NEWSLETTER

52nd ISSUE • DECEMBER 2024

EDITORIAL

Dear Readers,

We are delighted to connect with you again as we approach the end of the year to share the latest updates from the European ALARA network. This edition highlights key developments, upcoming events, and insights from the radiological protection community.
As always, we are committed to keeping you informed and engaged with the network's activities and progress. We hope you find this newsletter both enriching and enjoyable.

The first topic we will cover is the 3rd European NORM Association (ENA) Workshop, which will include an integrated session from the EAN. This workshop provided valuable insights and discussions on the latest developments in the field of Naturally Occurring Radioactive Materials (NORM), with a particular focus on regulatory practices and technological advancements. You can find more details from this event on pages 2 to 7.

The second topic will explore the contribution of radon to natural background radiation, in Slovenia, where radon accounts for over 80% of the average annual dose. This section will delve into the latest research findings and the ongoing efforts to mitigate radon exposure in the country. Full details can be found on pages 8 to 11.

We are pleased to highlight the upcoming 11th International Conference on NORM on page 12. This event will bring together experts in radioprotection, regulation, and industries dealing with NORM to share insights, advancements, and best practices.

We are pleased to inform you that the upcoming 21st EAN Workshop entitled "Optimization of the transport of radioactive material" will be held from the 23 to 25 of April 2025, in Petten, The Netherlands (page 13). Please mark this date in your calendar!

We hope you enjoy reading our newsletter. We also wish you a wonderful end of the year and a joyful holiday season.

See you next year!
The Editorial Team.

COORDINATED BY NUCLEAR PROTECTION EVALUATION CENTRE (CEPN, FRANCE) AND UK HEALTH AND SAFETY AGENCY (UK HSA, UNITED KINGDOM)
EUROPEAN ALARA NEWSLETTER
ISSN 1270-9441
C/O CEPN - 28, RUE DE LA REDOUTE - F-92260 FONTENAY-AUX-ROSES
WEB: HTTP://WWW.EU-ALARA.NET

3rd European NORM Association (ENA) workshop with integrated EAN session

Julie Morgan
European ALARA Network Steering Group
UK Health Security Agency (UKHSA)
Harwell Campus, OX11 0RQ, UK

The European NORM Association (ENA) organised its 3rd Workshop from 15 to 17 May 2024 held at the Instituto Superiore di Sanità, Rome. The objective of ENA is to promote and advance radiation protection in the context of exposure to NORM. The workshop dealt with various aspects of NORM including circular economy and the recycling of residues, regulatory approaches, radon, and sampling & characterisation of NORM. The third session was dedicated to the European ALARA Network and focussed on the application of the optimisation process to NORM materials and wastes, chaired by Julie Morgan and Cristina Nuccetelli (former EAN Steering Group members). The final scientific program is available on the ENA webpage (https://ena-norm.eu/event/3rd-ena-workshop/). This summary provides a brief overview of some of the topics discussed in each session including the dedicated EAN session.

Introduction: Invited speaker

Burçin Okyar, IAEA, presented an overview of NORM in the IAEA Safety Standards domain, an update concerning the ISEMIR-N Platform and results of an intercomparison exercise on NORM analysis. IAEA emphasize that dose assessment is the key to assessing effective dose to workers in industries where NORM is present and methodologies for dose assessment are already available. Burçin reported that typical assessed worker doses are less than 1 mSv, with some exceptions for workers in uranium and thorium mining and rare earths extraction. There is also potential for higher exposures if adequate control measures are not implemented.

In 2022, IAEA launched a digital information exchange platform ISEMIR-N (https://nucleus.iaea.org/isemir) that allows NORM industrial operators to share occupational exposure data and associated information to obtain feedback used to strengthen and optimise their radiation protection programmes. Information collection via ISEMIR-N will aid dose assessment benchmarking and analysis across different industries using NORM.

An essential element of worker dose assessment is characterisation of NORM samples (nuclides, activity concentrations). To investigate current approaches, a joint IAEA/EEAE (Greek Atomic Energy Commission) intercomparison exercise was carried out involving the radioanalysis of NORM samples by 31 laboratories across 21 countries. Preliminary results presented showed diversity in sample preparation and measurement procedures but clear evidence of competence in the characterisation of NORM samples.

Session I: Circular economy / reuse & recycling of NORM residues

Chairs: Cristina Nuccetelli (ISS, Italy), Stephane Pepin (ENA)

This session included an introduction by the ENA Chair, Rob Wiegers, IBR Consult BV, about the importance of critical raw materials (CRM) and the need to ensure a sustainable and secure supply of these materials within the EU. Part of the proposed approach includes the recovery of CRM from mining wastes and landfills, and it was highlighted there is a need for the ongoing development of separation techniques to recover CRMs from these wastes.

Presentations in this session focussed on the reuse and recycling of NORM residues and several presenters (W. Schroeyers, Hasselt University, K. Navrátilová Rovenská, SURO, L. Ferrara, Politecnico di Milano,) gave examples where bulk NORM residues (eg phosphogypsum, coal fly ash) could be treated and then incorporated in the production of cement-based products used in the construction industry.

Nazanin Love, Hasselt University, presented the findings of a qualitative study investigating stakeholders' perception of the usage of NORM contained by-products in cement-based building materials. One of the key findings being that whilst most stakeholders had a good awareness of the environmental benefits, many are unwilling to be early adopters and take on potential financial and safety risks from using new building materials with unproven performance and long-term durability. There were high concerns about the radioactive

component of the material and the long-term effects that could have on occupants living in constructions. Stakeholders wanted evidence and certification that materials were safe with no long-term negative effects on health.

