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NORM IX

Report of Sessions

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Plenary Session

Denver and NORM IX

- Excellent place to host due to its long history with NORM

Continued interest in NORM - Internationally

- IAEA is developing documents to give practical guidance
- IAEA is holding regional workshops
- The feedback from the regional workshops will feed into IAEA conference on the Management of NORM in Industry 2020 (Vienna)
- IAEA would like input from technical experts and industry about what advice they would like regarding the dose coefficient factor for radon

Continued interest in NORM - Internationally

- ICRP continuing to work on its publication – Approach for Radiological Protection from NORM in Industrial Processes
- ILO looking to help address concerns of Industries with NORM about the application of standards
  - Working with IAEA on regional workshop and promotion of practical applications

Continued interest in NORM - Internationally

- UNSCEAR
  - updating its information on occupational exposures
  - New public exposure review about to be started
  - Update of UNSCEAR 2006 Report on Lung Cancer due to Radon due to be published at the end of 2019
  - Committee recommends the continued use of the dose conversion factor of 9 nSv per Bq h/m3

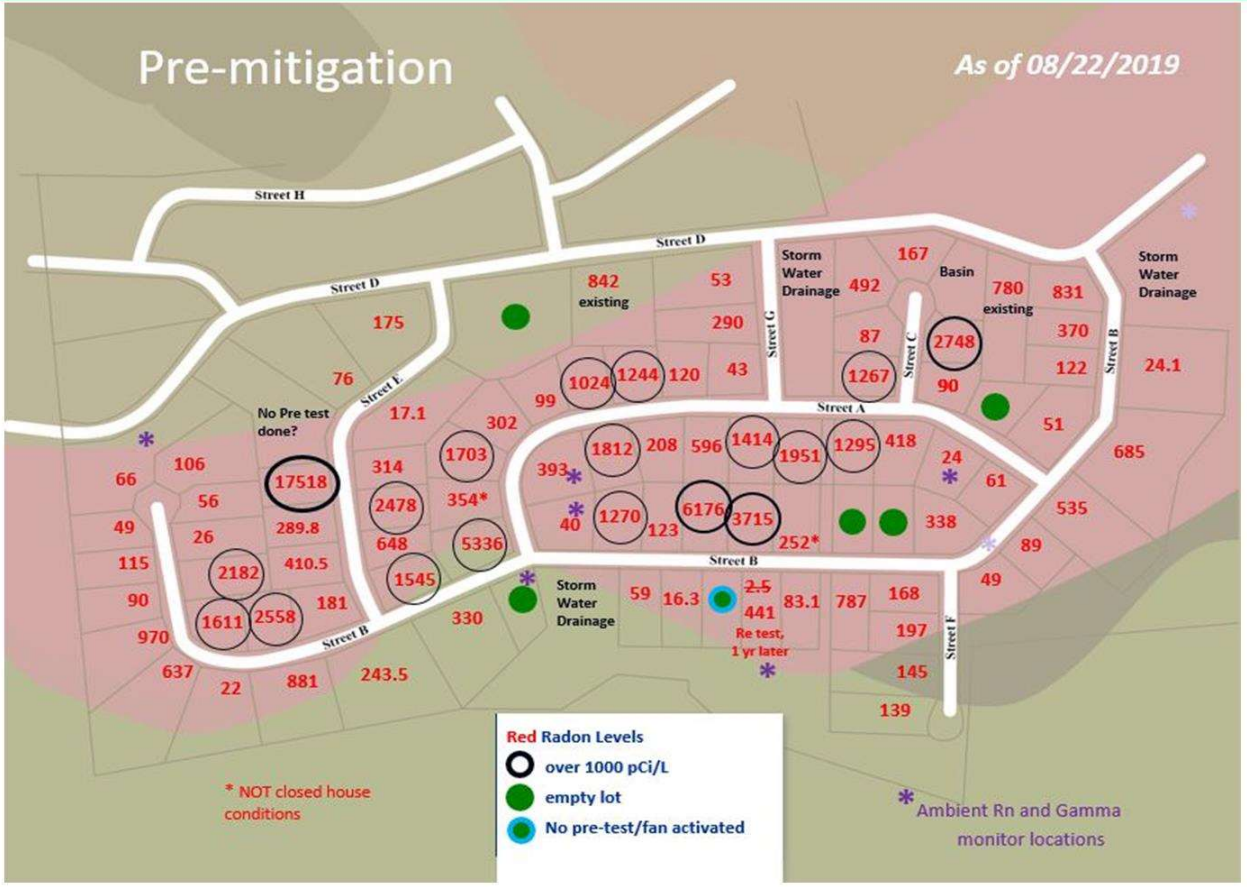
Continued interest in NORM - Internationally

- WHO
  - CODEX only applies to food following an accident and international trade – looking to address other areas
  - Stress the need to have harmonization on reference levels for radon and the dose conversion factor from concentrations to dose
- IRPA
  - Have set up a technical group on NORM
  - Looking to give practical advice on the graded approach to regulation
- European Norm Association (ENA) – formed in 2017
  - Working groups on NORM in Industry, Building Materials and Environment
  - www.ena-norm.eu – Next conference 20 – 22 Oct 2020 Vienna (AGES)

Continued interest in NORM – At a National Level

- CRCPD
  - No single federal state agency responsible for standards for radiation protection
  - Considerable variation in radiation control programmes at State level
  - Process of revising model state regulations
  - Review of NORM in Oil and Gas Industry 2015
- NCRP
  - Providing advice
  - SC 5-2: Radiation Protection for NORM &TENORM from Oil & Gas Recovery
- EPA
  - Providing technical guidance and reports e.g. National Action Radon Plan
  - Provides some of the regulation of NORM

Discovery of a Very High Radon Area



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Aspects of Protection of Workers, the Public and the Environment

Session included

- 9 presentation in person
- The main focus of 5 of the presentations was on the protection of the workers and the public in NORM industries from different countries.
- The remaining presentations discussed the history of NORM in Australia and radon monitoring in mines and identification and quantitation of Th-232 and U-238 decay series members
- The main observations from the presentations are summarized on the following slides

Radiation Protections – Past and Present

- In NORM industries, radiation protection has improved considerably from the 1930s (i.e. hand sorting radium ore)
- With better science and research in the past 30 years or so, numerous technique and assessment has applied for the protection of the workers and the general publics throughout the world in NORM industries.
- The use of ventilation, monitoring technique, personal dosimetries, personal protection equipment (PPE), worker trainings and site assessment are grand examples.
- IAEA graded approach remain the best way to do a general assessment of a NORM site.

Radiation Protection issues remain

- There is not a true consistent/harmonize NORM radiation safety guidance. Regulations for NORM industries remain a complicated issue for all countries.
- Identify source terms in NORM industries remain complicated (multiple isotopes, decays, physical and chemical properties)
- There is still a need for a more broad radiation safety guideline in different NORM industries.

Additional observations

- **With controlled protocols and procedures**, NORM injection disposal demonstrates safe radiological doses to the workers and the public (25 years of data compared and studied)
- With better identification and Quantitation of Th-232 amd U-238 Decay series members in different NORM industries, the industries can perform radiation safety related tasks more efficiently.
- When doing modelling be aware of uncertainties, focus on important parameters and check numbers are sensible

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Regulations and Recommendations for NORM

Seven Presentations

- International intergovernmental organizations
  - IAEA
  - ICRP
- Multi-national representation/approaches
  - Canada
  - USA
  - Australia (uranium mining sector)
  - Korea
  - Greece

ICRP 142 – A Preview

- Start-stop process that began in 2007
- To be published at end of 2019
- Highlights:
  - Integrated and graded approaches recommended
    - Wide range of industrial practices covered
    - Radiation rarely dominant hazard
  - Non-emergency situations predominate
  - Justification and optimization are applicable
  - Handle radon/thoron using ICRP 126

Developing IAEA's Platform for Worker Protection (NORMEX)

- Integrated and graded approaches are recommended
  - Industries are heavily regulated already
  - Grading based on likely annual effective dose and scope of available reduction needed
  - Radiation protection should be site specific
- Additional occupational exposure data needed/desirable
  - Survey of global occupational doses from NORM
  - Use UMEX as a model to collect this information
  - Create on-line web tool for information exchange

