (scaling). Presumably, these radionuclides are transported with the geothermal fluids and co-precipitate upon change of thermodynamic conditions with respect to the oversaturated mineral. Similar processes can be expected to occur in geothermal plants production of highly saline fluid from deep reservoirs.
At the geothermal research facility in Groß Schönebeck (North German Basin) the mobility of radionuclides of the natural decay series ^{238}U and ^{232}Th was intensively monitored. In this study we determined the radionuclide concentration in samples from reservoir rocks, scales (filter residues), and fluids.
It was found that the reservoir rock is relatively poor with respect to natural radionuclides, whereas elevated activity concentrations of some 10 Bq/l were found for ^{210}Pb and especially for the ^{226}Ra and ^{228}Ra in the fluids. Presumably, these elevated concentrations can be attributed to the formation of readily soluble chloro-complexes of Ra and Pb.
In filter residues and scales we found elevated specific activities of some 10 Bq/g for ^{210}Pb, ^{226}Ra and ^{228}Ra. These residues consist mainly of the minerals barite ($BaSO_4$) and laurionite (Pb(OH)Cl). Since Ra is known as substitute for Ba in minerals, barite seems to act as scavenger for these ^{226}Ra and ^{228}Ra and laurionite for ^{210}Pb.

ELIMINATION AND CONCENTRATION OF NATURAL RADIONUCLIDES IN DRINKING WATER TREATMENT PLANTS

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Keywords: drinking water treatment plant, natural radionuclides, gross alpha activity, alpha spectrometry

In this study we have evaluated all the radioactive parameters mentioned in the Spanish Royal Decree in different kind of samples from the DWTP located in l'Ampolla (Tarragona) such as the ingoing and outgoing waters, and also we have evaluated the radionuclides present in the generated sludge. In the water samples analyzed we could observe that, in the ingoing water the gross alpha activity values varied between 0.05 to 0.09 Bq/L in the last five years, whereas in the outgoing water the average values for this parameter varied between 0.04 and 0.07 Bq/L.
The occurrence of radionuclides in the sludge has already been studied by different authors [1]. In our case, for the gamma analysis results, we could observe that different natural radionuclides (isotopes from the ^{238}U and ^{232}Th decay chain and ^{40}K and ^{7}Be) showed concentrations between 20 and 600 Bq/Kg. The origin of these radionuclides could be attributed to the geology of the zone and also to the presence of the dicalcium phosphate industry close to the river upstream of the DWTP.
From all these results, it is important to highlight, that the DWTP process is able to remove the radioisotopes present in the incoming water producing a water with a higher quality (that accomplish the legal requirements), but on the other hand these radionuclides are concentrated in the generated sludge during the conventional treatment followed in these plants.
This work was financially supported by the Generalitat de Catalunya, project 2009 SGR223. The authors would thank especially to the Consorci d'Aigües de Tarragona (CAT) for its collaboration in this study.

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RADIATION MONITORING – AN ELEMENT TO PROMOTE EFFECTIVE AND SAFE OPERATION OF GEOTHERMAL POWER PLANTS

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Keywords: Geothermal, Radon, Dose, Monitoring

Some geothermal waters in Germany show enhanced Radium activity concentration up to some 10 Bq/l [1,2]. Circulation and mixing of fluids within the reservoir and inside the geothermal power plant causes a drop of temperature and pressure which will trigger corrosion and scaling. High activity concentration of NORM in scale with > 1 kBq/g and ambient dose rates in in the order of some µSv/h had been reported [3]. Heat sinks and filters are special points of interest. The scaling correspond in a yet insuffiently described way with production rate and modus operandi of the facility. Within the GRS project GEOSYS [4], a probabilistic approach of dose assessment was successfully used and provided information upon uncertainties of doses and decisive parameters [5]. The new project ANEMONA aims at the characterization of in-situ conditions in the reservoir and the process stream and the prediction of changes therein. New methods of an operational monitoring will be developed and tested under field conditions. ANEMONA provides important metrological and model-theoretic contributions to a deeper understanding of the entire geothermal system and will improve reservoir management and occupational safety. A continuous monitoring of the NOR signature of the water (i.a. Radon) will free yet idle geochemical data that allow modelling of the reservoir behavior. The metrological preconditions for a monitoring of Radon gas in high-mineralized, hot and pressurized waters are challenging. Special emphasis will be placed on the monitoring of relevant parameter of the dose assessment: The analysis of the ambient dose rate at selected points help to decide on radiation protection means or decontamination in due time. A non-destructive detection method is applied to provide precise information in terms of scale formation with temporal and spatial resolution. The developed methods and techniques own the potential for the exploration of further geothermal sites.

