Maxxam
A Bureau Veritas Group Company

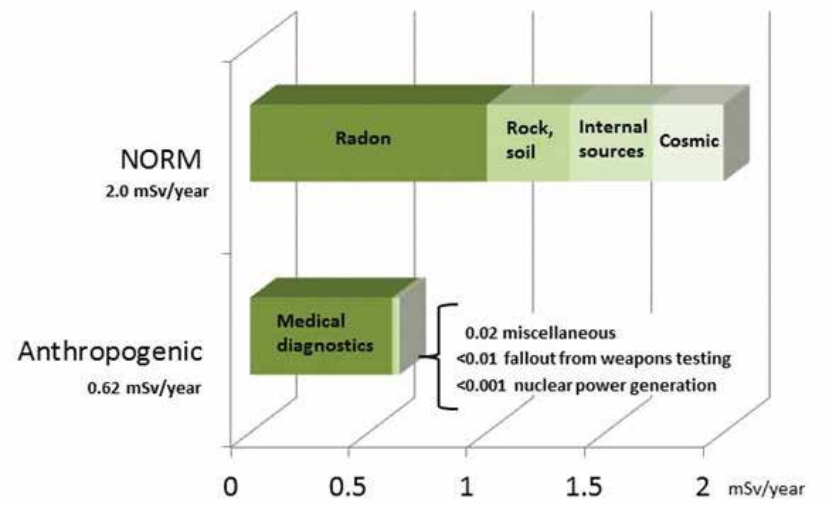
ENVIRONMENTAL SERVICES

NATURALLY OCCURRING RADIOACTIVE MATERIALS (NORM)

Radionuclides are naturally present in air, water, soil and rock. They originate from uranium, thorium and potassium-40 present during formation of the earth. Naturally occurring radioactive materials (NORM) are common in low quantities throughout the natural environment. They are in rocks, building materials, and even our bodies, given that we ingest and inhale radionuclides found in air, food and water. The majority (76 %) of human exposure to radioactivity is from natural sources, while a lesser amount (24 %) is from anthropogenic sources[1].

Average Annual Exposure of Canadians to Ionizing Radiation

[1](Adapted from Canada: Living with Radiation. Atomic Energy Control Board, 1995)



When human activities concentrate NORM or alter them in such a way that it increases exposure to people and/or the environment the resulting product is termed Technologically Enhanced Naturally Occurring Radioactive Materials **(TENORM)**. Common activities that generate TENORM include: oil and gas production, mineral extraction and processing and phosphate fertilizer production.

For more information please contact:
Email: **rad@maxxam.ca** or
Call us toll-free: **1 877 726 3080**

NATURALLY OCCURRING RADIOACTIVE MATERIALS (NORM)

Management of NORM

NORM is regulated at the provincial and territorial level, typically following the Canadian Guidelines for the Management of NORM (Health Canada). The Guidelines indicate that NORM may be released without radiological restrictions when the associated dose is not greater than 0.3 mSv/year. The table below shows the Unconditional Derived Release Levels (UDRLs) for diffuse NORM.

UDRLs for Diffuse NORM[2]

Radionuclide	NORM Disposal Level - Solids (Bq/Kg)	NORM Disposal Level - Liquids (Bq/L)
Uranium-238	300	1
Thorium-232	300	1
Potassium-40	17,000	N/A
Radium-226	300	5
Lead-210	300	1
Radium-228	300	5
Thorium-228	300	1

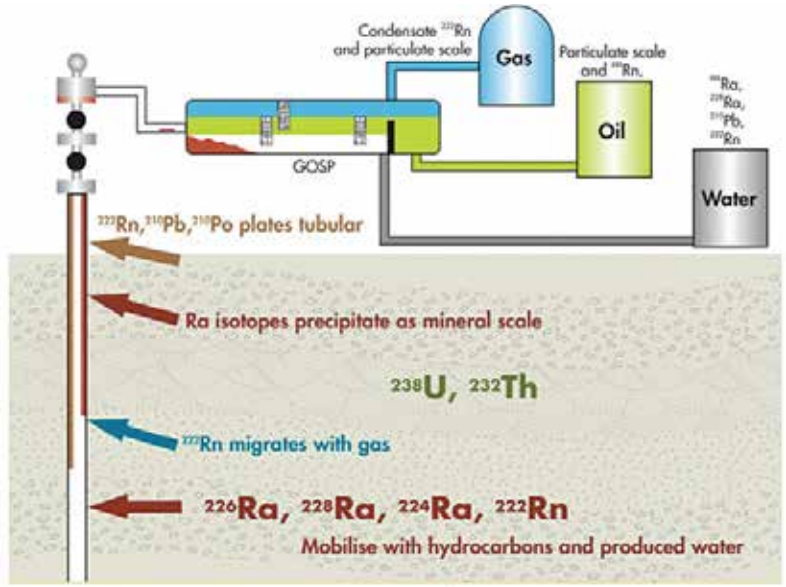
[2]Canadian Guidelines for the Management of NORM. Health Canada, 2014

Oil and Gas Production

NORM is found in the liquids and gases of hydrocarbon-bearing geological formations. As a result, drilling cuttings, fluids, mud, brines and flow-back water along with the oil, gas and produced water may be radioactive. The higher the salinity of co-produced water, the more NORM are likely to be mobilized.