Minor Changes, Major Impacts (Australia)

- ICRP 137 – case study, uranium mining
  - 2017 revisions
    - Radon – 2X decay factor (inhalation)
    - Other radionuclides – revised dose factors (inhalation/ingestion)
  - Substantial challenges for uranium mining industry
    - Radon – instant “doubling” of dose
    - Other radionuclides – increases up to 10X
- Practical implications for industry are significant and up front consideration might have been desirable

Strategy for Effective Management of NORM (USA)

- NORM is not regulated under the AEA
- EPA regulates NORM under other statutes
  - SDWA – MCLs
  - CWA – runoff standards
  - CAA NESHAPS – certain mines
  - NCRP 180 and ICRP 138
- NRC regulates uranium processing and tailings
- TENORM is a separate issue in USA
  - Addressed, but not regulated, by EPA
- NORM often regulated based on its source/pedigree

Transposition of EU directive 2013/59/Euratom (Greece)

- Requires a national plan and response
  - Presidential decree, ministerial actions
  - Regulatory program across industries
    - Greek atomic energy commission
    - Employs ISO standards and culture of transparency, openness and and integrity
- Industries impacted include oil, gas, fertilizer cement and metal mining
- Graded approach centred on notification and registration
- Active engagement with affected industries

Canada's Approach to NORM

- NORM has a long regulatory history
  - First identified in 1904
  - First regulated first in 1988 (Western Canadian NORM committee guidelines)
- CNSC and its predecessor excluded it from its mandate so regulated largely by provinces
  - Provincial regulations relatively consistent
  - Include worker dose constraints, ALARA, training requirements
  - Little development of waste control, except Newfoundland, managed ad hoc
  - Decommissioning has taken place at two facilities in western Canada

Implementation of NORM regulations in Korea

- NORM law and regulations
  - Requires action by national assembly, enforcement decree, regulations and notification
  - A 4 phase process that took place 2011 - 2012
- Implementation of NORM program and regulations
  - Registration of handlers (65 companies)
  - Field survey and analysis
- Comprehensive NORM database (CISRAN)
- Optimization, justification and the radon mattress issue

Overarching Conclusions

- International intergovernmental bodies (IAEA and ICRP) recognize need for graded and integrated approach to NORM management and regulation, and the value of collecting information
  - Soon to be published ICRP 142
  - IAEA NORMEX
- Seemingly minor changes in dose decay factors can have major implications in the field (Australia -- uranium mining)
- A decentralized system of NORM regulation, and TENORM, exists in the USA, where waste classifications are source/pedigree dependent
- EU transposition in member states requires an understanding of the NORM industries under jurisdiction, and a national and agency commitment to high operational principles (Greece)
- In Canada, NORM is largely controlled on the Provincial level, where standards and approaches are similar, but not completely consistent
- Establishment of a Korean NORM regulatory system requires a national commitment to information gathering and registration, and has been strongly influenced by public concern about consumer products.

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Decommissioning and Remediation

Session included

- Brief presentations on poster topics with presenters from several developing countries who discussed challenges in implementing radiation protection in their countries
- There were 6 full presentations with talks grouped in two main areas
    - 4 presentations discussed models and modelling challenges for assessing radioactive contaminated sites
    - 1 paper discussed planning for decommissioning structures and
    - 1 paper discussed Surveying and monitoring legacy sites

- The main observations from the presentations are summarized on the following slides

Socioeconomic Issues

- Socioeconomic issues vary in importance between developed nations and developing nations.

- This factor informs decisions related to risk assessment and assists in the determination of two factors: (1) the point at which no further action is required and (2) in determining the necessary and proper use of available funds.

Models and Modeling

- In all models, the underlying physics are all the same, but approaches to implementing the models and choice of parameter values may be different
- Inputs (default vs site specific parameters) may vary
- Scenarios (farmer vs recreation) may vary
- The uses and limitations of models should be well understood
- Always strive to use credible scenarios based on realistic assumptions
- Laws and regulations sometimes dictate scenarios and outcomes
- Always read the user's manual (and understand the underlying physics and chemistry)

Site Characterization

- The potential for interactions and synergistic effects of chemical and radiological toxicity should be considered to determine actual overall risk

- Pre-job detailed chemical and radiological characterization is critical for an efficient and successful decommissioning and remediation.

- Always make sure you are using the correct survey instrument for making measurements of NORM

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NORM Measurements

Session Included

- 6 presentations
- Topics covered during the session included analysis study and advancements in techniques and methods for NORM measurements.
- Overall, the presenters discussed the importance of awareness of advantages and limitations of measurement methods in different situations.
- Further improvements in techniques are crucial to increase the effectiveness of NORM measurements for regulatory compliance and public safety.

Measurement of the Radon Exhalation rate and Characteristic Parameters of Aerated Concrete Blocks

- **Yunyun Wu**, National Institute for Radiological Protection, Chinese Center for Disease Control and Prevention, Beijing, China.

- Measurement results of radon exhalation rate and characteristic parameters of aerated concrete block, which is a new material used for building construction that may contribute to the increasing trend of indoor radon concentration in newer buildings in China.
- 39 samples of aerated concrete block from 14 provinces were tested to measure dry density, open porosity, diffusion length, radium content, and radon exhalation rate.
- Results showed that the radon exhalation rate and radon diffusion length of aerated concrete are much higher than that of traditional building materials.
- New national standard is needed for new building materials.

DURRIDGE Continuous Radon Measurement Technology - Present and Future

- **Stephen Sadler,** DURRIDGE UK
- Comparison between DURRIDGE's RAD7 continuous radon monitor technique of electro static precipitation and other popular continuous radon monitors that use pulse ionization technique.
- The advantage of the technique is there is no building up of Pb-210 that reduce accuracy measurement over time and it can perform simultaneous and independent measurements of radon and thoron.
- Test results of the next generation device prototype were shown to have better sensitivity to the RAD7, but with half of the physical size, and come with several improvement, such as waterproof, WiFi connectivity, and faster electronics.

GPS-Based Gamma Survey for Decommissioning NORM Sites

- **Elizabeth Ruedig,** Environmental Restoration Group, Albuquerque, USA
- Improvement results to the GPS-Based gamma survey techniques for gathering soil concentration data for gamma emitting NORM over large areas for site decommissioning.
- Gamma survey parameters such as movement speed, transect spacing, and data logging frequency define the spatial resolution of the resulting surface, and can be optimized depending upon the desired survey sensitivity.
- There are possible confounding variables that may limit the utility of gamma survey at some sites, such as radon gas and spatial heterogeneity.
- By changing the scanning speed and distance to the ground, using a shield, using better electronics, and controlling for ambient radon, the correlation between gamma measurement results and concentration of Ra-226 in the soil greatly improved.
- Entities performing or using gamma survey as a decommissioning tool must be aware of both its advantages and its limitations before basing remediation or regulatory action on gamma survey results.

NORM Characterization and Applied Metrology in Daily Routine: Analyze Results? I Want It Now (I-WIN)

- **Leo van Velzen,** Private consultant, Huissen, Netherlands
- Background on the development of existing NORM metrology and intercomparison of the applicability of instruments and methods for the characterization of NORM in the non-nuclear industry.
- The intercomparison looked at sixteen different type of instruments and methods on fifteen different criteria.
- Results showed that no single instrument and method adequately covers all health protection and regulatory compliances. The best solution is to use a combination of handheld alpha/beta contamination monitor, handheld dose rate monitor and isotopic identifier, and lab gamma-spectroscopy with intermediate resolution.

Techniques for Indistinguishable From Background Surveys

- **Arthur Desrosiers**, Jacobs Engineering Group, Deerfield Beach, FL, USA
- A three-stage survey techniques has been developed based on screening measurements, followed by verification sampling and analytical determinations to establish if the data sets represent situations that are distinct from background.
- The typical 95 percent confidence level is replaced with a graded approach that provides high statistical power in large or small surveys.
- A Monte Carlo simulation provides technical justification for initial screening levels that can be applied in field surveys.
- The three stage survey method provides a technically robust decision making approach for determining if survey results are statistically distinguishable from background.

