A new technical guidance on how to establish a NORM inventory

Task group 2 – IAEA Environet NORM project

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International Conference on the Management of Naturally Occurring Radioactive Material (NORM) in Industry, 19th -23th October 2020

"Guidance on how to establish a NORM inventory"

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2. General methodology flow chart — Chapter 3
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Task 2 - Guidance on how to establish a NORM inventory

Content

"Guidance on how to establish a NORM inventory"

1. **Introduction**
2. General methodology flow chart
3. Inventory information
4. Sampling and measurement strategy
5. Dedicated inventory methodology for specific industries
6. Case studies
7. Conclusions & lessons learned

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Task 2: Guidance on the Assembly of Relevant NORM Information by Member State (NORM Inventories)

Develop a guidance on the **need and process for assembling information regarding NORM management infrastructures and NORM inventories**

- Discuss **value and use** of comprehensive NORM inventories, including legacy sites

- Identify important **elements of a NORM inventory**

- Develop **step-by-step guidance**

- Identify potential sources of information and strategies for addressing **data gaps**

- Compile **lessons-learned** from Member States

Desired Outcome:

- **Development of comprehensive national-level inventories** to inform NORM policy and strategies, and **support development of effective NORM-management infrastructure**

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General methodology flow chart

Start-up phase
Consortium building & limiting scope of the study

Initially no information on NORM in the local industry

1st datamining phase
Before contacting companies

Exploring radiological & non-radiological data sources

'Sentinel goods'

2nd datamining phase
Contacting industry

Strategies for getting companies on board

Keeping the inventory up to date

Licensing & notification requirements

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Inventory information

[14 cps] [19 cps] [32 cps] [421 cps] ii i [483 cps] iii [470 cps] [22 cps] (a) 50m (b) 50m 0 cps 500

Raw materials (R) → Process → By-products / residues / wastes (B)

Additives (A) → → main Product (P)

Mass balance
(for the whole process)

$$\sum M_R + \sum M_A = \sum M_B + \sum M_P$$

Unit: kg [entering/leaving during time interval Δt]

Activity balance
(for a specific long lived radionuclide (i), assuming no radiactive decay during the considered time interval Δt)

$$\sum A_{R,i} + \sum A_{A,i} = \sum A_{B,i} + \sum A_{P,i}$$

Unit: Bq [entering/leaving during time interval Δt]

Description operating or legacy site:

- ➢ Name of the site, owner
- ➢ Location data
- ➢ Short history of the plant
- ➢ Description of specific industrial activity **(qualitative information)**
- ➢ Flow chart + mass & activity balances **(quantitative information)**

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Sampling and measurement strategy
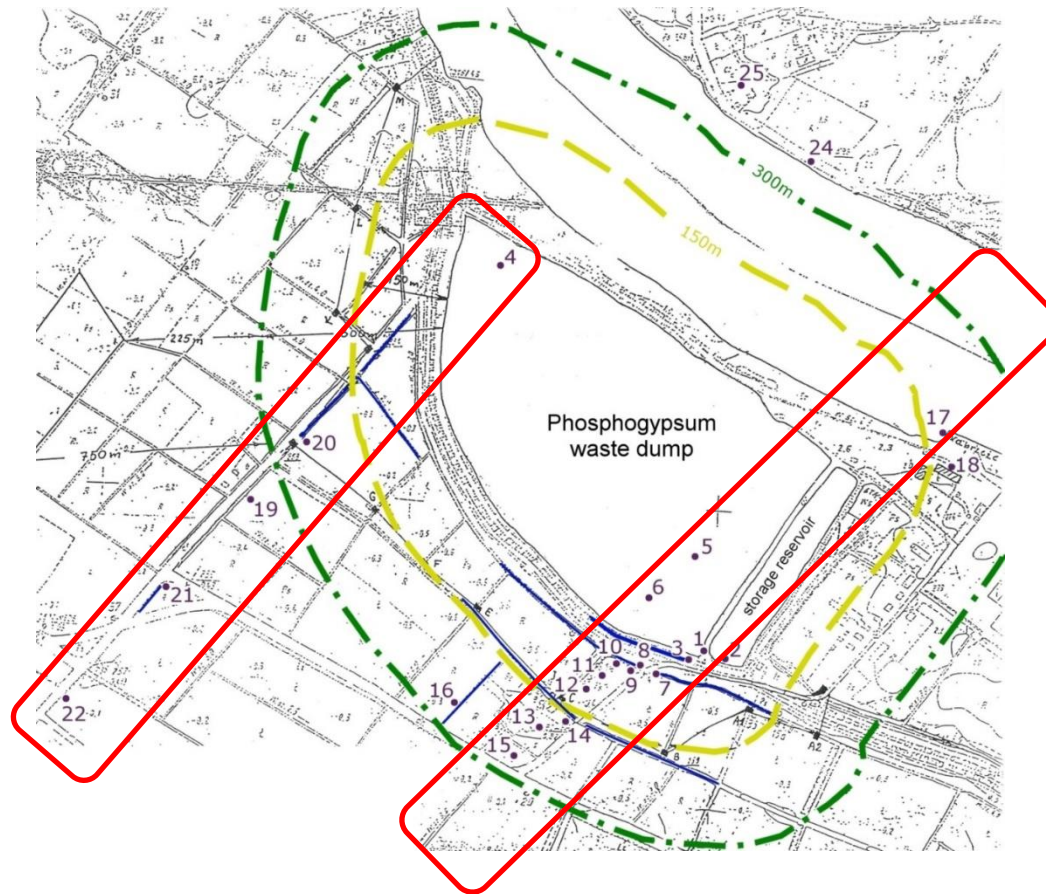
- ➤ Mainly referring to where the information can be found

