The management of NORM residues

Practical aspects

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INTRODUCTION

Two main mechanisms of the generation of radioactive residues:

a) Large quantities of raw materials with low radioactivity are directly transformed into small quantities of residues (mass transfer), for example coal combustion;

b) Small amounts of radioactivity are selectively transferred from large quantities of raw materials into residues (activity transfer), for example precipitation of scales.

Typical examples of the generation of NORM residues:

- Radioactive raw materials: phosphate fertilizer and titanium dioxide pigment production,
- Precipitation: generation of scales and sludges in oil/gas production and in water treatment,
- Volatilization: filter dust from coal combustion and metal smelters,
- Radioactive products: magnesium-thorium alloys, refractories.

DEFINITIONS

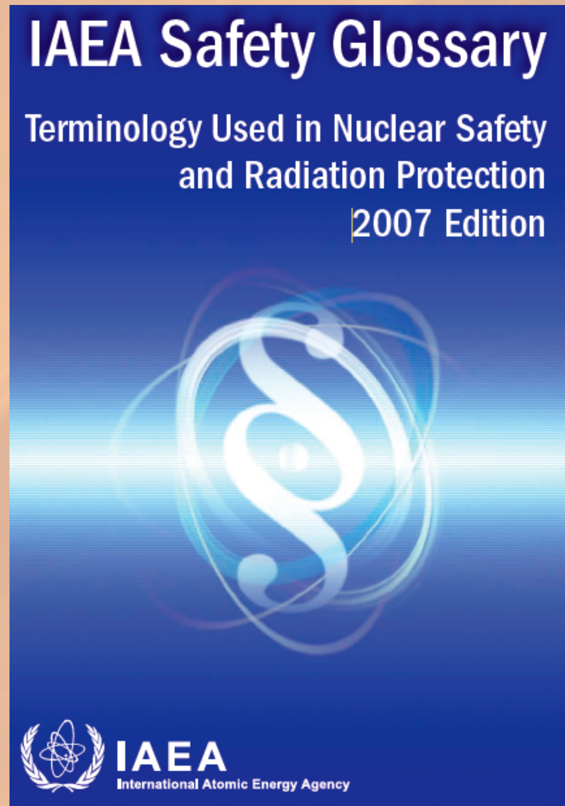
NORM waste:

Naturally occurring radioactive material for which no further use is foreseen.

NORM residue:

Material that remains from a process and comprises or is contaminated by naturally occurring radioactive material (NORM).

<u>A NORM residue may or may not be waste.</u>



OPTIONS FOR THE MANAGEMENT OF NORM RESIDUES

Depends on when they would be re-used:

The residue is transferred to a re-use/recycling facility as it is being generated – will be considered as a 'raw material' at the recycling facility.

If it is expected that the NORM residue will need to be stored for a period of time before re-use, it will need to be placed into an authorized storage facility – requiring the development of a long-term management plan.

OPTIONS FOR THE MANAGEMENT OF NORM RESIDUES

NORM residues	Products and/or reuse options
Small amounts of contaminated metals	Metal recycling
Phosphogypsum	Soil improvement, fertilizer, building materials, landfills cover, water purification, road construction
Slags	Road construction
Mining tailings	Underground or open pit backfill
Fly ash, bottom ash	Road construction, cement industry, fertilizer and soil conditioner
Contaminated plastic, wood and rubber	Reuse option has not been yet found
Filter masses and filter cloths from water treatment and processing of minerals	
Scale and sludge from oil and gas exploration and production (including hydraulic fracturing), and from geothermal energy generation	

OPTIONS FOR THE MANAGEMENT OF NORM WASTE

There are currently four different options for the management of NORM *residues* after it has been decided that no future for them is foreseen and therefore, they have been classified as *waste*:

a) Long-term storage followed by the disposal,
b) Concentrate and contain option,
c) Delay and decay option,
d) Dilute and disperse option.

MANAGEMENT OF NORM RESIDUES

Case 1: Immediate removal of NORM residues from a site for reprocessing

A product called silica fume (SiO_2) is generated in the production of zirconia (ZrO_2) from the mineral zircon ($ZrSiO_4$).