Determination of Radioactivity Concentrations in Building Materials With Respect to NORM Issue

- **Benoît Daniel,** Eurofins Eichrom Laboratories , Bruz, France.
- Methods for radiation measurement for industries to comply with Euratom-BSS directive (2013/59/EURATOM) and how to perform calculation according to European Committee for Standardization (CEN) technical report CEN/TR 17113 and a test standard CEN/TS 17216.
- He introduced an alternative efficiency calibration method using Monte-Carlo efficiency with software, in contrast to the classical way of using sealed sources to determine self-absorption factor C.
- The alternative method ensures reliable, cheap and quick results, and it is also suitable with unknown chemical composition and building materials.

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Phosphate and Phosphogypsum

Session included

- 8 presentations in person and 1 by video
- The main focus of 4 of the presentations was on the potential risks associated with the use of by-product PG arising from fertilizer production
- The remaining presentations discussed the distribution of uranium in Jordan phosphate ores, potential use of low grade phosphate rock, purification of PG and NORM and heavy metal contamination around a super phosphate fertilizer company

Main conclusions

- Low grade phosphate deposits can be utilized to produce fertilizer
- Potential opportunities to purify (i.e., remove radium and other contaminants) are available and when economic may support alternative use of PG
- Addition of binders (alkali activated materials) can improve the performance of PG use in cement

Main conclusions (cont.)

- Reuse of phosphogypsum (PG) in construction material will help to preserve primary raw materials and reduce current PG inventory – by 2025 there will be 7 to 8 billion tons for stored PG
- Current recycling rate is only about 5%
- Chemical contamination and radiological risk to human health are main concerns

Main conclusions (cont.)

- Management of PG is costly and creates specific disadvantages
- Dangers and costs of managing PG stacks long term, e.g. sink hole in Florida, recent flooding of 1.5 million tons of acidic PG slurry in the national park in Israel, are inherent dangers associated with legacy sites
- Radio contaminants and heavy metals are polluting the ground water through percolation and infiltration. Their runoff from the stacks to the soils and ground water has negative environmental impact and harmful effects in human health
- Reuse or recycling of PG preserve virgin materials; however, they are difficult in the US, because of the current EPA standards

Main conclusions (cont.)

- Various alternatives for use of PG were discussed, including soil amendment, uses in construction (gypsum as a retarder for Portland cement, bricks, road pavements, gypsum wallboards, geopolymers etc.) have been discussed
- All papers observed that the risks from the use of by-product PG for soil amendment are below the international limits adopted
- The importance of perception of risk by regulators and the public was emphasized, as well as the importance of harmonizing regulations (across international boundaries)

Main conclusions (cont.)

- Numerous assessments and experience have shown that there are several alternatives to storing PG in stacks that can be done safely, however the future remediation has to be considered
- Large quantities of PG are stored in stacks
  - This requires perpetual care
  - There are costs and
  - There are potential environmental risks
- Alternative uses of PG offer an opportunity to reduce the amount of material that requires in-stack management

Main conclusions (cont.)

- Regarding uses of PG for construction, further studies are necessary to justify the applications, case by case, mainly because of the need to meet the norms regulating radon and gamma emitters
- If the reuse of PG will be customized products in building materials industry, acceptance of end users is essential
- Starting point for a successful implementation of PG utilization is always „fresh material“ directly from the process, which could be quality checked transferred to next steps. The second step would be the reuse of old stacks, if suitable.

Main conclusions (cont.)

- An impediment to beneficial alternative uses of PG is the lack of harmonization of regulatory goals governing the use of PG, however before harmonizing the standards, it is important to strengthen the policies and measures to enforce reuse and recycling on NORM residues in general
- It is very important to have countries to get together to harmonize the use of PG
- Bringing industry, regulators and other stakeholders to participate in public discussions is must
- Participation of the industry, including phosphate producers, agricultural sector and producers of construction materials, in the implementation of the measures to minimize the environmental impact of landfills through reusing and recycling of PG, is of vital importance

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Oil and Gas Production Waste

Findings of PA O&G Industry TENORM Study - David J. Allard

- Reviewed the cradle to grave study of TENORM generation and disposal in the Pennsylvania oil & gas industry.
- The study looked at all solid, liquid and gas media.
- From that data worker and public radiation exposure was examined as well as potential environmental contamination.
- It was noted that potential public doses were below 1 mSv/a, however, follow-up regarding contaminated POTWs, discharge locations, pigging operations, and long-term environment surveillance is needed.

Air Monitoring of NORM Worker Inhalation Exposure – Bill Lemons

- There is potential in the gas industry for radon to be present on the order of 120 pCi/L, compressed gas can be 100x that concentration, and radon will carry-over with propane when fractional processing occurs.
- Radon decay products (e.g., Po-210 and Pb-210) may be present on pipeline inner surfaces, cause external X-ray fields, and when pigging is performed – airborne radioactivity may approach occupational exposure levels.

Assessment of Natural Radioactivity in Petro. Waste Ghana - David Okoh Kpeglo

- In 2010 O&G production increased off-shore in Ghana. This prompted a review of the type of NORM waste that may be generated including produced waters, pipe scale, and sludges. The potential fate and transport via fish is of particular concern.
- A major concern is the ability and capacity to manage the large volume of NORM waste expected to be generated.
- The responsible national authorities are exploring their options with Tech Service Companies.

Baseline Study of Radon in Groundwater S. Africa - Ryno Botha

- There is a very large natural gas shale play in the Karoo Basin of S. Africa.
- Prior to unconventional well development, a baseline survey of radon in groundwater was performed. At 53 sites shallow and deep test wells were drilled, then tested.
- Shallow wells were observed to have the higher radon; a few were above the WHO 100 Bq/L reference level.
- Future work planned includes: coal ash use in building materials, testing of wells for methane, and, testing of bottled spring water.

Waste Management of NORM Rejects in Brazil - Marcelo Valinhas

- From 1988 to 2018, oil production in Brazil has increased to about 2.6 million barrels per day.
- Similarly, the clearance level for NORM in waste has dropped from 100 to 10, to 1 Bq/g. Pipe with scale and drums with sludge continue to be generated.
- Thousands of drums have been segregated as Category I or II if above or below 5 µSv/hr, and are presently being store awaiting permanent disposal in Brazil.

Scoping NORM Waste From Drill Cuttings in Kansas - James Uhlemeyer

- Historical data was reviewed to identify and locate 6 sites where drill cuttings had been disposed of in Kansas.
- Using a GeoProbe rig, 4 sample cores were obtained from each former rock cuttings pit. Cores were taken down to 6 feet and sent to a lab for radchem analysis. Core material was dried, ashed, sealed, counted, held for over 21 days, and counted again for NORM radionuclides.
- Whencompared to local background samples with ~ 1 pCi/g, the rock cutting samples were found to be in the same range if activity.

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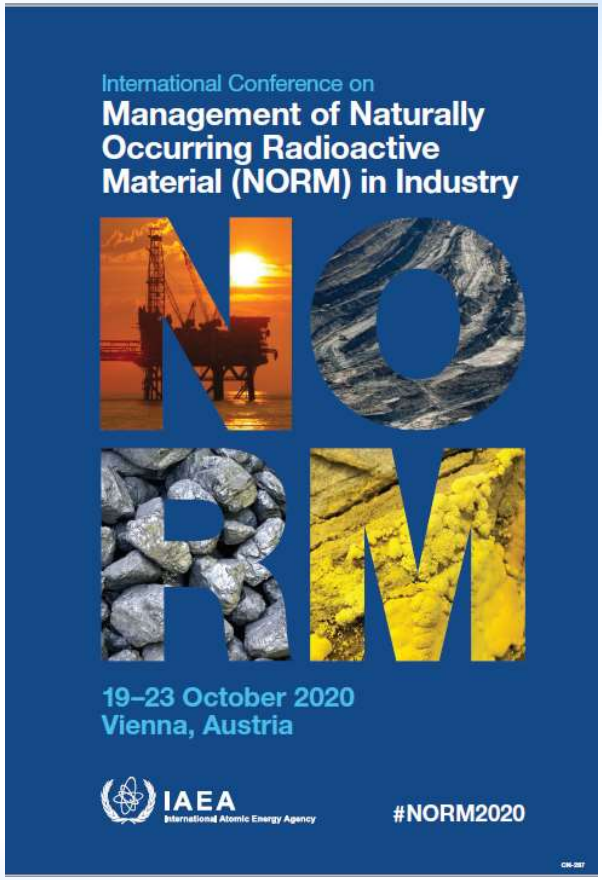
ENVIRONET Special Session