Radium is the major radionuclide associated with TENORM in oil & gas production, both as a source of radiation in scales and sludge and as the source of radon. Radon is transported as a gas downstream from its radium-226 parent and is the source of lead-210 and polonium-210 scale in pipes. Ionizing energy from these radionuclides pose a health risk to workers, particularly during maintenance, waste transport and handling and decommissioning.

Radionuclides Commonly Associated with Oil and Gas Production



Source: Douglas Chambers, 2013 (used with permission of the author)

NATURALLY OCCURRING RADIOACTIVE MATERIALS (NORM)

Analysis for NORM in Oil & Gas Production

Maxxam recommends gamma spectrometry as a first step for analysis of major natural radionuclides: Ra-226, Ra-228 and Pb-210. These measurements can be used to evaluate the material against the NORM UDRLs for scale, drilling mud, cuttings, and water that has low dissolved solids. Other analytical techniques may be necessary for analysis of sludge, flow-back water or brines with high total dissolved solids.

Metal Mining and Processing

Mining and processing of metal ores can generate large quantities of TENORM waste located in ore tailings and smelter slag or in concentrates.

- **Rare Earth Elements (REE)** are often found in conjunction with uranium and thorium. The production of REEs usually generates large volumes of thorium hydroxide and residues that contain lead-210 and radium.
- **Titanium** ores often have elevated thorium and uranium that are concentrated during the processing.
- **Tantalum** usually occurs with niobium and concentration by gravity methods retains radioisotope contaminants in the concentrate.
- **Zirconium** processing retains contaminating radionuclides which are also usually found with the concentrate.

Analysis for NORM in Metal Mining and Processing

Gamma spectrometry is a good first step for analysis of major natural radionuclides: Ra-226, Ra-228 and Pb-210. These measurements can be used to evaluate the material against the NORM UDRLs for solid concentrates and wastes and waters that have low dissolved solids. For processed samples, it is helpful to determine the uranium-238 and thorium-232 activity using neutron activation to provide concentrations of the parent radionuclides in the decay chain. The density of the material affects the gamma spectrometry determination and extended counting on a finely-divided powder is usually required for these types of samples. Other analytical techniques may be necessary for analysis of effluents with high total dissolved solids.

Maxxam provides analysis of metal in effluent, including Ra-226 analysis by alpha spectrometry to comply with the **Canada Metal Mining Effluent Regulations.**

NATURALLY OCCURRING RADIOACTIVE MATERIALS (NORM)

Maxxam is the Canadian market leader in analytical services and solutions to the energy, environmental, food and DNA industries and a member of the Bureau Veritas Group of companies – a world leader in testing, inspection and certification services. We support critical decisions made by our customers through the application of rigorous science and the knowledge and expertise of our over 2200 employees.

For more information contact us:
Email: **rad@maxxam.ca** or
Call us toll-free: **1 877 726 3080**

Consumer products

Many building materials, such as granite, concrete, gypsum board, ceiling tiles and fire brick may contain elevated levels of radionuclides, particularly radium-226, thorium-232 and potassium-40. Materials may be tested prior to use in construction projects to determine the activity level and human exposure. Materials may also be tested during demolition and prior to disposal to ensure the UDRLs outlined in the Canadian Guidelines for the Management of NORM are met and the material can be disposed of at landfill sites. There is a large range of radioactivity in building materials depending upon the content of the raw material source.

Radioactivity concentrations of NORM in building materials (Bq/kg)

Material	Ra-226	Th-232	K-40
Concrete	1-250	1-190	5-1570
Clay bricks	1-200	1-200	60-2000
Phosphogypsum	4-700	1-53	25-120
Cement	7-180	7-240	24-850
Tiles	30-200	20-200	160-1410

Source: IAEA Technical Reports Series no. 419 (2003)

Fertilizer

Phosphate rock used in fertilizer production is a source of NORM. Ores can have high radioactivity due to uranium, thorium and radium. Processing with sulfuric acid enhances the concentrations in the beneficiated ore, retaining Ra-226, Th-232 and U-238.

Waste and Recycling

Most waste disposal sites are now equipped with portal monitors used to detect radioactivity in material for disposal. These detectors generally do not indicate the radionuclides that are present, only the overall activity level. Waste such as ceramics, brick, cement and stones can trigger radioactivity monitors at disposal sites.

Analysis for NORM in Waste or Recycling

Gamma spectrometry is a good first step for analysis of major natural radionuclides of concern. It can often be challenging to obtain a representative sample from a diverse mix of waste. Maxxam analyzes a large, 500 gram sample to minimize sub-sampling bias. The material does not require special disposal if it is below the UDRLs outlined in the Canadian Guidelines for the Management of NORM.

Maxxam
A Bureau Veritas Group Company