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How to built the national-level NORM inventory?
An example developed from scratch.

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What we are talking about ?

- Radioactivity is a part of the Earth and has existed since its birth. Radioactive materials are found naturally in the Earth's crust, rocks, soil, ocean water etc.
- Not only that, but radiation is also present in our buildings, walls and floors; even our own bodies play host to certain naturally-occurring radioactive elements.
- Suffice to say that one cannot EVER be in a "radioactivity-free environment". So called **natural radiation background** is present almost everywhere …

Radioactivity in environment

Natural radiation background - usually is not considered to be harmful to humans and the environement

but .....

selective accumulation of radionuclides in some industrial processes occurs ...

causing significant contamination of human work and natural environment.

The problem is how to know where and when exposure to natural radioactivity should be considered as a source of additional risk ?

NORM vs. TENORM

(with no regard to abbreviations used by either IAEA or EPA)

- The term **NORM** should be used only when **elevated concentration of natural radionuclides**, significantly above the average background, **is the primordial property** of material of concern.
- NORM is taken into account in the radiation control **only in cases when appearing in the natural or work environment due to human activity,** otherwise they are treated as natural background component.
- **TENORM** is used towards any substance in which concentrations of natural radionuclides have been **enhanced as a result of technological processes.** It doesn't matter if the enhancement is intentional or not.
- **It's possible to create TENORM in processes where no NORM have been used as input materials!**

(TE)NORM inventory: *four tiers system of identification*

I. Inventory of natural resources
II. Inventory of ongoing mining industry (including other underground workplaces)
III. Inventory of mineral processing industry
IV. Inventory of products, products application and disposal

Tier 1: Inventory of natural resources

- list of raw materials of economic importance
- list of minerals usually associated (occurring together)
  - source of information - *national geological services*
  - characterisation of resources mineral composition - *minerals data bases* - ***radioactive minerals*** *(about 400 minerals are classified as radioactive (e.g. http://webmineral.com/determin/radioactivity.php)*
  - *Criteria:*
    - *content of uranium, thorium minerals, potassium compounds,*
    - *rare earth elements:* ^{138}La, ^{147}Sm, ^{148}Sm, ^{176}Lu, ^{142}Ce, ^{144}Nd, ^{152}Gd,
    - *others:* ^{174}Hf, ^{187}Re, ^{190}Pt, ^{192}Pt, ^{209}Bi, ^{113}Cd, ^{115}In, ^{128}Te, ^{130}Te.
  - *Existing (available) data about radionuclides activity concentration*

is there a radioactive mineral (NORM) ? - not - go to the next tier…

Tier 2: Ongoing mining industry inventory

The radiological hazards related to enhanced natural ionizing radiation may depend on:

- type of *mined raw material*,
- **local hydro-geological conditions,**
- **method of raw materials (ores)/fossil fuels mining**
- **applied ventilation system.**

Sources of exposure:

- radon and radon progeny
- by products released due to mining activity (water and sediments)

Tier 2: Ongoing mining industry inventory

- Source of information: national register
- Material excavated /residues → mineral data base , national waste catalogue
- **Excavation process applied:**
  - open pit,
  - borehole,
  - underground mining.
- **Similar activities not usually considered as mining:**
  - ground water use (geothermal energy, spas, water treatment plants),
  - caves, especially these ones adapted for tourism purposes where regular staff is involved as guides or for facility maintenance,
  - underground museums.

Open pit mining

In the case of open pit mining, the radiological hazards are mainly related to **the type of deposit**, and the exposure of workers will increase with the increase in the concentration of natural radionuclides in the mined material.

Sources of exposure: external gamma radiation and intake of radionuclides by inhalation and accidental ingestion.

Borehole mining

In the case of borehole mining (mainly related to oil and gas extraction) internal surfaces of the installation used and pipelines are often covered with a layer of sediments containing significantly increased concentrations of radium isotopes and Pb-210 and Po-210. The sediments are created from **radionuclides present in formation water** that usually coexists with fossil fuels.

Sources of exposure: external gamma radiation and intake of radionuclides by inhalation and inccidental ingestion when contacting with scales and sediments

Underground mining

„Bogdanka" colliery: longwall shearer

In the case of underground mining, confined space, poor ventilation and enhanced radon exhalation from crushed rocks may lead to a significant increase in the concentration of **radon decay products in the air,** even if the concentration of parent radionuclides in the surrounding rocks is not so high to be classified as NORM. An additional factor increasing the miners' exposure can be **formation waters enriched with natural radionuclides**, which flow into mining excavations

Sources of exposure: external gamma radiation, intake of radionuclides by inhalation and accidental ingestion, Potential Alpha Energy Concentration (PAEC)

Tier 3: Mineral processing industry

- **Industries processing NORM**
  - Inventory of raw materials, ore concentrates, minerals, fossil fuels imported → *trade/custom national register*
  - Characterisation of input materials processed → *minerals's data base, IAEA/EU positive list*

- **Mass reduction processes (→ TENORM):**
  - fractionation
  - inorganic chemistry
  - smelting
  - combustion