6 talks presenting different facets of IAEA ENVIRONET NORM project

- In 2015, IAEA established the ENVIRONET (Environmental Management and Remediation Network) **NORM Project to support Member States to acquire knowledge and practical experience related to the overall management of NORM residues/wastes and NORM legacy sites.**
- The target audience for the project includes regulators, industrial operators, and researchers in Member States
- Priorities for the ENVIRONET NORM Project relate to 3 distinct (but interdependent) tasks:
  1. Guidance on national NORM policies and strategies
  2. Guidance on development of NORM inventories
  3. Assessment of cost issues associated with NORM management

Outstanding Gaps in NORM Management and the Need for Additional Effort at the International Community Level: The Path Forward

1. ***Horst Monken Fernandes, IAEA***
    - Provided a retrospective on the **lessons learned** from the previous NORM conferences (since NORM IV), highlighting the inconsistencies and gaps in NORM management
    - Described the **need for national inventories** of NORM residues, wastes and contaminated sites, based on a harmonized methodology. Such inventories would inform the establishment of adequate policies and effective implementation strategies
    - Highlighted the **need for additional effort** at the international community level (including stakeholders, in particular the industry), and
    - Explained the strategic and policy goals of the **upcoming IAEA conference on "Management of Naturally Occurring radioactive material (NORM) in industry", in Vienna, 19-23 October 2020.**



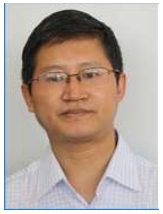
19-23 October 2020
www.iaea.org/events/norm-2020

Abstracts and participation forms due
28 February 2020

IAEA Scientific Secretaries

Horst Monken-Fernandes
NEFW

Burcin Okyar
NSRW



Zhiwen Fan
NSRW

Key Elements of a National NORM Policy and Strategy (Task Group 1)

2. Gert Jonkers, consultant

- Described the development of guidance **discussing aspects to be considered in developing national NORM policies and strategies,** including
  1. Definitions and terminology related to NORM management
  2. General information about NORM
  3. Principles and core values
  4. Elements of Policy and Their Implications
  5. Elements of Strategies and Their Implications
- Provided a case study on Stakeholder Engagement (UK study)
- Noted that the policy and strategy, and the legal framework, should cover all types of NORM and volumes of NORM generated in a Member State, all NORM (re)processing options and NORM storage facilities located in the Member State, and NORM imports or exports, the time periods involved and the NORM waste management options available.

Towards a New Guidance for Establishing a NORM Inventory (Task Group 2)

3. ***Wouter Schroeyers, Hasselt University***

- Described the work of Task Group 2 on NORM Inventories, and in particular a new **guidance document providing a user-friendly methodology for member states to build "step-by-step" an inventory of operating industrial sites and legacy sites**
- It uses the experience of several IAEA member states where NORM Inventories were built over several decades
- The guidance provides a **strategy for radiological and non-radiological data collection, sampling, and the filling of information gaps**
- It will deal with **challenges linked to the lack of resources for building a NORM inventory** (for example related to the available measurement methods)
- Aspects of the methodology flow chart were discussed using case studies from different industrial sectors (zircon and zirconia industry, phosphate industry, oil & gas industry and rare earth processing)
- Feedback was requested in order to finish the document prior to the October 2020 IAEA Conference

Assessment of Costs Associated with NORM Management (Task Group 3)

4. ***Horst Monken Fernandes , IAEA***

- TASK3 aims to develop (1) a **guidance document providing a roadmap for assessing costs associated with the management of NORM residues and wastes, across the full lifecycle of activities (including decommissioning)**, and (2) an annex providing different examples (cases studies) with cost values and ranges.
- Approach builds on the “Waste management hierarchy” (Prevention; Minimization; Preparation for re-use; Recycling; Other forms of recovery; and Disposal)
- Costs are affected by several technical factors (planning and licensing, construction, operation, decommissioning and closure, etc) and non-technical factors affecting costs (e.g. socio-political factors, regulatory requirements, taxes and insurance, land acquisition and cost of services)

Case study (Poland): How to Build the National-Level NORM Inventory? An Example Developed From Scratch

5. ***Boguslaw Michalik, Central Mining Institute, Poland***
   - **A 4-tier system of NORM identification developed is proposed, including**
     - Inventory of natural resources
     - Inventory of on-going mining industry (including other underground workplaces)
     - Inventory of mineral processing industry
     - Inventory of products, products application and disposal

Case study (Italy): Processing of Zircon Sands: the Italian Inventory

6. Cristina Nuccetelli, National Institute of Health, Italy

- In the context of the development of the "Guidance on how to establish a NORM Inventory“ (Task 2), case studies will be included on how to achieve the NORM process inventory according to specific procedures relevant to the different NORM industries
- Italy is developing a **case study concerning the zircon sand processing industries (raw materials containing 238U series above ordinary natural levels and sometimes 232Th series),** due to the important presence of this sector (tiles, refractory materials and ceramic items) in the country and the wide experiences made by public institutions in this specific field.
- Experience shows that **building collaboration with sector associations** can be a useful approach for the other NORM industrial sectors as well
- **Doses to members of public from effluents evaluated by past Italian surveys suggest a small radiological impact and importance of the relevant information difficult and expensive to be measured (activity concentration).**

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Waste Management

Regulations on Management of NORM Residues in Belgium: Lessons and Challenges

- Presenter Stéphane Pepin
- Belgium is dealing with an evolving NORM industry
  - Changing from production to remediation
- There are 96 declared NORM site and 11 authorized disposal facilities
- The radiation protection agency (FANC) has recognized issues related to data interpretation, conflicting guidance, liquid wastes, etc.
- More dialog is needed to address these issues and a graded approach is prudent: NORM is not the same as traditional nuclear waste.

International Network of Laboratories for Nuclear Waste Characterization (IAEA-LABONET): Support of the Non-Nuclear Industry at the Characterization of NORM

- Presenter Leo van Velzen
- IAEA launched LABONET in 2011 to improve the quality of, and to harmonize, activities related to radioactive waste characterization
- LABONET wants to share experiences related to radiological characterization and other topics (e.g., WAC compliance, analysis of radiological vs. non-radiological constituents, etc.) to benefit Member States
- The presentation discusses LABONET objectives and structure, and important but subtle differences between “IAEA GRS-3” and “EC Directive 2013/59/EURATOM” for characterization metrology (mostly the guidance therein is compatible)

Achieving Zero-Discharge NORM Waste Disposal using Slurry Fracture Injection (SFI) Technology

- Presenter Roman Bilak
- Slurry Fracture Injection (SFI) is an advanced deep well disposal technology providing an environmentally sustainable disposal method to achieve ‘Zero Discharge’ NORM waste management
- The method is fast, can handle large waste volumes (~10,000 m^3/mo), and is permanent
- Keys for success include careful planning and measured implementation, and the right geological environment
- Best practices, example sites (i.e., successful applications), and lessons learned are presented

Regulatory Framework for the Handling of Radiologically Relevant Legacy Sites in Germany

- Presenter Benjamin Klein
- Germany has experience with NORM remediation at legacy sites, but only in the former East Germany, before unification.
- Germany recently developed comprehensive framework for handling and remediation of legacy NORM sites
- The presentation summarizes the framework, including reporting possible legacy sites, investigations to confirm or rule out legacy site, the procedure of remediation planning and execution, public communications, and practical implementation guidelines

Leaching of Naturally Occurring Radionuclides From Roadway Pavements Stabilized With Coal Fly Ash: A Case Study From the U.S.

- Presenter Talal Almahayni
- Coal fly ash contains NPRM that is sometimes used in road bed construction
- The presentation summarizes a study on a US public roadway to estimate radionuclide migration into the leachate and groundwater, and compares results to limits
- Leachate concentration of uranium are above the 30 μg L^{-1} drinking water standard, but groundwater consumption doses are well below 0.1 mSv y^{-1}.
- This study is limited but calls attention to the need for more data and industry consideration.