Session II: Regulatory approach

Chairs: Burçin Okyar (IAEA), Rosabianca Trevisi (INAIL, Italy)

Heloisa Fonseca, HERCA, provided an overview of the activities of HERCA's National Radiation Sources Working Groups on radon, NORM and building materials. HERCA published guidance in 2021 for the application of exemption and clearance concepts in the regulation of NORM[1] as a means to assist national authorities with the implementation of the EU BSSD[2] provisions on NORM. HERCA collated responses from 21 countries to explore the degree of international harmonisation of approach and found that the majority of countries has adopted the exemption/clearance levels specified in the EU BSSD and all countries had adopted a dose criterion of 1 mSv per annum for workers, with half of the countries adopting more restrictive dose criteria for the public of 0.01-0.3 mSv per annum. Notably, NORM waste (waste with activity concentrations above exemption /clearance levels) is not always regulated as radioactive waste depending on the country. Around 80% of countries allow conditional disposal of NORM waste to conventional landfills. One of the conclusions of the guidance is that more collaborative efforts are needed to promote circular economy principles for NORM residues in line with EU BSSD. HERCA have also carried out a survey on the use of NORM residues in building materials and a report will be published in due course.

Nathalie Impens, SCK CEN (Belgian Nuclear Research Centre), presented a decision-making framework (MAESTRI) to consider different options for management of NORM residues and rank options based on economic, environmental and social criteria. In essence, the framework presented was a cost benefit analysis tool for NORM residue waste management. A recurring theme of the workshop, and highlighted in this presentation, is that the ideal option of reuse and recycle of residues is currently limited by the cost associated with the extraction of radionuclide content from residues (NORM treatment), as well as existing technology.

Raphael Stroude, FOPH, presented a "New NORM-Waste Directive in Switzerland" outlining the Swiss approach to the management of NORM wastes to ensure compliance with a 0.3 mSv annual public dose limit, with this dose threshold also applied to waste exported for disposal. It was noted that one of the main challenges was the many stakeholders involved in the waste disposal process, and the fact that radioactivity was not the only hazardous substance present in the residues (e.g. heavy metals). This emphasised that NORM disposal options/routes require an all-hazards approach and often the radioactivity is not the most hazardous component.

Anne Cordelle, IRSN (Institute for Radiation Protection and Nuclear Safety), spoke about the emission of gamma radiation from building materials and calculation of the activity concentration index, ACI, of common building materials. An ACI < 1 means the building product would give rise to an added dose of <= 1 mSv per year (external exposure) and would be suitable for use in accordance with the reference level of 1 mSv per year specified in the EU BSSD. Above this level, further calculation is needed to refine the dose assessment by taking into account the manner in which the material will be used (layout, thickness etc) and use of the CEN method was discussed. Under French regulations, the construction company is required to take into account the activity concentration indexes of all materials when designing the building.

Session III: European ALARA Network (EAN) session

Chairs: Julie Morgan (UKHSA, UK) and Cristina Nuccetelli (ISS, Italy)

The EAN chair, Fernand Vermeersch, SCK CEN, gave the opening presentation for the session providing an overview of the network's objectives and recent activities, a summary of the optimisation process and its application to NORM industries. It was stated that an optimisation approach to dose restriction is the cornerstone of radiation protection safety culture.

Sharon Ely, UKHSA (UK Health Security Agency), presented an overview of the UK regulations for NORM, detailing how a graded approach to regulatory control is achieved for occupational exposure and control of NORM materials and residues. A case study was presented involving the remediation of a legacy thorium gas mantle factory site, where the site had to be cleared prior to redevelopment for residential use. Tonnes of soil and building rubble was assessed with exempt NORM wastes going to general landfill, and a small

proportion of more active waste sent to an authorised radioactive waste disposal site.

Rafael Garcia-Tenorio, University of Sevilla, spoke on the circular economy as applied to the titanium dioxide (TiO_2) industry in south-west Spain. The commercial production of TiO_2 pigments gives rise to several co-products (coperas, iron sulphate monohydrate and red gypsum) including a residue/sludge. The coperas and iron sulphate co-products are treated and re-used for agricultural applications and play an important role in the economical balance of the TiO_2 industry in Huelva, Spain. The red gypsum has been evaluated for use in cement production.
Constantinos Potiriadis, EEAE, presented optimisation strategies for NORM industries and legacy sites in Greece. An overview of the legislative framework was given along with a map of which types of NORM industries are distributed around Greece. Industries that are using NORM are required to characterise the levels of NORM in their materials, identify activities that might cause the presence of NORM in water, and obtain authorisation from the regulatory body should they plan to incorporate NORM residues into building materials. In addition, an extensive monitoring programme is applied to NORM industries and NORM legacy sites. The presentation included multiple case studies, one detailing the decommissioning of a phosphoric acid production plant in Drapetsona, where initial surveys found dose rates between 0.1 - 65 μSv/h, radium-226 concentrations up to 50000 Bq/kg and uranium-238 concentrations up to 5000 Bq/kg in the buildings and construction materials. An extensive decommissioning project was successfully undertaken so that the site could be released from further radioactive regulatory control. Doses to workers involved in the decommissioning were monitored using TLD dosemeters, urine analysis and whole body counting. No uptake of activity was detected by the sampling and whole-body counter measurements. No worker received an effective dose greater than 1 mSv during the decommissioning works.

Flavio Trotti, ARPAT-Veneto (Regional Agency for Environmental Protection and Prevention of Veneto-Italy) presented a general methodology for the characterization of exposure critical scenarios in industries involving NORM using a graded approach. It is intended the methodology can be adapted to a specific Industrial sector or scenario. The first phase involves an analysis of the industrial process to identify the processes/situations that are of significance from a radiation protection standpoint, and assessment of NORM activity concentration of the matrices of interest. In the second phase, the relevant exposure scenarios are used to assess the dose to workers and the public. Several examples were given outlining how the methodology would be applied to TiO2 pigment production and cement production processes.

Franz Kabrt, AGES, spoke about the handling of contaminated commodities, the presence of radioactive material in consumer products and current developments in Austria. Typical NORM activity concentrations for the consumer products of interest were presented and though in excess of exemption limits, most products had not been labelled as radioactive by the manufacturer. AGES maintain a database of affected items which is updated based on emerging research or alerts are received (ie portal monitor alarm). This is used as an information resource by the regulatory authority to facilitate decision making and assist with the control of manufacture and distribution of such items with the aim of limiting exposure of the public.