- ➤ Adapted sampling plans
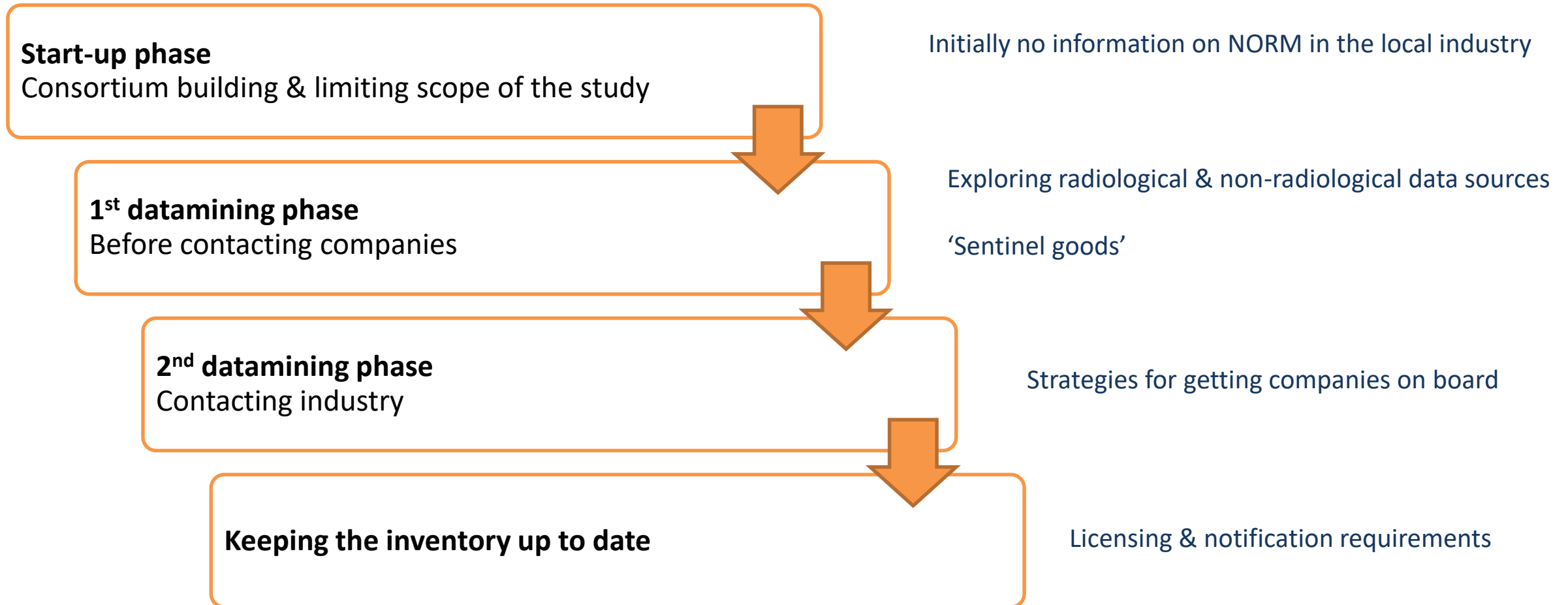
- ➤ QA for sampling and measurement procedures
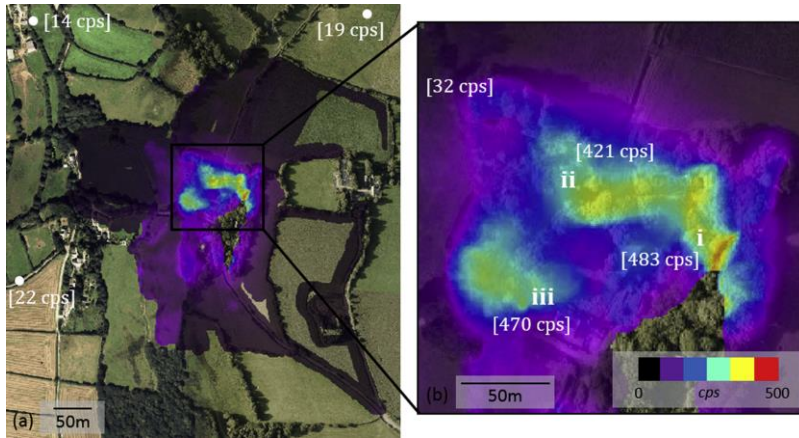
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