Simpósio Minérios & Radioatividade

NORM: Gerenciamento do Ponto de Vista da Proteção Radiológica

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Local: Instituto de Radioproteção e Dosimetria, Rio de Janeiro

The reuse of NORM residues

A reutilização de resíduos NORM

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Residue – Waste

NORM residues:

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

NORM waste:

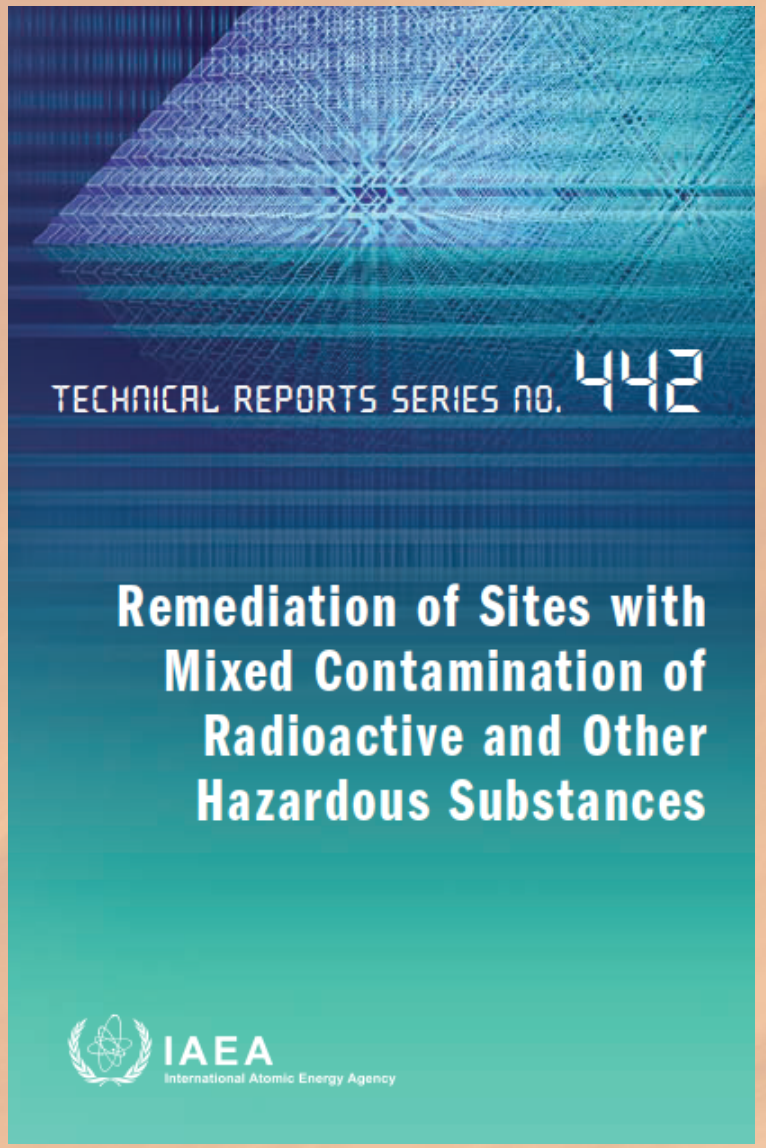
Naturally occurring radioactive material (NORM) for which no further use is foreseen.

A NORM residue may or may not be waste.

Definition

Dilution is the process in which a contaminant becomes less concentrated. It is similar for both organic and inorganic contaminants, including radionuclides.

