Management of Naturally Occurring Radioactive Material (NORM) in Industry

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MANAGEMENT OF NATURALLY OCCURRING RADIOACTIVE MATERIAL (NORM) IN INDUSTRY

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FOREWORD

The objective of the International Conference on the Management of Naturally Occurring Radioactive Material (NORM) in Industry — NORM2020 — was to share experiences of NORM management in industrial operations with the aim of contributing to the harmonization of practical approaches and adoption of good practices.

This was the first NORM conference organized by the IAEA; the conference built on previous events organized by the international community and on progress in this area to date worldwide. NORM2020 brought together different stakeholders to identify current issues, expected future challenges and possible strategies. Although the conference focused primarily on industrial operations, it also addressed the latest technological developments, research work, regulatory requirements and safety aspects.

The main message of NORM2020 was that a holistic approach that considers, among other things, appropriate policies, strategies and regulations is necessary to effectively manage NORM related issues. This includes a life cycle analysis which takes into account opportunities to (re)use and/or recycle NORM residues in line with the United Nations Sustainable Development Goals (SDGs), particularly SDG 9 on industry, innovation and infrastructure and SDG 12 on responsible consumption and production. For a NORM residue management strategy to be successful and sustainable, the involvement of different stakeholders, enhanced communication, training and education are key.

The international community has handled NORM for decades with different perspectives in different regions. Despite efforts and discussions, some issues remain and new challenges have presented themselves. NORM2020 identified many of these issues and provided an opportunity to share good practices to demonstrate that viable solutions exist. Key drivers for implementing this approach include political willingness and engagement with different stakeholders. The conference also recognized that cross-border problems need to be addressed and different areas called for harmonization. The IAEA can play a key role in providing guidance material and a platform for sharing good practices and discussion among the different stakeholders in an effort to harmonize practices wherever possible and appropriate.

This publication includes a summary of the conference sessions and workshops, opening remarks and the Conference President’s report. The supplementary files, available on-line, contain the contributed papers and respective posters, the list of participants and the presentations submitted with the papers.

The IAEA gratefully acknowledges the support of those involved in the organization of the NORM2020 conference, which was the first fully virtual IAEA conference. The IAEA officers responsible for this publication were H. Monken-Fernandes of the Division of Nuclear Fuel Cycle and Waste Technology and B. Okyar and Z. Fan of the Division of Radiation, Transport and Waste Safety.

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1. INTRODUCTION

1.1 Background

Over the past few decades, many studies have demonstrated that there are and have been elevated activity concentrations of radionuclides of natural origin (RNO) in wastes and residues from a wide range of industrial activities that are not part of the nuclear fuel cycle [1, 2]. Since then, despite some successful cases, many Member States have been struggling to find feasible and implementable approaches for the proper management of wastes and residues containing material referred to as Naturally Occurring Radioactive Material (NORM). The IAEA has issued a publication compiling different approaches to regulate NORM [3] and another providing good practice on how to manage NORM residues [4]. The IAEA has also examined radiological issues in the context of different industries related to NORM [5, 6, 7, 8, 9].

Many meetings have addressed different aspects related to NORM [10,11. 12, 13, 14]. Over time, NORM has been a topic explored in the context of conferences that covered a wider range of subjects such as Waste Management, Exposures to Natural Radiation and Radiation Protection. However, longstanding problems persist and the understanding that these challenges can only be conveniently addressed if a holistic approach – based on a well-structured set of initiatives to be implemented at the national level – is made available. For the success of this intent, member states saw value in addressing regulatory and/or safety issues, characterization of NORM, assessment of environmental impacts and monitoring altogether. Not only do these topics need to come together, but also the different organisations/institutions affected by the existence of NORM in their operations. In this sense, increasing the participation of the industry is of fundamental importance.

To address these issues, the International Atomic Energy Agency (IAEA) organized the International Conference on the Management of Naturally Occurring Radioactive Material (NORM) in Industry. This was the first conference on NORM organized by the IAEA, and it built upon inputs provided by previously organized events by the international community but with a clear focus on industry. The Conference also benefited from the Network of Environmental Management and Remediation and NORM (Environet) [15] that has initiated a project (The ENVIRONET NORM Project) aimed at providing guidance material to the IAEA Member States on how to tackle different tasks that need to be faced when establishing a comprehensive and functional framework to deal with NORM in industry.

The intent of the IAEA in organizing NORM2020 was motivated by the fact that non-nuclear industries are becoming increasingly aware of potential radiological issues in their operations, and some organizations have already established effective management practices. In this sense promoting the sharing of successful examples to support others to address NORM related issues effectively and efficiently is a keyway to contributing to improve the overall situation. The conference covered many of the industrial operations outside the nuclear fuel cycle that also have

to manage potentially elevated natural radionuclide activity concentrations in wastes and residues to ensure continued radiological protection of members of the public and workers.

1.2 Scope and objectives of the NORM2020 conference

The objective of the conference was to foster the sharing of experiences in the management of NORM waste and residues in industrial operations with the aim of contributing to the harmonization of approaches and the adoption of good practices that are both safe and cost-effective and take into consideration the protection of the environment, public and workers.

The conference explored the good practices that have been put in place worldwide and brought together different players to identify current issues and expected future challenges and possible strategies for dealing with them.

Although the conference focused on industrial operations, is considered the latest technological developments and research work, taking cognizance of regulatory requirements and safety aspects. The Conference promoted the discussion of cross-cutting topics such as stakeholder communication and engagement as well as principles of circular economy in the different sessions rather than being stand-alone topics. That strategy allowed for the integration of these topics in the different aspects of NORM pointing out the need for a holistic approach for proper NORM management instead of segregated ones.

The following themes were covered during the two weeks.

National Policies and Strategies: this session focused on the relevance of Policy, Strategies and Regulations to facilitate the proper management of NORM by the industry and provided for the sharing of practices and experiences. It examined approaches to set up a waste management organization, touched on the advantages and disadvantages and feasibility of centralized vs. multiple dispersed facilities for NORM waste disposal, and commissioning of NORM-dedicated facilities instead of facilities accepting multiple types of wastes.

NORM Inventories: this session covered the different approaches to determine NORM inventories in a country in support of the implementation of strategies for managing NORM waste and the application of regulations in the scope of the graded approach. Different methodologies and approaches for inventory determination were presented (e.g., identification of NORM-related industries operating within the country, amounts of residues and wastes being generated, radioactivity concentrations or exposure rates and other hazardous materials of concern).

NORM Characterization in Industrial Operations: This session reviewed well-established methods and approaches for the characterization of NORM in industrial operations and the environment and examined innovative techniques and technologies. It touched on appropriate sampling and

monitoring methodologies, analytical methodologies, infrastructure and equipment requirements, quality assurance and quality control and recordkeeping.

Residue and Waste Management: this session covered IAEA Member States approaches and progress in the management of NORM waste and residues, pointing out solutions and challenges yet to be overcome. The session dealt with life cycle management, cost assessment across all aspects of residue and waste management, management options for residues/wastes (application of the waste management hierarchy), selection of management options, financial guarantees, other considerations (e.g. economic impacts), transportation requirements and controls.

Decommissioning of NORM Facilities and Remediation of Contaminated Sites: this session addressed the approaches being used to decommission NORM facilities (with special emphasis on Oil & Gas offshore platforms) and remediate sites with NORM while discussing cost-effective solutions, innovative approaches and opportunities for improvement. Aspects such as decommissioning and waste management plans, decontamination technologies, dismantling technologies, remediation, identification of contaminated sites, remedial action evaluation and selection, costing and funding, long term stewardship of closed or decommissioned NORM management facilities and sites and institutional controls were all covered in this session.

Transportation and Transboundary: Transport of NORM and transboundary issues are indeed the main challenges faced by different Member States of the IAEA. This session reviewed current challenges examined the need for internationally accepted approaches (with as much as possible some level of harmonization) and investigated innovative mechanisms of detection and data interpretation.

Additionally, a series of workshops were held covering metal mining operations, the oil and gas industry, fertilizer and phosphogypsum, as well as groundwater treatment and radiation protection in the NORM related industry. A discussion lobby on Circular Economy was held to examine this approach through the lens of economic considerations, technology aspects and ethical principles. A section on Exhibitors allowed the participants to see the latest developments on products and services on NORM.

NORM2020 was implemented in a full virtual capacity though the original planning was to have the conference organized in a face-to-face format. That change was imposed by the sanitary conditions associated with the COVID-19 pandemic. Therefore, the plenary sessions were organized showcasing pre-recorded videos of the authors of selected and invited papers. At the end of the pre-recorded video, presentation authors addressed questions submitted by the chat function of the IAEA Conference App. Workshops were organized in real-time mode. Q/A sessions also took place after the panellists' presentations.

1.3 Objectives and structure of this publication

The objective of this publication is to present the main findings of the Conference, the most relevant challenges, and proposed recommendations. The President's Report summarizes some of these points that are derived from the inputs provided by the speakers' presentations, panellists, workshop lecturers and questions and comments contributed during the event by participants. The Publication structure follows the topical organisation of the Conference. Workshop outcomes will be presented in one section. The Conference President's Report is included in Appendix A. Appendix B contains the welcome address to the conference on behalf of the IAEA and Annex C contains an outline of the full papers (that are available in a separate CD/USB).

1.4 Key outcomes of the conference

Below the key outcomes of the conference are presented. Each topic will be discussed in more detail in the following sections.

The concept of a circular economy permeated many of the discussions during the conference. It has been agreed that waste management plays a key role in a circular economy that is intrinsically connected with the objectives of sustainability. A circular economy makes sense provided recyclables are of high quality, if not non-recyclables should be safely disposed of. Therefore, disposal facilities need to be available and maintained to provide proper protection of the environment. To make the circular economy a feasible option, adaptations in the current regulatory frameworks may need to be revisited, so that the conditions for NORM related industries to serve equally and equitably the needs of people in the pursuit of prosperity are created. This means that it will need to accompany the entire resource life cycle and in its new circular form. An example that illustrated these principles was the reuse of phosphosgypsum as a building material, in road construction, or even as an amendment to soils. Despite the numerous works developed worldwide it still faces impediments in some jurisdictions. The same is valid for other NORM residues (radioactivity is a known human carcinogen, and this places restrictions on its use and reuse). The application of these materials is not due to their radiological properties, according to the first radiation protection principle (the justification principle) the justification of the use would not be related to the radiological composition of the materials. Instead, other benefits would need to be considered such as adapting elements of a linear economy regulatory framework to one of a circular economy. It has also been raised the point that stakeholder positions are fundamental in this discussion. There can be a refusal by society to accept that some sort of materials containing radioisotopes are introduced into consumer products and the environment. This calls for efforts to (re)educate and communicate better with society. In these discussions, ethical considerations also need to be considered. That said, the use of residues cannot be seen simply as wastes to be "discarded"; instead, there should be good use made of the properties of the materials for the overall benefit of society. It was also pointed out that innovation in terms of technologies and techniques also need to be put in place and proper economic considerations need to be part of the

overall equation. Discussions during the conference raised the point that in some cases circular economy could only be possible if subsidies (i.e. tax-payer money) come into play, and that would not be, in principle, an appropriate course of action.

Another important topic of the conference was the need to have in place policies and strategies for NORM management. In this regard, the conference discussed that in many situations NORM related operations can be overseen by a multitude of regulatory bodies whereas in others, not be regulated at all. It's a matter of policy to provide, among other things, for such definitions. It is also important to define whether NORM waste is or is not radioactive waste. At the strategic level, the best management options for NORM waste should be considered. If reuse or recycling is not possible, then other options including making available NORM disposal facilities have to be considered. Strategies will depend to a large extent on the costs related to each of the options to be considered and on the specific situation of each country. The Conference raised the issue that harmonization would be useful in the pursuit of international convergence towards same principles, However it was recognised that it may be very difficult to achieve any meaningful level of international harmonization due to the prevailing characteristics of each country, for example, an extension of the territory, the abundance of natural resources, perception from the society, etc.

The conference did not have a particular session on regulatory-related issues. However, the topic of regulations was discussed in all sessions. There was the recognition that sensible regulations will play a key role in assisting the industries in pursuing the so-called good practices. The extent of comprehensiveness of such regulations needs to be commensurate with the risks associated with the activities. It was broadly recognised that NORM does not have the potential to present acute radiological risks to members of the public nor be related to any sort of radiological emergency[1]. However, the safe and effective management of NORM wastes is needed. Constructive dialogue between stakeholders, industry and regulators has the potential to inform one another about the different aspects involved in the individual operations. This dialogue will represent a key step in the adoption of effective and efficient regulations in line with the principles embodied in the graded approach. In this conversation, into which the IAEA can contribute, the adaptation of regulatory principles to the so-called circular economy, and incorporation of elements of sustainability could be included.

As long as Policy and Strategies dealt with in the item above are relevant instruments to allow for proper management of NORM, it has been recognized that inventories (i.e. amounts of wastes generated by a country, localization of the industries in its territory and amounts and extension of contaminated land) are a fundamental starting point. Inventories will inform policymakers and decision-makers when deciding on viable strategies. They will also make it clear whether a market exists to be explored by private companies (in this case policies established at the national level

[1] Events, such as spills are not considered emergencies in this context.

will allow that approach). As a result, governments are encouraged to have in place their inventories of NORM waste to facilitate decisions to be made regarding the management of NORM wastes and residues. The issue of communication with industries was raised as a potential constraint in obtaining the necessary information. In this regard, industry trade associations can play a key role in collecting information for planning purposes. They could be leveraged to provide information on, for example, NORM inventory volumes of a particular industry. Companies may be more willing to share data or participate in activities via these trade organizations. Some of these industry associations also may have already established internal NORM working groups that are positioned to respond to these types of requests. The IAEA could play a key role by guiding how to put together such inventories that might potentially be used by industry (and others) to shape/influence some of their strategies.

The conference recognized that decommissioning of facilities of NORM related industries will be a major endeavour in the years to come. That will be (and already is) the case of Oil and Gas platforms in the North Sea, off the coast of the USA and in other countries. Of relevance will be the arisings of NORM wastes to be generated if piping and other equipment are to be retrieved onshore and decontaminated. Clearance criteria to be applied to such materials will need to be in place. Detection systems, particularly for subsea materials would play a decisive role in the overall process. On remediation, it would be useful to know about the areas that might need to be dealt with. Elements such as characterization, Conceptual Site Models and Assessment Models will play a key role to inform the decision-makers on potential priorities.
Critical steps to support the management of NORM waste and residues involve the sampling and analysis of waste materials and residues. It's been demonstrated that NORM related activities give rise to a high variety of sample types, some of them needing non-conventional laboratory procedures to be radiometrically characterized. Also, important to consider that full radiological characterization demands a variety of sensitive techniques. Finally, due to the large amounts of the generated materials taking representative samples from bulk materials is a challenge and the absence of regulatory guidance in IAEA MS's represent an additional problem. The Conference expressed the need for broadly accepted (harmonized) approaches and urged the IAEA to contribute to this effort by providing guidance material in these topics. Also, the issue has been raised if laboratory certification specific for NORM samples would be necessary/appropriate.

It has been demonstrated that different criteria have to be considered for the proper management of NORM. These include compliance with limits and regulations, prevention of air, soil, surface and groundwater pollution, addressing environmental liabilities generated during the operational phase, maintaining environmental monitoring and, where needed, the industrial activity. Solutions are selected considering impacts on the entire residual lifespan activities related to the waste: storage, recovery and packaging, transport and disposal and integration of all environmental and radiological impacts (workers/public/environment), possible usage restriction and easements and technical and economic optimization. The so-called valorisation of waste (in the scope of circular economy) may be constrained in some jurisdictions by the adoption of numerical limits e.g. 1 Bq/g.