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INTERCOMPARISON OF THE APPLICABILITY OF EQUIPMENT AND ANALYZE METHODS FOR THE ASSESSMENT OF NORM IN DAILY ROUTINE

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At the end of 1970's international awareness grew that materials from natural origin and remains (e.g. waste) out of the non-nuclear industrial process could cause serious radiological health physics risks. The non-nuclear industry, government and service providers were in those early days certainly not familiar with radioactivity and had no experience how to deal with it in best practices and in an economic way.
Nowadays much has been improved, however it is evident, that the maturity of how to deal with NORM differs still by country and industry. As an example of how things go forward. Legislation did not exist in 1980 in most European countries and now it is explicitly mentioned and regulated in the new released European Directive 2013/59/Euratom [1].
To be able to deal in the daily routine of the non-nuclear industry with NORM, it is of course a must to have access at least to instruments and methods to assess health physics risks according to best practices and in the most economic way.
The aim of this paper is to give an overview of the applicability of instruments and methods to be used for:

- o Direct actions in the case of an increased health physics risk has been detected that has to be dealt immediately;
- o To assess if instruments and methods can be used to prove to be in agreement with the requirements stated in the European Directive 2013/59/Euratom [1].

This aim can be reached by defining a list of eight different criteria on which instruments and methods can be judged, like: destructive versus non-destructive; correction for self absorption in the sample by a change of density or chemical composition of the sample; correction for sample size, correction for equilibrium versus non-equilibrium, etc..
These criteria are applied to nine different hand held and laboratory instruments based on detection of NORM by alpha- , beta- and gamma radiation. Results of individual scores of each of the nine different hand-held and laboratory instruments are discussed as well as the overall result of this intercomparison.

[1] European directive 2013/59/Euratom; 5 December 2013.

PERFORMANCES OF A LIGHTWEIGHT COLLIMATED γ-RAY SPECTROMETER FOR IN-SITU SURVEYS

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Keywords: collimated γ-ray spectrometry, full spectrum analysis, in-situ survey, environmental radioactivity

In-situ γ-ray spectrometry is a widely used technique for assessing environmental radioactivity. Efforts are made to improve the accuracy of in-situ measurements in order to apply such technique as a screening method to fulfill the requirements of the forthcoming Euratom Basic Safety Standards regarding building materials and NORM residues. However, in many situations like site remediation, building materials quarrying, mineral exploration etc., both the contamination history and geochemical processes can lead to a spatial variability of the radionuclide concentrations. The drawbacks of reducing the detectors' field of view by folding them with lead are the increasing of weight and counting time.
We improved the "lead plate" method in order to increase the capability to filter the background in presence of high-spatial variability. The collimation effect is obtained by subtracting from the spectra acquired without the lead plate the one acquired with the lead plate. The difference spectrum gives the unattenuated γ-rays from a selected range of polar angles. In order to achieve a reliable calibration the "fundamental spectra" of background, ^{40}K, U, Th and ^{137}Cs are obtained using the Full Spectrum Analysis method with Non-Negative Least Squares constraints [1]. The calibration has been validated by comparing in-situ measurements and laboratory measurements on sample collected in 30 sites.

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[1] A. Caciolli et al., (2012). A new FSA approach for in situ gamma-ray spectroscopy. Science of The Total Environment 414: 639-645

AN ANALYTICAL METHOD TO DETERMINE ACTIVITY CONCENTRATIONS OF URANIUM- AND THORIUM-SERIES IN THE INHALED AIR DURING ARC WELDING

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Keywords: arc welding, NORM, radioactive decay equations

