Naturally occurring radioactive material: A modeled approach for professional education courses in radiology

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ABSTRACT

Natural radioactivity is a characteristic present in several materials in the Earth's crust, known as Naturally Occurring Radioactive Materials (NORM). These materials include minerals such as uraninite, which contains uranium and other radioactive elements, and are widely distributed in nature. With the advancement of industrial exploration, especially in mining and oil and gas extraction, Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM) emerge, which result from industrial processes that increase their concentration or radioactive activity. This study aims to analyze the presence and management of these materials, highlighting their importance in radiological and environmental safety. Proper management of NORM and TENORM is essential to prevent risks to human health and the environment. Uraninite, for example, is a significant source of uranium used in nuclear energy production, a process that transforms NORM into TENORM through activities such as mining and processing. The literature review carried out in this study highlights the diversity of sources and forms of NORM and TENORM around the world, evidencing its presence in various industrial sectors such as metal mining, oil extraction, fertilizer production and civil construction. Each sector presents specific challenges for the management and safe disposal of these materials, requiring the rigorous application of regulatory standards and radiological protection techniques. Professionals in the field of radiology play a fundamental role in the application of these standards, ensuring the safety of workers and the general population in the face of exposure to NORM and TENORM. The dissemination of knowledge about these materials is crucial to train professionals and students in the safe and effective handling of these substances, ensuring that industrial practices are conducted with environmental responsibility and adequate radiological protection. In summary, the study emphasizes the importance of understanding and applying the concepts of NORM and TENORM in modern industry, highlighting the challenges and best practices for the management of these materials, aiming to protect human health and preserve the environment.

Keywords: NORM, TENORM, Professional education.

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INTRODUCTION

With the advent of radioactivity in 1896 by the couple of scientists Pierre and Marie Curie together with Antoine Henri Becquerel, the radioactive properties of certain natural atomic elements were discovered (MARTINS, 1990). However, it is observed that these radioactive elements are not found in their pure or concentrated form in nature. On the contrary, its occurrences demonstrate a much lower activity than those measured when radioactive material is extracted and/or purified, and may present risks if proper precautions are not taken (LINCE, 2024). Radioactive elements are present in water, air, soil, that is, everywhere in the earth's crust and its atmosphere. Due to their natural occurrence, such elements have not presented risks to human health, but with the increase in mining and oil and gas exploration, their risks become more of a concern.

OBJECTIVE

To expose concepts about common naturally occurring radioactive materials (NORM) and technologically improved radioactive materials (TENORM), showing how companies live with them on a daily basis, as well as the importance of this knowledge being disseminated to the community of professionals of radiological techniques.