Laureline Février, IRSN, presented an overview of the RadoNorm project and the research questions emerging related to NORM. The objective of RadoNorm Work Package 2 (WP2) is to provide a better characterisation of exposures of the public and workers and biota to NORM. Information and data were collected from 22 European countries to characterise NORM exposure situations and identify where gaps in knowledge exist. They found that there are multiple NORM industrial activities not currently listed in the EU BSSD Annex VI, and IAEA SRS 49 including, for example, the building and construction industries. A further objective was to acquire knowledge on the factors and processes that impact on the transfer of NORM in the environment to enable transport and dispersion models to be developed to assist dose assessments. It was noted that the behaviour in the environment of some radionuclides such as polonium and radium is still poorly understood and further data is needed.

Session IV: Young professionals

Chairs: Christian Kunze (IAF-Radiokoölgie GmbH, Germany), Lonneke Van Bochove (Stralingsupport BV, The Netherlands)

This afternoon session provided opportunity for young professionals to present and included time for a selection of poster presentations. During the three-day workshop there were over 20 posters displayed, encompassing a wide variety of NORM related studies.

Marcin Plachciak, Amphos 21 Consulting, gave an overview of the decommissioning of a NORM legacy site associated with the phosphate industry. The main wastes arising were large volumes of phosphogypsum and fluorite sludge, both containing elevated levels of NORM, which are stored/buried in ponds and stockpiles. This was another example of the fact that the options for remediating sites where NORM residues have been buried on-site, or in landfill, is exceptionally difficult after the fact, and hence it is imperative to consider waste management whilst the plant is still operational.

Linde Pollet, EC, presented a study investigating the hazards posed by the presence of NORM in geothermal energy installations and how the risks were perceived by those affected. This study involved a qualitative aspect including interviews with those working in the sector where the exposure risk is associated with specific maintenance tasks and waste management operations. Interestingly, the individuals affected did not perceive the occupational exposure risk as significant, perhaps due to their training and awareness of control measures in place. However, there can be concern from members of the public near to a geothermal installation, but there is often little communication to the public on the radiation risk.

Misbah Javed, University of Campania, Italy, presented the methodology and results from a study where active measurements of radon (^{222}Rn) and thoron (^{220}Rn) exhalation were carried out for natural building materials commonly used in the Campania region using a high-resolution alpha spectrometry approach, with exhalation rates being significantly higher for pumices, yellow tuff and lavic stone materials.

Session V: Radon & NORM

Chairs: Federica Leonardi (INAIL, Italy) and Boguslaw Michalik (GIG, Poland)

Sonia Fontani, ISIN (National Inspectorate for Nuclear Safety and Radiation Protection), presented details of a new national NORM database under development, intended to collect an updated inventory of NORM-related industrial sectors in Italy, to include details of NORM content per material type (raw material, residue, effluent, products). This will sit alongside an existing section of the SINRAD database used to collect information on radon gas concentration measurements carried out in workplaces, school and homes in Italy.

Govert de With, NRG, and Andrea Maiorana, ISS, each presented details of studies assessing the thoron exhalation rates, and radon exhalation rates, respectively from several building material samples.

Jörg Dilling, BfS (Federal Office for Radiation Protection), gave an overview of the presence of radon (^{222}Rn) and associated decay products (^{210}Pb) arising from the production of liquid natural gas. The build-up of ^{210}Pb scales and residues on pipework and filters present an occupational risk to workers tasked with maintaining and cleaning plant items. To ensure workers doses from potential intakes remains below 1 mSv suitable PPE including RPE is needed for specific work activities.

Carmela Carpentieri, ERA, gave an overview of the history and objectives of the European Radon Association (ERA), and the need to promote public awareness of radon through the European Radon Day on 7th November, radon videos and their website. ERA also contribute to the education and training in all aspects of radon and serve as a pool of experts to national and international agencies. The Journal of the European Radon Association (JERA) provides an open access focus on radon research and practices.
The session concluded with a panel discussion on radon and NORM in workplaces.

Session VI: NORM in industry and the integrated approach of radioactive and non-radioactive contaminants

Chairs: Gennaro Venoso (ISS, Italy) and Rob Wiegers (IBR Consult BV, The Netherlands)

Jelena Mrdakovic Popic, DSA (Norwegian Radiation and Nuclear Safety Authority), spoke on an "Integrated Approach in Regulation and Management of Exposure Situations Containing NORM and Other (non-radioactive) Hazards". Radioactive and chemical hazards have the potential to cause damage to human health and the environment and both are found in different NORM involving exposure situations. However, the legislative approach for these hazards is currently covered by separate regulations with different exposure criteria in most countries making a holistic approach to regulation challenging. Assessment models are typically used to estimate the risk from

these wastes to humans, animals and the environment but the models are limited by uncertainties in the source term and what is known about the environment and exposure pathways (i.e. transport of hazardous substances through the ecosystem, critical groups, habits, exposures, etc). This can be addressed by better characterisation of NORM sites and measurement of site-specific uptakes of the hazardous substances in plant and animal species.

Per Varskog, Zpire Ltd, presented on the topic of decommissioning NORM surveys performed in the oil and gas industry. These surveys are typically performed as part of the planning for the dismantling and scrapping of an installation to assess where NORM is present and estimate amounts of NORM waste present (scales and sludges typically contain elevated activity concentrations of ^{226}Ra, ^{210}Pb, ^{238}U). An overview of the survey process was covered with many pictures of real-life examples of decommissioning projects.