Produced in low quantities (several tons per month), transported to a customer every several weeks. Usually sold as a by-product for use as an additive to cement and in brick making.

The care is always taken to ensure that final materials (such as cement) do not contain more than 8-10% of silica fume.

MANAGEMENT OF NORM RESIDUES

Case 2: Long term residues storage – monazite concentrates

Temporary storage of monazite concentrates (containing 90-110 Bq/g of ^{232}Th and 10-15 Bq/g of ^{238}U) at the "arid" and "remote" site:

The mineral contains significant concentrations of rare earth elements – thus it is considered to be a valuable resource and some sales of monazite concentrates have already occurred.

If all accumulated material would not be sold in the intermediate future, the temporary storage location could be converted into a long-term storage by simply covering the material in the mined out pit and having this valuable resource available to future generations.

MANAGEMENT OF NORM RESIDUES

Case 3: Long term residues storage – neutralized used acid

Neutralized used acid (NUA) is generated in the production of the synthetic rutile from titanium mineral ilmenite and typically contains 0.5-0.7 Bq/g of ^{232}Th and 0.2-0.3 Bq/g of ^{238}U.

The product may be used in agriculture and a radiological impact assessment is usually required.

Was stored for several years until the application has been found: the NUA is mixed at a 5% ratio with sand to construct a “nutrient filter” to enhance soluble phosphorus removal from the surface water streams.

MANAGEMENT OF NORM WASTES

Case 1: Long term NORM waste storage followed by disposal

Phosphogypsum

The concentrations of radionuclides in phosphogypsum ($CaSO_4 \cdot 2H_2O$) may be in range of 0.01-0.50 Bq/g of ^{238}U and 0.02-3.20 Bq/g of ^{226}Ra.

Very large volumes of phosphogypsum have been generated by the phosphate industry. Concerns about its radioactivity content resulted in restrictions on the use of phosphogypsum, even though such concerns do not always have a proper scientific foundation. This has resulted in phosphogypsum stacks being turned from short-term holding piles into long-term disposal facilities.

MANAGEMENT OF NORM WASTES

Case 1: Long term NORM waste storage followed by disposal

Mineral processing tailings

The tailings containing approximately 9 Bq/g of ^{232}Th, 1 Bq/g of ^{238}U, 8 Bq/g of ^{228}Ra and 2 Bq/g of ^{226}Ra are generated at a rate of 90,000 tons per year. The use for this NORM residue has been found as an additive to the road construction.

The project abandoned:

- Almost one million tons of "clean fill" was needed to be purchased annually,
- Only 15-20% of this NORM residue could have been utilized for the construction of necessary roads; there was simply no need for such large volumes of material.

MANAGEMENT OF NORM WASTES

Case 2. Concentrate and contain option

Oil and gas industry

Concentration of ^{226}Ra in scales inside pipes and different valves can reach or exceed 15,000 Bq/g and in sludges – 800 Bq/g. The scales are removed at treatment plants and are compacted into drums that are kept in a controlled area and then disposed of in authorized facilities.

Titanium dioxide pigment industry

Activity concentrations in scale and discarded filter cloths can exceed 1,500 Bq/g of ^{228}Ra and ^{228}Th. The scales and filter cloths are small in volume and are usually kept in containers prior to the disposal.

