IAEA
International Atomic Energy Agency

Management of Bulk NORM Residues and Waste (Part 1)

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Definitions

- NORM residue
  - Material that remains from a process and comprises or is contaminated by NORM
  - NORM residue may or may not be a NORM waste
    - It may be recycled back to the process or used as a by-product
- NORM waste
  - NORM for which no further use is foreseen

Managing NORM residues and waste

IAEA Fundamental Safety Principle 7:

Protection of present & future generations

- People and the environment, present and future, must be protected against radiation risks

- Radioactive waste must be managed in such a way as to avoid imposing an undue burden on future generations; that is, the generations that produce the waste have to seek and apply safe, practicable and environmentally acceptable solutions for its long term management.

Types of NORM residue

- NORM residues take various forms:
  - Solids (or solid–liquid mixtures)
    - Bulk residues
    - Scale
    - Sediments and sludges
    - Slag
    - Furnace dust
  - Liquid residues
  - Gaseous residues

Bulk NORM residues

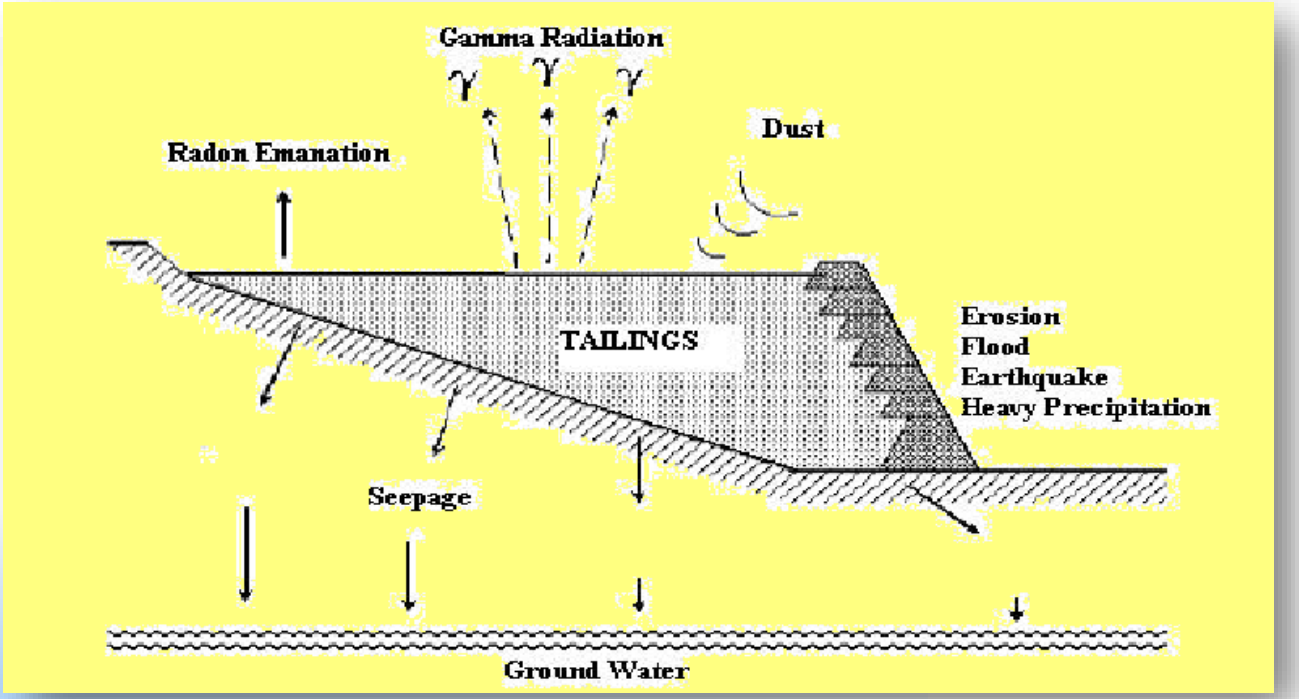
Process / residue	Radionuclide	Activity concentration (Bq/g)
Uranium mining — tailings	^{230}Th, ^{226}Ra	<10 to several 100
Uranium mining — waste rock	^{238}U	0.1 – 20
Copper mining — waste rock	^{238}U	0.1 – 2
Dry separation of mineral sand— tailings	^{232}Th	1 – 20
Bauxite processing — red mud	^{232}Th	0.1 – 3
Beneficiation of phosphate rock — tailings	^{238}U	0.01 – 2
Phosphoric acid production — phosphogypsum	^{226}Ra	0.01 – 3
Titanium dioxide production – filter cake	^{232}Th/^{238}U	~1