Paolo Cerri, ENI, spoke on NORM in the oil and gas industry, and presented example data for the maximum contact dose rates (0.8 - 8 μSv/h) at specific locations on plant where residues accumulate. Corresponding maximum dose rates at the operator positions were between background and 0.5 μSv/h. In the scenario presented, external dose rate exposure over a calendar year would be less than 0.2 mSv. The employees involved in maintenance activities on the plant where NORM is present are at risk of intakes if suitable RPE (FFP2 mask) isn't worn. In the scenario presented the committed effective doses for maintenance work where PPE+RPE is worn was assessed to be very low at approximately 0.2 μSv per year, versus 5.2 μSv per year where no mask is worn.

Session VII: Sampling & characterization

Chairs: Christian Di Carlo (ISS, Italy) and Wouter Schroeyers (Hasselt University, Belgium)

The final workshop session was dedicated to work done to investigate sampling and characterisation processes for NORM materials.

Christian Kunze, IAF-Radiokoölgie Gmbh, presented a project involving radiological characterisation of deep-sea (manganese) nodules.

G Trotta, CRNR, presented a technique for the simultaneous radiochemical determination of radium, thorium and uranium in solid matrices.

Professor Konstantin Kovler, NBRI, Technion - Israel Institute of Technology, spoke on the challenges in controlling NORM in building materials. Most common building materials have very low activity concentrations of ^{226}Ra, ^{232}Th, ^{40}K nuclides compared to those found in industrial residues. There is not a standard approach to determining the activity concentration index mentioned in the EU BSSD for building materials at a given reliability of decision making (at least 95% confidence interval). A universal ACI conformity assessment algorithm needs to be developed to implement the EU BSSD requirements for controlling ACI in building materials.

Mauro Magnoni, ARPA-Piedmont , presented work on self-absorption correction in gamma spectrometry ^{210}Pb measurements in complex NORM samples.

Similarly, Tereza Doksanska, SURO, spoke on optimisation of ^{210}Pb gamma spectrometry determination in NORM: A comparison of the different self-attenuation correction factor approaches.

Alejandro Barba-Lobo, University of Huelva, presented a project that analysed the space-time evolution of pollution due to NORM and heavy metals in several rivers by studying soil and sedimentation samples. Elevated levels of ^{238}U series radionuclides were seen presumably as a result of pollution from a phosphogypsum pile located near a large industrial complex near the estuary.

Flavio Trotti, ARPA-Veneto, spoke on the topic of disposal of NORM residues in landfill and a methodology for standardized estimates of compliance to exemption levels in terms of effective dose for members of the public. Under Italian legislation, NORM residues can be exempted for disposal to landfill provided an assessment demonstrates that the resulting effective dose to members of the public is 0.3 mSv per annum or lower. The work presented outlined a method for carrying out this dose assessment using the methodology In RP122 part II[3] and occupational Intake dose coefficients from ICRP137[4], to produce modified clearance levels based on more realistic assumptions relating to the NORM waste to ultimately determine compliance with the dose criterion of 0.3 mSv per annum.

Final comments

The EAN extends its gratitude to ENA and the workshop organising committee for inviting the network to contribute to session 3.

References

1 Garcia-Talavera M., Mrdakovic Popic J., Görts P., Pepin S., Jones K. (2021). Application of the concepts of exemption and clearance to the regulation of naturally occurring radioactive material (NORM) across HERCA countries. *HERCA Report 2021*, HERCA WG NAT.

2 Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, *Official Journal of the European Union*, L13/1, 17 January 2014.

3 EC (2002). Practical use of the concepts of clearance and exemption - Part II: Application of the concepts of exemption and clearance to natural radiation sources. European Commission, Luxembourg, Radiation Protection 122

4 Paquet F, Bailey MR, Leggett RW, et al. ICRP Publication 137: Occupational Intakes of Radionuclides: Part 3. *Annals of the ICRP*. 2017;46(3-4):1-486.

Radon contributes more than 80% to the average annual dose from natural background radiation in Slovenia

Selma Fijuljanin
Slovenian Radiation Protection Administration (SRPA), Ministry of Health

Introduction

A new assessment of the annual natural background radiation dose in Slovenia has been completed, driven by the updated measurements of radon concentrations in homes and workplaces, levels of radioactive isotopes in soil, food, drinking water, and air, as well as radiation emitted from building materials. Additionally, the assessment incorporates newly introduced dose coefficients for radon exposure.

The new estimate of the average annual dose from natural background radiation per capita in Slovenia has increased from the previous estimate **2.5–2.8 mSv**, assessed in 2001, to **5.98 mSv ± 0.60 mSv** in 2023 [1],[2]. The breakdown of contributions is as follow :

Average annual dose from natural background radiation	2001	2023
Soil radioactivity	0.2 mSv	0.11 mSv
Building materials	0.3 mSv	0.21 mSv
Cosmic radiation	0.4 mSv	0.36 mSv
Ingestion of natural radionuclides from food, water, and air	0.4 mSv	0.36 mSv
Radon and its progeny	1.2-1.5 mSv	4.97 mSv
Total	**2.5-2.8 mSv**	**6.0 mSv**

The new annual dose estimate from natural background is substantially higher due to a considerably higher estimate of radon contribution, which now represents 83% of the total dose. The higher estimated contribution of radon is due to the use of increased dose coefficients for radon, and recent measurements showing elevated radon levels in buildings compared to previous years. Average annual doses from natural background radiation are ranging from 1.99 mSv (0.97 mSv due to radon) in Piran, the municipality with the lowest average radon concentration in buildings, to 17.77 mSv (16.63 mSv due to radon) in Mirna Peč, the municipality with the highest average radon concentration in buildings [2]. Other natural radiation contributions (external exposure due to cosmic radiation and radioactive elements in soil and building materials as well as internal exposure due to ingestion of radioactive elements in food and drinking water) have not significantly changed compared to previous analyses.

National Radon Program

In comparison to ICRP 65, the recommended dose coefficients for radon and radon progeny inhalation have doubled based on data showing a higher risk for lung cancer due to radon exposure. Under ICRP 137, the new recommended dose coefficient is 3 mSv per mJ h m^{-3} (approximately 10 mSv/ WLM) for most exposure scenarios. For workers involved in significant physical activity or working in tourist caves, the dose coefficient is higher, 6 mSv per mJ h m^{-3} (approximately 20 mSv WLM) [3].