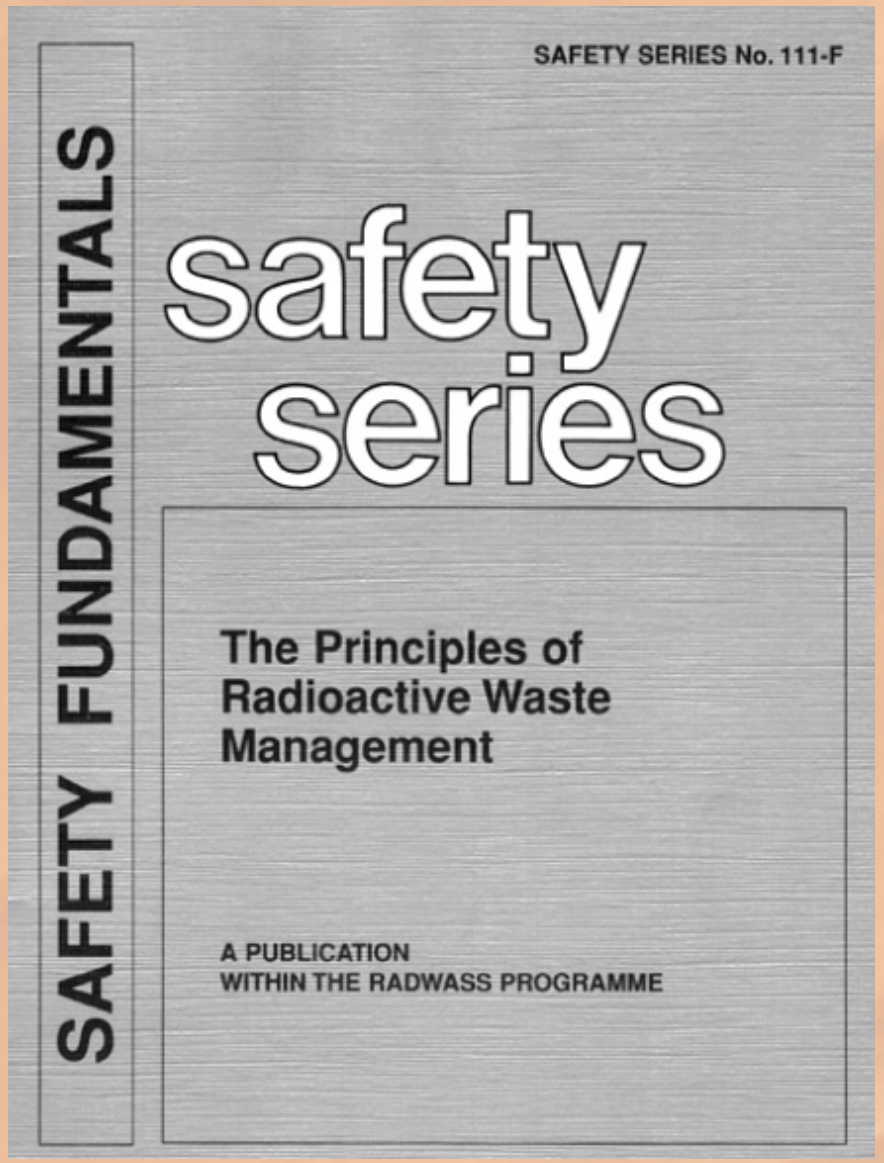
It reduces risk because resulting exposures will be lower. By itself, however, dilution does not reduce contaminant mass; rather it spreads the area of potential exposure.



Approaches – IAEA

"(308.) …The preferred approach to radioactive waste management is concentration and containment of radionuclides rather than dilution and dispersion in the environment.

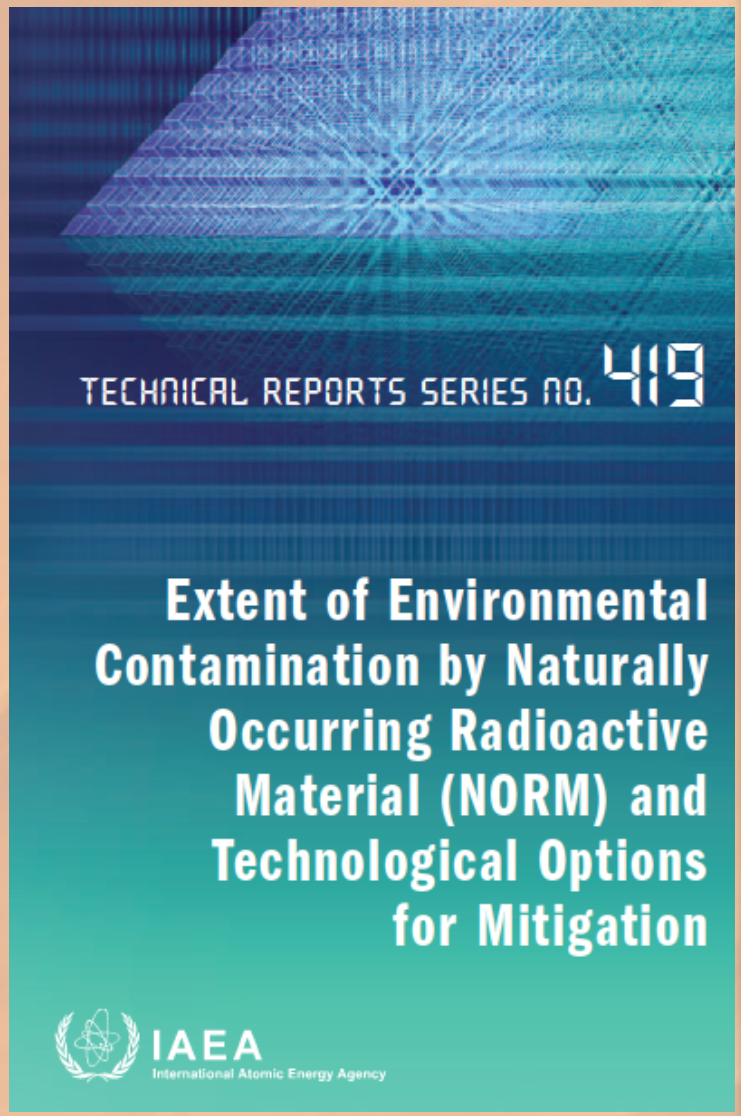
However, as part of radioactive waste management, radioactive substances may be released within authorized limits as a legitimate practice into the air, water and soil, and also through the reuse of materials."