Bulk NORM residues

- Uranium tailings:
  - Concentrations of ^{230}Th, ^{226}Ra and their decay progeny remain high for about 10^5 years
    - The only opportunity for recycling is the future extraction of residual uranium and other minerals
    - Viability depends on extraction technology and market prices for uranium and other minerals
- The very high volumes limit the options for storage/disposal:
  - Above-ground engineered containments (tailings dams)
  - Backfilling of mining voids
    - Underground
    - Open pits

Bulk NORM residues

- For tailings dams, comprehensive engineering control measures must be applied to ensure structural integrity
- Prevention of migration of hazardous constituents (including radionuclides) into the surrounding environment needs to be considered



Example: Tailings dam

Disposal considerations

- Control of hazards from tailings dams should rely as much as possible on passive control measures and the use of natural materials as barriers
- Measures need to be taken for radiation protection of workers and radiological monitoring of the surrounding environment (groundwater, surface water, air, soil, biota etc.)
- After closure of a tailings dam facility, ongoing institutional controls are likely to be required to restrict access and unauthorized use
  - The need for and extent of institutional control should be minimized by good siting, design etc.

Waste rock

- Usually generated in very large quantities
- May have a significant radionuclide content
- Has to be stored/disposed of in surface or near-surface containments (waste rock piles, backfilling into open pits).
- Not necessarily waste:
  - The mineral content might be worth recovering in the future
  - Can be used as a construction material
  - Safety assessment is required

Waste rock

Waste/residues from mineral sands operations

- May have a significant thorium content
- Management options:
  - Dispose of in earthen trenches with soil topping
  - Backfill into the mining void and cover with non-radioactive sand or overburden
  - In dredge mining operations, it may be returned to the dredge pond and recycled along with fresh feed to the plant
  - If the monazite component of the tailings is not recovered, blend with residual (non-radioactive) sand and backfill into the mining pit

Bauxite residue (red mud)

- Red mud is the residue generated by the digestion of bauxite in sodium hydroxide, as the first step in the production of aluminium
- It is disposed of as a slurry (10–30% solids) in engineered containments with adequate linings or dry disposal on land after dewatering
- The radioactivity content is low, and only one of several constituents posing a potential risk to the environment

Phosphate rock tailings

- Low levels of uranium
- Pumped as a slurry back to the mining void
- Environmental protection considerations
- Radiological considerations are minor due to low activity concentration

Phosphate rock tailings returned to the mined-out area

Phosphogypsum

- Generated in large quantities (160 million t per year) during the production of phosphoric acid from phosphate rock
- ^{226}Ra concentrations are moderately elevated
- A variety of uses:
  - Agricultural soil amendment
  - Construction materials — buildings, roads
  - Cover and liner material for conventional landfill disposal facilities
  - No significant radiological implications except possibly in buildings
- Stored in large engineered containments (‘stacks’)
  - Wet deposition (slurry) or dry deposition
  - Safety and environmental issues are similar to those for mine tailings
  - Radiological issues are insignificant—structural integrity, heavy metals and acidity are the main concerns
- Production far exceeds demand
  - Many phosphogypsum stacks are likely to become final disposal sites

Phosphogypsum stack

Titanium Dioxide

- Titanium dioxide pigment is made by reacting titanium ores with either chlorine gas or sulphuric acid
- Pigment contains very little NORM with almost all activity in solid waste and liquid effluent
- Activity concentrations in solid waste and effluent vary depending on ore used but typically are around 1 Bq/g and 1 Bq/l (both ^{232}Th and ^{238}U decay series)
- Solid wastes used for construction materials or disposed to landfill

Titanium Dioxide

Minimize NORM waste

- Recycling of NORM residues, or their use in other applications (rather than disposing of them as waste) should be the first consideration: NORM residues should be regarded as a resource rather than as waste.
- Examples may include:
  - Recycling of contaminated waters in the process
  - Salvage and recycling of reagents (e.g. resins, solvents)
  - Agricultural use, e.g. phosphogypsum
  - Building materials, e.g. fly ash, phosphogypsum, red mud
  - Road construction, e.g. slag, phosphogypsum, fly ash
  - Recycling of contaminated scrap

Key messages

- Very large quantities
- Low activity concentrations
- Can be regarded as a potential resource
- Appropriate protection is achievable through different management options