Slovenia updated radiation protection legislation in 2017 and 2018, transposing Council Directive 2013/59/Euratom of 5 December 2013 into national law. The dose coefficients for radon recommended in ICRP 137 stepped into effect on January 1, 2023, under the Decree on the National Radon Program.

Based on radon concentration measurements in the soil, and taking into account different geological compositions, the content of radium-226 in the rock, its permeability, and average annual indoor radon concentration levels, areas with higher radon levels have been designated in the National Radon Program. These areas include territories of 24 municipalities (Figure 1), primarily located in the south, southeastern and southwestern regions of the country [4].

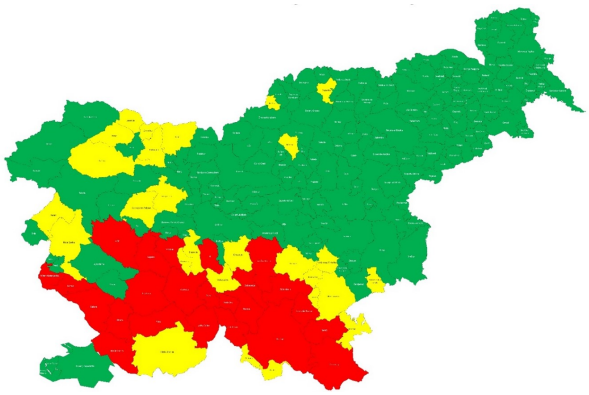


Figure 1: Radon map [5].

Methodology of dose estimation

Protection Administration (SRPA) in 2023. The company is a recognized radon measurement contractor with expert knowledge on radon exposure. Their dose estimation took into account historical measurement results as well as results from recent measurement campaigns.

The beginning of radon measurements within the framework of the national program dates back to 1990. Buildings designated for educational, cultural, and healthcare programs, with particular focus on schools and kindergartens, have had measurements conducted continuously since 1990. The latest update to the legislation in 2017 ensured an increase in funding allocated for systematic radon monitoring and the commencement of measurements in citizen dwellings. Annually 325 passive measurements and 60 complex measurements are made, primarily in schools and kindergartens. There are also approximately 480 measurements made in dwellings, with a particular focus on areas with higher radon concentrations are performed. Since 2021, employers in areas with higher radon concentrations have been legally obligated to conduct radon measurements at workplaces located at ground and basement levels. All measurements are reported to SRPA and entered into the Radon register.

As part of the assessment more than 7000 radon concentration measurements have been included, carried out by ZVD d.o.o. between 2018 and 2023. This encompasses measurements conducted in kindergartens, schools, and residential buildings under the national SRPA program, as well as measurements in companies stemming from individual requests. The data indicates that the measurements have primarily focused on areas with higher radon concentrations (Figure 2) [2].

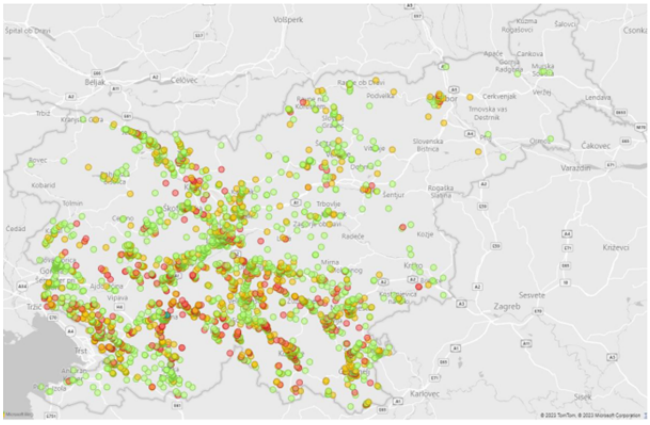


Figure 2: Map of radon measurements (ZVD d.o.o.: 2018 – 2023). The colors of the circles indicate levels of measured radon concentrations at locations; green < 300 Bq/m³, yellow < 1000 Bq/m³, and red > 1000 Bq/m³ [2]. Precision: "Bq/m³" stands for becquerels per cubic meter, a unit measuring the concentration of radioactive activity in the air.

For areas where ZVD d.o.o. did not have available measurements, radon data from a comprehensive national measurement campaign from previous decades conducted by the Jožef Stefan Institute were used. Since previous measurements have shown that radon concentrations are higher in winter than in summer, seasonal differences were taken into account in the analysis. Numerous measurements in schools and kindergartens, conducted both in winter and summer, indicated that the ratio of winter to summer concentrations is lower in karst areas due to convection, whereas it is higher in other regions due to diffusion. Based on these findings, a ratio of **2** was established for municipalities with higher radon concentrations, and a ratio of **3** for remaining municipalities, which were then used to calculate the average annual radon concentration for buildings where measurements were only taken in one season. In cases where multiple measurements were available from different years, the measurements were combined into a single average value. Measurements taken in poorly ventilated spaces that are not in constant use, such as basements and storage rooms, were not included. The calculated annual average radon concentration in buildings in Slovenia is 109 $Bq/m^3 \pm 33$ Bq/m^3 [2].
Data on the population, age groups, and number of workplaces for each individual municipality were obtained from the Statistical Office of Slovenia. Based on different daily movement habits of the residents, they were divided into three groups: school children up to 14 years old, the working population aged 15 to 64 years, and retirees aged 65 and over. The following exposure times to indoor radon were determined for each age group [2]:

Children

- For 9 months: 4 hours at school + 15 hours at home + 5 hours outside, resulting in 80% of time spent indoors and 20% outdoors.
- For 3 months (summer months): 19 hours at home + 5 hours outside, which is 80% of time indoors and 20% outdoors.