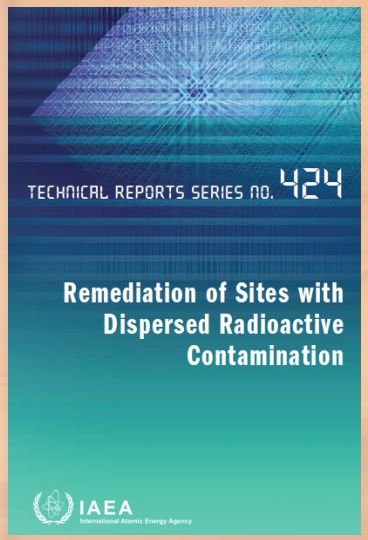
Observations – IAEA

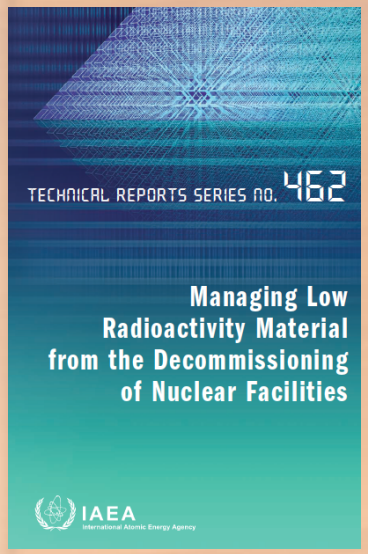
The problem is aggravated by accumulating effects along the food chain. Another uncertainty that to date remains unresolved is the potential effect of prolonged exposure to very low concentrations.

In the light of these concerns, discharges and releases have been prohibited (declared radioactive waste) or significantly curtailed in some regions of the world through international agreements, for example the London convention 1972 on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter.



Observations – IAEA

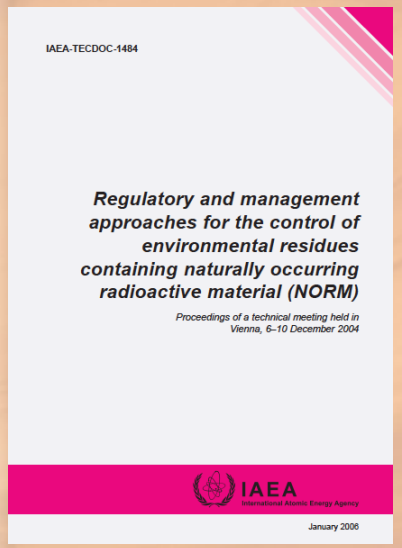




There is no doubt that, even where not proscribed by legislation, the dilute and disperse option is opposed by regulators, environmental groups and the public at large.