The need to have disposal options for the materials that end up being considered as waste, after the consideration of all steps in the scope of the waste management hierarchy, is of paramount importance. The Conference reported that some countries do not have available such options and the industries generating the wastes have no other option but to store the wastes within their own premises. An example of the exportation of waste from one country to another was also mentioned, but this option could eventually not be the most sustainable and cost-effective. Therefore, addressing this issue is of paramount importance and needs close attention by authorities in the IAEA Member States.

Regarding transportation of NORM, it has been pointed out that transboundary movement of NORM materials can contribute to the implementation of circular economy (waste management hierarchy) as it facilitates, for example, the reuse/recycling of materials. However, authorization for import and export of materials contaminated with NORM for further processing may be required along with the submission of information on the expected (radioactive) residual waste generation. Such request entails the early assessment of processing, storage and disposal capacities, and the establishment of boundary conditions to be applied; it also provides a starting point for a discussion on the return of residues to the country of origin. Along with recognition of these issues, it can be added that differences in definitions between the countries remains an important issue and again some sort of harmonization might be beneficial. Also, it is noted that some countries do not allow the importation of waste materials containing natural radionuclides for disposal in their territories. In this sense, the use of the exportation of NORM waste as a strategy to overcome the lack of local disposal capacity will not be an option for many countries.

The potential implications of the presence of materials containing radionuclides of natural origin in cargos subjected to security checks in the scope of international transportation have been raised. The sensitivity required to detect nuclear materials results in Radiation Portal Monitors (and other detector types) alarming on very small quantities of radionuclides of natural origin (RNO). The presence of radionuclides from natural origin results in a lot of alarms to be resolved with more than 99% from non-security concerns. In this regard, the decision to hold/release a cargo container, vehicle, or person needs to be quick and reliable. It will also need to facilitate trade/movement while ensuring security (and safety). A tool for radiation alarm and commodity evaluation (TRACE) [16] developed by the IAEA was demonstrated. Activities are being planned (developed) to provide data to support TRACE and other tools and support usage and further improvement the main goals being facilitating safe and secure trade for peace and prosperity; providing the right information at the right time and supporting effective, efficient, and sustainable nuclear security and safety activities.

The Conference shed light on another activity that is related to NORM and that so far did not get proper attention, i.e. the demolition industry. It accounted for 8% of alarms registered in Belgium in recycling parks, scrap collectors and landfills between 2012 and 2019. In many of the cases, detected materials were essentially refractory materials, insulating material or scales deposits

within pipes or tubes. The presence of NORM in demolition materials is associated with limited health risks for demolition workers though they are not properly informed about these risks. The situation has the potential to somehow change when demolition of large NORM related facilities takes place, and that situation demands dialogue between NORM-operator, demolition, contractor, and relevant regulatory authority. To address these issues, the conference pointed out the need of raising awareness among different stakeholders that include the legal persons in charge of a NORM related facility, policymakers, relevant regulatory authorities and providing training to demolition contractors so that potential risks can be identified and assessed and decontamination techniques or other approaches can be considered in a case by case approach. The IAEA can help to improve the social awareness of NORM and contribute to improving the understanding and perception of stakeholders regarding the associated risks to NORM. A greater understanding is required of what NORM is and how it should be safely assessed and managed. However, it is equally important to demonstrate that in many cases NORM will not lead to a hazard to human health or the environment, therefore applying a graded approach to safety assessments and waste management. All in all, NORM will benefit from a concerted effort of communication with a wide range of stakeholders, education and training. In this sense, the social-sciences community can play a key role in this process.

2. OPENING SESSION

The conference opened with remarks from the Director General of the IAEA and the Conference President. Leadership figures within the IAEA provided a summary of the work of their respective Divisions that have been undertaken concerning NORM.

The IAEA Director General – Mr Rafael Mariano Grossi - commented that NORM was an important topic but not a new issue. He underscored that it was an opportune time to hold this conference to bring together representatives from the industry, leading experts and members of other international organisations. He highlighted that NORM is present in many countries, but that now there is no consensus on how to establish national inventories or define policies and strategies to manage NORM wastes and residues. Despite that observation, Mr. Grossi recognized that relevant industries are addressing the potential radiological issues in their operations. He raised the issue of carefully considering the “circular economy” approach in the scope of NORM operations as it can lead to greatly reducing waste through recycling and reuse. To support that position, Mr. Grossi emphasized that NORM residue, after all, is not necessarily waste and that innovative thinking and new recycling strategies to make intelligent and imaginative use of it was needed. In this context, it was proposed that IAEA Safety Standards, universally applied in the nuclear sector, may have a useful contribution to make to the NORM related industry. Mr. Grossi also informed that different initiatives are being implemented in the IAEA to support its Member

States to manage NORM safely but also cost-effective way. Among them is the creation of a Working Group which will focus on sampling and characterization of NORM residues and waste as well as an information repository where case studies can be shared. He concluded by saying that the IAEA is very happy to collaboratively with industry and other relevant contributors and stakeholders.

The President of the Conference – Ms. Janelle Branch Lewis – highlighted that there are different approaches and challenges related to managing NORM across the IAEA Member States. In some regions, a lack of feasible NORM waste management options is seen as a constraining factor to the proper management of these wastes. Of relevance, she mentioned the lack of in-country disposal options, lack of in-country laboratory capabilities, or lack of other critical infrastructure to effectively manage NORM waste. She stressed that these challenges may be exacerbated by a lack of clear and effective NORM policies and strategies. In her speech, she mentioned that other gaps include a lack of full understanding of the lifecycle cost associated with managing NORM, partly due to the lack of knowledge of the understanding of current and forecasted NORM inventory volumes of particular concern. Despite the existing challenges, Ms. Lewis stated that there are already many successful examples of safe and cost-effective management of NORM across the Member States. Her expectation towards the NORM2020 was that by leveraging the information shared during the event the international community would be able to work towards the specific goals of further developing critical in-country infrastructure and expertise to appropriately manage NORM as well as effective, and practical strategies that consider the full lifecycle cost of managing NORM while involving key stakeholders. She concluded by saying that NORM does not pose a significant threat to human health or the environment and that it can be effectively and economically managed using a risk-based approach and graded approaches to management.

Mr. Grivot de Grand Court, Assistant of the Ministry of Mines and Energy from Brazil, spoke on the behalf of Minister Bento Albuquerque. He congratulated the IAEA for the organization of the NORM2020. He highlighted that the management of NORM by non-nuclear industries is a challenge as these industries need to deal with concepts that were developed to cover safety-related issues in the context of nuclear energy-related industries operation. He emphasized that due to a large amount of NORM related industries in Brazil, the country attaches great importance to discuss solutions for NORM related issues to these operations that should include protection of the workforce, environment while making available options for the management of NORM wastes. He pointed out the creation of the Nuclear Regulatory Authority in Brazil and underscored that in some circumstances NORM residues can be used safely. He concluded by stating that Brazil was ready to share its experience in this field and wished the participants a fruitful conference.

After Mr. Grivot de Grand Court, Ms. Kayula Siame, Permanent Secretary of the Ministry of Higher Education from Zambia also greeted the conference. She congratulated the organizers of

the Conference and the IAEA for the organization of NORM2020. She informed that Zambia, like many other countries in the world, has to deal with NORM, however, the country has no baseline data on NORM, particularly regarding mining industries. According to her, that represents a challenge to the establishment of appropriate regulations and strategies to implement remediation activities. She also informed the Conference that mining and processing of copper and cobalt are very important activities for the economy of the country and that uranium is present in association with the rocks in which ores of these metals are found. Zambia has received the assistance of the IAEA through the Technical Cooperation Programme to implement environmental characterization vis-à-vis the presence of natural radiation in relevant areas of the country. She stressed that in addition to regulations, collaborative work with the industries would contribute to maximizing the benefits for the society of mining activities and reduce the risks associated with radiation cost-effectively. Zambia is committed to developing Policies and Strategies and Regulations for NORM and trusts on the support to be provided by the IAEA to that end. She conveyed her expectation that other countries in the world will embrace good practices to deal with NORM and wished the participants a productive conference

From the perspective of the Division of Nuclear Fuel Cycle and Waste Technology (NEFW), Director Christophe Xerri stated that the prime responsibility for safety rests with the person or organization responsible for facilities and activities that give rise to radiation risks. The role of governments would be to develop Policy and Strategies and Safety Regulations (harmonized when possible). Within these boundary conditions, the industry would then need to be in charge of developing solutions to address the different technical issues and take care of the implementation of the proposed solutions (pending approval from the regulatory organisations). To this end, the IAEA is promoting the sharing of experience and success stories; providing a forum to discuss solutions and identify gaps and; encouraging more interaction between NORM problem holders, policy makers and regulators. These goals, among others, are achieved through the role played by different professional networks; in the case of NORM, through the Network on Environment Management, Remediation and NORM (ENVIRONET). Networks host eLearning training materials promote webinars and other types of meetings and sustain dedicated projects that revolve around topical areas. In the case of NORM, the IAEA ENVIRONET group developed the NORM Project, which is intended to gather experience from different Member States and share them in the form of guidance documents. Existing working groups on Policy and Strategy for NORM, Inventory Determination and Cost Estimate of Different NORM Waste Management Options will provide guidance on their respective topics. A working group on Sampling and Analysis was launched during the Conference.

The Director of the Division of Radiation, Transport and Waste Safety (NSRW), Mr. Peter Johnston, informed that IAEA is the main collaborator to the organization of NORM Symposia and other events also in partnership with other international organisations such as the World Health Organization (WHO), International Labour Organization (ILO), International Commission on

Radiological Protection (ICRP), United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the United States National Council on Radiation Protection and Measurements (NCRP). The NSRW produces a broad range of safety Standards (i.e. Safety Requirements and Safety Guidance) as well as Safety Reports and TECDOCS. He focused on some of the challenges faced at the level of Radiation Safety such as those faced in the transportation of NORM where harmonized approach for interpretation and implementation that demonstrates compliance with SSR-6 requirements is needed. He also mentioned that there is a continued desire for harmonization, particularly for Radon reference levels, dose conversion factors and regulatory limits where there have been many barriers to harmonization even within the same country. Finally, reference was made to the reuse and recycling of NORM residues which are increasingly being recognized as a resource instead of waste. Mentioning the use of phosphogypsum, it has been pointed out that an impediment to beneficial alternative uses of phosphogypsum is the lack of harmonization of regulatory goals governing the use of that residue. Attention was called, however, to the fact that before harmonizing the standards, it is important to strengthen the policies and measures to enforce reuse and recycling on NORM residues in general. This notion, by the way, is aligned with one of the goals of the ENVIRONET NORM Project that specifically recognizes the need to have in place Policies and Strategies for NORM at the national level. Finally, Mr Johnston highlighted the role played by different IAEA Review Missions and Advisory Services such as the Integrated Regulatory Review Services (IRRS) and Occupational Radiation Protection Appraisal Service (ORPAS). The first one is intended to help host States to strengthen and enhance the effectiveness of their regulatory infrastructure for nuclear, radiation, radioactive waste and transport safety. The second one aimed at providing a cross-cutting review, against the relevant IAEA Safety Standards, of the regulatory framework for occupational radiation protection, technical service providers, and the application of the requirements at all facilities and activities utilizing radiation technologies in the host State.

The Director of the Division for Asia and The Pacific at the Department of Technical Cooperation, Jane Gerardo-Abaya, informed an increasing trend of submission of projects to the IAEA on NORM over the last two decades. Most of the support provide (41%) is placed through the field of activity related to Waste Management and Remediation. The support provided to the Member States involves Expert advice, training, sharing of information and good practices in workshops, meetings, symposia and conferences and procurement of equipment.

3. PANEL SESSION – NORM UNDER THE PERSPECTIVE OF DIFFERENT STAKEHOLDERS

3.1 Session description

The objective of this session was to lay the foundations for the conference by gaining insight from a range of international stakeholders representing different sectors involved on issues related to NORM. In this regard, the panel was formed by I. Bahari from Lynas Corporation and R. Chavasse from the Tantalum-Niobium International Study Center representing the industry sector; J. De France from the World Health Organization (WHO) and S. Foster from the United Nations Economic Commission for Europe (UNECE) representing International Organisations; P. Egidi from the United States Environmental Protection Agency (USEPA) and A. Stackhouse from UK Environmental Agency representing regulatory bodies and C. Xerri representing the IAEA. The goal was to hear from these stakeholders on the current challenges faced by NORM related industries, examples of activities being implemented to address these issues and those steps that can contribute to the efficient management of NORM in the industry. Three main angles were explored during this session: i) Communication and Education; ii) Circular Economy and iii) The Role of International Organisations (such as the IAEA) in contributing to overcoming the barriers for implementation of good practices

3.2 Communication and education

In this first topic, it was stressed that educating the industry is an effective way to avoid reoccurring problems that can be avoided by taking a proactive approach (e.g. problems related to the shipping of materials). That strategy was assessed as being very effective from the point of view of the industry representative. In the transportation of NORM, for example, due to the very low turn-over of personnel involved in shipping in different companies the sustainability of such efforts was quite robust. Therefore, by stopping the industry from making mistakes the number of problems has decreased to a considerable extent in this area. It has been pointed out that in an attempt to promote communication with non-technical people it is crucial to use clear, concise, and consistent language that can be understood by non-experts and that translation of communication materials in different languages needs to be done very cautiously. It has been proposed to refer to risk rather than dose when providing education. By converting dose to risk the public may understand better where radiological hazards lie against other types of hazards. The benefits of leveraging social media to communicate information with the public at large were also highlighted. The so-called “Educate the Educators” was pointed out as a useful approach and that tailored communication is needed. Communicating also involves listening to other stakeholders, including the affected public. The IAEA may have a key role to play by providing and sharing relevant information on NORM e.g. using e-briefings. An ideal communication team should include a combination of social scientists and technical personnel for a successful outcome. On the regulatory side, in addition to enforcement of regulations, regulators could educate management and workers about

practices that are protective of public and workers health and the environment. Finally, it has been proposed that being regulated can be advantageous to the industry as it can be demonstrated to the public that companies are held to appropriate standards of care that require appropriate protection of the worker, public health and the environment.

3.3 Circular economy

There is a general recognition that at some level, society is now expecting practices that put less pressure on natural resources and entail the recycling and reuse of materials. The background for this position is that our society is consuming natural resources way beyond any sustainable level. These are paramount principles of the so-called circular economy. In this context, consideration should be given to how to integrate NORM into this model. For some industrial operations e.g. the tantalum industry the margins for recycling is very narrow as there is very little material of interest in the waste due to the high price of the commodity. Therefore, it would not be feasible for that industry to go to a more circular economy now. The shift to a context of circularity in the current economy would demand actions in three major directions:

- Constructive regulation: Regulatory systems are very linear. In this sense, NORM regulations could be revisited focusing on an increase in resource efficiency and recovery, including clear lines of liability and treatment, to the extent possible, to remove radioactivity prior to recycling. Because of these issues, regulations should be revisited so that they can address the sustainability challenges where appropriate.
- Graded regulations: In this item, the application of principle-based standards would be more appropriate than having in place prescriptive regulations,
- Integrated Management of Resources: This concept ends up being an extension of the principles-based approach.