MANAGEMENT OF NORM WASTES

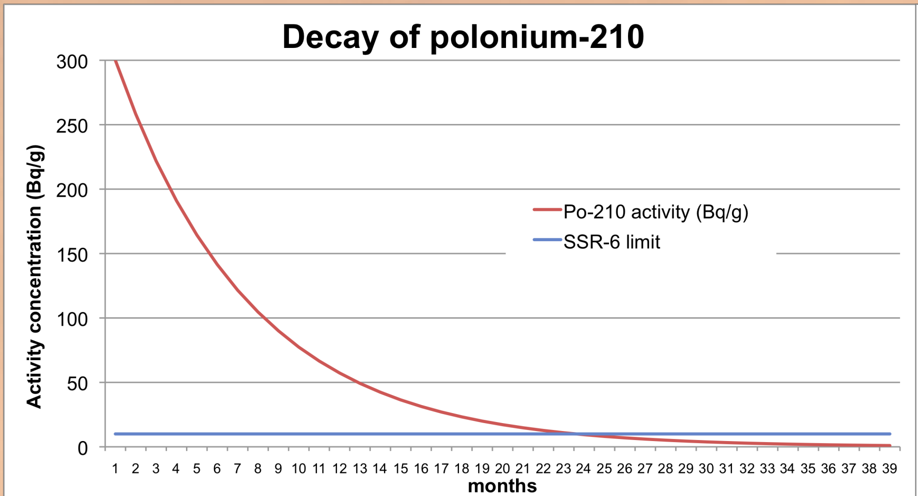
Case 3. Delay and decay option

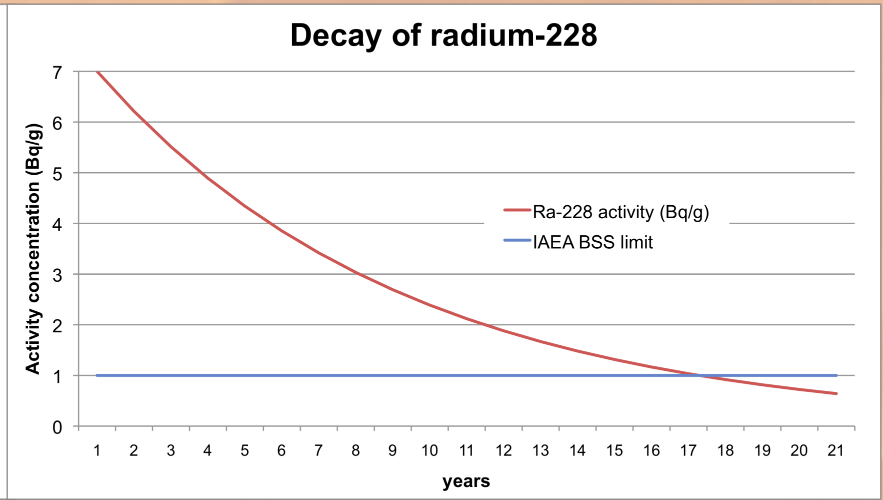
Dust containing ^{210}Po

The dust containing 300 Bq/g of ^{210}Po (half-live of 140 days) will be exempt from radiation safety regulations (less than 1 Bq/g) in just over three years.

Processing tailings containing ^{228}Ra

Waste stream containing 7 Bq/g of ^{228}Ra could be disposed into an industrial landfill (concentration will be below 1 Bq/g) after 17 years.





MANAGEMENT OF NORM WASTES

Case 4. Dilute and disperse option

Monazite concentrates

Example, Western Australian regulations:

Each responsible person at a mine site must ensure that, so far as is practicable, radioactive waste is diluted with other mined material before it is finally disposed of in order to ensure that in the long term the use of the disposal site is not restricted.

Monazite concentrates containing approximately 100 Bq/g of ^{232}Th and 12 Bq/g of ^{238}U are transported to a mine site where they are blended thoroughly with mine tailings (sands and slimes, containing only trace amounts of NORM).

The final tailings stream for the disposal contains only 0.4-0.6 Bq/g of ^{232}Th (^{238}U is below the limit of detection). Therefore, no 'legacy sites' that would require institutional control for a very long period of time are created.

