Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM)

Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) is defined as, "Naturally occurring radioactive materials that have been concentrated or exposed to the accessible environment as a result of human activities such as manufacturing, mineral extraction, or water processing.”

"Technologically enhanced" means that the radiological, physical, and chemical properties of the radioactive material have been concentrated or further altered by having been processed, or beneficiated, or disturbed in a way that increases the potential for human and/or environmental exposures.

Naturally Occurring Radioactive Material (NORM) is defined as, “Materials which may contain any of the primordial radionuclides or radioactive elements as they occur in nature, such as radium, uranium, thorium, potassium, and their radioactive decay products, such as radium and radon, that are undisturbed as a result of human activities.”

Background radiation, which is present in terrestrial, cosmic, and cosmogenic sources, is always around us. Some man-made radioactivity is considered part of background for regulatory purposes (e.g., fallout from weapons testing).

Learn about radon, a naturally occurring radioactive gas found in soils, rock, and water throughout the U.S.

TENORM Industries and Sources

Radioactive elements are present in many soils and rock formations, and consequently in the water that comes into contact with them. Extraction and processing of these resources may expose or concentrate NORM, causing them to be classified as TENORM.

This list of TENORM sources is not comprehensive, as TENORM is known to occur in other processes, but provides a general sense of the hazards posed by this class of radioactive substances. The major industrial sectors that generate TENORM are:

- Mining
  - Hard Rock Metal Mining
  - Rare Earths Mining Wastes
  - Uranium Mining Wastes
  - Copper Mining and Production Wastes
  - Bauxite and Alumina Production Wastes
- Energy production
  - Oil and Gas Production Wastes
  - Coal Combustion Residuals
- Water treatment
○ Drinking Water Treatment Residuals
○ Wastewater Treatment Residuals

• Consumer products
  ○ Fertilizer and Fertilizer Production Wastes
  ○ Cigarettes
  ○ Building Materials
  ○ Granite Countertops

EPA's Role

EPA is working to understand the problems associated with TENORM and to develop effective ways to protect people and the environment from unnecessary exposure to the radiation from these materials. Because TENORM is generated by many industries in varying amounts and occurs in a wide variety of products, the management of TENORM is a complex issue. Although EPA and others working on the problem have already learned a great deal about TENORM, we still do not completely understand all the potential radiation exposure risks it presents to humans and the environment.

EPA is investigating TENORM challenges in three ways:

• Studying the TENORM-producing industries to characterize their residuals and wastes, and evaluate potential exposures.
• Identifying and studying TENORM to assemble an understanding of where TENORM wastes are from, what's in them, and the risks they present to people and the environment.
• Working with other organizations that are also confronting the problem, including states, tribes, other federal agencies, industries, environmental groups and international organizations.

Many of the materials that are considered TENORM have only trace amounts of radioactivity and are part of our everyday landscape. However, some TENORM has relatively higher concentrations of radionuclides that can result in elevated exposures to radiation. EPA is investigating TENORM and its management because it can be a hazard to human health and the environment.

¹ All definitions referenced on this page are taken from the EPA combined report, Technologically Enhanced Naturally Occurring Radioactive Materials From Uranium Mining, Volume 1: Mining and Reclamation Background, and Volume 2: Investigation of Potential Health, Geographic, and Environmental Issues of Abandoned Uranium Mines.

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TENORM: Bauxite and Alumina Production Wastes

Bauxite refineries produce alumina (aluminum oxide), which is used to create aluminum metal. Bauxite is also used to manufacture other industrial products, such as abrasives, cement and chemicals. There are two operating bauxite refineries in the United States, both of which are located in Louisiana. The most frequently-occurring radionuclides and their decay products found in bauxite and bauxite processing residuals include:

- Uranium.
- Thorium.
- Radium.

On this page:

- The Bayer Process
- Waste generation, disposal and reuse

The Bayer Process

The Bayer Process, which is used by about 80 active plants worldwide, is the primary method of producing aluminum from bauxite. Bauxite ore is dissolved in sodium hydroxide, or lye, at a high temperature and pressure. Then, the alumina and bauxite ores are separated by washing out the waste (red muds or sands) from the alumina. Finally, hydrated alumina is crystallized and calcinated (dried in a furnace) to produce solid alumina.

Naturally-occurring radioactivity in bauxite ores is concentrated during the refining process, creating TENORM in bauxite refining residuals. The most frequently-occurring radionuclides found in red muds or sands include uranium, thorium, radium and their decay products. There are an estimated three billion tons of bauxite residue at both active and legacy processing sites.
Waste Generation, Disposal and Reuse

Bauxite is used to produce alumina, which is then used to produce aluminum. Wastes can be generated at several points in the production process, including during the mining of the bauxite ore, and during the refinery production process. The refinery processes used to produce aluminum generates about 2 - 2.5 tons of solid waste for every 1 ton of aluminum produced. This includes a small amount of waste rock, waste “muds” and a small amount of other scrap and solid wastes. These wastes can contain TENORM.

The red mud waste dries to a very fine, powdery solid and contains significant amounts of iron, aluminum, calcium and sodium. The types and concentrations of minerals present in the muds depend on the composition of the ore and processing conditions. In some plants, red muds are further processed to produce aluminum oxides.

Red muds are caustic, and the United States does not currently approve any secondary use of the waste. The radioactivity content is only one of several concerns that pose a risk to the environment, as red muds also have a high salinity and pH. In some red mud samples, the EPA has identified elevated arsenic and chromium concentrations; in some cases, arsenic levels were as high as 16,000 parts per billion (ppb), and chromium, 374,000 ppb. In the United States, wastes are usually disposed in large impoundments that are lined with clay or synthetic liners.

The European Union, however, has an index of Naturally-Occurring Radioactive Material (NORM) content that is allowable in various building materials; some countries in the EU have used red muds in building materials. Internationally, only about 2-3% of bauxite residuals are reused in a productive way.

The Ajka red mud spill in western Hungary in October 2010 was the largest documented release of alumina industry byproducts into the environment; about 3.5 million cubic feet of red mud suspension breached a failed retaining wall, and may still have lasting effects today.
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