In a broader perspective, the panel advocated for local solutions recognizing that different areas of the world may not have equivalent resources to implement strategies that are in place elsewhere. It has also been noticed that the adoption of circular economy principles is dependent on “Political Drive”; i.e. it depends on bringing together policymakers, regulators, politicians and the society at large so that proper ambience for the adoption of such principles can be successfully achieved. It was noted that “Political Drive” is very much dependent on perception and again communication and engagement have key roles in the process. Good prospects were mentioned regarding the fertilizer and rare earth industries and the use of coal ash. Attention was called however to pitfalls that need to be avoided. It was mentioned that in the past waste was reprocessed in the USA to get uranium out of it but, in the end, the main intention behind that operation was to change the regulatory status of the waste i.e. from hazardous waste to uranium mill tailings so that the liability could go from the generator to taxpayer. The lesson to be learned with that example is that there is a need to assess the real economic value in the recovery of materials from waste and residues. Another experience that

was shared was that in the reprocessing of a given material one may end up going through sequential steps. At the end of the overall process, the residual materials may become radioactive waste. All these aspects call for ethical considerations so that the creation of environmental injustice is avoided.

3.4 Key areas of work for the international atomic energy agency

The IAEA was commended that NORM2020 was the first Conference organized with a specific outreach for the industry. It has been recognized that the value of NORM2020, in addition to sharing relevant information and good practices, was to attempt to build bridges between different stakeholder groups working on NORM.

It was stated that IAEA safety Standards are not legally binding and interpretation and or implementation of the Standards by the Member States may follow different paths. Because of that, it has been recognized that mechanisms of harmonization of legal requirements could be a positive step in the direction of having a unified approach to NORM. In the lack of such harmonious approaches, it can become very difficult to have convergence in Member States positions with a clear effect – for example – in international trade. In this context, even recognizing that it is not the responsibility of the Agency to provide for such harmonization, as an international organization, the IAEA could play a key role in providing an environment for discussion in the pursue of international consensus on the adoption of harmonized regulatory practices and policies on NORM.

The technical work of the IAEA was praised, and the panel agreed that the Agency could continue providing quality Technical Documents on NORM. Provision of training to regulators was also called for. In addition to these, the IAEA could also play a role in establishing a forum for discussions on the circular economy and sustainability regarding NORM management. During these discussions, consideration should be given to the development of communication tools on NORM, and on how sustainability can be embedded in the Safety Standards.

3.5 Sustainability of environmental remediation

The principles set out in the United Nations' Rio Declaration on Environment and Development of 1992 [13] encompass concepts that are important to the application of sustainable remediation such as intergenerational equity, environmental protection, and waste minimization. In a more recent publication [14], sustainable remediation has been defined as "remediation actions that deliver a net benefit and are informed by the short- and long-term impacts on safety and the environment society and the economy, natural resources and climate change". That definition relates to the principle of justification for remediation in that; "if the remediation activities cause greater negative impact to the well-being of people and the environment than the contamination they seek to address, then they would not be considered to be sustainable" [14].

When defining the end state, there are two levels at which the principles of sustainability are considered. At a *strategic* level, the end state may be influenced by local or regional sustainability factors such as land-use planning, economic and/or social regeneration, and waste disposal management capabilities and capacities. At a *tactical* level, the principles of sustainability will also influence the remedial techniques selected to implement the end state. At the tactical level, factors such as energy use, physical impact on workers, members of the public, and sensitive habitats, and the number of people employed may be relevant. These two levels of sustainability are interlinked, and it would be difficult to define one without an understanding of the other. Thus, the process of determining an end state in this publication includes consideration of these factors with evaluation for the site-specific situation.

3.6 Session outcome

It was agreed that improved communication and education is vital if the risks from NORM are to be better understood. Published documents should be written in a simple language because target audiences are not always specialists in radioactivity. In some Member States, even the regulators and policymakers will not always be conversant with the subject area. The U.S. Environmental Protection Agency (USEPA) primarily refers to risk rather than dose when providing education. By converting dose to risk the public may understand better where radiological hazards lie against other types of hazards.

Public support and improved perception are crucial if sustainability is to be achieved. Information should be consistent and presented in understandable language. With engagement, it is important to listen to people's aspirations and concerns not merely to inform them on project progress. An ideal communication team should include a combination of social scientists and technical personnel and there should be a greater leveraging of social media.

Society now expects the industry to apply the concept of a circular economy and recognise that it should move more towards a cradle to cradle rather than a cradle to grave approach. NORM needs to be incorporated within this model as well as the concept of the graded approach. As a resource and environmental management are crucial, society should consider taking advantage of the fact that materials containing NORM can sometimes have beneficial uses and not always be regarded as waste. However, for the circular economy to be both supported and successful, some boundaries need to be respected. On the other hand, political drivers need to be in place to put forward this concept with the consequent need of analysing the convenience of any adaptation of regulatory framework that can back up this approach. When the concept of circular economy is being promoted it is important to consider specific situations in conjunction with more generic principles.

NORM management is not yet fully understood in some Member States, so the international community needs to share its experience. The IAEA can provide a role in such debates. Additionally, there needs to be a greater level of engagement between regulators and industry, and

IAEA best practice guidance can be used to promote this. In this context, the paradigm of regulations that used to be focused on the "safe disposal of residues" may need to be changed to what can be called 'optimal management of residues' The dilution of materials with higher activity concentrations may (is) not prohibited provided that this approach is taken as the right thing to do under the prevailing circumstances.

3.7 Main challenges

Challenges relating to communication and education for NORM persist but there are opportunities to address these challenges by promoting awareness in addition to capacity building. It is still necessary to enhance the understanding of radiation risk associated with NORM in society at large.

One of the challenges associated with the circular economy is trying to demonstrate that sustainable opportunities are being pursued. Therefore, cultural changes in regulatory activities might be needed because radiation safety regulations do not embed the sustainability concept. The sustainability principles need to align with the justification principle (a cornerstone of Radiation Protection) in such a way that benefits from the reuse/recycling of materials containing residual natural radionuclides, eventually after decontamination whenever applicable, will balance the risks of adding radionuclides in the environment i.e. when no net benefit comes from the presence of radionuclides in such materials.

3.8 Conclusions

For communication and education, it is imperative to use clear, concise, and consistent language that can be understood by non-experts. Social media should be leveraged to communicate information and NORM should be communicated more in terms of risk thus allowing stakeholders to benchmark hazards associated with NORM to other hazards.

The greater consideration to the circular economy should be given as well as the opportunity to revisit some existing regulations applicable to NORM which may be based on a linear economy where disposal is to be considered the destination of residues and waste. That would mean, regulations that keep the focus on safety-related aspects but also consider sustainability elements. Frameworks should be in place to allow for the proper balancing of risks and benefits when trying to extract more useful materials from NORM waste and residues. It is to be noted that one can end up with materials (wastes) with enhanced activity concentrations and therefore adequate infrastructure will need to be in place to allow for the proper management of these more radioactive residues. All these aspects need to be balanced in the application of the circular economy concept. It is important to recognize the relevance of local solutions and that different area of the world may not have equivalent resources to implement their NORM strategies.

There needs to be further support for the industry to take an integrated, holistic, and risk-based management approach encompassing the whole lifecycle associated with NORM and reflecting the potential value of NORM materials.

The IAEA could promote practical examples to help provide guidance for developing an integrated and at the same time graded management approach to NORM while working with industry in terms of thinking in a more integrated way, moving ahead from the linear concept. They could provide direct support to the Member States to raise awareness, train regulators, and help develop national strategies related to NORM and continually integrate the concept of sustainability into IAEA safety standards. It was seen as beneficial if consistency within the IAEA standards were improved the same being true to signposting as this would increase the accessibility of existing information.

The IAEA was called to continue to promote NORM related events and issue technical documents to raise awareness and provide education. A compendium could be compiled listing success stories on the management of NORM residues and wastes.

The IAEA could also provide a forum for discussions that would deepen the analysis of the feasibility of blending/dilution/mixing/removal/segregation as viable treatments for NORM waste and by doing so contribute to overcoming the fear that dilution is a bad thing and that society could be more open to addressing these practices.

The IAEA could also contribute to the establishment of national focal points to facilitate, coordinate and inform stakeholders in their countries about any hazards associated with NORM residues. Communication with other focal points is also important to clear issues on NORM, avoid incurring mistakes and facilitate international trade considering safety considerations.

4. NATIONAL POLICIES AND STRATEGIES

4.1 Session description

The objective of this session was to highlight the current international and national policies and strategies applicable to the various NORM related industries and identify existing gaps and challenges which may be impeding successful sustainable NORM management approaches taking also into consideration worker safety and protection of members of the public and the environment.

The session featured introductory remarks from the chairpersons, eight presentations and a question-and-answer session.

4.2 Session outcome

Many Member States, even those with nuclear fuel cycle facilities, have yet to develop national policies and strategies for the management of NORM. However, some countries have reviewed their NORM management policies and strategies, and others were considering drafting regulations related to NORM management and disposal. While radiological safety is of paramount importance, it was agreed that sustainable approaches, eventually embodying circular economy principles should be considered.

Policies will play a key role in the establishment of an operational approach when a wide range of regulatory bodies will have a say over NORM. Therefore, policies and derived strategies need to be developed through an integrated multi-actor process involving the public, industry and regulators working together to ensure the proper management of NORM in industrial activities which can find the balance of gaining economic growth (e.g., creating jobs), applying sustainability practices and preventing contamination that is harmful to society and the environment. Without proper communication, there will always be the risk of preventable environmental pollution, e.g. caused by improper disposal of waste, with the consequent public exposure to radiation taking place. Adding to that, the slow flow of legal amendments with misconnection between government agencies has also the potential to affect the handling of NORMs by industry.

Policies need to define the possibility of using by-products (residues) or having them recycled in the context of the waste management hierarchy. Recent permission by the United States EPA to have phosphogypsum used in some road construction was a significant step in that direction[2].

It was discussed whether the regulatory requirements now in place, that were in principle developed in the context of a linear economy, can be useful in the context of a circular economy. Innovative regulations are now desired, and a certain level of pragmatism might need to be adopted so that such regulations can be better defined.

4.3 Main challenges

One of the main challenges for the Member States is to work together to overcome inconsistencies found in international and national standards on NORM. Within Member State roles and responsibilities need to clarify especially when duplication of functions takes place. At the international level, it is of utmost importance to develop a quantitative and universal definition of the scope for radiation safety standards relating to NORMs. The existing ICRP's nonspecific recommendations may yet not be sufficient for international intergovernmental organizations to address this need.

[2] It may be the case that this decision is revoked though.

For some Member States, the development of an effective regulatory system is seen to be a challenge for NORM residue management. However, regulatory requirements per se will not be enough and Member States will need to overcome the challenge of establishing proper routes for NORM waste disposal. This is particularly important when the state (government) holds the sole responsibility for this activity. All in all, overcoming the limited number of options for disposal has to be seen as a priority. The costs associated with NORM waste management will significantly influence any proposed strategy, especially for the Member States who do not have nuclear fuel cycle facilities.

In a practical sense, it is difficult for NORM related industries to develop a holistic framework when there are both chemical and radiation risks. Applying a graded approach to a wide diversity of industrial sectors, with a broad variability in radiation risk among facilities, even within the same sector is not straightforward.

Specifically, concerning transportation, examples were cited where the same cargo had to be submitted to fulfil different regulatory requirements, initially in the same country and then during transboundary movement. This necessity places an undue burden on industry without adding any significant benefit in terms of safety.

4.4 Conclusions

Member States may benefit from formulating policies and strategies for NORM in addition to regulation. An integrated and graded approach is recommended, and this means that consideration of non-radiological hazards (e.g., hazardous chemicals as well as worksite safety) should be integrated with the radiological hazard and that the protection is optimized.

There should be greater encouragement to encompass circular economy solutions for reuse or recycling and ensure that adequate waste disposal infrastructures are available in the Member States for residues not viable for further use. Proper adoption of circular economy solutions should involve the consideration of liability, safety and economic aspects as already pointed out in the opening panel.

Improvement of the measures undertaken, and the quality of regulatory and technical activities will contribute to the improvement of NORM risk management. There is a need for the continuous identification of sustainable management practices and improvement of NORM risk management in legacy sites. The IAEA can play a key role in the provision of further guidance, training, and capacity building especially in the development of policies and strategies While promoting enhanced communication and collaboration between regulators and industry.

5. NORM INVENTORIES

5.1 Session description

The objective of this session was to discuss mechanisms for the identification of different NORM-related industries and determine the amounts of residues and wastes being generated by each one of them at the national level as a key part towards the development of management strategies. The session also allowed for the discussion of radioactivity concentrations in different NORM materials and exposure rates verified in different industrial practices. The identification of other hazardous materials that might be of concern in these operations was also covered. Participants coming from different Member States described, in the form of case studies, how their NORM inventories had or were being established.

The session featured introductory remarks from the chairpersons, eight presentations and a question-and-answer session.

5.2 Session outcome

As already demonstrated in various events, some studies presented in this session did recognize that some industrial activities have led to enhanced (over the background range) doses to some members of the public. In some instances, more precise knowledge about doses potentially incurred by a member of the public associated with NORM-related industries is not yet available; the same being true for the potential existence of legacy sites contaminated by NORM. These are due to past activities or even contemporary disposal of waste without compliance with existing safety requirements. In such conditions, NORM (ongoing or past) activities are in many instances, not being dealt with (i.e. regulated) to the extent required to adequately protect workers, the public and the environment.

Each of the presentations demonstrated that the IAEA Member State has embarked on or wishes to initiate a process of managing the NORM challenge by either developing and/or improving the regulatory framework. The implemented effort to date has included the regulatory infrastructure, regulatory standards and the quantification of the extent of the challenge. These activities all required financial and human resources, as will be needed going forward.

The IAEA, within the ENVIRONET network, is developing a user-friendly guidance document to support Member States in the process of establishing a NORM inventory. The guidance is intended to provide a framework that will contribute to the quantification of NORM generated residue/waste at the national level leading to the adoption of appropriate strategies.

It was noted that stakeholders have raised concerns about groundwater protection as well as the potential impacts from uranium mining legacies.

In the discussion, during the session, it was seen that abandoned NORM sites are a specific topic that needs specific detailed attention and approach due to the lack of relevant information and the financial aspects related to it.

5.3 Main challenges

Many Member States have recognized that NORM activities pose regulatory challenges. Based on the outcome of the inventory it can be assessed whether gaps exist and whether the required infrastructure meets the demands of the (amongst other stakeholders) the industry. Moreover, the results can also be used as a basis for the reuse and recycling of numerous (bulk) NORM wastes. Therefore, inventory is the beginning of a process that allows for the identification, characterization, planning, management, and disposal of NORM waste. The disposal of NORM waste poses an international challenge due to the large quantities and the form in which it exists. It is critical however to establish clear protocols to ensure that information shared will be kept and used in the scope of the intended objectives, i.e., to inform the development of policies and strategies at the national level.

Whilst good examples of inventory formulation were presented, in almost all situations the inventory was mainly associated with the establishment of waste management strategies. The need for such strategies seemed to be driven more by industry rather than as a government priority.

Interaction between governmental authorities and industry was demonstrated, but there is still a requirement for greater cooperation and disclosure of information also in the scope of existing exposure situations. Attention needs to be paid to existing exposure situations. Gaining detailed inventory information from the industry is sometimes difficult due to concerns over confidentiality and public perception.

Member States were still finding it challenging to establish their NORM inventories due to the lack of analytical capabilities associated with non-agreed protocols for sampling and characterization.