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Miscellaneous NORM Topics and Stakeholder Communication

Some Proposals on Technical Requirement for Radiation Environmental Impact of Industrial Activities Involving NORM- Liao Yunxuan

China Pollution Sources Census is conducted every 10 years. The first census was completed from 2007 to 2009

The basic Law is: Law of the People's Republic of China on Prevention and Control of Radioactive Pollution

At present, the regulations and standards for NORM industry are not perfect, but several relevant standards and management requirements exist for key NORM industries, such as rare earth, niobium, tantalum and vanadium. This industries should be managed by graded management.

- Further study on comprehensive utilization and disposal of residue should be carried out.
- The environmental impact assessment of NORM facilities with occupational exposure dose greater than 5 mSv/a and specific activity of solid waste greater than 10 Bq/g, should be carried out to find out the weak links and to improve the measures.
- Based on the results of radiation assessment and related research results of existing NORM facilities, it is suggested to speed up the formulation of regulations and standards for radiation protection and environmental protection of NORM facilities.

FINNORM – Steps towards surveying the NORM in Finland- Mila Pelkonen

The industrial activities in Finland that include naturally occurring radioactive materials needed to be registered. Reformed Radiation Act came into force on December 2018.

Radiation and Nuclear Safety Authority (STUK) launched a new project called FINNORM on January 2019.

Main goals of the project are:

- Build a NORM inventory of Finland (excluding radon and building materials)
- Provide new information about the existence of NORM in Finland
- Provide communication and guidance for the industry about new NORM regulations in Finland
- Recommendations for the practical enforcement of existing regulations
- Assess screening-level doses for workers and public from NORM-related operations and evaluate how this can be done using test-cases and modelling

Many challenges in Project Implementation eg getting sampling permits can also be difficult, concerns of mining companies, private land owners

Environmental Radiation Impact of the NORM Activities in China - Wu Qifan

The NORM site in Yunnan in the southwestern Yunnan province, China which is a coal mining area was chosen as a Case Study.
Dose assessments were based on environmental monitoring data;

- external radiation dose rate
- outdoor and indoor radon concentration
- 210Po and 210Pb in aerosol, crop and vegetables
- 226Ra, 210Po and 210Pb in drinking water.

The result of Dose assessment showed an Average annual effective dose for the public exposure is 5.1 mSv/a in the site research area.

Conclusions

- The results present annual effective dose in current situation. Historical background data is difficult to prepare.
- The activity concentrations of radionuclides in materials (coal, bottom ash and fly ash) are higher than the radiation exemption level, or exceed 1Bq/g.
- Radon concentration level is higher, and turns to be most contribution of annual effective dose, and results from waste spread.
- Regulatory and management approaches for the control of NORM should be strengthen

Preliminary analysis of the results of NORMs in the second China Pollution Sources Census - Zheng Guofeng

The second China Pollution Sources Census will be done 2017 to 2019

The survey objectives were the radioactive mineral resources below:

1）Rare earth elements 2）Niobium/tantalum 3）Zircon/Zirconia 4）Tin 5）Lead/zinc 6）Copper 7）Iron 8）Vanadium 9）Phosphate 10）Coal 11）Aluminium 12）Molybdenu 13) Nickel 14）Germanium/ Titanium 15）Gold

The main purpose of Survey was to define:

- The type and distribution of minerals
- The level of radioactivity of minerals
- The quantity of associated radioactive solid waste
- The discharge of effluent
- Set up a database

The Survey database which includes the following:

- Quantity Location of population sources
- Effluent Discharge
- Radioactivity level
- Quantity of waste production and storage

Introduction to Radiation Environmental Regulation for Exploitation and Utilization of Other Radioactive Mines in China, Yang Chun

Management of Radioactive Solid Waste from NORM Industries

- The solid waste, mainly smelting waste residue, is a realistic problem for several main reasons.
- First, China's industrial solid waste, hazardous waste and radioactive waste storage and disposal facilities have clearly excluded radioactive waste.
- Second, the distribution in China is relatively scattered, and the quantity is far more than the radioactive waste generated by the nuclear industry. It is not suitable for long-distance transportation.
- Third, the half-life of natural radionuclide is particularly long, bringing more complicated follow-up management problems.

Conclusions

- There are several main ideas how to properly handle this problem.
- To encourage comprehensive utilization and minimize waste.
- To study the feasibility of using tailings (slags) repositories of uranium mining and milling enterprises.
- To unify the construction of natural radioactive solid waste facilities.
- Coordination of relationships between local governments, enterprises and other sectors.

Discharge Limits of Development and Utilization of Effluents from NORM Industries, Xiaowei Xiong

- In China, there are more than 10 industries related to development and utilization of NORM. There are four national or industrial standards related to effluent of uranium mining and NORM industries.

- Discharge Limits of Gaseous Effluent
- It is proposed that the discharge limits of uranium and thorium from gaseous effluent should be no more than 0.1 mg/m3.
- But, special industries should be considered in a particular way, i.e. monazite grinding process.

- Discharge Limits of Liquid Effluent
- Concentration of radioactive wastewater in typical NORM industries:
- Wastewater from Rare Earth Separation Plant（238U：16.8Bq/L；232Th：2.57Bq/L；226Ra：2.49Bq/L

Discharge Limits of Development and Utilization of Effluents from NORM Industries, Xiaowei Xiong

Common Treatment Methods of Radioactive Wastewater:

- Ion Exchange Method
- Precipitation method
- Reverse Osmosis Method:
- Distillation Method
- Absorption Method

Principles for Determining Discharge Limits in Wastewater

- Considering the treatment technology of radioactive waste water, the control level of radioactive pollutants, and the degree of damage of radioactive pollutants
- Considering cost-benefit analysis, taking into account operability and certain forward-looking
- Refer to the relevant emission standards at home and abroad, which are equivalent or stricter than those countries, and consistent with domestic similar standards;
- Considering the diversity and complexity of the development and utilization of NORM industries
- Control Items in wastewater (U, Th and ^{226}Ra)
- Discharge Limits (Concentrations of U and Th in wastewater are not more than 0.3mg/L, ^{226}Ra is not more than 1.1Bq/L)

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Rare Earths and Zirconium

Radiological and Mineralogical Characterization of the Tailings of a Niobium Ore Treatment Plant in Brazil

- Objective of the study was to characterize carbonate concentrate tailings for use as soil amendment.
- Methodology – neutron activation, x-ray fluorescence, SEM analysis, gamma spectroscopy
- Carbonate concentrate average radionuclide concentrations – U-238 series: 200 Bq/kg; Th-232 series – 1200 Bq/kg
- Radiological hazard indices were calculated
- Estimated average dose rate for the 10 tailings samples – 835 nGy/hr
- Estimated average dose rate for the amended soil – 54 nGy/hr
- Carbonate sample average radionuclide concentration exceeds exemption limit for agriculture
- Dilution factor from application of carbonate as soil amendment results in acceptable radiological hazard levels

Determining Coal Ash Impacts on Radium and Thorium Background Levels in Soil Using Rare Earth Element Analyses

- Presence of rare earth elements used to differentiate background NORM radioactivity from the cleanup criteria for a former gas mantle facility
- Cleanup criteria – 5 pCi/g over background established at 2 pCi/g total Ra and total Th
- NORM activities in fill (red brick, coal ash, etc) in some of the commercial/industrial sites exceeded the cleanup criteria
- Samples from commercial sites were classified as to whether they contained NORM fill or no NORM fill
- Samples were analysed for rare earth elelments (REE)
- Concentration ratios of REE to radionuclides of concern (ROC) were calculated for NORM fill areas impacted by facility operations and non-impacted areas

Determining Coal Ash Impacts on Radium and Thorium Background Levels in Soil Using Rare Earth Element Analyses-continued

- REE/ROC ratios were significantly different
- Background radionuclide concentration in NORM fill areas was determined to be 6 pCi/g compared to the site-wide background of 2 pCi/g
- Therefore, NORM fill area cleanup criterion was 11 pCi/g rather than the 7 pCi/g site-wide criterion
- REE/ROC determination was generally straightforward, inexpensive and quick with definitive, defensible results - Minimized cleanup of non site-related NORM

Naturally Occurring Radioactive Materials (NORM) Waste Management (Malaysia)

- Atomic Energy Licensing Board (AELB) controls NORM as radioactive material
- Control limits for U-238 and Th-232 are 1 Bq/g; limit for K-40: 10 Bq/g
- Rare earth industries in Malaysia generates NORM residues as waste – monazite cracking and rare earth extraction
- Options for NORM disposal include near surface landfill
- Some by-products can be reused and recycled
- By-products must be treated to reduce uranium and thorium to below permissible limits before reuse or recycling

Conclusions

- Large amounts of NORM waste generated from the rare earth industry
- The reference level for reuse and recycle or disposal of NORM waste should be established within the VLLW classification
- Dilution should be considered provided that the reference level is not exceeded.