Active Population

- 5 days a week: 12 hours at home + 7 hours at work (based on job types in the municipality) + 1 hour outside for commuting + 1 hour outside at work + 3 hours outside, totaling 15 hours at home (80% indoors and 20% outdoors) and 9 hours at work (including 2 hours outside and commuting). Daily migrations between municipalities were neglected.

- 2 days a week: 19 hours at home + 5 hours outside (80% indoors and 20% outdoors).

Retirees

- 19 hours at home + 5 hours outside (80% indoors and 20% outdoors).

The dose from radon and radon decay products was calculated based on radon concentration and conversion factors:

$$D = DCF \cdot C \cdot F \cdot t,$$

where t is the time spent indoors, C is the measured radon concentration in Bq/m³, F is the equilibrium factor (0.4), and DCF is the dose coefficient (10 mSv/WLM) [2].
Using the equation, the median radon concentrations measured in each municipality and the average duration residents spend indoors, the average annual effective dose from radon and radon progeny for the population of Slovenia was calculated to be 4.795 mSv ± 0.598 mSv [2].
Radon is also present outdoors. Based on an average outdoor radon concentration of 10 Bq/m³, the equilibrium factor of 0.6, and assessment that residents spend 20% of their time outdoors, the estimated additional annual dose from outdoor exposure is approximately 0.177 mSv ± 0.018 mSv [2].
The total average annual dose from radon and its progeny in Slovenia is estimated to be 4.972 mSv ± 0.598 mSv [2].

The reassessment of the radiation dose for the population of Slovenia from natural background radiation shows that it roughly doubled compared to the previous estimate. While the contributions from natural radiation sources such as soil radioactivity, building materials, the intake of natural radionuclides through food, water and cosmic radiation have remained largely unchanged compared to earlier analyses, a significant increase has been observed in the contribution from internal exposure due to the inhalation of radon and radon decay products.

The WHO estimates that radon contributes to between 3% and 14% of all lung cancer cases worldwide, depending on the average radon level and the prevalence of smoking in the country [6]. An epidemiological study on the impact of radon on lung cancer incidence in Slovenia reviewed data from the last 40 years (1978-2017). The study linked data on lung cancer cases from the Cancer Registry of Slovenia, population statistics from the Statistical Office of Slovenia, and the radon map of Slovenia. According to the National Institute of Public Health, from 2010 to 2014, 1,279 people were diagnosed with lung cancer each year, making it the fourth most common cancer among both men and women. A study on lung cancer incidence revealed that approximately 60 individuals per year in Slovenia develop lung cancer due to radon exposure in residential environments, representing 5.5% of all newly diagnosed cases of this disease [7], [8].

Conclusion

The results of the epidemiological study and the reassessment of exposure due to inhalation of radon and radon progeny in Slovenia emphasize the need for continuing efforts to reduce health risks associated with elevated radon levels. Significant variations in annual doses between municipalities highlight the importance of ongoing radon monitoring, especially in areas with higher concentrations. Continued measurements will improve understanding of radon distribution and provide updated data for more accurate future risk assessments.

Raising public awareness and educating the public about the risks associated with radon exposure continues to be one of key priorities for SRPA. A significant challenge remains in motivating citizens to implement radon mitigation measures to reduce radon levels in their dwellings.

References

[1] Uprava Republike Slovenije za jedrsko varnost. 2023. *Poročilo o varstvu pred ionizirajočimi sevanji in jedrski varnosti v Republiki Sloveniji leta 2022*. https://podatki.gov.si/dataset/letna-porocila-o-varstvu-pred-ionizirajocimi-sevanji-in-jedrski-varnosti-v-republiki-sloveniji (10. 10. 2024).
[2] Žohar, Andrej; Gregor Omahen, Peter Jovanovič, Manca Podvratnik, Matija Škrlep, Marko Giacomelli. 2024. *Letna doza v Sloveniji zaradi sevanja naravnega ozadja.* LMSAR-20230024-AŽ-rev1. ZVD, 2024. https://www.gov.si/assets/organi-v-

sestavi/URSVS/Letna-doza-v-Sloveniji-zaradi-sevanja-naravnega-ozadja.pdf (10. 10. 2024).
[3] ICRP, 2017. Occupational intakes of radionuclides: Part 3. ICRP Publication 137. Ann ICRP 46 (3/4).
[4] *Decree on the national radon programme*. Official Journal of the RS, No. 18/18, 86/18 in 152/20.
[5] Uprava Republike Slovenije za varstvo pred sevanji. Zmanjšanje izpostavljenosti radonu. https://www.gov.si/teme/zmanjsevanje-izpostavljenosti-radonu/ (15. 10. 2024).
[6] *WHO Handbook on Indoor Radon: A Public Health Perspective*. Geneva: World Health Organization; 2009.
[7] Birk, Mojca; Tina Žagar, Sonja Tomšič, Katarina Lokar, Ana Mihor, Nika Bric, Miran Mlakar, Vesna Zadnik. 2022. *Impact of Indoor Radon Exposure on Lung Cancer Incidence in Slovenia*. Cancers 2024, 16, 1445 https://doi.org/10.3390/cancers16081445 (10. 10. 2024).
[8] NIJZ: *Incidenčna stopnja pljučnega raka*. https://obcine.nijz.si/kazalniki/K4.16 (10. 10. 2024).

SPECIAL ANNONCEMENT – UPCOMING NORM 11 CONFERENCE

The Ghana Atomic Energy Commission, Ghana Association for Radiation Protection, African ALARA Network and the Nuclear Regulatory Authority, Ghana, in association with the International Atomic Energy Agency, are organizing the Eleventh International Symposium on Naturally Occurring Radioactive Material (NORM XI) in Accra, Ghana.

NORM XI, the first-ever NORM Symposium to take place in Sub-Saharan Africa, will unite industrial, technical, scientific, and regulatory stakeholders involved in managing naturally occurring radioactive material (NORM). The event aims to foster the harmonization and streamlining of international approaches to radiation protection for workers, the public, and the environment, as well as the effective management of residues in industrial processes involving NORM.