5.4 Conclusions

The IAEA ENVIRONET network is expected to provide an excellent platform for Member States to exchange information on challenges encountered and solutions developed in the process of managing environmental contamination related to NORM activities. Many Member States are developing an infrastructure to quantify the extent of the challenge, and the new NORM inventory methodology developed by the IAEA through ENVIRONET can assist in achieving this. Due to the need for greater cooperation and disclosure of information between regulators and stakeholders a cooperative framework should be developed especially for existing exposure situations.

Member States may wish to recognize the importance and association of the inventory when they are establishing their strategies for waste management. Improved surveys and characterization of NORM material, leading to a balanced approach, should be encouraged to provide a more detailed inventory.

Assistance in expanding the analytical capability of some Member States will facilitate an ability to establish more accurate NORM inventories. Guidance on how to develop protocols for sampling and characterization can be provided through training and capacity building.

Assistance and guidance are required on funding and funding mechanisms for the development of inventories in existing exposure situations. In addition, it could be considered to involve other toxic components in the inventory since in many cases the NORM aspect is not the only aspect of concern and to develop effective measures to protect the public, workers and environment, these other components can be of relevance and, therefore, should be addressed.

6. EXPERIENCES RELATED TO DECOMMISSIONING OF FACILITIES AND REMEDIATION OF SITES

6.1 Session description

The objective of this session was to provide Member States information relating to the decommissioning of NORM facilities and remediation of sites contaminated with NORM. Such sites facilities included offshore oil and gas platforms and rare earth element mining and processing facilities. The benefit of applying the circular economy concept in the scope of decommissioning and the reuse of phosphogypsum as a resource was also discussed.

The session featured introductory remarks from the chairpersons, ten presentations. Due to glitches with the internet, there was no question-and-answer session.

6.2 Session outcome

It was seen that decommissioning presents a significant challenge for many NORM-related industries and that research is needed to identify optimal approaches. Specifically, in relation to the offshore oil and gas industry, the magnitude of decommissioning is significant and presents major engineering challenges especially around the generation of substantial waste volumes. Per one presentation, it is estimated that between 2016 and 2021 about 600 offshore assets will be decommissioned worldwide and, based on data from Norway, decommissioning may generate as much as 4 tons of waste with activity concentrations of 10 Bq/g or more per offshore installation. Research has shown that adverse effects to marine biota are possible during decommissioning

activities including, non-radiological contaminants and further research is needed to understand potential impacts from NORM.

For other NORM-related industries, the magnitude of decommissioning work and potential waste volumes are not that well-defined but are nonetheless believed to be substantial. Opportunities exist to maximize recycling/reuse and minimize waste generation through the application of the circular economy concept.

The nature of environmental contamination and the related remediation challenges vary by industry and key considerations were addressed in this session. For example, it was noted that remediation projects themselves present their risks and impacts in the form of potential industrial accidents, air emissions, water quality impacts, increased noise, or traffic, etc. that need to be carefully managed. The conceptual site model was highlighted as a key tool for the planning and management of remediation projects by its function in assembling relevant site information, identifying key data gaps, and defining potential exposure pathways. In recognition of the waste management hierarchy, it was pointed out that a detailed site characterization plan is needed to accurately define which areas of a site, or which environmental media need to be remediated as opposed to those that do not and to ensure all waste streams are segregated and managed appropriately. As in the case of decommissioning, circular economy opportunities may exist for some remediation waste streams and can be used to offset costs or develop new revenue streams. An example of this demonstrated that the addition of phosphogypsum to soils enhanced the yield of food products and proved that the build-up of radionuclides in both the soil and product was low.

Demonstrating the prevention of environmental contamination during operations, increasing stakeholder confidence, and applying sustainability within operations is invaluable to achieve safe, timely, and cost-effective solutions for existing situations while enhancing the confidence within different stakeholders (including regulatory bodies) for new operations.

6.3 Main challenges

As noted in the summary of session findings, there are several major challenges associated with decommissioning of NORM facilities and environmental remediation of NORM-contaminated sites. In particular, the amount of future decommissioning work and the resulting waste volumes are expected to be extended across most NORM-related industries. However, industry-by-industry and country-by-country assessments have not been conducted. While there are well-developed safety and environmental regulations for many decommissioning and remediation-related activities, practical guidance is needed to assist the Member States in addressing these challenges safely, appropriately, and cost-effectively. In addition, opportunities to apply the circular economy concept to both decommissioning and environmental remediation need to be fully examined and defined, again on an industry-by-industry and country-by-country (or at least regional) basis.

6.4 Conclusions

It was agreed that further research and analysis is required in several areas to support NORM decommissioning activities. For example, the information further defining the projected scale, timing, and geographic distribution of decommissioning work is needed, along with a solid understanding of expected resource requirements (e.g., workforce; treatment, storage, and disposal infrastructure, transportation impacts) and waste generation (e.g. types, volumes, activity level ranges, non-radiological contaminants of concern). The potential environmental effects of decommissioning activities should also be researched to inform regulation of decommissioning. The application of the waste management hierarchy should be examined, particularly identifying and developing a circular economy framework related to decommissioning activities.

The new ENVIRONET NORM Project task on decommissioning should provide valuable guidance to the Member States on how to assess the scope of current and future decommissioning activities on an industry-by-industry basis. This guidance should include, but not be limited to, identifying best practices for applying the waste management hierarchy (and other sustainability principles) to decommissioning, establishing circular economy structures, as well as incorporating information about anticipated decommissioning activities into Member State's NORM inventories and ultimately into their national NORM policies and strategies. Knowledge transfer to less experienced IAEA Member States is required and the transfer of experience is particularly important early within the decommissioning process.

For remediation, practical guidance and examples of NORM remediation on an industry-by-industry and country-level basis are needed, and research into opportunities to establish a circular economy for NORM residues and remediation wastes would be beneficial. The new ENVIRONET NORM Project task on sampling and characterization should provide valuable guidance to Member States related to NORM site remediation.

7. CHARACTERISATION IN INDUSTRIAL FACILITIES AND THE ENVIRONMENT

7.1 Session description

The objective of this session was to understand the successes and ongoing challenges of characterizing NORM materials and residues, both in industrial facilities and the environment. A wide range of case studies from a variety of NORM related industries were presented during two parallel sessions. The two parallel sessions were required due to the high interest in this subject area. Discussions centred on appropriate sampling and characterization methodologies, the advantages and disadvantages of different analytical methodologies, infrastructure and equipment requirements, quality control and record-keeping.

The session featured introductory remarks from the chairpersons, fifteen presentations and a question-and-answer session.

7.2 Session outcome

The importance of accurate and reproducible characterization was noted in many of the presentations and subsequent discussions. However, a lack of experience in the interpretation of analysis results and the collection of representative samples was also evident from the presentations. It was apparent that NORM characterization and gaining representative samplings is not an easy task, both being crucial to reduce the total throughput time from sampling to reporting.

There has been significant progress in the past years in radiometric characterization methods for NORM. While the limitations, advantages and disadvantages of these methods are well understood the more advanced metrologies for NORM are not always available to all Member States.

Special efforts for the development of *in-situ* and automatic methods for NORM characterization were demonstrated. It was clear that an in-situ approaches provide opportunities to offer highly efficient means for characterizing radioactively contaminated sites, facilitating shorter times for decision making, cost reduction, minimizing exposure and an ability to quickly delineate hot spots. Different techniques were applied against various scenarios including the characterization of NORM residues or rare earth elements in minerals and assessing the radiological impact from a former di-calcium phosphate production plant. Different procedures have also been evaluated to compare the in-situ measurements. It was noted that there is often an inadequate assessment of the potential exposure to workers.

7.3 Main challenges

An improvement in the definition and performance of sampling protocols to obtain representative results of high quality is required as this remains a barrier to proper radiological characterization. There are distinct challenges in the implementation, validation and harmonization of analytical methodologies, including laboratory and on-site measurements. There is often uncertainty around the reliability and appropriateness of the sampling and monitoring methodologies currently being implemented and there is little evidence of the implementation of sound Quality Assurance and Quality Control programs. Adding to that, interpretation of the obtained results can also be an issue. The lack of accredited laboratories in many countries also constitutes a challenge for those who depend on such services.

In general, long throughput times for the radiological characterization and analysis of NORM samples impact dramatically on the decision-making process related to the sentencing or reuse of materials. Once characterization data is collected it is often not adequately recorded and databased.

7.4 Conclusions

The scientific community needs to collaborate further to gain improved harmonization of the sampling of NORM materials and the format of reporting of naturally occurring radionuclides, and further to establish a consensus on eventual applicable radiologically characterization methodologies. A detailed study evaluating in-situ versus laboratory characterization of NORM (eventually with the support of reference samples) and the creation of protocols for the combination or individual use of both approaches would be invaluable. Package form problems can arise, not least oily sludge and associated issue of dry weight analysis, also the issue of NORM standards (e.g., thin gross alpha standards and thin samples). Guidance is needed on the use of dedicated landfill sites and beyond this the design of near-surface low-level waste (LLW) disposal facilities dedicated to NORM affected media. Risk characterization of disposal sites, using computational codes should also be addressed eventually supported by the training in the use of such codes, including the understanding of the output values, cancer risk and potential for use of the de minimis dose concept or similar (negligible risk) in communicating with stakeholders.

Within its training programs, the IAEA could guide sampling and characterization of NORM, and interpretation of the results. A greater level of practical training with focused demonstration exercises could be incorporated into such training.

Many Member States face challenges in establishing an analytical capability. This is a key area for the IAEA to support. Member States may benefit from taking cognizance of the IAEA's ENVIRONET NORM project which has a new task on sampling and characterization.

8. TRANSPORTATION OF NORM MATERIAL AND TRANSBOUNDARY ISSUES

8.1 Session description

The objective of this session was to discuss both the challenges and potential approaches of transporting NORM including raw materials, residues and waste. A lack of consistency and conformity of regulations associated with transboundary issues was cited. The session also depicted the transport and eventual disposal of NORM waste from Brazil to the USA which was seen as a successful outcome under the prevailing local circumstances i.e. absence of disposal routes for the waste. Debates however took place arguing if that solution can be seen as a sustainable one.

The session featured introductory remarks from the chairpersons, eight presentations and a question-and-answer session.

8.2 Session outcome

NORM is mainly transported both by land (rail and truck) and sea and sometimes by air. But differences exist between the Member States on how the transportation of NORM is regulated and it can be difficult for industry and even regulators to apply the regulations correctly. One presenter noted different transport regulations existed in neighbouring jurisdictions, depending on whether the material was classified as a residue or as waste. The lack of international harmonisation (flexibility) could be improved upon better communication and training and cooperation between states and regions. More robust characterisation and quality assured documentations have the potential to demonstrate the material is not a security issue, exemption from transport regulations, and so reduce the impact of false alarms from radiation monitors.

Some Member States had demonstrated an increased level of communication between industry and regulators, and data had often been gathered as part of a national strategy. Authorities in some European countries (e.g. The Netherlands) have set up a Working Group to address the problems surrounding the provisions of NORM residues and wastes.

The high sensitivity of Radiation Portal Monitors was leading to a high amount of false positives alarms when NORM was being scanned. In many instances, these alarms were not related to any security concerns, so it was important to be able to distinguish between these and genuine alarms i.e. alarms that could be triggered by the presence of a material of concern to security. Enhanced communication and characterisation could support the implementation of improved national security strategies and remove many of these false alarms. Some national institutes provide a helpline service to better interpret Radiation Portal Monitor alarms.

Improved capacity building, including training, better management of waste, and the clearance of materials and sites is required. It was agreed that the deployment of tools and information to facilitate safe and secure trade will help support effective approaches.

8.3 Main challenges

There are significant volumes of materials, limited economic resources, poor waste inventories and an absence of adequate regulatory criteria for NORM. These issues could be improved through capacity building and more robust management practices. Differences in the approaches taken, especially about regulation and the definition of clearance levels lead in turn to transboundary issues.

Even though it should be an essential element of national policies, residue and waste management, and the circular economy, transport considerations are often overlooked. Transport should be included within comprehensive waste management and decommissioning plans, national strategies on residue and waste management and when determining whether transportation of waste to other countries for processing and disposal is possible and/or desirable.

It was clear that some sectors of industry were taking a less proactive approach to NORM than others and there was a need to reinforce awareness and provide adequate training. Whenever there is a lack of regulatory oversight and inadequate transport requirements (lack of documentation coupled with the poor labelling of packages) as barriers to transportation might be encountered.

NORM is often perceived as a nuclear security concern due to the sensitive nature of portal monitors. Most alarms are from NORM related materials but in many instances are not a security concern. However, they may be used as a source of information in the development of a national NORM inventory.

There is in general a lack of simple and inexpensive measurement techniques available to the Member States struggling to implement successful NORM transportation.

8.4 Conclusions

The industry itself needs to improve its communication practices and ensure staff are suitably trained in the necessary radiation protection and dangerous goods transport skills. The preparation of further guides should be encouraged to increase awareness among industry stakeholders. Industry can also maintain connections with the relevant authorities and international agencies through its active membership of IAEA committees, involvement in multi-stakeholder bodies such as the Transport Facilitation Working Group, and through the provision of knowledge and expertise.

Regulators should look to strengthen communication links across geographical and thematic areas and could reappoint National Focal Points. Regulators and the IAEA could reach out to the industry and attend annual conferences to conduct awareness-raising.

Regulators could look to work alongside the industry on IAEA initiatives, to maximize knowledge sharing and lessons learned. The IAEA might wish to consider involving more NORM related industry members within its technical projects so that technical cooperation between industry and regulators will be enhanced.

Regulators should continue current efforts of employing technology to improve the interpretation of alarms (e.g. US Department of Energy service or IAEA TRACE system), to assist personnel in judgment calls. Consideration of a future tool to provide a summary of the applicable regulations for a specific material could be beneficial.

The IAEA could continue to raise awareness in this subject area through training and its many other mechanisms of capacity building.

9. SOLUTIONS FOR RESIDUE AND WASTE MANAGEMENT

9.1 Session description

The objective of this session was to discuss international experiences related to NORM residues and wastes. The themes of strategy and regulation, the potential reuse of materials, residue and waste management as well as commercial solutions were debated. The circular economy was discussed further especially concerning how NORM could be classed as resources rather than wastes.

The session featured introductory remarks from the chairpersons, nine presentations and a question-and-answer session.

9.2 Session outcome

Strategic and regulatory aspects were highlighted in several of the presentations. The importance of strategy building, where the scientific community could act as a bridge between regulators and industry, was discussed.

Some examples for the reuse or recycling of mine tailings were presented showing that evolution from the “cradle to grave” approach to a real circular economy was achievable. A poly commodity approach to material recovery provided a wide range of opportunities including reduced remediation costs, reduced long term environmental problems, the ability to reprocess tailings, and the potential reuse of remediated tailings.

It was felt that adopted solutions for waste and residue management should be proportionate to the hazard. It was important to rebalance the environmental-economic equilibrium and promote more about reusable material rather than waste. While the primary defining principle of a circular economy is conservation (i.e., zero waste), this may be more of an ambition than a feasible goal. The Implementation of the circular economy approach does involve a series of considerations that encompass technical/technological, economic and social dimensions.

Commercial and proposed solutions for industries that generate NORM were presented including reinjection or volume reduction. Exporting waste from one country to another while implementable was not deemed a sustainable solution.

9.3 Main challenges

A key challenge for many countries States is that they have limited solutions for managing NORM wastes and yet they host operations that generate large quantities of NORM residues and this can lead to the creation of large wastes stockpiles. Consideration needs to be given about how to reduce the hazardous potential of NORM waste and reduce the overall volumes.