Strategies for specific industrials sectors
NORM in oil and gas industry
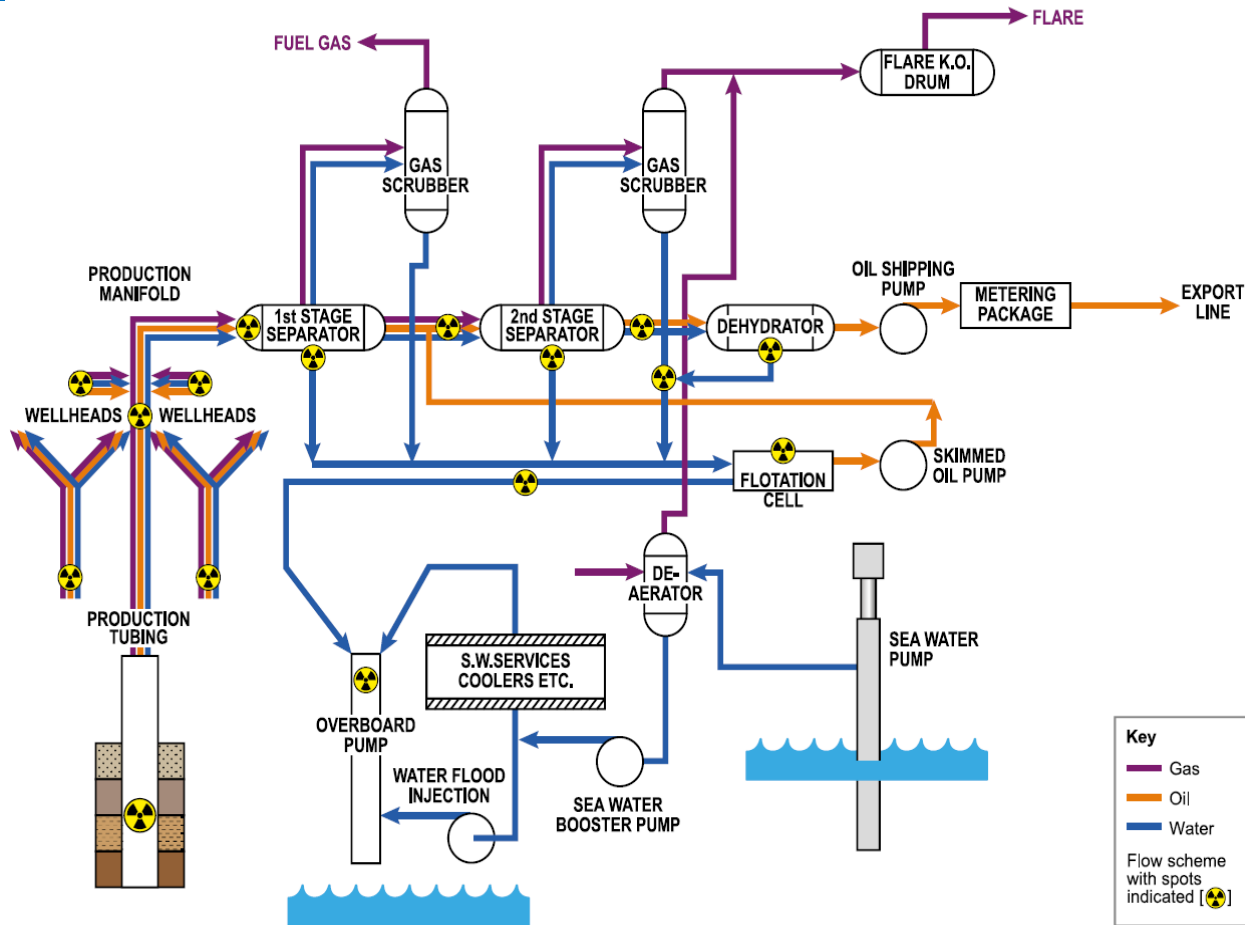
Survey to determine if/where NORM is being accumulated?