The Symposium's theme is 'Broadening Optimization in Industrial Processes Involving NORM: A Focus on Sustainability in Extractive Industries.' Key topics will include industrial processes such as water treatment, oil and gas production, and the management of legacy sites, along with updates on progress made since the 2022 NORM X Symposium.

Participants can look forward to presentations, discussion forums, networking opportunities, refresher training courses, and side events hosted by relevant organizations. The program will highlight the latest research, the application of a graded approach, the utilization of NORM residues, and strategies for optimizing protection and safety.
This event is designed for operators of industrial processes involving NORM, technical service providers, radiation protection professionals, researchers, and regulators.

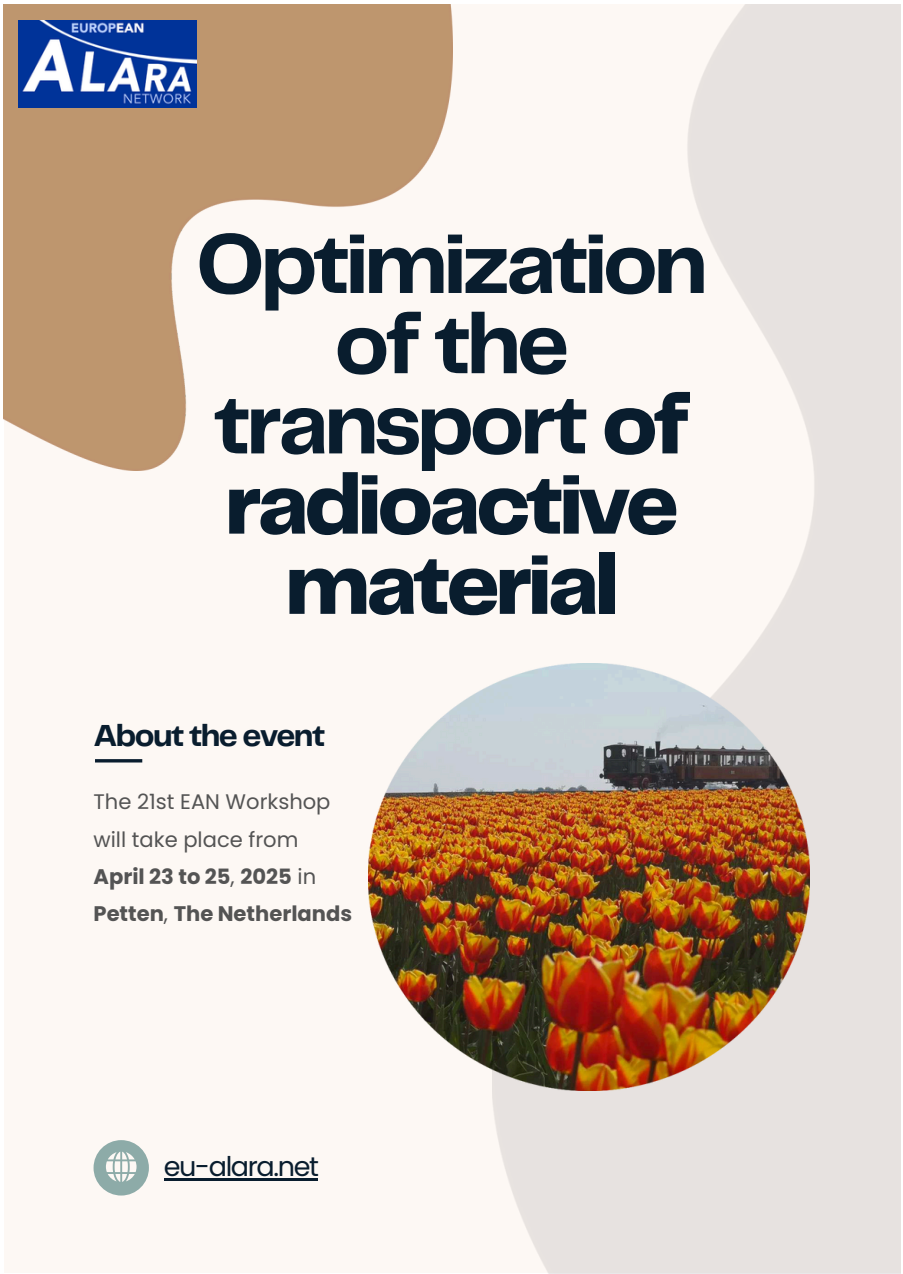
SAVE THE DATE – UPCOMING 21ST EAN WORKSHOP

The 21st EAN Workshop on "Optimization of the transport of radioactive material" will be held from 23 to 25 of April 2025, in Petten, The Netherlands.

Each year, over 20 million packages of radioactive material are transported globally across roads, railways, and shipping routes. These shipments serve three main sectors: non-nuclear industry and research (e.g. gamma radiography devices), medical applications (e.g. radiopharmaceuticals), and the nuclear industry (~5%).

While regulations aim to protect workers, the public, and the environment from radiation exposure, incidents, accidents, and security breaches can occur due to insufficient safety measures. Workers in the medical sector, for instance, often face higher exposure levels. To address these challenges, companies must establish robust radiological protection programs, authorities should conduct regular inspections, and training should be enhanced to improve the culture of radiation safety.

The 21st EAN Workshop will explore these issues by analyzing case studies, sharing feedback, and identifying recommendations to optimize radiation protection practices in transportation. Contributions from regional networks like AFAN, REPROLAM, and ARAN are encouraged.



Additional information about the workshop, including details on fees, registration, and more, will be available soon. Stay tuned!

HIGHLIGHTS OF 2024: key events that shaped the year and upcoming dates to mark in your calendar!

June 4-6, 2024 – ISOE European Symposium, organized by the European Technical Center of the collaboration with EPZ and ANVS was held in Rotterdam, The Netherlands.

June 18-19, 2024 - The ALARA Days, organized by the French Society for Radiation Protection, (SFRP) took place in Saint Malo, France.