While different technological solutions for waste volume reduction or disposal have been developed and successfully applied, approval would be required from the regulator within the Member State where that solution will be applied. It is not evident if regulatory approval for NORM management in one country is valid in another and therefore the solution provider may have difficulties in gaining approval for a specific technology to be applied in another country.

The valorisation of NORM waste via reuse and recovery and its entrance into the circular economy concept will be challenging for the different parties (regulators, industry and local community stakeholders). This will require all different parties to work together towards a common understanding of the potential long-term benefits.

Current algorithms for the assessment of risk versus benefit do not yet match the aspiration of applying a sustainable and integrated management approach of all resources. There is a need for a graded and classified regulatory approach to NORM Waste.

One of the greatest challenges associated with the NORM related industries is the perception of risk. Stakeholders view anything with a radioactive connotation as a health and environmental concern. Even though this concern might be sometimes overstated it is still valid. Therefore, to achieve reasonable solutions, enhanced engagement and dialogue with different stakeholders is needed to get risk into its real perspective. This will allow for the implementation of some approaches that will end up bringing clear benefits to society but might be perceived differently.

9.4 Conclusions

The terminology (waste x residue) used to describe and regulate the NORM industries could be refined to facilitate movement towards achieving a circular economy. Regulation could be amended to allow ranges of activity for exemption and clearance to provide regulatory bodies with further flexibility around the treatment and disposal of low and medium activity waste streams, thus allowing the adoption of different options.

The knowledge and understanding about NORM wastes should be improved through the participation of the scientific community to promote consistency in the communication (enhance the effectiveness of dialogue) of information and to facilitate greater integration between regulators and the industry.

For the Member States which do not have alternatives to final disposal, a term of reference could be developed so that steps can be taken towards finding technical and economically viable solutions, reducing transport risks, and seeking local solutions within the framework of the circular economy concept.

Within its training and general communication programs, the IAEA could reinforce the emphasis on understanding NORM and place the potential risk into context with other risks. The IAEA could

assist in gaining international consensus in public health issues, especially in today's world where biological risks are now taking precedence.

For countries that do not have alternatives for final disposal, a term of reference (some sort of guidelines) could be developed so that steps can be taken towards technical and economically viable solutions, reducing transport risks, and effectively seeking a local solution within the circular economy concept. The sustainability of exportation might not be there in the future.

10. SPECIAL SESSION ON EMERGING ISSUES

10.1 Session description

The objective of this session was to discuss some of the subject areas which had not been discussed at length in the primary conference plenary sessions but are germane to the topic. These subject areas included radiological risk assessment, capacity building and the contribution that social sciences can make to successful NORM management. These subject areas include communication of NORM hazards with valuable contributions from social sciences, essential observations and challenges concerning a circular economy, aspects of capacity building and an industrial sector involving NORM missed out thus far.

The session featured introductory remarks from the chairpersons, nine presentations and a question-and-answer session.

- Communication and social sciences,
- Circular economy (examine in-depth the requirements and associated aspects that lead to the need for subsidies, and liabilities that cannot be ignored),
- Capacity building – a key aspect would be lack of regulations (structured approach),
- Demolition industry as a new activity to be paid given attention to.

10.2 Session outcome

Across most industries involving NORM, expert capacity building is essential for the different activities due to the identification of scarcity inadequate industrial training programs. For optimum NORM inventory assessment, there is a requirement for robust characterization and management. Initiatives like the School of Uranium Production under the auspices of the World Nuclear University is successfully providing capacity building and training for managers, researchers, operators, regulators and students in the many Member States.

It was shown that there was very little knowledge of NORM within the demolition industry and even a recent European Union (EU) produced Construction and Demolition protocol did not mention NORM. This industry requires greater NORM awareness training especially for experts

performing the pre-demolition audits. While mobile Geiger counters on every demolition site would be useful, it was recognized that they would not measure everything, and relevant training would be required.

As mineral resource extraction continues to increase there is a potential for some NORM residues to fuel the circular economy by keeping these materials in the loop and not sentencing them as waste. Uranium and other critical metals could be extracted from copper tailings for example. However, required chemical treatments will affect the mobility and potential toxicity of minerals that ultimately remain in the newly generated waste that should be disposed of in dedicated disposal facilities ('safe sinks') to protect the environment. It may be clear that further innovation and investigations will be required.

Social sciences can provide a valuable contribution to NORM management and the existent capacities and expertise in the platform for Social Sciences and Humanities. Research related to Ionizing Radiation (SHARE) can be readily applied in ongoing and future NORM management projects. It was agreed that decisions related to NORM cannot be isolated from the socio-political and cultural environment and a holistic approach was needed. Stakeholder perception was influenced by different factors including responsible research and innovation, historical practices, stakeholder engagement practices, risk and health communication as well as the radiological protection culture. The European Commission's OPERRA project - "Open Project for the European Radiation Research Area" - has shown that NORM projects are not holistically focused and that there is now more focus on industry working closely with society.

10.3 Main challenges

A key challenge is undoubtedly the lack of or ill-developed national NORM regulations which provide a barrier to successful NORM management and application of the circular economy. There is additionally insufficient training, especially for NORM radiation protection. NORM inventory data is often unreliable and is rarely based on robust characterization data.

There is a requirement to improve quality management, increase operator safety and optimize operational costs. Safe protocols for cleaning, containment and disposal of NORM need to be established. Innovation needs to be applied within the technical, environmental, social and regulatory arenas.

There is a necessity to find opportunities to get the circular economy going in a practical manner, thereby maintaining disposal facilities, sanitary landfills and incinerators to protect the environment. There is a need to raise awareness of the benefits of integrating social sciences into NORM management projects.

10.4 Conclusions

It is necessary to raise awareness of the risks associated with NORM to industries that unknowingly may come in contact with NORM. The provision of an inventory of the different industries that may encounter NORM in their operations could be beneficial.

The international community is encouraged to continue research on possible material valorisation exploiting technical, environmental, social and regulatory innovations.

There is a clear need to formulate or improve national NORM regulations through enhanced international cooperation by exchanging good practices and recommendations. The IAEA could assist in setting up the requirements (e.g. templates) for national NORM regulations.

Standardized procedures are required more and more for NORM management although local aspects need to be recognized.

The social acceptance of mining activities is decreasing, and social sciences and humanities should be involved in all types of NORM management. Social media should be used more to sensibly challenge disinformation.

11. WORKSHOP – PERSPECTIVE FROM THE OIL AND GAS INDUSTRY

11.1 Workshop description

The objective of this workshop was to gain a perspective from the oil and gas industry on current collaboration work with NORM, the technical gaps related to waste management, and decommissioning assets with NORM. The final discussions centred on the key areas of work the IAEA could be doing to help the oil and gas industry in its NORM related challenges.

The workshop featured introductory remarks from the chairpersons and a question-and-answer session.

11.2 Workshop outcome

Several examples were provided on industry-led efforts related to NORM in oil and gas. In Australia for example, researchers and industry are working together to understand more about the potential risks and benefits of leaving certain infrastructure in place using eco risk studies. A risk-based framework is therefore encouraged.

Approaches to assess the different types of infrastructure and their NORM content are lacking so further work on sampling and measuring sub-sea pipeline infrastructure is crucial. It was clear that the many Member States have difficulties in finding a disposition path forward.

The ENVIRONET's NORM project is launching a Working Group to focus on the sampling of NORM wastes.

11.3 Main challenges

Volumes of waste generated from unconventional wells far exceed those from conventional oil and gas wells. Therefore, with an increased amount of waste, there is an increased potential for NORM waste. However, increased volumes and concentration of NORM are dependent upon many things, not just conventional vs unconventional. For example, formation, age of the well, salinity in the production well, etc. If NORM is identified in a given structure of the submarine system, manipulating this structure may bring greater risk, both for human health and the environment.

It was noted that there is very little public domain data that can be utilised to assist with characterisation studies and the sharing of data is difficult because of potential litigation issues.

The lack of waste disposal options and available screening methods are major challenges for some countries. There needs to be a greater desire for the general acceptance of field instrument measurements to aid real-time decision making. Risk-based approaches are a viable option to evaluate everything more holistically.

11.4 Conclusions

Member States are expected to encourage the different NORM related industries to share characterisation data more freely, through efforts such as highlighting that more robust underpinning datasets can lead to more effective strategies. There is also an opportunity to develop good quantitative technologies to provide more accurate characterisation data. The IAEA can help provide their expertise to help the Member States establish in-country radiochemistry laboratories.

Collaborative research projects should be established aimed at providing more data on NORM exposure pathways in the marine environment. The IAEA could gain input from the onshore nuclear industry in how it has approached decommissioning and established frameworks for assessing potential marine impact.

For countries that do not have alternatives for final disposal, guidance could be developed so that steps can be taken towards technical and economically viable solutions, reducing transport risks, and effectively seeking a local solution within the circular economy concept.

It is necessary to create more specific guides for NORM. IAEA Member States can be involved with the ENVIRONET Working Group on NORM sampling and characterisation.

12. WORKSHOP - URANIUM AND OTHER METAL RESOURCES IN MINING AND MILLING WASTES: TOWARDS CIRCULAR MATERIAL USE

12.1 Workshop description

The objective of this workshop was to discuss current EU uranium market strategies, the regulatory issues and strategies around waste rock reuse, the business risks and global challenges of extracting uranium from mine wastes and the limits associated with recycling. The final discussions centred on the role the IAEA could play on these issues.

The workshop featured introductory remarks from the chairpersons, four presentations and a question-and-answer session.

12.2 Workshop outcome

All panellists concurred that innovations in mining are needed not only to comply with ambitious policy goals, such as those set out by the EU but also to address environmental and human health. These innovations should be expressed in the fields of technology, communication with different stakeholders, regulations and governmental policies. They are therefore very much needed in the mining industry. However, innovation should not be seen as merely linked to technological developments but also encompass innovative approaches to communication in a way to foster public acceptance of (re-mining) activities. Another suggested innovation concerned regulation, and that could be translated into the application of "thresholds" not only in defining maximum levels of a contaminant in the environment but also on the levels of certain elements in the waste i.e. these should be below a certain threshold.

Holistic steps forward should combine regulatory, technical, economic, social and environmental progress to allow sustainability from mining by the adoption of circular economy concepts. However, in this context, it is important to stress, that "zero waste" – something that is often promoted in the circular economy context - is a noble goal yet may not be fully achievable. Balanced approaches are needed to maximize the materials in the loop. However, there will always be drains and it will never be possible to make use of all wastes generated in the process. Therefore, the main objective of the circular economy approach should be indeed to minimize the amount of wastes that need to be disposed.

12.3 Main challenges

A key challenge is the growing importance of gaining public acceptance. For the European Member States, public acceptance of mining and re-mining continues to diminish due to reduced land availabilities, appreciation of established post-mining landforms, and image problems of the mining industry. It is however important to differentiate the context related to each specific Member State because where employment opportunities are scarce, resistance to mining activities may be less pronounced.

A problem for modern-day society is the growing paradox between resources needed and resource availability. In the EU, this led to the plans on circular economy schemes for mining wastes to recover what the EU defines as critical raw materials from their lands and wastes to decrease dependencies. While the demand is rising, the "social license to operate" continues to decline as does the public acceptance of new activities.

The gap in regulatory development between developed and developing countries requires attention. In extraction industries within the EU, the occurrence of NORM in a wide variety of polymetallic ores poses a regulatory challenge due to waste management obligations and licensing issues.

Recovery of a multitude of metals is still constrained by market realities when (additional) extraction costs are not covered. The re-mining of wastes has the potential for long-term benefits including resource efficiency, no future energy requirements for re-mining, and a reduction of contaminants that can get re-mobilised.

12.4 Conclusions

All of the panellists stressed that more research and knowledge is needed in addressing mining wastes and their potential stocks of various critical raw materials in addition to the consideration of non- uranium critical raw materials from uranium mines to complement the economics of uranium mining and processing wastes.

Additional training in regulation would be beneficial for the specific Member States especially to radiation protection. The IAEA needs to continue to provide platforms for discussion, exchange of information and dissemination of good practice. The IAEA might consider to pursue mechanisms to communicate more frequently and efficiently with its Member States on topics such as the availability of training materials.

There is the potential to provide greater innovation in communication technologies. Modern communication tools like social media platforms could be used to help to shift negative perceptions.

13. WORKSHOP – PHOSPHATES FOR SUSTAINABLE DEVELOPMENT: FERTILISERS AND PHOSPHOGYPSUM IN THE CIRCULAR ECONOMY

13.1 Workshop description

The objective of this workshop was to discuss the various applications of phosphogypsum and how the phosphate industry in general could play a major role in supporting sustainability. The workshop featured introductory remarks from the chairpersons, six presentations and a question-and-answer session.

13.2 Workshop outcome

NORM related industries span the whole gamut of food-energy-water nexus. Safe and efficient management of the material handled by these industries is essential to meet the objectives of several SDGs such as #2 on zero hunger, #6 on clean water, #7 on clean energy, #12 on the responsible use of natural resources and #13 on climate action. Several applications of phosphogypsum (PG), which can support 100% PG utilization discussed in the workshop include agriculture, forestry and construction materials. PG utilization can support the post-COVID-19 reconstruction and will also contribute to the UN Decade of Action. The phosphate industry can play a role in sustainability. Several applications of phosphogypsum that can support 100% utilization were discussed including those relating to agriculture, forestry and construction materials. The recent approval by the US EPA for reuse of phosphogypsum in road base was mentioned as a positive example as was evidence of improved biomass through adding phosphogypsum to soil in-situ when establishing forests on gypsum stacks in Canada.

To achieve the above objectives, it will be crucial to turn a perceived problem into an opportunity. in alignment with the UN SDG's. Partnerships are the key components of this effort and, as much as possible, the application of recycling and reuse approaches should be embraced by different countries.

13.3 Main challenges

The change in the perception of NORM purely being a waste product was indicated as one of the main challenges to its use and there is a need to reclassify such waste as a resource.

The utilization of phosphogypsum could help support the post-COVID-19 reconstruction and will also contribute to in achieving the UN Decade of Action. A milestone-based approach based on UN and IAEA standards and best practices will be required to progress the various projects to a commercial scale.

13.4 Conclusions

The workshop recommended an update to the IAEA Safety Report 78 (Radiation Protection and Management of NORM Residues in the Phosphate Industry) to include aspects of the UN SDG's and the food-water-energy nexus. The workshop also recommended the creation of a multi-stakeholder platform to share information and collaborate on the sustainable use of NORM materials, especially phosphogypsum.

14. WORKSHOP – SAMPLING AND RADIOLOGICAL CHARACTERISATION OF NORM RESIDUES AND WASTES

14.1 Workshop description

The objective of this workshop was to assess the effectiveness or otherwise of the sampling and characterisation of NORM wastes and residues.

The challenges surrounding representative sampling and the use of reference materials were discussed. The workshop featured introductory remarks from the chairpersons, seven presentations and a question-and-answer session.

14.2 Workshop outcome

The lack of certified reference materials for NORM was highlighted as a major concern, exasperated by the long process to compile and publish these.

It was noted that there was a lack of harmonization to regulatory requirements for NORM products. However, regulation needed to be fit for purpose and take cognisance of national legislation and local regulations. The role of the regulator was crucial when working within the circular economy context.

In-situ characterisation of NORM at offshore platforms and inside subsea pipelines is vital either by direct measurements or sampling regimes.

The creation of a working group for sampling and analysis of NORM within the ENVIRONET NORM project was again noted.