Zircon and Zirconia under the U. S. System of TENORM Regulation

- Zircon and zirconia contain uranium and thorium decay series radionuclides in equilibrium within the crystal matrix
- Environmental mobility of radionuclides in zircon/zirconia is *de minimis*
  - Low radon emanation
  - No leaching of radioactivity into water
  - No data on bioavailability
- TENORM regulatory interaction
  - Increased landfill radiation monitoring that results in rejection of traditional foundry wastes
  - Triggers mandatory investigation
  - TENORM licensing and disposal restrictions are “hard”
  - Both are desirable

Zircon and Zirconia under the U. SI. System of TENORM Regulation - continued

- Regulatory issues
  - Prohibitions on landfill disposal of radioactive waste intended for hydraulic fracturing but are overbroad
  - TENORM standard developed for U mill tailings (5 pCi/g Ra) not applicable to zircon/zirconia
- Hazard communication issues
  - Civil Liability – failure to warn about the presence of NORM
  - California Proposition 65 that lists radionuclides as carcinogens
- Zircon, zirconia are exempt from regulation under some circumstances
- Conclusions:
  - Regulation of “source material” as defined by the US Atomic Energy Act, complicates US TENORM regulation
  - Concentration- based standards are “easy”
  - Dose-based standards are “hard”
  - Both are desirable

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Radon and Thoron

Radon in Canada – Protecting Canadians in their Indoor Environment

1. ***Pam Warkentin, Canadian Association of Radon Scientists and Technologists (CARST)***
   - Provided general overview of radon issues in Canada, including **assessment and mitigation of radon levels in buildings**
   - Testing indicates higher Rn concentrations in winter months; regional variability exists but, overall, **~ 7% homes are above 200 Bq/m^3 (Health Canada action level)**
   - Presented information about motivations and challenges associated with mitigation of Rn exposures both in workplace and homes
   - Provided overview of Health Canada mitigation guidelines
   - Data indicates **average Rn reduction rate of ~91% and average cost of ~$2,800 per home**

Measurement of Indoor Radon Concentrations at Uranium Mining Legacy Sites and Sites of Elevated Natural Radioactivity With the Aim of Deriving Mitigation Measures

2. ***Peter Schmidt, WISMUT***

- Provided observations regarding factors determining **Rn concentrations related to uranium mining legacy sites (ULS)**
- Measurement of Rn levels is easy to do; derivation of mitigation measures requires detailed understanding of conditions
- Schneeberg case study: history of intensive mining, with multiple near surface mine galleries; Rn concentrations up to 100,000 Bq/m3; **focused mitigation on source of Rn in the air in the mines, rather than mitigation of individual homes**; mitigation included enhanced ventilation of the mines; pilot study results indicate approach is very effective
- Central Asia ULS case study: collected indoor and outdoor high-density gamma measurements and Rn measurements; **adopted graded approach to characterization of area and 2,000 buildings**; ultimately, conducted detailed investigations of 6 homes and successfully derived mitigation measures for each home

Natural Radiation Exposure Due to Radon and Thoron Indoors in the Mining and Ore Bearing Regions of Cameroon

3. Saïdou, Nuclear Technology Section, Institute of Geological and Mining Research, Cameroon

- Reported on studies of natural radiation exposure primarily conducted in areas of mining or oil & gas development; **since 2012 have focused on indoor Rn**
- Described the sampling and analysis program and presented results
- **Efforts lead to a new IAEA project, starting in March 2018,** to provide training, equipment procurement, and support to Rn risk mapping, regulation development, and development of National Radon Action Plan
- **Conclusions:**
  - Rn-222 and Rn-220 exposure occurs in Cameroon
  - Rn-220 reference level needs to be developed (or combined level for Rn-220 and Rn-222)
  - Rn-220 risk mapping should be conducted
  - Regulations should be developed
  - A National Radon Action Plan should be developed

Assessment of Radon Concentration in Earthquake Affected Areas of Nepal

4. ***Dr. Buddha R. Shah, Nepal Academy of Science and Technology***

- Reported on studies of **indoor Rn-220 concentrations conducted both before and after massive earthquake in April 2015**
- Described Regional Cooperative Agreement under which this work has been conducted
- Presented results of survey in three regions, including data for one region collected before and after the earthquake
- **Conclusions:**
  - Rn concentrations highest at Barpak, the epicenter of the earthquake
  - All Rn concentrations well below permissible level of 200 Bq/m^3 (ICRP 65)
  - Annual effective dose below the ICRP recommended levels of 3-10 mSv/y
  - The radiological risks (life-time fatality) from Rn-220 in residential areas is low

Thoron: the Unrecognized Carcinogen in Earthen Dwellings Typical to Rural Africa and Asia

5. Margaret Chege, Kenyatta University, Kenya

- Reported on the **potential risks of exposure in earthen dwellings typical in rural areas due to naturally elevated Th levels in soils used in construction**
- In such dwellings, **Rn-220 can present a greater risk than Rn-222 due to**
  - Use of soil as building material
  - Higher natural concentrations in soil
  - Higher exhalation rate from soil
  - Greater progeny production rate
  - Higher energy
- **Conclusions:**
  - More research is needed on isotopes in earthen dwellings
  - Epidemiological studies are needed to investigate link between living in earthen dwellings and risk of cancer

Discussion About Radon and Thoron Dose Coefficients

ICRP Pub 137 (2017) recommends new dose coefficients, from 2x to 3x compared to previous recommendations

IAEA organizing Technical Meeting next week in Vienna on implications of the new Rn dose coefficient

Comments from NORM IX participants:

- Inconsistency in ICRP and UNSCEAR recommendations will create a significant challenge; **a single value is critical**
- ICRP's new value will result in an **economic impact on industry**, requiring additional mitigation activities in many workplaces
- The recommendation for a new value will be **difficult to explain to industry**; this could lead to a **loss of trust** and reluctance to comply with new monitoring or mitigation requirements
- What is the degree of certainty regarding the new value? Have all relevant data sets been considered?

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IAEA Workshop on Safe Management of NORM

IAEA Workshop on the Safe Management of NORM

Conclusions/Recommendations	Lecture Title	Lecturer
The structure and contents of the GSG-7 is explained, with the focus on Occupational Radiation Protection related to NORM industries.	IAEA Safety Standards- General Safety Guide on Occupational Radiation Protection (GSG-7) & its coverage for NORM	Burcin Okyar

IAEA Workshop on the Safe Management of NORM

Conclusions/Recommendations	Lecture Title	Lecturer
• Regulatory control of industries involving NORM **is a challenge** and an open issue. • Characterization of materials and processes and realistic dose assessments are the first step for the both **an efficient and effective regulatory control** as well as the further optimization through the radiation protection programme. • Most relevant exposure pathways ✓ Direct external exposure ✓ Inhalation to dust ✓ Exposure to radon • Simple Bq/g to mSv/y relationships **are useful generic screening tools**, but may not be always sufficient. • Understand the technological process and hence the typical nuclide vector of materials involved. • Adequate sampling strategy. • Scientific data when used appropriately can lead to realistic assessments. • Software can lead to realistic assessments if realistic parameters have been selected.	Challenges in Regulating NORM for proper Worker Protection – Prior Radiological Characterization and Realistic Dose Assessment	Konstantinos Karfopoulos

IAEA Workshop on the Safe Management of NORM

Conclusions/Recommendations	Lecture Title	Lecturer
• RPPs should be established and maintained for NORM facilities to demonstrate that an operator understands the radiological aspects of their activities and to outline the required management controls. • The levels of detail should be commensurate with the risk (i.e. a graded approach) • The content of an RPP is based on components outlined in GSR Part 3 • Key aspects of a good RPP: – Fit for purpose – Requirements consistent with actual risk – Practical and able to be implemented – Auditable – Contribute to radiation protection – Integrate with existing management plans – Effective	Radiation Protection Programme (RPP) (how to establish and maintain)	Jim Hondros