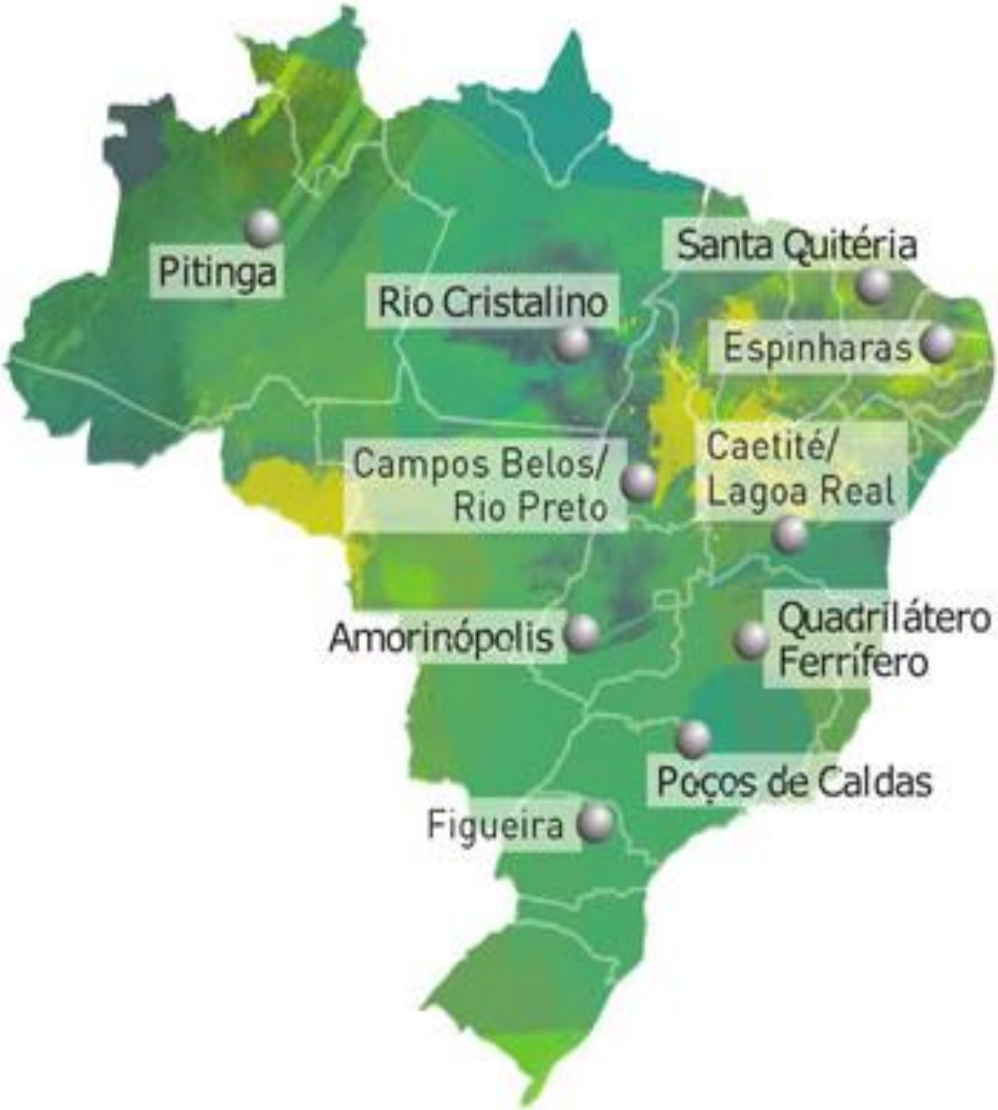
METHODOLOGY

A bibliographic study was carried out to observe the importance and the forms of application of knowledge about NORM and TENORM.

RESULTS

NORM is an acronym for "Naturally Occurring Radioactive Material". These materials are found in nature and are often used by laypeople who are unaware of their radioactive potential (LINCE, 2024). NORMs are natural radioactive materials found through mining, that is, it is any type of primary material in natural radiation; it is the raw material of the soil without alterations, which is extracted linked to other materials such as some types of metals or precious stones depending on its extraction site (DUARTE, 2021). A great example of NORM is the uraninite found on a large scale in Brazil. Uranium can be extracted from uraninite, because uraninite is a radioactive uranium oxide mineral of the oxide class that contains small amounts of radium, thorium, polonium, lead and helium, being a natural radioactive material formed in the soil by volcanic rocks or hydrothermal vents of medium and high temperature or can be found in sedimentary deposits (REI, 2014). According to the International Atomic Energy Agency (IAEA), there are several reservoirs of NORM scattered around the planet. Some of them are found in Brazil, as shown in figure 1, considering that it is the seventh country with the highest reserve of NORM (IAEA, 2018).

Figure 1 - Uranium geological reserves in Brazil.