14.3 Main challenges

There are several challenges associated with NORM characterisation, including the wide range of materials and their homogeneity, complex nuclide combinations, and the prerequisite for only qualified staff to operate the equipment.

There are challenges associated with long turn-around times for analytical data and the desire for greater acceptance of field instrument measurements to aid real-time decision making.

In some situations, such as offshore oil platforms, the limitations on space and the need to take immediate decisions on the future residues, imposes a compelling need to outline sampling and in-situ measurement practices. The validation of analytical methods is often hampered by the lack of suitable certified reference materials and dedicated proficiency test exercises. There was a need to develop sampling procedures based on strict statistical principles to ensure the representativeness of the sub-sampled amounts.

The use of in-situ methods, although offering obvious advantages in terms of speed of analysis, require further studies to attain a comprehensive assessment of their performance characteristics and to make them acceptable to the regulatory bodies.

In some Member States, a lack of disposal facilities limits the available management options.

14.4 Conclusions

It was felt that the IAEA could provide expertise to help the Member States establish in-country radiochemistry laboratories.

The IAEA could consider producing suitable reference materials to fill the gap on availability currently in existence, thus supporting the validation of analytical protocols and increasing their recognition by regulatory authorities.

15. DISCUSSION LOBBY WORKSHOP – THE CIRCULAR ECONOMY IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT: ITS MEANING TO THE NORM INDUSTRY

15.1 Workshop description

The objective of this workshop was for the panellists to present their thoughts on the NORM related industry in the context of the circular economy and the three dimensions of sustainability (environmental, economic and social). The final discussions centred on the role the IAEA could play on these issues.

The workshop featured introductory remarks from the chairpersons, and a question-and-answer session.

15.2 Workshop outcome

All panellists agreed that there is an opportunity to transfer the NORM related industry from a linear to a circular economy concept, as the latter is more likely to be sustainable. However, it was recognised to be successful it would require a more innovative approach. There was already resource stress to the food – energy – water - security nexus and it was appreciated that the IAEA was already undertaking work towards improving this issue. It was important to communicate that public health risks, especially chronic ones are partly due to resource stress. The IAEA can help to communicate around finding the right equilibrium, emphasizing that the health of the public and environment are interlinked.

Three aspects of the circular economy were extensively discussed relating to technology, regulation and the social and ethical dimension. Ethical, technical and economic issues need to be balanced and considered alongside environmental regulations. Specifically, to the ethical dimension, stakeholders may need to contemplate the fact that there will always be some residues and radioactive materials in the overall balance of costs and benefits.

As highlighted in the waste management hierarchy, actual disposal should be viewed as the least satisfactory solution, especially as future generations will inherit the economic burden. The principles of intergenerational equity are therefore important. If the generation of some waste cannot be avoided, then it can be better dealt with through improved governance.

The panellists noted that there were stakeholder concerns around the reuse of material containing radioactivity. The more concentrated the residual is, the higher the hazards and risks might be. In the mining industry, most risks are physical in nature and radiological risks should be put into context with these other risks.

In addition to NORM related industries, the circular economy has been shown to also be attractive for nuclear-decommissioning projects. It can facilitate dialogue, is effective for applying the waste hierarchy and can be integrated into the post decommissioning life of a facility or site.

15.3 Main challenges

One of the challenges when working within a circular economy is that the practice of processing materials considered for reuse can result in increased concentrations and therefore higher hazards being left behind and final disposal cost prohibitive. But new mining projects are finding it harder to get licensed and gain public acceptance so it might be necessary to reframe and rethink material sciences.

Public health risks (both acute and chronic) within the NORM related industries are still poorly understood. Regulators need to identify if requirements for public and worker health protection can be set.

Facilities that handle very low-level radioactive waste are sometimes assessed in line with standards for high-level waste facilities due to such waste legally being termed hazardous. This often leads to disproportionate benefits to human health and the environment.

While the circular economy already embraces the ethical challenge it still needs to be viewed by stakeholders as the application of good practice. Stakeholder involvement is therefore crucial and public opinion needs to be sought.

15.4 Conclusions

The IAEA has the potential to become a mediator of a reflection process on the socio-political and ethical aspects of a circular economy concerned with NORM.

In terms of risk, in addition to considering dose effects, the IAEA could encourage the Member States to sometimes consider communicating risk in a manner that radiological risks can be compared with other risks and hazards.

The IAEA could provide additional guidance on active stakeholder involvement for NORM related issues, especially thinking of future generations.

It is important to consider if and how the IAEA's Safety Report Series documentation could be re-written to provide a balance between safety and all the other factors required for NORM management decision making.

Many Member States don't have available technologies to apply the circular economy. The IAEA could assist with this aspect. Support in setting up in-country chemical laboratories would be beneficial for some Member States.

The IAEA could provide Member States with further guidance on potential NORM management and disposal options.

16. WORKSHOP – GROUNDWATER 360º

16.1 Workshop description

The objective of this workshop was to discuss issues relating to groundwater protection. These included guidance from the World Health Organisation on drinking water standards, radiological consequences of fossil aquifers, and groundwater treatment.

The workshop featured introductory remarks from the chairpersons, five presentations and a question-and-answer session.

16.2 Workshop outcome

The radiological characterization of groundwater is important for assessing radionuclide health risks from drinking water, especially in areas where fossil[3] aquifers are the main source for irrigation and drinking water. Different criteria are needed to assess sites and understand the geochemical processes in action.

Although a variety of groundwater treatment approaches are available, the most appropriate one will often depend on site conditions, types of contaminants and the concentrations present within the groundwater. When choosing a specific groundwater treatment approach, cognizance should be taken of any waste management implications. Risk assessment and cost-benefit analysis should be considered along with the availability of financial resources. Long term assessment and modelling was crucial, and decisions should take account of the potential benefits of monitored natural attenuation.

It was agreed that drinking water screening and guidance levels, due to their conservative nature, are not water quality standards but guidelines. If exceeded, it may not necessarily mean that drinking water is unsafe but that further analysis should be considered.

16.3 Main challenges

It was seen that there was no single decision-making approach or simple solution being applicable for supporting the justification of groundwater treatment.

Besides radiological criteria, different additional factors should be considered before a decision on water treatment is made. These might include features of the hydrogeology and geochemistry of the site, features of the use of groundwater and the time factor of the formation of water pollution, as well as social-political and economic conditions.

Assessing the many issues related to groundwater is complex. Extensive data is required and communicating risk to the public has to be done rapidly and regularly by public health officials. Relative risks have to be evaluated of providing a water supply elevated in radionuclides against having insufficient water distribution. The potential risk from radionuclides relative to chemical

[3] Fossil Aquifers are large underground reserve of water that were established under past climatic and geological conditions. They can underlie present-day semi-arid environments, provide key source of groundwater in otherwise water scarce regions.

risks of uranium, arsenic, and other contaminants should be compared and communicated. The efficiency of water treatment to reduce the generation of radioactive waste and ensure appropriate handling and disposal of low-level radioactive waste needs to be improved.

16.4 Conclusions

As screening and guidance levels are conservative, they should not be interpreted as mandatory limits. Exceeding a guidance level should be taken as a trigger for further investigation, but not necessarily as an indication that drinking water is unsafe.

Studies to understand the pathways of radium in agriculture and dairy products would be useful and radium mitigation measures should be adopted for water quality management. Monitoring and mitigation of natural radioactivity should be viewed as an essential component of water quality management.

The World Health Organisation could undertake more work on comparing relative risks from chemicals against radionuclides. When considering the risks from radionuclides it is important to consider all others, chemical and biological in groundwater systems.

17. WORKSHOP – COMMUNICATING THE RADIOLOGICAL RISKS OF NORM

17.1 Workshop description

The objective of this workshop was to discuss challenges and advancements in the communication of radiological risks from NORM. The importance of communication between different stakeholders, e.g., industry, regulators and the public were discussed.

The workshop featured introductory remarks from the chairpersons, four presentations and a question-and-answer session.

17.2 Workshop outcome

It was agreed by all participants that knowledge is key. Having the ability to accurately characterise and assess NORM materials and ensuring that organisations have competent radiation professionals can help to put radiation hazards into better perspective.

It was noted that the controls in place for non-radiological hazards usually also act to control radiation (for example dust controls). Some practical examples where risk had been put into perspective were discussed, including the construction of risk tables for NORM related mining activities. A graded approach for assessing risk was supported, as highlighted in IAEA Safety Principle No 3 (Leadership and Management for Safety).

All panellists noted that successful communication should be based around trust, openness, honesty and transparency. Trust should be established before an attempt is made to communicate

risk to stakeholders. Ideally, communication should be undertaken by individuals who have gained specific skills and knowledge for communicating with the public. It was often seen that community leaders, medical professionals and religious leaders were more trusted than industry representatives. Listening to stakeholders and understanding their perspectives provided a sound foundation for relationship building.

Concerning education, it should commence with the younger generations. For example, having radiation background as part of the school study. It was also noted that a real-time radon monitor in a classroom could also provide a practical experiment for science, technology, engineering and mathematics (STEM) education.

The benefits emanating from NORM related industries including the extraction and use of drinking water, the energy we gain from oil and gas as well as the many applications from rare earth elements should be promoted more.

17.3 Main challenges

The significant quantities of NORM residues and wastes are of concern and are of particular relevance when considering how to move towards a circular economy.

The communication of risk with the public remains difficult and there was a need to support this with practical tools for communication. The public often compares NORM with the nuclear industry and the differences need to be set out. Residue and waste management is a concern due to the significant volumes.

It was noted that in many Member States the regulatory system is “binary”, in that if a material exceeds the nominal “1Bq/g”, it is regulated but when below this level rarely so. Work is required to provide better guidance on a more graded approach to regulation, particularly due to the natural variability of activity concentrations and statistical uncertainties in the determination of values.

There is currently a lack of international harmonisation of regulation around the world with many different approaches being adopted. The IAEA plays a central role in developing a harmonised approach, but this requires additional consensus and education.

17.4 Conclusions

Several examples of practical community communications best practices were presented during the conference. The IAEA could develop a database of practical community communication best practices and disseminate this to the Member States. Further work will imply in fostering continued harmonisation of international standards. Tools, recommendations, methods for comparing radiological risks with other risks occurring in NORM related industries, particularly relating to chemically toxic substances should be developed. Further assistance with training and capacity building to the acquisition of specific skills and knowledge for communicating with the public is crucial.

18. CONFERENCE CLOSING SESSION

The closing session started with the presentation from Ms. S. Sanchez from Venezuela who was the winner of the "Young Generation Contest". She made a presentation on the theme "From the Line to the Circle". In her presentation, she emphasised that so far industrial societies have been working under the paradigm "take-make-waste". i.e., whatever was taken from the soil went through industrial processing to deliver the desired products and discarding the rest. She proposed that it is high time that this operative system was changed. As to make this shift possible Ms. Sanchez suggested that a transformation of the linear system should begin at school; reach the families and eventually embrace all the society members, from the children up to the highest position in the companies and decision-makers. In the process to sensitize the industrial sectors to embrace this approach, it was suggested NORM has to be part of the value chain. One proposed approach would then involve the establishment of Research + Development + Innovation (RDI) networks promoting the joint efforts between the Universities and Research Institutions, the Industry, and the States. This partnership would lead to "safe, technically and economically viable solutions, based on the characteristics of the materials and considering possible synergies with other industries".

After that presentation, Mr. Monken-Fernandes, one of the Scientific Secretaries of NORM2020, explained the different initiatives being implemented by the IAEA in the direction of fostering the development of sustainable solutions for NORM management. References to the UN SDG's were made. It was stressed that the prime responsibility for safety rests with the person or organization responsible for facilities and activities that give rise to radiation risks. Governments are in charge of developing Policy and Strategies and Safety Regulations (with a desirable level of harmonization). Industry will be in charge of working out ways on how to implement viable but also safe and cost-effective solutions. The need for constructive dialogue involving a wide range of stakeholders was highlighted. Mr. Monken-Fernandes also indicated the main areas where IAEA Member States request assistance from the Agency (eventually through the Technical Cooperation Programme). These areas are:

- Support in the establishment of a Policy and Strategy (P&S) for NORM Waste,
- Training on the identification of NORM generating industries, NORM generation estimates, decontamination techniques, radon measurements and NORM waste treatment and storage,
- Advice on plans for NORM disposal, techniques for conditioning and storage, long term storage design and cost (design + facilities + operations),
- Training on technical works required for waste treatment, storage, radiological measurements and disposal options,
- Examples of procedures for decontamination, conditioning and pre-storage and calculation of the cost of disposal facilities,
- Capacity-building to implement comprehensive NORM waste management options,

- Programme of action to minimize the impact of radioactive residues on populations and to create a favourable condition for the sustainable development of the affected territories,
- Improvement and upgrade of the analytical and technical capabilities.

To address these requests and in support to National, Regional and Inter-Regional Projects run by the IAEA through the Technical Cooperation Department, efforts are also put in place through initiatives like professional networks; the one dealing with NORM being the Network on Environmental Remediation and NORM Management (ENVIRONET). Different activities such as the Mobile Unit for Site Characterization; eLearning materials; Databases and dedicated Projects such as the ENVIRONET NORM Project (which sustain different tasks groups on Policy & Strategy for NORM, Inventory, the Cost estimate of Management Options, Sampling and Radiological Measurements, Valorisation of Waste under the Circular Economy and Decommissioning of NORM Facilities are or will be soon in operation).

Mr. B. Okyar, another Scientific Secretary of NORM2020, provided an outlook on the safety of NORM Management. He emphasised the resolutions formulated in the 64th IAEA General Conference on Nuclear and Radiation Safety pointing out the need to strengthen Member States capabilities for the realistic assessment of radiological impacts of NORM and in developing plans for the safe decommissioning and remediation of facilities involving NORM residues. He also mentioned the efforts of the IAEA in supporting NORM Symposia and in the publication of Safety Guides, Safety Reports and TECDOCS in different areas. Reference to the Regulatory Forum for Safety of Uranium Production and NORM (REGSUN) and the Occupational Radiation Protection Network (ORPNET) that produces a wide range of training materials was also made. Mr. Okyar also introduced IAEA Review Missions and Advisory Services provided by the IAEA such as the Integrated Regulatory Review Service (IRRS) aimed at helping Member States to strengthen and enhance the effectiveness of their regulatory infrastructure for nuclear, radiation, radioactive waste and transport safety and the Occupational Radiation Protection Appraisal Service (ORPAS) that provides a cross-cutting review, against the relevant IAEA safety standards, of the regulatory framework for occupational radiation protection, technical service providers, and the application of the requirements at all facilities and activities utilising radiation technologies in the host State

The main outcomes of the conference were summarized in the President's Report (Appendix I?), which was presented during this session. The highlighted issues included:

- There are opportunities to increase education and improve communication related to NORM.
- There is room for a graded approach related to NORM. Policies for managing NORM can consider non-radiological hazards so that they can be integrated with the radiological hazard to optimize overall protection.
- There are opportunities for increased collaboration between industries and regulators that consider finding the right balance between public and company information. There is also work that can be done to establish a clear path forward on how NORM inventories will be used to inform the development of strategies and regulations.