IAEA Workshop on the Safe Management of NORM

Conclusions/Recommendations	Lecture Title	Lecturer
• ORPAS provides a **cross-cutting review**, against the relevant IAEA safety standards, of the regulatory framework for ORP, technical service organisations / providers, and the application of the requirements at all facilities and activities utilising radiation technologies in the host State. • Provides an opportunity for a MS to have its ORP program independently assessed and evaluated • As a part of ORPAS preparation, MS is encouraged to complete the self-assessment in the form of questions (ORPAS questionnaire) tailored to the three set of participants involved in an ORPAS mission. • The case study demonstrating the implementation of ORPAS in Indonesia was presented.	Case Study: ORPAS Peer review and how NORM is covered	Burcin Okyar, Teng Iyu Lin

IAEA Workshop on the Safe Management of NORM

Conclusions/Recommendations	Lecture Title	Lecturer
The following Information Exchange Platforms have been described: • ORPNET - Occupational Radiation Protection Networks • UMEX - Information System on Uranium Mining Exposures • NORMEX - Web-based Information Exchange Platform on ORP in Industries involving NORM	Information Exchange Platforms (ORPNET/UMEX/NORMEX)	Burcin Okyar

IAEA Workshop on the Safe Management of NORM

Conclusions/Recommendations	Lecture Title	Lecturer
Management of NORM residues should be justified: • Understand origin and characteristics of NORM in the country • Establish regulatory framework in a graded approach • Develop solutions integrated with existing infrastructure	Introduction to Development of IAEA Safety Standards for NORM Residues Management	Zhiwen Fan, Stephane Pepin

Report on the IAEA Workshop on the Safe Management of NORM
25 Sept. 2019, Denver, CO, USA

Conclusions/Recommendations	Lecture Title	Lecturer
• SSG60, Section 2.0 provides stakeholders data on identifying residues and practices that should be subject to a residue management strategy. • Annex I provides typical volumes and concentration ranges, as well as the radionuclides of concern, associated with NORM practices. • Annex II provides recommendations on sampling, analysis, and lab selection to support NORM characterization.	Origin and Characterization of NORM Residues	Gary Forsee

Report on the IAEA Workshop on the Safe Management of NORM
25 Sept. 2019, Denver, CO, USA

Conclusions/Recommendations	Lecture Title	Lecturer
• Development of a regulatory framework for NORM is a iterative process • It requires several prerequisites, such as stakeholder involvement • Graded-approach is a key-point in all components of the regulatory framework	Regulatory Framework in Graded Approach	Stephane Pepin

Report on the IAEA Workshop on the Safe Management of NORM
25 Sept. 2019, Denver, CO, USA

Conclusions/Recommendations	Lecture Title	Lecturer
• SSG60 provides recommendations on NORM management strategies regulators may adopt that will be in accordance with IAEA standards • Utilizing the graded approach, SSG60 proposes residue management strategies, putting industry and regulator resources where they are best utilized to mitigate public and environmental exposure to ionizing radiation • SSG60 details a stepwise approach for building a national framework for NORM residue management. • Member states are encouraged to participate in REGSUN technical meetings (next in June 2020) to develop training and technical capacity in member states on this topic.	Strategy of NORM Residues Management	Zhiwen Fan, Gary Forsee

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CRCPD Workshop: Continuing Efforts for NORM Regulatory and Risk-Informed Decision Making

WORKSHOP GOALS

- Identify Priority Issues in Regulation of NORM
- Identify Barriers to Regulatory Framework
- Suggest Resources

PRIORITY ISSUES

- What is the origin of 5 pCi/g limit?
- Should regulations move to a dose based limit?
- Why regulate by origin (type of production) not by a dose based limit?

PRIORITY ISSUES

- Po-210 and Pb-210 are issues as well; need effective monitoring.
- Portal Monitors – What standards and guidance are there?

PRIORITY ISSUES

- Harmonizing Regulations to the Extent Possible
- Institutional Controls

PRIORITY ISSUES

- Financial Assurance
- Communication with Members of the Public

PRIORITY ISSUES

- Cleanup of Legacy Sites
- Sites vary in life cycle timelines:
  - Operations
  - Closeout

BARRIERS TO IMPLEMENTATION

- Setting lower bound of regulatory scope without regulating background materials or impeding interstate commerce.

BARRIERS

- License Termination
- Ownership and Financial Assurance
- Take into Account Institutional Controls

BARRIERS

- Need industry-specific guidance.
- Physical characteristics, administration, and engineered controls may negate need for regulatory oversight.

TOOLS

- IAEA SSG 60 Management of NORM Residues
- ASTSWMO
- CRCPD ISRI Video

TOOLS

- NCRP Commentary for Oil and Gas NORM- soon
- TECDOC to Come from IAEA in the Future

Tools

- CDC Website – Radiation Awareness Training in Layman Terms and Other Resources

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Water Treatment

Jordanian National Capabilities in Investigation and Treatment of Natural Radioactivity in Drinking Water: Hydrogeology, Geochemistry, and Radium Removal[1]

- Challenges in providing drinking-water due to population size, recent influx of refugees from surrounding countries, and low natural rainfall
- Wellfield in southern Jordan currently providing drinking-water to Amman with a system life-expectancy of 10-30 years
- Drinking-water contains relatively high concentrations of radium, especially in the western portion of the aquifer, due to Cambrian-Ordovician geology of the wellfield
- Geochemical modeling of drinking-water performed using PHREEQC model to assess potential water treatment options
- Further assessment of treatment options using a pilot-scale system; also considering options for minimizing radium using wellfield management

- [1] Presenter: Billy Dam from Billy Dam Consulting

NORM in Formation Waters in Polish Coal Mines

- South-western Poland impacted by extensive coal mining operations
- Ra-226 and Ra-228 are the predominant isotopes; coprecipitation with radium-barium-sulfates is the primary method for removal of radium in the coal mine waters
- In the absence of barium, high concentrations of radium in surface waters of the Oder and Vistula rivers are observed at long distances from the mines
- Considering mitigation measures for radium removal from formation waters in high activity mine waters
- Two underground purification stations constructed in 1999 and 2005 used barium chloride, drawbacks included toxicity of material and the need for safety training for workers
- Ongoing testing of a zeolite process with 90% natural and 10% artificial zeolites
- [1] Presenter: Izabela Chmielewska from the Central Mining Institute

Production and Disposition of TENORM Waste Generated from Water Treatment Activities in Southern New Jersey[1]

- Two options for treatment: accumulating treatment with disposal as solid waste versus regenerative treatment which generates wastewater for disposal at wastewater treatment plants
- Some injection or spreading of wastewater treatment residuals for agricultural application
- Over ten years of sampling data from agricultural applications – decreases in recent years indicated change in radium residuals handing
- When compared to background concentrations, little difference observed in agricultural fields, possibly due to natural distribution processes or differences with dose modeling assumptions for application rates

- [1] Presenter: James McCullough from the New Jersey Department of Environmental Protection

Radioactivity Level Estimation by Using Alpha Scintillation Detector Based Smart RnDuo Monitor in the Water Samples[1]

- Assessing radon concentrations in water samples in District Palwal, Faryama India
- Using the SMART RnDuo with bubbler and a scintillation detector for detection of radon
- Sampled surface water and ground water from hand-pumps, borewells, and tap water
- Calculated inhalation dose, ingestion dose, and annual effective dose
- Relatively low radon concentrations compared to other regions of India correlate to underlying geology due to its alluvium nature
- All concentrations were well below WHO limits for drinking-water, but some sample concentrations were above the USEPA Safe Drinking Water Act Maximum Contaminant Limits

- [1] Presenter: Krishan Kant, Aggarwal College Ballabgarh

Importance of Redox Interfaces Regarding the Fate and Behavior of Radium in Surface Waters Impacted by NORMs[1]

- Mining operations resulted in an increase in radium in the waters of south-western Poland, with barium assisting with radium trapping under oxidizing circumstances in settling ponds
- Redox interactions at the sediment/water interface may determine the role of the sediments as a possible source of ongoing contamination
- Sampling process underway to determine chemical constituents of various locations by depth
- Reducing conditions due to bacterial activity found in sediments may contribute to remobilization
- Critical to understand the interactions to develop a long-term sustainable NORM waste management strategy
- [1] Presenter: Mathilde Zebracki from IRSN