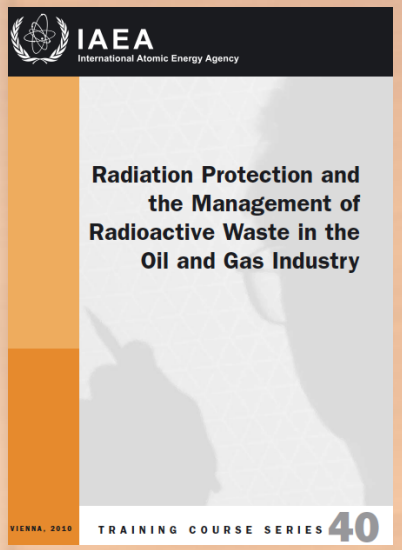
The deliberate dilution should not be used as a means to release relatively high specific activity materials by the deliberate mixing of contaminated and uncontaminated building rubble in order to meet clearance levels. This is a different situation to the use of dilution in order to meet specific disposal criteria on the content of waste packages…
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.

Observations – IAEA: NORM waste



Some legal options for NORM residue disposal might include the release and dilution of residues into water bodies, incorporation back into the natural environment or underground placement.

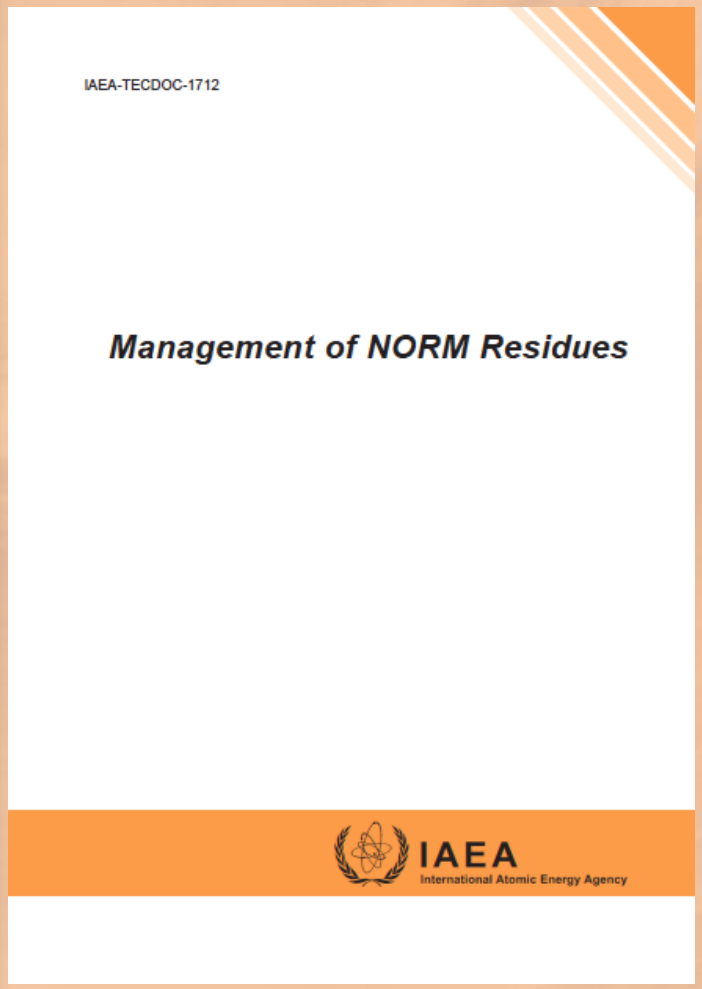
However, in some Member States one or more of these options may not be legally acceptable. The same situation may exist when considering possible recycling and reuse of material. For example, the recycling of residues containing NORM for use in road construction is permitted in some Member States but not in others.



Disposal methods for NORM wastes fall into four main categories:

i. Dilution and dispersal of the waste into the environment, e.g. liquid or gaseous discharges;
ii. Concentration and containment of the waste at authorized waste disposal facilities;
iii. Processing of the waste with other chemical waste by incineration or other methods;
iv. Disposal of the waste by returning it back to the initial source of the material (reinjection into the reservoir).

Observations – IAEA: NORM waste



The use of slag as a component of construction materials such as cement or bricks may need to involve dilution with other materials such as fly ash in order to meet radiological standards for construction materials.

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.