- Decommissioning and remediation activities can generate large quantities of waste, some of which may be NORM impacted. Characterizing this waste and making available management options for the waste will be important to manage the anticipated increase in decommissioning activities.
- NORM characterization and their representative samplings are important to reduce the elapsed time between sampling to reporting. The conference expressed a desire for more in-situ measurements of radionuclides
- While importing of NORM waste may be prohibited by some countries, there are real examples of when NORM has been exported to another country that has appropriate waste management capabilities. However, it should be considered if this is a sustainable approach and highlights the importance of developing in-country capabilities for the Member States.
- Some available technologies and methods have been applied to appropriately manage NORM waste, but there may be challenges to adopting these technologies more broadly across different regions due to local capabilities or regulations.
- It was proposed that technical, environmental, social, and regulatory innovations will be needed to help address emerging issues such as the concept of NORM in the circular economy.

After the presentation of the main highlights of the Conference by the NORM2020 president, Mr. van Velzen, who is one of the organisers of the upcoming NORM X Symposium introduced the plans for the event that will celebrate 25 years of NORM Symposia. The event will take place from 9 to 13 May 2022 in Utrecht in The Netherlands and will revolve around the topic of "Residues Applied in a Circular Economy" that was highly debated during NORM2020 Conference.

NORM2020 was closed with the final speech of Mr. M. Chudakov, Deputy Director General of the Nuclear Energy Department of the IAEA. He emphasised that the underlying topic of the conference was the circular economy. He highlighted that the circular economy concept also applies to nuclear decommissioning therefore, according to him, the conference pointed out to the conclusion that the continued sharing of information, knowledge, and good practices between industries—such as nuclear and oil and gas decommissioning—is of real mutual benefit. He continued by stating that the conference further confirmed that IAEA Member States would significantly benefit from additional support on many NORM-related issues and that many Member States still need disposal routes for wastes not considered residues and which have no other use, also because of the presence of radioactivity. He stressed that this is a serious problem that needs to be addressed. And the situation will become more critical with the future decommissioning of many oil and gas platforms around the world.

Finally, he added, NORM 2020 marked a turning point by recognizing that industry could be fully part of the conversation if safe and cost-effective solutions for NORM are to be put in place. In this context, the IAEA has also a role to play as a global platform for sharing information, knowledge and experience, in alignment with UN SDG 12 on "Ensuring Sustainable Consumption and Production Patterns."

APPENDIX I.OPENING REMARKS OF THE PRESIDENT OF THE CONFERENCE

Janelle Branch Lewis, Waste Environmental Engineer, Chevron Technical Center

I am pleased to provide my perspective of the International Conference on the Management of NORM in Industry as one of the opening remarks for the conference.

One of the most important aspects of this conference is that it will facilitate information sharing on NORM and build relationships among the attendees. This will help each of us to deliver concrete and effective solutions related to NORM. Relationship building will look a little different than originally envisioned because of the virtual format. However, I trust that there will be many opportunities for engagement between participants such as through the conference app.

This conference brings together a diverse perspective on NORM. There are over 70 IAEA Member States represented through participation as panellists, workshop chairs, and paper or poster presenters. We have many more countries represented through conference attendees and the event is being live streamed around the world. Representatives at this conference include professionals from the oil and gas industry, the metal mining industry, and the fertilizer and phosphate industry. In addition, we are bringing together other key stakeholders such as regulators, academics, policymakers and representatives of different international organizations.

I was honoured to be a part of the planning Programme Committee for the conference where I already witnessed enthusiastic collaboration among these individuals. They have been working diligently to deliver the IAEA's first-ever organized conference on NORM.

Relationship building among our many professionals can extend even beyond the boundaries of this conference. This is especially relevant to educating and energizing younger generations to participate in the science, technology, engineering, and mathematics field or more simply "STEM". This can start at the most basic level such as introducing young children to STEM activities. This also involves promoting our current early-career members in the scientific community. I am thrilled that this conference hosted a Young Generation Contest. The winner of this contest is Samira Sanchez. She is an MSc. Student of Electronic Engineering at the Nuclear Physics Laboratory of Simon Bolivar University in Venezuela. Miz. Sanchez will be making a presentation on the final day of the conference with the title "From the Line to the Circle". As someone who would qualify as a "Young Generation" member, I'm excited to learn from the more experienced members of our community. And conversely, I trust the young generations can also bring relevant contributions to more experienced members of the community. This will benefit all of us from state-of-the-art knowledge and fresh eyes perspective. I encourage everyone at this conference to engage in dialogue, seek mentors or mentees, and other forms of relationship-building across our diverse group of participants.

These types of activities will be important when working together to further develop concrete and technical solutions for NORM and ensure that implemented policies are clear. This can enable the development and implementation of effective and practical strategies and regulatory frameworks.

There are currently many different approaches and challenges related to managing NORM across the IAEA member states. In some regions, there is a lack of feasible NORM waste management options. Specifically, this may include a lack of in-country disposal options, lack of in-country laboratory capabilities, or lack of other critical infrastructure to effectively manage NORM waste. These challenges may be exacerbated by a lack of clear and effective NORM policies or the policies that are currently in place do not allow for environmentally sound NORM management options. For example, private companies may be discouraged from investing in new infrastructure such as NORM disposal facilities. This may be due to the uncertainty in future approved management options. In another example, some regions prohibit the deep well injection of NORM for disposal, even though this method is used in other jurisdictions as one offering a very high degree of isolation of NORM from humans and the environment.

Other gaps include a lack of full understanding of the lifecycle cost associated with managing NORM. This includes understanding current and forecasted NORM inventory volumes. Creating NORM inventories can be a complex endeavour. There may be limited available technologies that can predict potential NORM waste generation such as in decommissioning scenarios. Finally, the different approaches and capabilities between the member states may also create transboundary issues related to NORM management. In some countries, the only practical long-term solution (and this would be other than indefinite on-site temporary storage) in cooperation with a country that has appropriate NORM management capabilities.

There are challenges, but fortunately, there are already many successful examples of safe and cost-effective management of NORM across the Member States. For example, some Member States have adopted risk-based approaches to managing NORM or are in the advanced stages of developing strategies to manage NORM. Other examples of success that come to mind are: 1) companies that have developed technologies that can reduce the volume of NORM that needs to be disposed of, 2) countries that have established a robust network of management options for NORM waste and 3) countries that have an abundance of accredited in-country radiochemistry laboratories. This conference aims to highlight many of these successful examples while also exploring the gaps in capabilities to effectively manage NORM. This will be accomplished through key sessions including topics on waste management, decommissioning, transportation, reuse and characterization. We will also hear the perspective of different industries through conference workshops on their key challenges and good practices related to NORM management. To offer additional insights, there will be sessions exploring the perspective of national policies and strategies and establishing NORM inventories. This conference also recognizes the importance of the global circular economy and leveraging symbiosis between different industries. This will encourage the reuse and recycling of materials. We will have a session specifically on this emerging issue to brainstorm ideas for moving towards a more sustainable future in the context of NORM in the circular economy.

By leveraging the information shared during this conference we can work towards the specific goals of further developing critical in-country infrastructure and expertise to appropriately manage NORM. We also can work towards developing clear, effective, and practical strategies that consider the full lifecycle cost of managing NORM while involving key stakeholders. These key stakeholders include industry representatives, academics, regulators, and policymakers participating in this conference.

To meet these goals, we have to recognize that NORM can be effectively and economically managed using a risk-based approach such as setting exemption levels and graded approaches to management. We can continue to promote this message beyond the boundaries of the conference, including to members of the public.

In closing, I'd like to again say that I am looking forward to the knowledge sharing that will take place over the next two weeks. We will identify and discuss key challenges and best practices related to NORM.

I'd especially like to thank the IAEA Team and the Programme Committee for their efforts in organizing NORM2020. I'd also like to thank my employer, Chevron, for their support of my participation in this conference.

I hope that the professional and personal connections established over the next two weeks will extend beyond this conference. I wish you all a wonderful conference and appreciate your engagement.

APPENDIX II. PRESIDENT'S CONFERENCE REPORT

Janelle Branch Lewis, Waste Environmental Engineer, Chevron Technical Center

OVERVIEW

I am pleased to provide my closing remarks on the International Conference on the Management of NORM in Industry (NORM 2020) which has been the first-ever IAEA organized conference on NORM. There were over 70 IAEA Member States represented at this conference through participation as panellists, workshop chairs, and paper or poster presenters and there were many more countries represented through the 700+ conference attendees. NORM2020 brought together a diverse perspective on NORM including the perspectives from representatives in the oil and gas industry, the metal mining industry, the fertilizer and phosphate industry, as well as regulators, academics, policymakers and representatives of different international organizations.

Many successful examples related to NORM across the IAEA Member States were shared during the conference in the areas of waste management, decommissioning, remediation, transportation, and characterization. Perspectives were also shared on national policies and strategies and establishing NORM inventories. NORM2020 also recognized the importance of the global circular economy and leveraging symbiosis between different industries. The circular economy was an overarching theme for the conference and there was a session specifically on this emerging issue which brainstormed ideas for moving towards a more sustainable future in the context of NORM in the circular economy.

There were also several challenges discussed throughout the conference such as the lack of feasible NORM management options in some regions. This included a lack of in-country disposal options, lack of in-country laboratory capabilities, or lack of other critical infrastructure and expertise to effectively manage NORM. In some cases, these challenges have been exacerbated by a lack of clear and effective NORM policies or the policies that are currently in place do not allow for environmentally sound NORM management options. Other gaps highlighted include a lack of full understanding of the lifecycle cost associated with managing NORM and the challenges associated with understanding current and forecasted NORM inventory volumes. Finally, examples were provided on how the different approaches and capabilities between the Member States have created transboundary issues related to NORM management. In some countries, the only currently available option for the management of NORM is cooperation with a country that has appropriate NORM management capabilities.

CROSS-CUTTING THEMES

During my opening remarks for the conference, I stated, "One of the most important aspects of this conference is that it will facilitate information sharing on NORM and building relationships among the attendees." I believe we delivered on this aspect and executed a very successful conference. Our panellists and presenters worked together to deliver effective sessions and workshops. I also witnessed active participation from the audience from the many questions that

were posed to the presenters. As a result, we have built a repository of all the information shared at this conference through the recorded sessions, workshops, and written conference materials.

This active and diverse participation is important. When reviewing my notes from the conference, I noticed that the words “stakeholder” and “communication” appeared very frequently. Many presenters emphasized the importance of stakeholder participation and effective communication strategies when engaging in activities such as developing policies and strategies, executing remediation activities, evaluating radiation protection, and developing waste management practices. We have already made progress on stakeholder engagement through this conference that brought together important stakeholders to work towards identifying and developing concrete and technical solutions related to NORM. In terms of communication, many presenters emphasized the importance of clear, concise, and consistent communication. This communication also includes awareness building across many different aspects related to NORM.

Another common theme that emerged from the sessions was the desire for increased sharing of good practical examples on NORM to inform on a wide range of activities including developing policies and strategies, compiling NORM inventories, developing waste management solutions, and developing characterization capabilities. As suggested, this may also involve cooperation between the Member States especially between those that have extensive experience with NORM and Members States who are just beginning to develop their NORM infrastructure. Finally, the harmonization approach and the challenges associated with lack of consistency was a frequent topic across the different sessions. There were many suggestions made on the role that the IAEA can take to promote a common understanding of NORM across industries and regions, while also recognizing that guidance developed may still need to be taken in context for local situations.

SESSION SPECIFIC KEY TAKEAWAYS

In addition to the cross-cutting themes, each session provided specific outcomes and recommendations. I would like to highlight some of the key outcomes and recommendations from each session from my perspective. Additional details from each session will be shared by the session chairs.

Key Takeaways:

NORM under the Perspective of Different Stakeholders- There are opportunities to increase education and improve communication related to NORM. Specifically, we can focus on using clear, concise, and consistent messaging. Additionally, some suggested there is an opportunity to revisit regulations that may have previously been built on a linear economy in the context of a circular economy.

National Policies and Strategies- There is room for a graded approach related to NORM. Policies for managing NORM can consider non-radiological hazards so that they can be integrated with the radiological hazard to optimize overall protection.

NORM Inventories- There are opportunities for increased collaboration between industries and regulators that considers finding the right balance between public and company information. This

may include leveraging trade associations to help alleviate potential concerns related to disclosing information. There is also work that can be done to establish a clear path forward on how NORM inventories will be used to inform on the development of strategies and regulations such as using them to assess whether the national NORM infrastructure is capable to address the NORM issue

Decommissioning of Facilities and Remediation of Contaminated Sites- Decommissioning and remediation activities can generate large quantities of waste, some of which may be NORM impacted. Characterizing this waste and making available management options for the waste will be important to manage the anticipated increase in decommissioning activities.

Characterization in Industrial Facilities and the Environment- NORM characterization and their representative samplings are not easy tasks, and both are important to reduce the elapsed time between sampling to reporting. There is a desire for more in-situ measurements of radionuclides that can allow for real-time decision making. Several successful examples were presented on this approach and we can look for opportunities to extend the application more broadly.

Transportation of NORM Material and Transboundary Issues- While importing of NORM waste may be prohibited by some countries, there are real examples of when NORM has been exported to another country that has appropriate waste management capabilities. However, it should be considered if this is a sustainable approach and highlights the importance of developing in-country capabilities for the Member States.

Solutions for Residue and Waste Management- Some available technologies and methods have been applied to appropriately manage NORM waste, but there may be challenges to adopting these technologies more broadly across different regions due to local capabilities or regulations.

Special Session on Emerging Issues- It was proposed that technical, environmental, social, and regulatory innovations will be needed to help address emerging issues such as the concept of NORM in the circular economy.

Workshops- Several workshops were well attended and focused on specific areas of activities. These brought together many different stakeholders and highlighted the specific challenges and opportunities in the focused areas of the oil and gas industry, metal mining industry, fertilizer and phosphate industry, sampling and radiological characterization, NORM in the circular economy, groundwater, communication of radiological risks, and exhibitor presentations.

PATH FORWARD

The IAEA can proceed with the different recommendations that have been made at this conference. To consider these suggestions, we have to continue to work together and leverage the information shared during this conference towards the specific goals of further developing critical in-country infrastructure and expertise to appropriately manage NORM. We also can work towards developing clear, effective, and practical strategies that consider the full lifecycle cost of managing NORM while involving key stakeholders. NORM can be effectively and economically managed using a risk-based approach and we have identified many opportunities to increase awareness and capacity building among the Member States.

In closing, I'd like to thank the IAEA Team and the Programme Committee for their efforts in organizing NORM2020. I'd also like to thank my employer, Chevron, for their support of my participation in this conference. I look forward to continuing the work and collaboration on NORM beyond this conference.

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ANNEX: SUPPLEMENTARY FILES

CONFERENCE MATERIALS

The following papers and presentations from the International Conference on Advancing the Global Implementation of Decommissioning and Environmental Remediation Programmes are available as online supplementary material on the publication's individual web page at www.iaea.org/publications

RELATED DOCUMENTS

Programme of the International Conference on the Management of Naturally Occurring Radioactive Material (NORM) in Industry

President's Report

J. B. Lewis

Chevron, USA

Book of Abstracts of the International Conference on the Management of Naturally Occurring Radioactive Material (NORM) in Industry:

Opening Session, Panel – NORM under the Perspective of Different Stakeholder, Sessions 1, 2, 3, 4A, 4B, 6, 7, Closing Session.