Arc welding is the most used welding process. An electric arc is set up in it between two conductor pieces or electrodes. The temperature provided by the arc is enough to melt the electrodes, resulting aerosols emitted into the air and inhaled by the welder.
Among consumable electrodes, covered electrodes and flux cored wire contain ^{40}K and uranium- and thorium-series in secular equilibrium. However, the temperature and chemical reactions at the welding point affect elements differently, and radionuclides from each element are emitted at a particular rate.
In order to determine activity concentrations in the inhaled air, samples of aerosols were collected by filters. Then, early gamma spectrometry was performed, filters were dissolved and U, Th, Ra, Pb and Po were isolated. Finally, gamma and alpha spectrometry and beta counting measurements were carried out.
From them, activity concentrations of long-lived nuclides were assessed directly. However, to assess activity concentrations of short-lived nuclides, their time evolution must be modeled, following the general Bateman solution introducing a collection term, and matched with their experimental values.
Results show that radon progeny is emitted into the air at the same activity concentration (21.2 mBq m^{-3}). The same is true for nuclides before radon, but with values 15 – 20 lower (1.21 mBq m^{-3}). The long-lived nuclides before radon follow the same activity distribution as the covering or flux mass does, respectively, and remain mainly in the slag or bead. In addition, the ratio between activities of both series in the consumables remains also in aerosols, so that the activity concentration of thorium-series in the air is around 2.75 times lower.
Based on all these data, it can be concluded that activity concentration of both series in the inhaled air can be assessed only by the early gamma measurement of ^{214}Pb and ^{214}Bi. And thus, internal dose via inhalation, which results below 1 mSv a^{-1}, can be estimated sooner.

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NATURAL RADIOACTIVITY IN GROUND WATER TREATMENT FACILITIES IN BELGIUM

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Keywords: water treatment, contaminated filters, radon

Ground water production and treatment facilities, designed to produce drinking water for public consumption can become a significant source of natural radiation exposure to the workers under certain conditions. If the source aquifer of the pumped ground water consists of uranium or thorium rich layers, part of the radioactive isotopes are pumped up along with the water. Filter systems intended to remove harmful substances such as iron or calcium from the water can concentrate on the long run these radioactive isotopes of the Th-232 and the U-238 series.

In the southern part of Belgium, several drinking water producing aquifers consist of fractured black shale with relatively high concentrations of uranium and thorium. The water is pumped and filtered, then directed to the public water distribution system. During the renewal process of the filter material (consisting of sand, iron rings, etc), several alarms at the level of the radiation monitoring equipment of the waste processing facilities receiving the used material highlighted the problem of natural radioactivity.

The presentation gives an overview of the surveys and measurement campaigns at the water treatment facilities in terms of natural radioactivity of the water at different processing levels, external gamma exposure, radon exposure at different levels and activity concentrations on different parts of the installations. It also discusses the approach followed and the measures taken for radiation protection purposes.

DRINKING WATER TREATMENT PLANTS IN CZECH REPUBLIC

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Keywords: water treatment, drinking water, radioactive residuals, uranium, NORM

Most of drinking water for public water systems in Czech Republic comes from underground sources. Limits and parametric values for drinking water are determined by legislation for public health and radiation protection. Any of underground sources of water can satisfy all legislation requirements, while others need additional treatment. Some treating technologies for removing common contaminants, for example hardness, iron or manganese, remove also NORM contaminants. Uranium from groundwater is removed on filters with an anion exchange resin. The experience and case reports of management of radioactive residues from drinking water treatment plants in Czech Republic are described in mentioned work. State Office for Nuclear Safety and stakeholders solve management of radioactive residuals from water treatment plants. Sand filters contaminated by NORM may be used as remediation materials for tailing ponds. Used ion exchange resins with uranium are processed in the chemical treatment plant of uranium ores.

THE EUROPEAN METROLOGY RESEARCH PROJECT METRONORM

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The European Association of National Metrology Institutes (EURAMET) represents and supports the European Metrology Research Programme (EMRP) annually. The EMRP is a long-term program for research and development, with high quality in the metrological community in Europe, which provides essential support to underpin the quality of our lives. One of the supported projects is The European Research Project MetroNORM "Metrology for Processing Materials with High Natural Radioactivity", contract identifier JRP IND57. The aim of this project is to develop and apply new measurement systems for NORM (Naturally Occurring Radioactive Materials) industry. The MetroNORM project brings together twelve national metrology institutes and two other research institutes.
Naturally occurring radionuclides are present in many natural resources. Industry sectors are focused on the measurement of ionizing radiation originating from artificial radionuclides. Naturally occurring radionuclides are often taken as part of the natural background, regardless of their concentrations. This project includes 9 industry sectors: extraction of rare earths, niobium/tantalum ore processing, TiO_2 pigment production, phosphate industry, building materials, tin, lead and copper smelting, water industry, recycling industry and oil and natural gas processing.
New laboratory and on-site methods and measurement systems with total relative uncertainties lower than 10 % (k = 1), reference materials, standard sources, improvement of nuclear data of ^{238}U, ^{235}U, ^{232}Th radionuclide series and study of ^{138}La decay will be prepared and developed to ensure accurate and precise measurements. All this will help to increase the production effectiveness and improve and optimize production technology in NORM and TENORM industries.