Residues types and reuse options

NORM residues	Products and/or reuse options
Small amounts of metals with high activity concentration	Metal recycling
Phosphogypsum	Soil improvement Fertilizer Building materials Landfills cover Water purification Road construction
Slag	Road construction
Liquid residues	Reuse, closed-circuit process
Tailings	Underground backfill

Residues types and reuse options

NORM residues	Products and/or reuse options
Fly ash Bottom ash	Road construction Cement industry Fertilizer and soil conditioner Inclusion concrete
Decommissioned constructions materials (concrete, soil, bricks, etc)	Gravel
Rock	Cover material for tailing ponds
Mineralized rock	Metal extraction
Solid residues from TiO2	Backfill into remediated sites
Red mud	Backfill into remediated sites

Residues types with no clear reuse options

NORM residues	Products and/or reuse options
Plastic	-
Rubber	-
Zinc-rich filter cake	-
Filter masses from water treatment	-
Scales, sludge	-

Observations – different countries

USA:

Conference of Radiation Control Program Directors (CRCPD) Suggested State Regulation Part N for TENORM (2001):

Rationale:

"The CRCPD does not consider it appropriate to perform purposeful dilution of TENORM in order to be excluded from these regulations unless otherwise allowed by specific state regulatory actions."

Implementation Guidance:

"Using purposeful dilution to render TENORM waste exempt shall not be allowed without prior agency approval."

Part N.4a. "does not explicitly prohibit the purposeful dilution of waste to render the waste exempt from regulation... Purposeful dilution to render TENORM exempt shall not be performed without regulatory agency approval. "

Observations – different countries

Belgium:

"…deliberate dilution with non radioactive material in order to reach the clearance level is forbidden."

Spain:

The deliberate mixing of contaminated and non-contaminated materials in order to achieve declassification levels has been expressly prohibited during the dismantling of Vandellos-1 nuclear power plant.

Netherlands:

The by-product use of NORM residues as the primary target of a NORM residue management system. For application in civil engineering, a specific requirement in Dutch legislation is that the NORM residue is diluted to a level such that it is no longer considered radioactive (in that it does not exceed the relevant 'exemption' level). Thus, dilution in this case is not only a treatment option but also a legal obligation. Only if the options of recycling or use are not feasible can the material be disposed of, and only then is it considered to be waste.

"Practical Issues for Dealing with NORM in The Netherlands", Jeroen Welbergen et al., NORM-6, 2010

Three options for dealing with NORM waste

- Concentrate and contain
- Delay and decay
- Dilute and disperse

All three should be considered in each case.