July 7-12, 2024 – 16th International Congress of the IRPA: Radiation Harmonizing: Standing United for Protection, was held in Orlando, The United States.

December 6th, 2024 - Administrative Board and Steering Group meetings of the EAN. The meetings took place in the CEPN facilities, in Fontenay-aux-Roses, France.

21st EAN Workshop, 23-25 April 2025, Petten, The Netherlands.

15th International Congress of the French Society for Radioprotection (SFRP): June 17-19, 2025, La Baule, France.

7th European Congress of the IRPA, 1-5 June 2026, Liverpool, United Kingdom.

17th European Congress of the IRPA: 29th May – 2nd June 2028, Valencia, Spain.

Contacts

AUSTRIA
Franz KABRT
Osterreichische Agentur fur Gesundheit und Ernahrungssicherheit GmbH
Spargelfeldstraße 191, 1220 WIEN
Tel.: +43 (0)5 0555-32922 |
E-mail: franz.kabrt@ages.at

BELGIUM
Fernand VERMEERSCH
SCK•CEN
Boeretang 200, 2400 MOL
Tel: +32 14 33 28 53; Fax: +32 14 32 16 24
E-mail: fvermeer@sckcen.be

CROATIA
Mladen NOVAKOVIC
Radiation Protection Authority – EKOTEH Dosimetry
Vladimira Ruzdjaka 21, 10000 ZAGREB
Tel: +385 1 604 3882; Fax: +385 1 604 3866
E-mail: mlnovako@inet.hr

CZECH REPUBLIC
Jan KROPACEK
State Office for Nuclear Safety,
Syllabova 21, 730 00 OSTRAVA
Tel: +420 596 782 935; Fax: +420 596 782 934
E-mail: jan.kropacek@sujb.cz

DENMARK
Jens Peter BANGSGAARD
National Institute for Radiation Protection
Knapholm 7, 2730 HERLEV
Tel: +45 44 54 34 63
E-mail: krb@sis.dk

FINLAND
Maaret LEHTINEN
Säteilyturvakeskus – Radiation Practices Regulation
Laippatie 4, 00880 HELSINKI
Tel: +358 9 75988244 Fax: +358 9 75988248
E-mail: maaret.lehtinen@stuk.fi

European ALARA Newsletter
Coordinated by CEPN and UKHSA

ISSN 1270-9441
c/o CEPN
28, rue de la Redoute
F-92260 Fontenay-aux-Roses
http://www.eu-alara.net

FRANCE
Gwenaëlle LORIOT
Institut National des Sciences et Techniques Nucléaire, Commissariat à l'Energie Atomique (CEA/INSTN),
17 rue des Martyrs 38054 GRENOBLE Cedex 9
Tel: 01 69 08 25 82
E-mail: gwenaelle.loriot@cea.fr

FRANCE
Pascal CROÜAIL
Nuclear Protection Evaluation Centre),
28 rue de la Redoute 92260 FONTENAY-AUX-ROSES
E-mail: pascal.crouail@cepn.asso.fr

GERMANY
Ulrike Kulka
Bundesamt für Strahlenschutz,
Ingolstädter Landstrasse 1, 85764 OBERSCHLEISSHEIM
E-mail: UKulka@bfs.de

GREECE
Sotirios ECONOMIDES
Greek Atomic Energy Commission
P.O. Box 60228, 15310 AG-PARASKEVI
Tel: +30 210 6506767; Fax: +30 210 6506748
E-mail: sikonom@eeae.gr

ICELAND
Jónína GUÐJÓNSDÓTTIR
Rauðararstigur 10, 105 REYKJAVIK
Tel: +354 552 8200; Fax: +345 552 8202
E-mail: Jonina.Gudjonsdottir@gr.is

ITALY
Gennaro VENOSO
Istuto Superiore di Sanità – Technology and Health Department
Viale Regina Elena 299, 00161 ROME
Tel: + 39 06 4990 2203
E-mail: gennaro.venoso@iss.it

IRELAND
Barry O'CONNOR
Environmental Protection Agency,
Office of Radiological Protection
3 Clonskeagh Square, Clonskeagh Road, DUBLIN 14
E-mail: b.oconnor@epa.ie

NORWAY
To be decided
Norwegian Radiation and Nuclear Safety Authority
Regulatory Cooperation Programme,
Grini næringspark 13, 1361 Østerås, P.O. Box 329, 0213 OSLO
Tel: -
E-mail: -

SLOVENIA
Selma FIJULJANIN
Slovenian Radiation Protection Administration
Langusova 4, 1000 LJUBLJANA
E-mail: Selma.Fijuljanin@gov.si

SPAIN
Arturo PEREZ MULAS
Consejo de Seguridad Nuclear
Justo Dorado 11, 28040 MADRID
Tel: +34 91 346 02 62; Fax: +34 91 346 03 16
E-mail: apm@csn.es

SWEDEN
Petra Hansson
Stralsäkerhetsmyndigheten,
17116 STOCKHOLM
Tel: +46 8 799 44 38
E-mail: Petra.Hansson@ssm.se

Stefan ROESLER
Centre Européen de Recherche Nucléaire (CERN)
Groupe Radioprotection, Unité Santé, Sécurité et Environnement
Esplanade des Particules, P.O. Box 1211 GENEVA 23
E-mail: Stefan.Roesler@cern.ch

SWITZERLAND
Patrick VONLANTHEN
Swiss Federal Office of Public Health,
Radiation Protection Division,
Schwarzenburgstrasse 157, 3003 BERN
Tel: +4158 468 70 40;
E-mail: patrick.vonlanthen@bag.admin.ch

THE NETHERLANDS
Folkert DRAAISMA
NRG
Utrechseweg 310 B50-West,
6812 ARNHEM
E-mail: draaisma@nrg.eu

UNITED KINGDOM
Laura WOODWARD
UK Health Security Agency,
Leeds, LS16 6RW
Tel: +44 113 267 9041
E-mail: laura.e.woodward@ukhsa.gov.uk