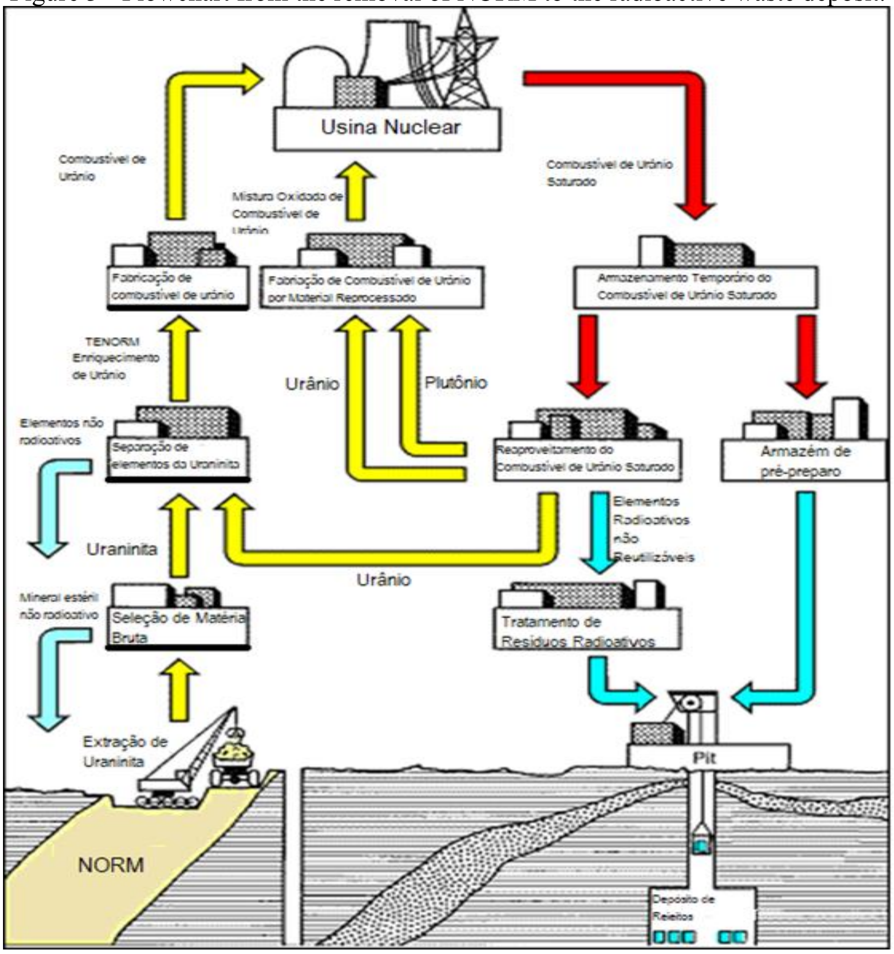


Just as NORM is an acronym, so is TENORM, and stands for "Technologically Enhanced Naturally Occurring Radioactive Materials" (CNEN, 2016). TENORMs are natural radioactive materials that have undergone some kind of modification or enrichment, see figure 2, which means that they have undergone some kind of human intervention. One of the most used in Brazil is the modification of uraninite (NORM) to become uranium (TENORM), through the Uraniferous District of Lagoa Real, located in Serra Geral, Caetité-BA, where its exploration began only in 1998 by Indústrias Nucleares do Brasil - INB (LINCE, 2024).

Figure 2 - Transformation of NORM into TENORM.

Since then, its raw material, uraninite (NORM), has been used in the production of uranium pellets (TENORM) that supply the energy production of the Angra I and Angra II nuclear power plants (REI, 2014). Figure 3 shows NORM that contaminated a water reservoir in Juazeiro, in Caetité, Bahia - a large site of uraninite extraction. Greenpeace collected water and sediment samples in August 2008, the results of which indicated the presence of NORM and TENORM in two natural lagoons in the vicinity of the mine.

Figure 3 - Flowchart from the removal of NORM to the radioactive waste deposit.



The research included a sample of water collected from an artesian well about eight kilometers from the extraction mine, which showed uranium concentrations seven times higher than the maximum limits indicated by the World Health Organization (WHO) (REI, 2014). Another example of TENORM formation is in the pipelines of oil extraction platforms, illustrated in figures 5 and 6.

Figure 5 - Image depicts the transformation of NORM into TENORM on oil and gas platforms.

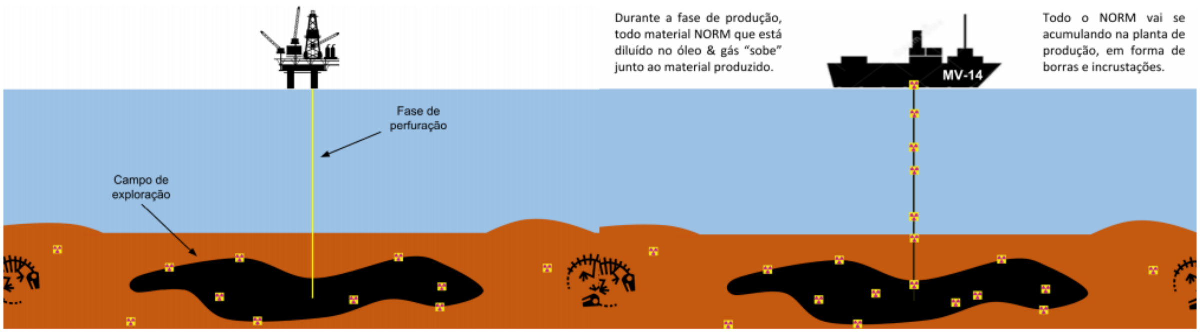
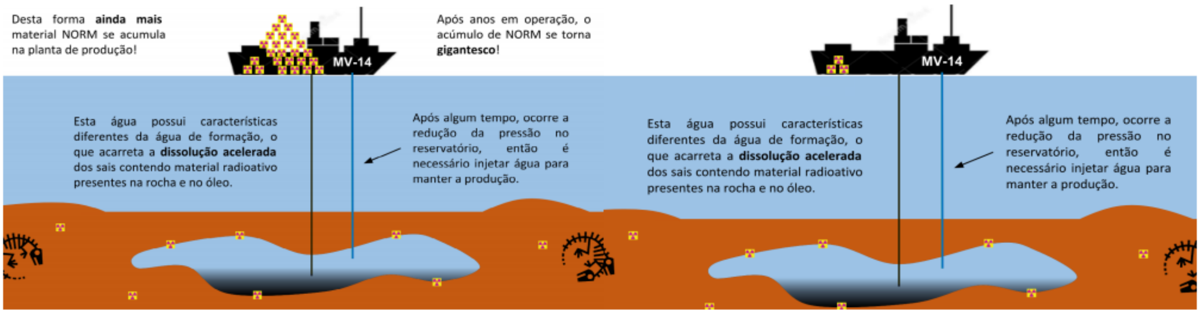


Figure 6 - Image depicts the transformation of NORM into TENORM on oil and gas platforms.