Concentrate and contain example – sludges from oil and gas industry

- Dewatering
- Removal of mercury
- Solidification and distillation

From "reuse and recycle of NORM", Jeroen Welbergen & Rob Wiegers

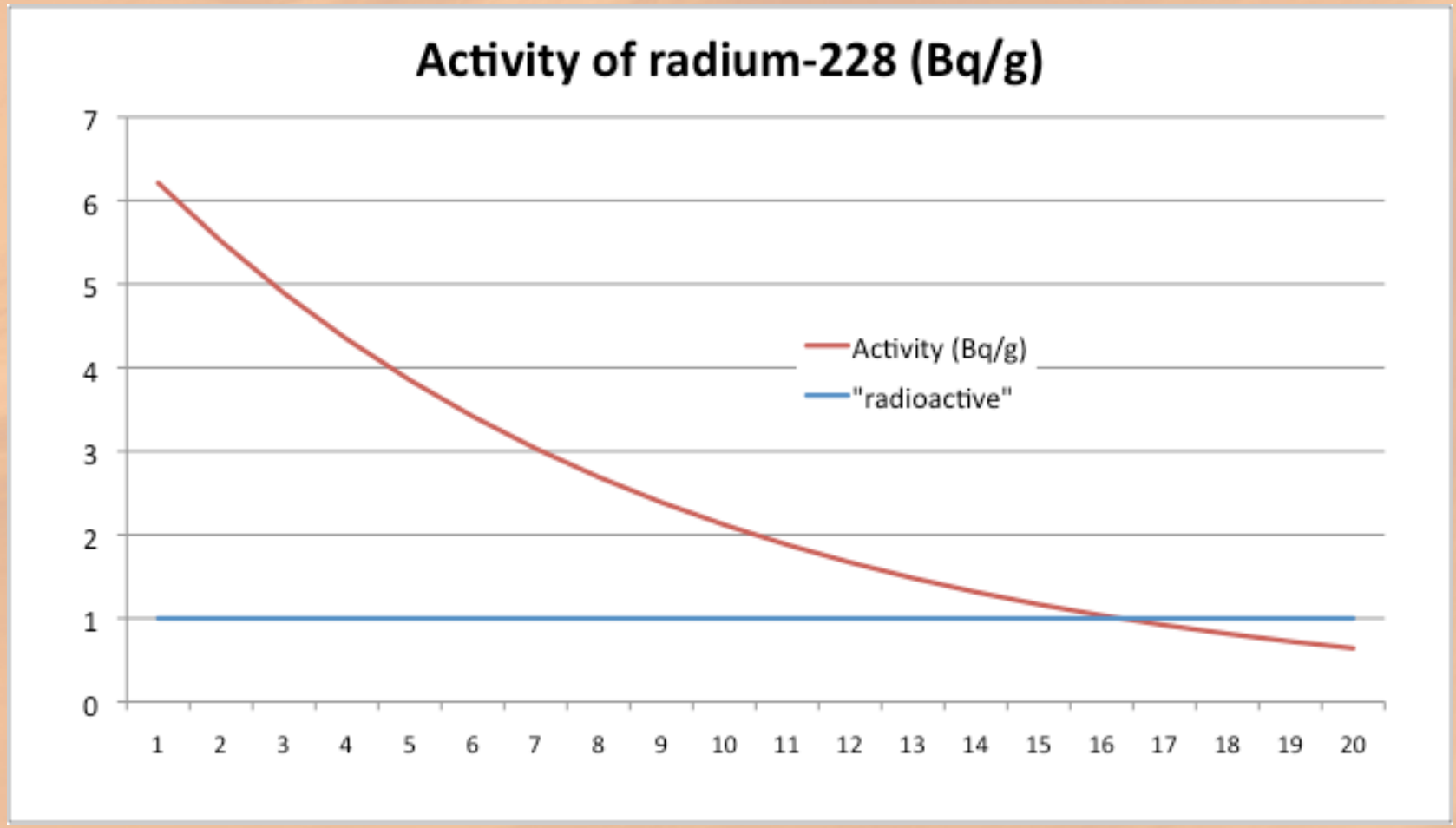
Concentrate and contain example – titanium pigment production

Solid waste filters with Ra, U and Th + daughters
5 m^3/y
1000 Bq/g

Contaminated pipe disposal (shredded, super-compacted and conditioned with cement)

From "reuse and recycle of NORM", Jeroen Welbergen & Rob Wiegers

Delay and decay example – rare earths production



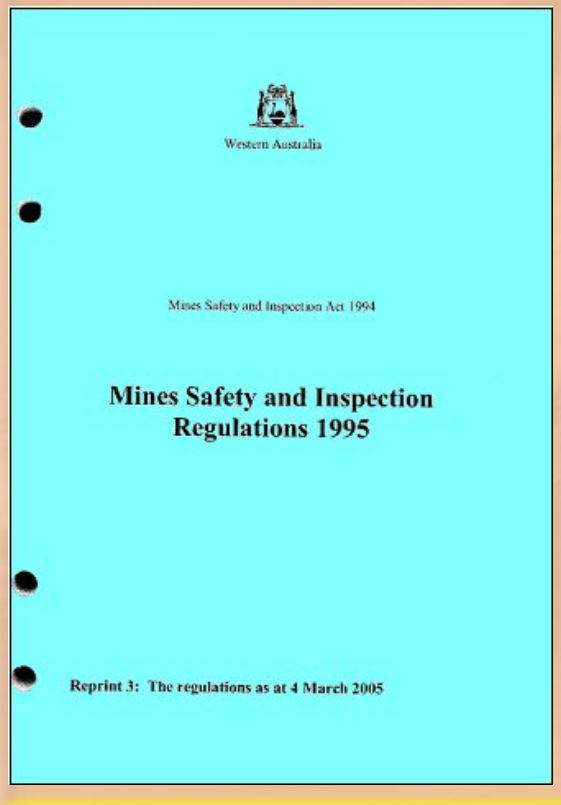
Specific case of waste enriched especially in ^{228}Ra, at ~ 6.5 Bq/g

Dilute and disperse example – Brazil

Trials of the use of phosphogypsum to improve soil fertility in the Cerrado Region of Brazil

From "Radiological Impact Associated to the Use of a NORM Material as a Soil Conditioner in Brazilian Agriculture", Vanusa Jacomino et al., WM2010, USA

Dilute and disperse example – Western Australia


Western Australia

Mines Safety and Inspection Act 1994

Mines Safety and Inspection Regulations 1995

Reprint 3: The regulations as at 4 March 2005

16.35. Long term waste management

(2) Each responsible person at a mine 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.