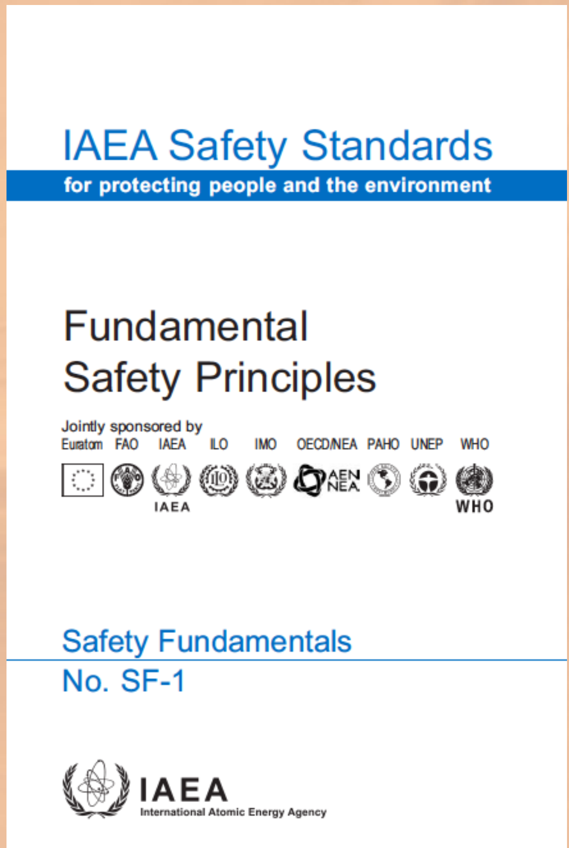
MANAGEMENT OF NORM WASTES

Case 4. Dilute and disperse option

Monazite concentrates: Details reported at the Simpósio Minérios e Radioatividade, IRD/CNEN, Rio de Janeiro in 2014, available from the IRD website.



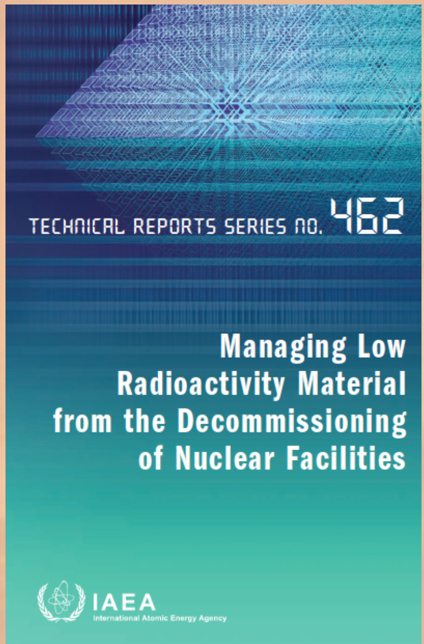

DILUTE AND DISPERSE OPTION ADDITIONAL COMMENTS



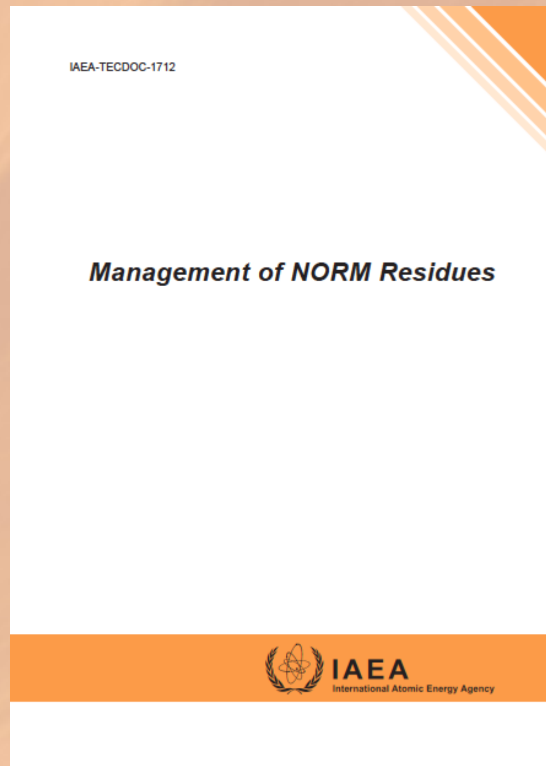
3.29. ...The generation of radioactive waste must be kept to the minimum practicable level by means of appropriate design measures and procedures, such as the recycling and reuse of material.

Therefore, reuse and recycle of radioactive waste needs to be considered in each case.

DILUTE AND DISPERSE OPTION ADDITIONAL COMMENTS



Dilution needs to be used sensitively in order to demonstrate implementer credibility and ethics in the management of radioactive waste and thereby maintain public acceptance. Nevertheless, it is a potentially valuable technique in appropriate situations and has been used successfully.



Dilution as a means of increasing the amounts of NORM residues that can be used as by-products should not only be permitted in terms of the national approach, but should actually be encouraged.