This material has the potential to create radiation fields whose dose values exceed the safe limits established by the National Nuclear Energy Commission (CNEN) for occupationally exposed individuals - 20mSv/year - and, especially, for the general public - 1mSv/year (CNEN, 2016).

The U.S. Environmental Protection Agency (EPA) provides a list of TENORM sources that provides a general insight into the hazards posed by this class of radioactive substances. The main industrial sectors that generate TENORM are: Mining > Gold, silver, zircon and titanium mining waste; Gemstone mining waste; Uranium mining waste; Mining waste and copper production; Residues from bauxite and alumina production. Energy Production > Oil & Gas Production Waste; Coal Combustion Residues. Consumer Products > Fertilizer and Fertilizer Residues; Cigarettes; Building materials; Granite countertops (EPA, 2008).

Many of the materials that are considered TENORM have only traces of radioactivity and are part of our everyday landscape. However, a few dozen TENORM concentrations result in a relatively higher rate of radionuclides that can result in high radiation exposures (EPA, 2008). For the time being, the radioprotection of NORM is treated more specifically by CNEN through standard 4.01, which regulates radioprotection in the mining of materials that may contain radionuclides. Workers' safety should be obtained through frequent training offered by the institution's radiological protection supervisor (SPR), as well as the Radiological Emergency Plan, Physical Protection and Fire Protection Plan, and Occupational Radiological Protection Plan. It is up to CNEN to verify that companies are complying with the provisions of the law (CNEN, 2016). On the international scene, the International Atomic Energy Agency and the European Community have published recommendations on the application of the concepts of exclusion, exemption and exemption for activities with TENORM products. The exclusion applies when it is detected that regulatory control is inapplicable to exposures whose intensity or probability of occurrence is not material, at the discretion of the regulatory body. Exemption, on the other hand, is the regulatory act that exempts a practice or source associated with a practice, from the point of view of radiological protection (DUARTE, 2021). The person who advises the company in relation to the processes is the radiological protection supervisor (SPR), a position occupied by a professional who necessarily qualified to exercise after CNEN qualification exams.

CONCLUSION

Professionals in the field of radiation protection must be able to ensure that all workers, individuals from the public and the environment involved have adequate radiological safety. To this end, it is necessary to be familiar and knowledgeable about the work procedures and inherent safety requirements, which demands scientific dissemination actions in this field of radiological knowledge, to generate professional sedimentation in this area.

REFERENCES

1. Martins, R. A. (1990). Como Becquerel não descobriu a radioatividade. Instituto de Física "Gleb Wataghin" UNICAMP. São Paulo. Disponível em: <https://periodicos.ufsc.br/index.php/fisica/article/viewFile/10061/14903>. Acesso em: 16 jun 2024.

2. Lince Instrumentos e Radioproteção. (2024). NORM e TENORM - O que são, quais os riscos e como fazer sua gestão? Rio de Janeiro. Disponível em: <https://lincebrasil.com/norm-e-tenorm-o-que-sao-quais-os-riscos-e-como-fazer-sua-gestao/>. Acesso em: 15 jun 2024.

3. Duarte, J. C. M., et al. (2021). Radioatividade natural na exploração e produção de óleo e gás não convencional. Editora Atena. Paraná.

4. Rei, A. G. F. D., et al. (2014). Contaminação da água por urânio em Caetité-BA. Rio de Janeiro. Disponível em: <https://educacaopublica.cecierj.edu.br/artigos/14/7/contaminacao-da-agua-por-uranio-em-caetite-ba->. Acesso em: 16 jun 2024.

5. International Atomic Energy Agency (IAEA). (2018). Unveils Unique World Uranium Map. Disponível em: <https://www.iaea.org/newscenter/news/iaea-unveils-unique-world-uranium-map>. Acesso em: 16 jun 2024.

6. Environmental Protection Agency (EPA). (2008). Technologically Enhanced Naturally Occurring Radioactive Materials From Uranium Mining. Disponível em: <https://nepis.epa.gov/Exe/ZyPDF.cgi/9100I3Y4.PDF?Dockey=9100I3Y4.PDF>. Acesso em: 16 jun 2024.

7. Comissão Nacional de Energia Nuclear (CNEN). (2016). Requisitos de segurança e proteção radiológica para instalações mínero-industriais. Rio de Janeiro. Disponível em: <https://www.gov.br/cnen/pt-br/acesso-rapido/normas/grupo-4/grupo4-nrm401.pdf>. Acesso em: 16 jun 2024.