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LNR: A RADIATION LABORATORY WITH HIGH LEVELS OF NATURAL RADIOACTIVITY FOR TESTING INSTRUMENTS UNDER REAL WORKING CONDITIONS OF TEMPERATURE, HUMIDITY AND PRESSURE

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The new Basic Safety Standards (BSS) have been approved by the Council of the European Union. In particular, the Directive applies to the management of existing exposure situations, including the exposure of members of the public to indoor radon, the external exposure from building materials and cases of lasting exposure resulting from the after-effects of an emergency or a past activity.
The Laboratory of Natural Radiation (LNR) is located in an old uranium mine site where the values of natural radioactivity allow testing instruments and detectors under typically variations of environmental conditions. This is a laboratory with enough requirements for checking the adequacy of those instruments used in NORM industries for measuring natural radiation.
We present the results obtained at LNR concerning intercomparison exercises carried out with regard to external gamma dose and radon gas. First of all, the results achieved by 19 instruments belonging to 12 institutions from 7 different countries in terms of gamma dose rate are discussed. The tested gamma detectors measured the dose rate in three locations with reference values from 110 to 1800 nGy h^{-1}. The measurements show agreement within 25 % in all sites. Evaluation criteria based on accuracy and statistical uncertainty were also carried out and 25 % of participants passed the test in all points [1]. Additionally, new results about the quality assurance of radon distribution in the radon rooms of LNR are shown. Continuous measurements performed simultaneously in different positions of the room provide a good evidence of the homogeneity of radon gas concentration. Furthermore, the independence of this homogeneity from external environmental conditions is also discussed.

[1] Gutierrez-Villanueva, J.L., Sainz-Fernandez, C., Fuente-Merino, I., Saez-Vergara, J.C., Correa-Garces, E. and Quindos-Poncela, L.S. (2013). INTERCOMPARISON EXERCISE ON EXTERNAL GAMMA DOSE RATE UNDER FIELD CONDITIONS AT THE LABORATORY OF NATURAL RADIATION (Saelices el Chico, Spain). *Radiation Protection Dosimetry*, 155 (4), 459 – 466.

SIMULTANEOUS DETERMINATION OF ^{NAT}U, ^{241}AM, ^{90}SR/^{90}Y AND ^{137}CS BY LIQUID SCINTILLATION COUNTING AND PARTIAL LEAST SQUARES IN WATER SAMPLES

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Keywords: liquid scintillation counting, chemometrics, alpha-beta discrimination

Liquid scintillation counting is meaningful technique for the determination of alpha and beta emitters. It has appropriate detection efficiency but poor resolution which hinders simultaneous determination of different emitters in the same spectrum. In the case of beta emitters overlapping is unavoidable on account of their continuous spectra. In addition, although alpha and beta emissions have different energetic range, on account if their different excitation efficiency, alpha and beta signals are also overlapped in liquid scintillation spectra.
However, simultaneous determination of several alpha and beta emitters, just by an easy and fast sample treatment and measurement by liquid scintillation counting, avoids expensive and time consuming radiochemical separations.
To achieve this aim, in this work evaporation of the sample and liquid scintillation spectrometry with alpha/beta discrimination and Partial Least Square (PLS) calibration was used to determine different alpha and beta emitters (^{nat}U, ^{241}Am, ^{90}Sr/^{90}Y and ^{137}Cs) in composite water samples.
The analytical procedure consist on evaporate to dryness a 100 mL aliquot of the sample. The precipitated obtained is dissolved in 10 mL of deionised water acidified by HCl to pH = 1.5. This treatment entails a 10 times concentration and the subsequent improvement in MDA. Also after this treatment most of the samples maintain a constant quenching do to the controlled media. Afterwards 8 ml aliquot of this sample is mixed with 12 ml of cocktail in PE vials. Then the sample is counted with the ultra low level liquid scintillation spectrometer QUANTULUS 1220, with alpha beta discrimination mode [1].
For each radionuclide, three replicates for three different activity levels were analyzed and these spectra were used as calibration set. Several composite spectra simulated by the addition of different single isotopic spectra were used to validate the PLS model.