GENERAL SUGGESTION 1 – DO NOT OVER-REGULATE

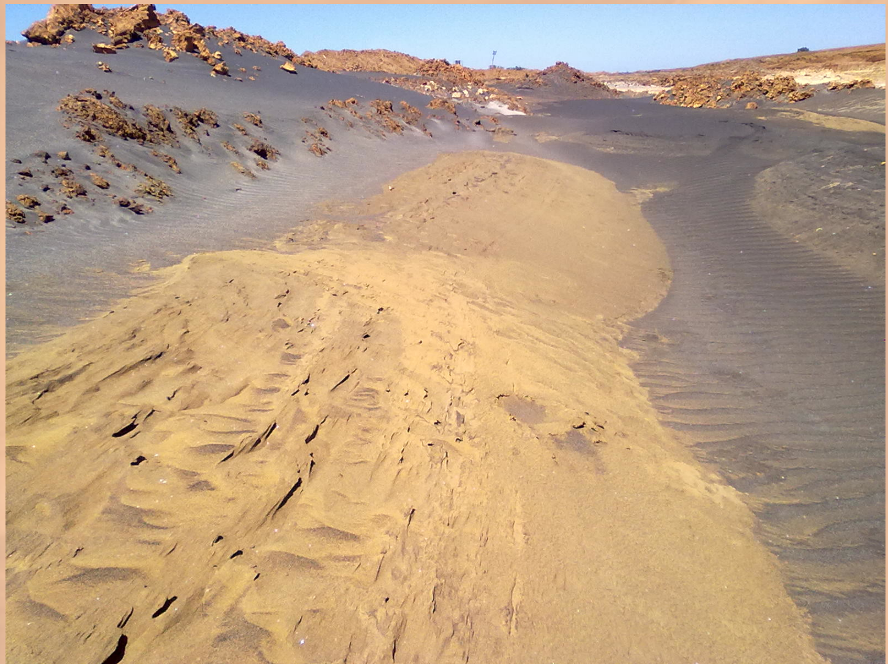
Do not write detailed compulsory specifications on how to meet the performance standards – the system of radiation protection will quickly degenerate into a continuing industry effort to comply with ever more complicated regulations, procedures and guidelines – completely losing sight of the basic goal of safe operation.

Do set the "release" or "re-use" limits for different branches of the minerals industry and leave it to the industry itself to develop technical systems to meet these standards in specific circumstances.

GENERAL SUGGESTION 2 – INVOLVE THE INDUSTRIES

- There is still more confusion than certainty in the management of NORM residues and wastes, and the situation has <u>not</u> improved significantly since late 1990's.
- The IAEA Safety Reports issued for the different industries remain largely unknown and unused by the industries for which they were intended. No industry representatives at NORM-VI and NORM-VII.
- To increase industry involvement:
    - Short articles in industry-specific publications – **not** in radiation protection journals,
    - Presentations at industry conferences – **not** at radiation protection congresses,
    - Specific invitations for industry to participate in congresses such as NORM-VIII, through individual companies and relevant industry associations.

CASES OF UNACCEPTABLE NORM WASTE MANAGEMENT



CASES OF UNACCEPTABLE NORM WASTE MANAGEMENT

Radioactive material on the municipal rubbish tip

CASES OF UNACCEPTABLE NORM WASTE MANAGEMENT

Livestock grazing on NORM waste

CASES OF UNACCEPTABLE NORM WASTE MANAGEMENT

Lack of the tailings dam maintenance



Contaminated equipment & mineral dumped in publicly accessible areas



CASES OF UNACCEPTABLE NORM WASTE MANAGEMENT

DO NOT FORGET THE MINERAL EXPLORATION!

Organic waste (including out-of-date food) disposed together with samples, leading to termite intrusions, gamma radiation levels on the surface of termite hills are ~ 2-4 μSv/hour.

CONCLUSIONS

- There are many different options for managing various types of NORM residue and NORM waste – the selection of a method would depend not only on technical and economic considerations, but also on what options are permitted by the regulations applicable in the particular jurisdiction, and on public opinion.
- A possible management method typically cannot be based on a limit of activity concentration, due to the large variety of NORM residues and wastes and possible migration of different radionuclides into the environment. However, industry- or substance-specific guidelines may be developed.
- Additional approvals from an appropriate authority will be required in each case, based on a separate radiological impact assessment carried out for all reasonably possible scenarios.


Thank you for your attention!