List of Meeting Participants

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Sustainable solutions for NORM Management

C. Xerri

Perspectives on the Safe Management of NORM

P. Johnston

Overview of the Technical Cooperation on NORM in Asia and the Pacific

J. Gerardo-Abaya

Session 1 (Tuesday, 20 October 2020): National Policies and Strategies

- **Oral Presentations**

Kyrgyzstan: Challenges in Remediation Policy and Control Responsibilities of the Radioactive and Hazardous Wastes

G.M. Makhmudova
Industrial Safety Regulatory Authority, The State Committee of Industry, Energy&Mining, Kyrgyzstan

Analysis of Indonesian policy on management of NORM waste and residue and the implementation problems
V. Zahrawati
Nuclear Energy Regulatory Agency of Indonesia (BAPETEN), Indonesia

THE WISMUT Policy and Strategy for Remediation of the German Uranium Production Legacy Sites
P. Schmidt & M. Paul
Wismut GmbH, Germany

Considerations in developing policies and strategies for the management of NORM
M. García-Talavera
Consejo de Seguridad Nuclear (CSN), Spain

Radiological Issues in Norm Related Industries -Regulatory Approach
P.V. Mohandas & S. Sinha
Atomic Energy Regulatory Board, India

- **Poster Presentations**

Brazilian Regulatory Framework for Norm in Mining and Milling Facilities
F. L. S. Borges et al.
Brazilian Commission of Nuclear Energy (CNEN), Brazil

Situation on radiation safety management at titanium mining facilities in Binh Dinh province of Vietnam
D.G. Nguyen
Vietnam Agency for Radiation and Nuclear Safety, Vietnam

Sustainability aspects of the Uranium Production Cycle and NORM in Argentina
L. López
National Atomic Energy Commission (CNEA), Argentina

Developing A National Strategy for Management of Naturally Occurring Radioactive Materials (Norm) in Uganda – Opportunities and Challenges
A. Byamukama
Atomic Energy Council, Uganda

Regulatory Aspects of Norm Management in Indonesia: Implementation, Achievement, and Challenges
I. M. Ardana et al.
Nuclear Energy Regulatory Agency of Indonesia (BAPETEN), Indonesia

Regulatory Approach for Norm in Cuba. Current Status, Challenges and Perspectives
J.R. Fuentes
Nuclear Safety Division. Office for Regulation and Environmental Safety, Cuba
Regulatory Review and Development of Norm Regulations in Indonesia
H. P. Yuwana & A. Sanyoto
Nuclear Energy Regulatory Agency of Indonesia – BAPETEN, Indonesia

Conditions for the discharge of radioactive substances from certain workplaces with potentially increased exposure to natural radiation in the Czech Republic, Atomic Act
M. Bercikova
State Office for Nuclear Safety, Czech Republic

Regulatory Aspects of NORM Management in Turkey
L. Ö. Ünver & S. Türkeş Yilmaz
Nuclear Regulatory Authority, Radiation Protection Department, TURKEY

Overall assessment against regulatory control requirements to be specified in terms of the natural radiation in Turkey
S. Turkes Yilmaz & L. O. Unver
Nuclear Regulatory Authority, Turkey

Challenging issues associated with NORM regulation
Sami Alharbi
King Saud bin Abdulaziz, University for Health Sciences, Saudi Arabia & Queensland University of Technology, Australia
Riaz Akber
Safe Radiation, Australia

Control of Building Materials and Basic Safety Standards
H. Janžekovič
Slovenian Nuclear Safety Administration, Slovenia

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In-Situ Indoor and Outdoor Radiation Monitoring and Evaluation of Radiation Risk to Public in Dhaka City, Bangladesh
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Health Physics Division, Atomic Energy Centre, Bangladesh

Current profile of NORM conventional mining and milling facilities in Brazil
N.F.G. Santos & F.L.S. Borges
National Nuclear Energy Commission, Brazil

NORM Inventories: The Dutch approach
R.B. Wiegers & M.G.J. Sijbers-Wismans
IBR Consult.nl, Netherlands

Assessing the survey of NORM activities in Hungary
Z. Déri
Hungarian Atomic Energy Authority, Hungary
M. Lajos
National Public Health Center, Department of Occupational Radiation Protection, Hungary

NORM industry Survey Results from the Second National Pollution Source Census in china
Z. Shang, et al.
Nuclear and Radiation Safety Center, Ministry of Ecology and Environment, China

The South African Norm Inventory and Management of Waste Material above Release Limits
T. Kekana & S. Rasmeni
National Nuclear Regulator, South Africa

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Assessment of Radioactivity Concentrations of NORM-Related Industries Operating in Thailand
S.Chanyotha et al.
Natural Radiation Survey and Analysis Research Unit, Department of Nuclear Engineering, Faculty of Engineering, Chulalongkorn University, Thailand

Current Profile of NORM Conventional Mining and Milling Facilities in Brazil
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National Nuclear Energy Commission, Brazil

Grey Monazite in Central Spain: Norm Mining Implications
R. Garcia-Tenorio
Centro Nacional Aceleradores (University Sevilla- Junta Andalucía-CSIC), Spain

Study on NORM Inventory and NORM Waste Management from Tin Industry in Bangka Island, Indonesia
D. Iskandar
Center For Radioactive Waste Technology, BATAN, Indonesia

Progress of Research on the Radiological Impact of Norm-Related Industries in China
F. Wen & S. Wang
Department of Radiation Safety, China Institute of Atomic Energy, China

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National Center of Nuclear Sciences and Technology, Tunisia

Building the NORM-Inventory in Finland
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Radiation and Nuclear Safety Authority, Finland

The Norm Survey Plan on the Second National Pollution Source Census in China
Z. Shang et al.
Nuclear and Radiation Safety Center (NSC), Ministry of Ecology And Environment, China

The South African Norm Inventory and Management of Waste Material Above Release Limits
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National Nuclear Regulator, South Africa

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Management of Norm Formed in the Process of Iodine-Bromine Production in Azerbaijan
V. Huseynov & A. Guliyev
State Agency on Nuclear and Radiological Activity Regulation, Ministry of Emergency Situations of Azerbaijan Republic, Azerbaijan.

Integrated site descriptive modelling as a coherent means of step-wise enhancement of conceptual model for NORM situations
A.T.K. Ikonen et al.
EnviroCase, Ltd., Finland

Getting Uranium and Ree Projects Licensed and Efficiently Operated
H.G. Jung
GeoEnergy Consult, Germany

Use of Phosphogypsum as a resource for soil reclamation
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Atomic Energy Commission of Syria, Syrian Arab Republic

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State Agency on Nuclear and Radiological Activity Regulation, Ministry of Emergency Situations of Azerbaijan Republic, Azerbaijan

Measurement of Radon Concentration in Workplaces at Thailand Institute of Nuclear Technology (Tint), Khlong 5, Pathumthani, Thailand Prior and During Decommissioning
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Thailand Institute of Nuclear Technology, Thailand

Recycle of Polluted Nitric Acide Leaching Solution with Radium Isotopes
N.S.Ahmedzeki et al.
Chem. Eng. Petr. Ind. Dept. Al-Mustaqbal University College, Iraq

Sensitive Design Parameters to Radiation Dose in Disposal Facility of Natural Occurring Radioactive Material Waste from the Oil and Gas Industries
C. A. W. Dwipayana
Indonesia Nuclear Energy Regulatory Agency (BAPETEN), Indonesia

Experience on the Clearance Process for Decommissioning Materials from Phosphate Acid Purification Plant
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Center for Radioactive Waste Technology, National Nuclear Energy Agency of Indonesia (BATAN), Indonesia

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Saïdou
Nuclear Technology Section, Institute of Geological and Mining Research; Nuclear Physics Laboratory, Faculty of Science, University of Yaoundé, Cameroon

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Iraqi Ministry of Science and Technology/ Al-Tuwaitha Nuclear Site, Iraq

In Situ Characterization of NORM Waste from the Oil Industry
J.C. Dellamano et al.
Nuclear and Energy Research Institute – IPEN, Brazil

Measurement of Naturally Occurring Radioactive Materials (NORM) in Black Sand and Soil Samples
K. N. Myaing
Technological University (Kyaukse), Myanmar
K. H. Naing
Nuclear Physics Laboratory, Myanmar

A Case Study of Radiological Investigation in The Oil and Gas Fields in Western China
S. Wang & F. Wen
Department of Radiation Safety, China Institute of Atomic Energy, China

The CORSAIR Project A Cloud Oriented Radiation Sensor for Advanced Investigation of Rocks
M. Corbo et al.
Caen Spa, Italy

Method Validation of In-Situ Gamma Spectroscopy for Quantification of Naturally Occurring Radioactive Materials (Norm) K-40, Th-232 and U-238 in Soil
P. R Dabare et al.
Sri Lanka Atomic Energy Board, Sri Lanka

Radiological Impact Study from a Site of a Former Dicalcium Phosphate Production Plant
B. Bravo & F. Suárez
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NORM Characterization Using Laboratory Measurements: An Italian Case of Study
S. Mariani et al.
National Inspectorate for Nuclear Safety and Radiation Protection (ISIN), Italy

In Situ Measurements and Mapping to Support Characterization of Norm Contaminated Sites.
R. Padilla-Alvarez
Division of Physical and Chemical Sciences, Department of Nuclear Sciences and Applications, International Atomic Energy Agency, Austria

- **Poster Presentations**

Use of 226ra and 228Ra Radiometry in the Investigation of Norm Formation Processes in Shale Gas
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Gamma dose rate evaluation of the working places in A zinc-lead mine
I.M. Fernández Gómez et al.
Center for Radiation Protection and Hygiene, Cuba

Investigation of radioactivity level and evaluation of total effective dose at SPA facilities in Turkey
A.Dirican
Turkish Atomic Energy Authority, Radiation and Accelerator Technologies Department, Turkey

Natural Radionuclides and Hazard of the Several Selected Building Materials in Thailand
S. Nuchdang
Nuclear Technology Service Center, Thailand Institute of Nuclear Technology, Thailand

Spectropscopic Measurements for Quantitative Removal of Naturally Occurring Radioactive Materials from Monazite Green Leachate
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Atomic Energy Authority, Egypt

Occupational Exposure to Radon in Workplaces in Underground Mining Operations
A.Espinoza et al.
Instituto de Salud Pública, Chile

Geochemical Study of Natural Radiation of Limestones and Shales of Puyango, Ecuador
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Private Technical University of Loja, Ecuador

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Nuclear Application Centre, National Nuclear Research Institute, Ghana

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Proposal for Norm Treatment and Final Disposal in Brazil
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Jabarra Radioproteção, Brazil

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A.S. Arabi et al.
Department of Geology, Faculty of Earth and Environmental Sciences, Bayero University, Nigeria

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Center for Radioactive Waste Technology, BATAN, Indonesia

Conceptual Design of TENORM Landfill from the Tin Industry in Indonesia based on the Regulatory, Security and Safety Aspect Overview
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Center for Radioactive Waste Technology – BATAN, Indonesia

Spatial Distribution of Gamma Dose Rates Due to Enhanced Naturally Occurring Radioactive Materials at Environs of Mrima Hill and Kwale Heavy Mineral Sand Deposit in South Coastal, Kenya
P.K. Kilavi
Department of Physics, University of Nairobi; School of Physics and Earth Science, Technical University of Kenya, Kenya

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G. Nurliati
Center For Radioactive Technology – National Nuclear Energy Agency, Indonesia

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E.O. Ali
Sudanese Nuclear and radiological regulatory Authority, Sudan

Estimation of the Environmentally Affected Parameters of Coal Combursion Residuals Containing NORM to be used as Backfill Material - Case Study in Vietnam
N. T. K. Dung
Institute for Technology of Radioactive and Rare Elements (ITRRE), VINATOM, Vietnam

Radiological Impact of Iraqi Phosphate Fertilizers on Humans and the Agricultural Environment
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Iraqi Radioactive Sources Regulatory Authority (IRSRA), Iraq

Individual and Collective Doses Due to Thorium in Welding Electrodes and Other Norm Appliances in Uruguay
E. Morales
National Radioprotection Regulatory Body (A.R.N.R.), Uruguay

Review of occupational exposure and radioactivity associated with Amang in mineral processing industries in Peninsular Malaysia
M.S.M. Sanusi
Department of Physics, Faculty of Science, University Teknologi Malaysia, Malaysia

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N. H. M. Kamel
Radiation Protection Department, Nuclear Research Center, Atomic Energy Authority, Egypt

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A. A. M. Dicko
Department of the Malian Radiation Protection Agency, Bamako

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Division of Atomic Energy, Department of Research and Innovation, Ministry of Education, Myanmar

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F.K. Pappa
Institute of Oceanography, Hellenic Centre for Marine Research, Greece

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A. I. Alsayahien
Ministry of Wter and Iriigation, Jordan

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T. N. Nyein
Department of Atomic Energy, Ministry of Education, Myanmar

Radiological risk assessment due to Naturally Occurring Radioactive Material (NORM) in the proposed radioactive waste storage area of Pilikwe, Botswana, using Radiometrical techniques.
T. Solomon
Radiation Protection Inspectorate, Botswana

Radiological impact of stack releases of an integrated steel plant in China
J. Li & Y. Zhang
China Institute of Atomic Energy, China

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Sri Lanka Atomic Energy Board, Sri Lanka

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J. Lee
Department of NORM Analysis, Korea Institute of Nuclear Safety; Department of Chemical Engineering, Hanyang University, Republic or Korea

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C. M. Peixoto
Center of Development Nuclear Energy – CDTN/ National Nuclear Energy Commission – CNEN, Brazil

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Adeniran Ogunsanya College of Education, Nigeria

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University of Kinshasa, Faculty of Sciences, Department of Chemistry, Democratic Republic of the Congo

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Spanish Institute of Cement and its Applications (IECA), Spain

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Angolan National Atomic Energy Authorities, Angola

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Department of Science Laboratory Technology, Federal Polytechnic, Nigeria

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National Inspectorate for Nuclear Safety and Radioprotection (ISIN), Italy

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National Nuclear Regulator, South Africa

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DURRIDGE Company Inc., USA
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E. Fialova & P. Ps Otahal
National Institute for Nuclear, Biological and Chemical Protection, Czech Republic

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National Institute for NBC Protection, Czech Republic

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L. Rodrigues
Lotus Llc, EUA

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Slovenian Nuclear Safety Administration, Slovenia

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S. Mukhopadhyay & R.J. Maurer
Remote Sensing Laboratory, Nevada National Security Site, USA

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Slovenian Nuclear Safety Administration, Slovenia

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R. A. Bilak
Terralog Technologies Inc., Canada

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M. S Al-Masri & B. Kajijan
Safety and Protection Department, Atomic Energy Commission, Syrian Arab Republic

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International Atomic Energy Agency (IAEA), Austria

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J. M. Godoy
Pontifical Catholic University of Rio De Janeiro, Brazil

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Universiti Kebangsaan Malaysia, Malaysia
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Nuclear Technology Development Center, CDTN, CNEN, Brazil

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Ss Cyril and Methodius University in Skopje, Faculty of Technology and Metallurgy, R. of N. Macedonia

Standards for NORM Waste Management and Safe Work Practices in the Offshore Oil and Gas Industry. Elaboration of a Best Practices Guide for Brazil
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Brazilian Petroleum, Gas and Biofuels Institute – IBP, Brazil

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Ukrainian Hydrometeorological Institute, Department of Environmental Radiation Monitoring Ukraine

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DIAMO, state enterprise, Czech Republic

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B.G. Lottermoser
Institute of Mineral Resources Engineering, RWTH Aachen University, Germany

An Innovative Platform Allowing Digitization of Operative Radioprotection Measurements and to Characterize NORM And TENORM
A. Pepperosa et al.
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Adapted Method of Radiological Risk Assessment in Goldextraction Mining in Burkina Faso
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NORM in Venezuelan oil & mining industry. Existing situations and challenges
H. Barros et al.
Nuclear Physics Laboratory at Simon Bolivar University, Venezuela

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