- Sampling & analysis

Useful knowledge:

- Locations where NORM (e.g. as scale or sludge) potentially can accumulate
- Historic records of NORM build up
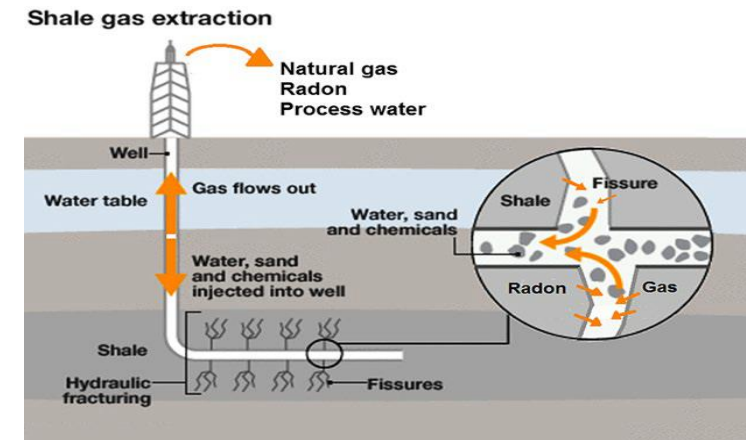
Strategies for specific industrials sectors
NORM in rare earth processing

Ore — Ore is crushed into gravel size → Crusher — Ore is crushed into gravel size → Mill — Gravel is milled into silt → Floatation Process — Mineral containing REE is extracted i.e.: Bastnaesite, Monazite, xenotime → Separation Process — REE is separated from mineral → Oxide — REE is first separated as an oxide → Metal — Oxides are turned into metals → Alloy — Metals are combined to create alloys → High tech applications — There are hundreds of high tech applications for REE. → Green energy, Hybrid electric vehicles, Water treatment, Defense, High tech

- Strategies to generate a **flowchart** for the **distribution of naturally occurring radionuclides** during rare earth processing
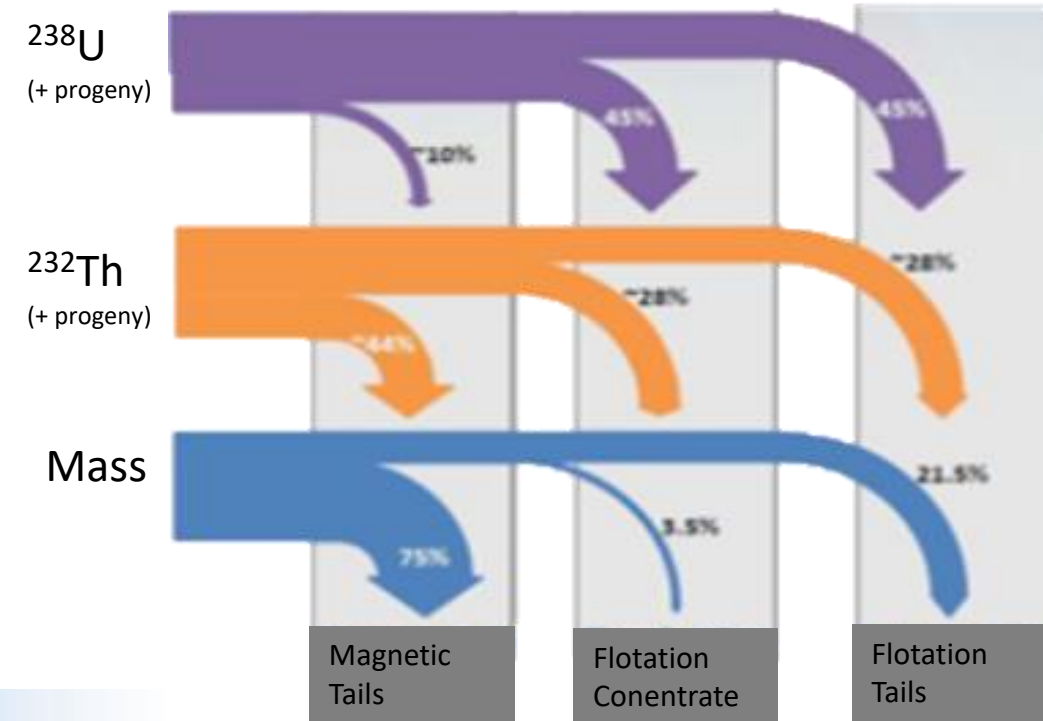
^{238}U (+ progeny)