NORM blending for disposal – Western Australia

The levels for the possible utilisation of residues
(subject to the governmental approval on the case-by-case basis)

Many regulatory suggestions were studied: EU (1999 and 2009), Czech Republic (1999), Poland (2002), Finland (2002), People's Republic of China (2002), Azerbaijan(2005), Tajikistan (2006), etc. A combination of Polish and Chinese standards was accepted in 2008 Guideline on waste management:

Two indexes are established:

1. External exposure index: $f_1 = \frac{C_{Ra}}{300} + \frac{C_{Th}}{200} + \frac{C_K}{3000}$
2. Internal exposure index: $f_2 = \frac{C_{Ra}}{200}$

Where: C_{Ra}, C_{Th} and C_K are the concentrations of radium–226, thorium–232 and potassium-40, respectively, expressed in Bq/kg. If both uranium and thorium decay chains in the material are in a secular equilibrium, the value for the concentration of radium–226 can be replaced by uranium–238, and the value for thorium–232 can be replaced by radium–228.

The index f_1 describes the content of NORM in a particular material and is calculated on the basis of concentrations of radium–226, thorium–232 and potassium–40.

The index f_2 limits the concentration of radium–226 due to the potential internal radiation exposure to radon–222 and its decay products.

Index f_1 is used in all cases, index f_2 – only in situations when it is known that radon exhalation rate from a particular material cannot be disregarded from the radiation protection point of view.

NORM blending for disposal – Western Australia

Application of the levels:

Potential use of residues has been classified in five groups and the limiting factors are:

1. Material for buildings for human habitation. Application of the material is not restricted: $f_1 \leq 1$, $f_2 \leq 1$.
2. Decorative material (tiles, boards, etc.) for buildings for human habitation. Application of the decorative material is not restricted: $f_1 \leq 1$, $f_2 \leq 2$.
3. Decorative material (tiles, boards, etc.) for buildings for human habitation. Application of the decorative material is restricted to the external walls of a building: $f_1 \leq 3$, $f_2 \leq 5$.
4. Material is not recommended for buildings for human habitation. Application of the material is restricted to the underground parts of a building, including road and rail tunnels: $f_1 \leq 5$, $f_2 \leq 7$, and a thorough assessment of potential exposures will be required. The material can also be used as a base in road construction.
5. Material with values of $f_1 > 5$ and $f_2 > 7$ can only be used after a comprehensive dose assessment *and* a detailed environmental impact study – and only in situations where *both* the exposure of the members of the general public *and* the release of radionuclides into the environment are extremely unlikely. Examples of such situations are the construction of central parts of large bridge piers and sea shore erosion control applications (such as the construction of sea walls and/or artificial reefs – preferably in and around industrial ports).