Discussion

- After completion of presentations, attendees discussed:
  - Measurement methods used for determining radium in small quantity samples
  - Potential methods for determining the speciation of radium and barium
  - Sampling methods for determination of radium at depth
  - Potential radium treatment methods for drinking-water
  - Soil-to-plant transfer under agricultural application scenarios of radium treatment residuals

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Uranium Recovery

Uranium Recovery Topics

- Guidance Documents
  - IAEA
  - US Nuclear Regulatory Commission (NRC)
- In-situ Leach/Recovery (ISL or ISR)
  - Alkaline based ISR
  - Acid based ISR
- Experiences with conventional mining and milling
  - Portugal
  - Australia Northern Territories
  - Egypt

Uranium Recovery Guidance Documents

- International Atomic Energy Agency Safety Report on Occupational Radiation Protection
  - Safety Report on ORP in Uranium in the Mining and Processing of Uranium (SR-100) estimated to be published by the end of 2019
  - Numerous countries, especially from Africa, requested simple guidance on uranium mining and processing.
  - The IAEA has tried to capture best practices used internationally to provide both junior operators and regulators information to ensure “good practices in operation and regulation.”
  - Report includes a global survey (UMEX project) to examine global occupational exposures in uranium mining and processing
    - Survey provides a snapshot of the doses in 2012
    - 36 operating facilities and 36,000 workers covering ~85% of global uranium production

Uranium Recovery Guidance Documents

- US NRC published (June 2019) Interim Safety Guide for Radon and Radon progeny surveys at U recovery facilities
  - Radon-222 and its progeny are the most significant contributors to public dose at many uranium recovery facilities
  - The guidance includes discussion and guidance on multiple topics, including:
  - survey methods,
  - radon measurement methods and related issues such as locations of the measurements,
  - assumptions such as time on site, simple dose calculations
  - inputs to the calculations such as equilibrium fraction, process parameters, and point of compliance

Uranium Recovery ISL or ISR

- US alkaline based ISR primary radiological hazards are:
  - U in dusts associated with drying and packaging, radium that precipitates out in processing units and radon released to atmosphere
  - Various worker protection controls are thus needed to address the different hazard sources
- In-situ acid leach U recovery can pose risks to surface and ground water from the combination of low pH and elevated concentrations of metals
  - International and US examples were provided to illustrate the issues associated with the use of acids
  - There are no US acid based commercial facilities but a license has been submitted for one

Uranium Recovery Conventional Mining/Milling—Portugal experience

- Portugal has been addressing 60 legacy radium and uranium mining and milling sites that were operated 1908 to 2001
- Conducted multiple measurements of food, air, water, & soil
- Environmental remediations goals:
  - Confine the mill tailings, such as with geomembrane covers to prevent water infiltration
  - Concentrate mining waste in 4 disposal sites
  - Treat acid mine waters
- Effort is largely successful, though some sites need continuing water treatment
  - Highlighted one bioremediation effort using *Typha* (sp.) plants to uptake metals, including radionuclides, that eventually get incinerated, with disposal of ash put in rad disposal site

Uranium Recovery Conventional Mining/Milling

- The Australian Northern Territory has a long history with U mining (since the 1950s) and with remediation efforts
  - Early sites were simply abandoned, while historic legacy sites have been and are being remediated
  - Some remediation efforts failed to last, but recent remediation operations are showing signs of success.
- The Gator ore processing plant in Egypt has been investigating a 3 stage process to address liquid wastes
  - Precipitation using ammonium hydroxide and pH 5
  - Carbonate leaching of precipitated material
  - Uranium precipitation as yellow cake using hydrogen peroxide
  - Process captures over 90% of the uranium in liquid wastes and results in a “friendly environmental liquid effluent”

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Industry Challenges

Geothermal Energy and NORM in the Netherlands - Gert Jonkers

- Discussed NORM associated with geothermal water sources being used for heating of greenhouses in the Netherlands
- Ra 226 and 228 do not pass through heat exchangers into heating systems
- Only Pb 210 is the issue as deposits in tubing and in filter bags
- Dose estimates < 50 μSv/yr at current regulatory limit recommendation of 100 Bq/g Pb 210
- Government wants to reduce to 1 Bq/g but costs associated with this are extensive and prohibitive for operators
- Major point of paper is there is no justification for this reduction since doses already very low.

Coal Mining and Natural Radioactivity in the Coastal Area of Halong Bay in North Vietnam- Fernando Carvalho

- Assessment of NORM content and impacts on environment and fisheries industry from coal mining at coastal areas and transport via sea routes from this Bay
- Sediments and organisms living therein (mollusks, worms and fish) analyzed for NORM content including U 238 + 234, Th 230, Ra 226, Pb 210 and Po 210.
- All values quite low when compared to other locations (e.g., Portugal)
- Conclusion = no evidence of impact on environment of Bay or organism that live there; projected doses very low
- Po 210 higher than other radionuclide species but this is expected in marine organisms

NORM in Western Australia – Plenty of Mineral But Not Enough Human Resources - Nick Tsurikov

- Objective / purpose of paper is to demonstrate lack or radiologically trained resources and associated radiological training programs relevant to the extensive mining operations in Western Australia
- Individuals assigned responsibilities as “Radiation Safety Officers” lack requisite technical skills and are inadequately trained
- Training that is provided has little relevance to mining operations and associated radiological issues
- Instructors generally unqualified to provide RSO training relevant to mining operations
- Almost anyone can promote themselves as trainer in radiation safety with no minimum government imposed criteria
- Courses currently being developed specific for radiological safety aspects of mining operations using IAEA radiological training guidance (e.g., training series # 40 – Oil and Gas)

Communicating Retesting Protocol During and After Subsurface Disturbing Disasters - Art Nash

- Large areas of Alaska have not had measurements made to develop database of radon concentrations in homes
- Concern is that strong earthquake events could create new fissures that provide paths for radon to enter structures
- Want to build more comprehensive “radon map” particularly of earthquake prone areas
- Program imitated to conduct extensive radon monitoring program in preparation for next major earthquake event to be included as part of emergency response programs

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Transportation Security Issues

Session included

- 8 presentations
- The main focus of 6 of the presentations was on the challenges in safety and security of NORM faced by Customs – they have to balance trade facilitation with their security and safety obligations - and discussed how the use of IAEA TRACE program assists in carrying out their duties.
- The remaining presentations discussed the potential of realisation of the value in rare earth concentrates, and discussed that inconsistent application rules and standards, as well as lack of rules in many countries, makes transport difficult for industry. Industry was supportive of compliance and wants to see consistent, implementable rules, that can address common issues relating to security and safety in international transportation of NORMs.
- The main observations from the presentations are summarized on the following slides

Main Observations

- Every customs port in the world has a need to address how to efficiently and safely to process with containers with NORM.
- 90% of the alarms are related to NORM
- IAEA TRACE program has over 40 countries participating. Every country who presented at this conference had positive feedback about TRACE, and were willing to help TRACE to build up the database in order to improve the program effectiveness.
- TRACE provides faster info for the custom officers to assess radiation instrument alarms. It provides a mechanism for consistent, objective, assessment of alarms.

Main Observations

- In general, everyone agrees that more training is needed for the custom officers. Clearer and more easily methods for determining what rules, limits, etc, apply is needed.
- Legalization and regulation of NORM is a big challenge for every country (regulators) and industries – and for the agencies responsible for enforcing safety and security.
- States (industry) want to have some way to consolidate/integrate various limits (dose rate, activities Bq/g) into a more understandable, accessible, and implementable format.
- IAEA should continue to pursue integration of safety and security activities. Tools such as TRACE should be supported. CRPs that involve MS institutes in identifying challenges and developing sustainable solutions should be supported.
- NORM trade/industry is interested in providing information and working with IAEA and regulators (safety and security) to improve understanding of what “innocent” and rule “compliant” shipments look like. Industry wants shipments to be safe and compliant and supports measure to improve facilitation of safe and secure trade.


IAEA
International Atomic Energy Agency
Thank you!