^{232}Th (+ progeny)

Mass

Magnetic Tails | Flotation Conentrate | Flotation Tails

*China's Rare Earth Elements Industry:
What Can the West Learn? Cindy Hurst, IAGS (2010)*

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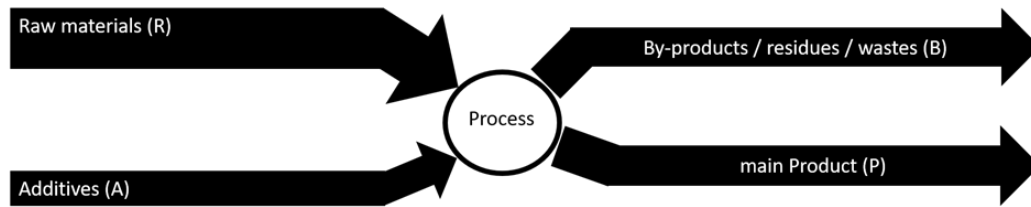7. Conclusions & lessons learned

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Case studies – Phosphate industry

Brazil

Initial stages of inventory building completed

Phosphate Rock → Sulphuric acid treatment → Gypsum → Filter

From Phosphate Rock:
^{238}U 100%
^{232}Th 100%
Ra 100%
^{210}Po 100%
^{210}Pb 100%

Sulphuric acid treatment → Purification and concentration steps → Phosphoric Acid

From Phosphoric Acid:
^{238}U 90%
^{232}Th 20%
Ra 10%
^{210}Po 22%
^{210}Pb 0%

Phosphoric Acid → Fertilizer production / Other applications

Filter → Phosphogypsum Piles:
^{238}U 10%
^{232}Th 80%
Ra 90%
^{210}Po 78%
^{210}Pb 100%

Case studies – Phosphate industry

Belgium

Detailled inventory studies that include:

- Information on the **location of cadastral parcels** that contained NORM related industries, deposit sites and contaminated sites.

Gathering information on the **legacy sites**
=labor intensive and time consuming activity.

- In the case of bankruptcy or cessation of activities
  ➔ difficult to find the right contact person.

*H. Vanmarcke, J. Paridaens, and P. Froment, "Overzicht van de NORM-problematiek in de Belgische industrie," 2003.

*J. Paridaens and H. Vanmarcke, "Radiological impact of almost a century of phosphate industry in Flanders, Belgium," *Health Phys.*, vol. 95, no. 4, pp. 413–424, 2008

*Stals M, Pellens V, Schroeyers W, Schreurs S, Hult M, Lutter G, "Actualisering van de synoptische balans van de NORM-problematiek in de Belgische industrie," 2015.

https://www.deme-group.com/news/terranova-solar-largest-solar-park-low-countries?lang=nl