NORM blending for disposal – Western Australia

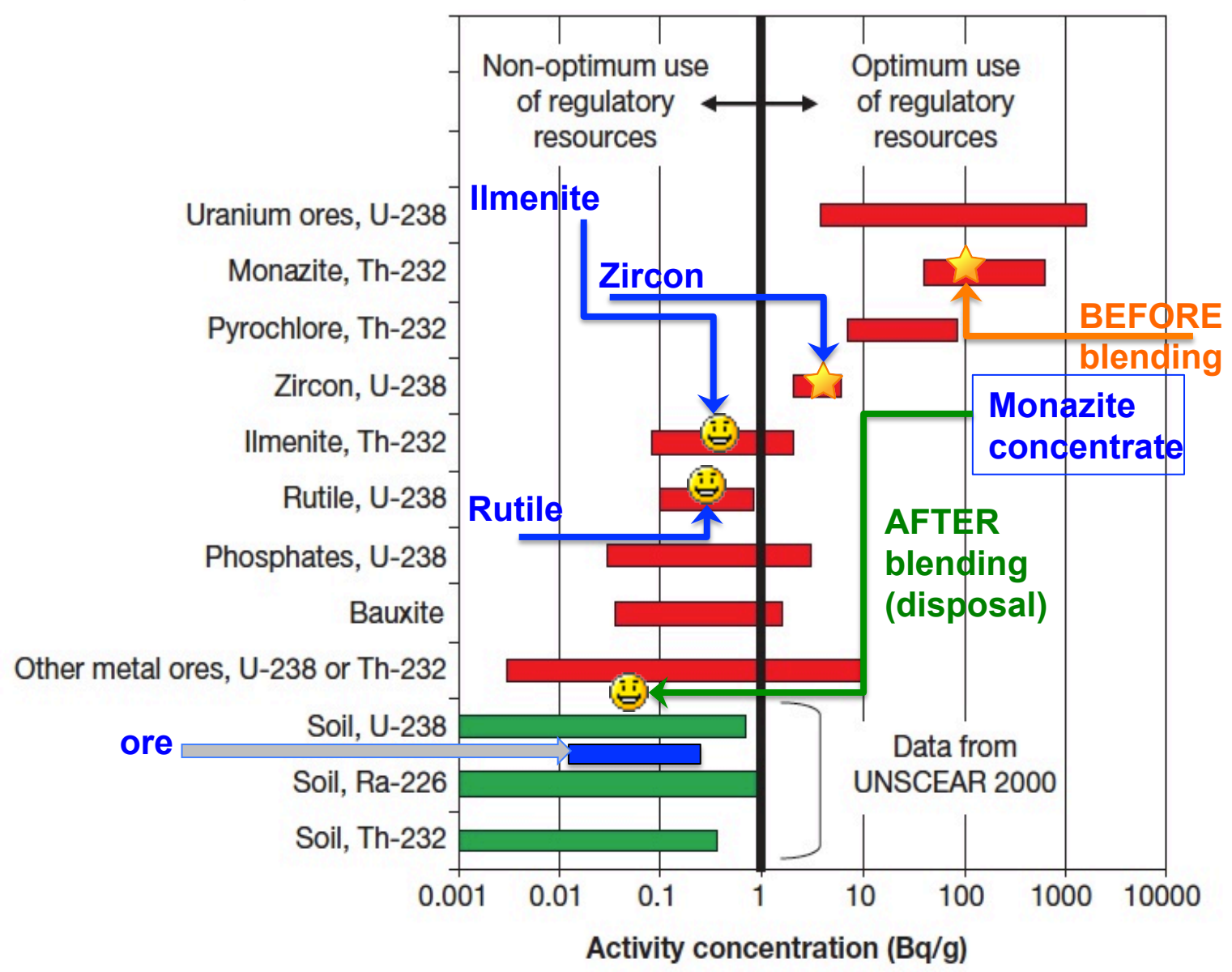
Please note that –

These indexes should be used only as screening tools for identifying of the likely use for particular materials.

Additional approvals from an appropriate authority will be required in each case, based on a separate dose assessment carried out for scenarios for the situations where the material is used in a typical expected way.

Example – blending of monazite with mine tails

The diagram from IAEA 2007 NORM-5 conference



Example – blending of monazite with mine tails

- Monazite – rare earth phosphate, typically containing ~ 7% thorium
- ^{232}Th specific activity concentration ~ 250-280 Bq/g, plus ~ 30 Bq/g of ^{238}U
- Typical dose rate at ~ 50 cm from the typical concentrate, 140-150 μSv/hour.

'Blending unit': Monazite concentrate (> 100 Bq/g) + mine tailings (< 0.05 Bq/g)

→ RESULT – final tail for disposal (0.4 – 0.7 Bq/g)

Example – blending of monazite with mine tails

Step 1 – monazite concentrate loaded into the hopper from the truck

Example – blending of monazite with mine tails

Step 2 – water added to concentrate and it is pumped to the ore processing facility

Example – blending of monazite with mine tails

Step 3 – wet concentrate is mixed with mine tailings at the ore processing facility

Example – blending of monazite with mine tails

Step 4 – final 'non-radioactive' tailings are disposed in the mined out pit

Summary

- There are different options for dealing with the NORM waste, re-use and recycle is one of them.
- It can be done in many cases and it could even be a legal requirement in some jurisdictions.
- The most important typical constraint to re-use and recycle is the volume of the NORM residues that is being generated, some millions of tones per year.