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
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.
NORM residues take various forms:

- Solids (or solid–liquid mixtures)
  - Bulk residues
  - Scale
  - Sediments and sludges
  - Slag
  - Furnace dust

- Liquid residues

- Gaseous residues
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Uranium tailings:

- Concentrations of $^{230}\text{Th}$, $^{226}\text{Ra}$ 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
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
• 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