Case studies – Oil and gas industry

Brazil

Industrial practices for inventory keeping

Norway

All hazardous and radioactive waste is declared using an **expanded web-based form**
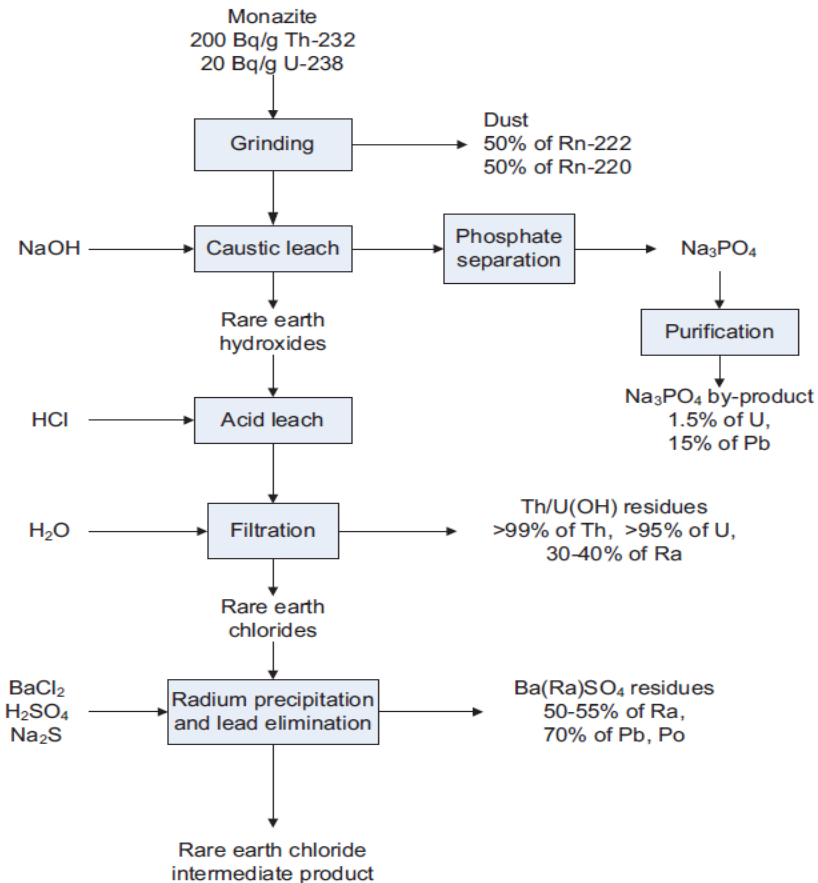
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Case studies – Rare earth processing

France

Monazite
200 Bq/g Th-232
20 Bq/g U-238

Grinding → Dust 50% of Rn-222, 50% of Rn-220

NaOH → Caustic leach → Phosphate separation → Na₃PO₄

Rare earth hydroxides

Purification → Na₃PO₄ by-product 1.5% of U, 15% of Pb

HCl → Acid leach

H₂O → Filtration → Th/U(OH) residues >99% of Th, >95% of U, 30-40% of Ra

Rare earth chlorides

BaCl₂, H₂SO₄, Na₂S → Radium precipitation and lead elimination → Ba(Ra)SO₄ residues 50-55% of Ra, 70% of Pb, Po

Rare earth chloride intermediate product

The sodium hydroxide process for treatment of monazite concentrate

Inventory building approaches used by:

- Association Robin des Bois (2004-2005)

- IRSN (Institute for radiation protection and nuclear safety) (ongoing)

	Thorium (Bq/kg)	Uranium (Bq/kg)
Hard rocks (sands)	40 - 600	< 70 - 250
Heavy ore concentrate	600 – 6,600	< 250 – 1,700
Ilmenite	400 – 4,100	< 250 – 750
Zircon	1,200 – 2,500	3,700 – 7,400
Monazite concentrate	80,000 – 450,000	12,000 – 60,000

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Case studies – Zircon & zirconia

Italy

- Most significant materials that need to be considered from Radiation protection point of view

Production step	Ceramic industry	Refractory industry
Raw material preparation	Zircon flour	Zircon sand and zircon flour
Baking process	Hydrated lime	
Fusion process		Fusion furnace dust
Scrap recovery		Scrap grinding dust
Products	Particular types of tiles	Refractory materials
Process water depuration	Sludges	Sludges

- Selection criterion: exemption – clearance level of EU and international BSS (1 kBq/kg for ^{238}U and ^{232}Th series and 10 kBq/kg for ^{40}K)

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Lessons learned

- ➢ The operators are careful regarding the release of information
  - ➢ Important challenge = **getting industry on board**
  - ➢ **Trust** = key
  - ➢ **Transparency** about what happens with the collected information
  - ➢ Inventory builder: needs **strong industrial network**
  - ➢ **Level of detail = compromise**
  - ➢ Sometimes a 'problem of **dissemination**'

- ➢ Available **information = fragmented**
- ➢ Gathering information on the **legacy sites = labor intensive and time consuming**

- ➢ Modify inventory approach for **specific industries & countries**
  - ➢ **Complex, interlinked industrial landscape**

- ➢ **Getting involved in international networks = crucial**

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Team effort: Task 2 - NORM project IAEA-Environet

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