[1] Fons, J., Zapata-Garcia, D., Tent, J., Llauradó, M., (2013). Simultaneous determination of gross alpha, gross beta and ^{226}Ra in natural water by liquid scintillation counting. *Journal of Environmental Radioactivity*, Vol. 125, 56-60.
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RADIOLOGICAL INVESTIGATION OF DEPOSITED OIL SLUDGE IN HUNGARY

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As a result of the activity of oil industry significant amount of oil contaminated drilling sludge is originated has to be stored in safe reservoirs to avoid the pollution on environment.
In case of recent study the 2-2 samples were taken (20 and 40 cm depth) from 4 different locations of reservoir found in Zalatárnok (Hungary). The radionuclide content were determined by HPGe gamma spectrometer. The ambient gamma dose rate measurements were performed on the sampling sites with Automess AD6150 portable dose rate meter. Water samples were also taken from 3 monitoring wells and the Ra-226 content were measured after microcoprecipitation source preparation method with PIPS detector alpha-spectrometry.
The obtained results of gamma spectrometry (Ra-226 = 18.8 ± 1.1 – 40.4 ± 2.4 Bq/kg with mean of 31.4 ± 2.0 Bq/kg; Th-232 = 22.0 ± 2.0 – 52.2 ± 4.0 Bq/kg with mean of 34.5 ± 1.0 Bq/kg and K-40 = 356 ± 22 – 673 ± 40 Bq/kg with mean of 502 ± 32 Bq/kg) clearly proved that the average natural radionuclide content of the investigated samples did not exceed the world average of the soils (Ra-226 = 32 Bq/kg, Th-232 = 45 Bq/kg and K-40 = 412 Bq/kg according to UNSCEAR 2008).
As a result of ambient gamma dose rate measurements the obtained values ranged between 67 – 85 nSv/h with average of 76 nSv/h, which is equivalent to world average of natural background radiation.
The Ra-226 activity concentration in the investigated water samples (3.4 ± 1.4 – 5.2 ± 1.2 mBq/l with mean of 4.5 ± 1.5 mBq/l) were relatively low compared to the Hungarian drinking waters published in UNSCEAR2008.
On the basis of the results it can be stated that the radiological features of the investigated by-product does not spell danger on workers in radiological point of view.

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CALIBRATION OF AMBIENT DOSE RATE METERS FOR LOW DOSE RATES AT NATURALLY OCCURRING RADIOACTIVE MATERIALS

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Since more than 20 years the German Federal Office for Radiation Protection (BfS) in collaboration with the Wismut GmbH has offered and evaluated calibration measurements for users of ambient dose rate meters. Three circular concrete surfaces with different ambient dose rates between 0.1 µSv/h and 0.8 µSv/h have been constructed at a site belonging to the Wismut GmbH, the former uranium mining company. These surfaces are used as calibration standards. The service was established because ambient dose rate devices are not factory-calibrated for measurements on areas contaminated with naturally occurring radionuclides. This is partly due to the special kind of radionuclide mixtures, partly due to low dose rates near the background level. BfS was given the task to provide reference values of high quality for the "off-label" use of dose rate meters. For that purpose a BfS transfer standard is calibrated against to probes of the German national metrology institute PTB.
Problems resulting from the transition H_x to H*(10) will be discussed.

NORM ANALYSES BY LABORATORIES AND INDUSTRIES: SOME BASIC STATISTICS ON MATERIALS AND METHODS

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Keywords: NORM, Analysis, methods, reference material

In the scope of the Euramet MetroNORM[1] project, questionnaires were sent out to radiological laboratories and companies involving NORM. The area covered includes the entire European Union, carriers are several JRC affiliated institutes, the EAN NORM network and the COST NORM4Building network.
The questionnaire form was different for laboratories and industrial companies. Industrial companies were asked about portal monitors, on-site (portable) instrumentation and their on-site laboratory infrastructure. Laboratories were asked about (amongst other things) about reference materials, quality control measures and analytical methods.
Statistical facts such as most commonly used analytical methods, reference materials and the different types of samples requiring analyses were derived from the data. This poster presents a brief overview of most interesting findings from the Metro NORM questionnaire.

[1] http://www.euramet.org/fileadmin/docs/EMRP/JRP/JRP_Summaries_2012/Industry_JRPs/IND57_Publishable_JRP_Summary.pdf