No mineral processing industry? go to the next tier

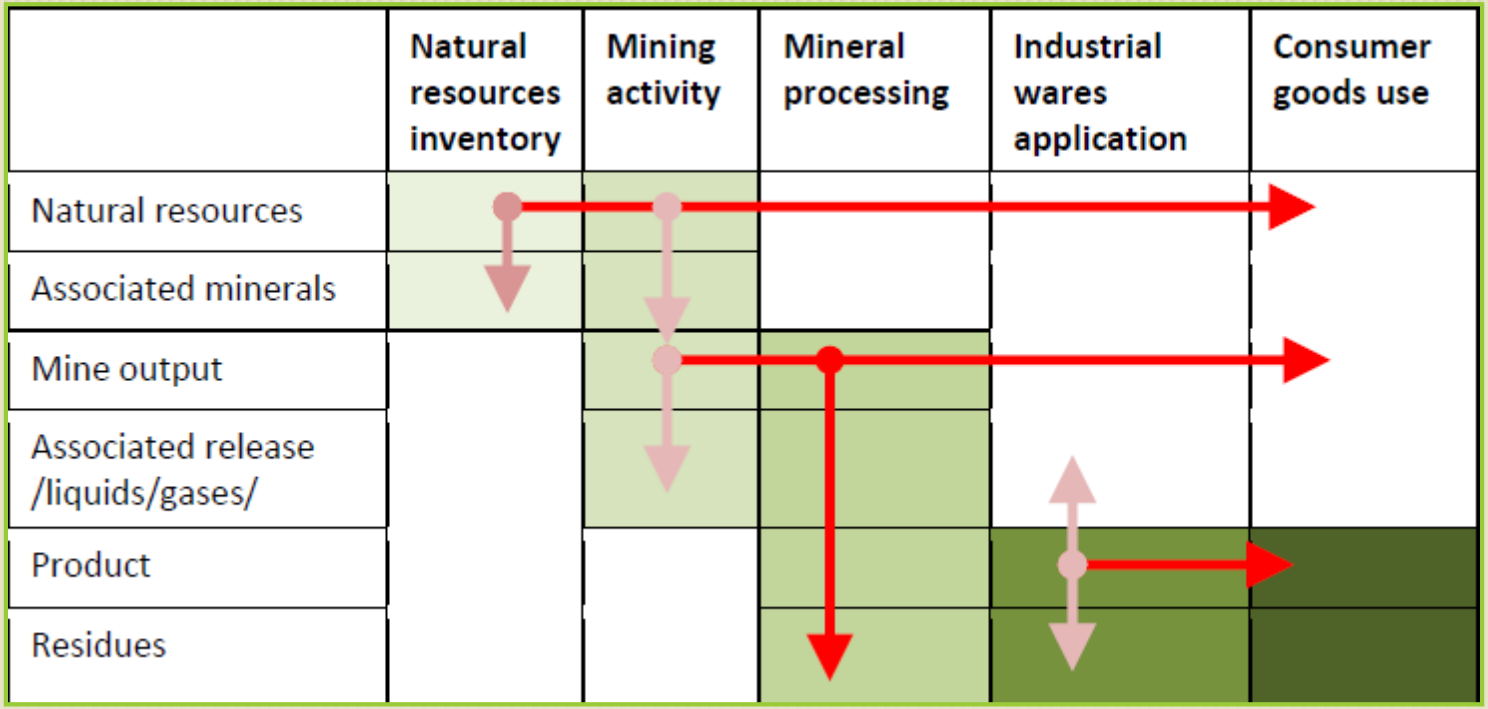
Tier 4: Product application and utilisation

- Household items (very rare)
- **Industrial materials and tools** (welding rods, refractories, abrasive materials, ceramics, glaze)
- Construction and building materials (tiles, natural rocks, products with waste origin)

Energy Scalar Technology Pendant

Source of information: **mineral origin** (conection with mineral processing industry), chemical composition, IAEA/EC positive list

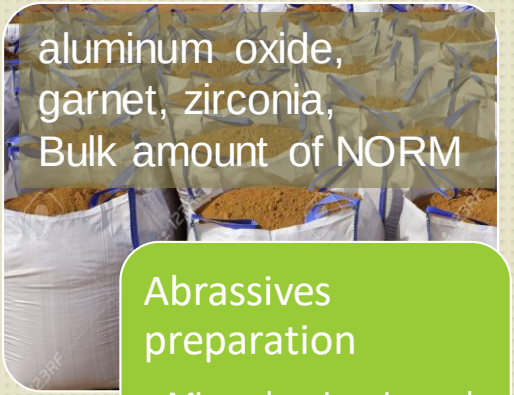
NORM inventory matrix



Release from industry …

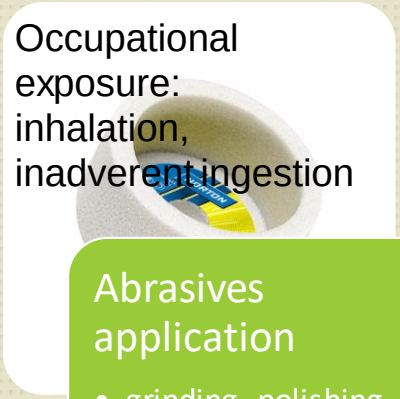
Primary process (determined by industry)	*result*	**Secondary process** (determined by receiving environmental compartment)	*result*	**Subsequent processes** (independent from industry)
Gaseous emission +PM	Dilution in air	Deposition (wet/dry)	Accumulation on soil surface	erosion leaching resuspension adsorption /desoprtion scouring bioturbation bioirrigation farming ….
Effluents / waste water /process water	Dilution in water	Deposition (precipitation / sedimentation)	Accumulation in bottoms	
Landfill	Accumulation at landfill site	Leaching / seepage / surface runoff	Dilution in neighborhoods	

LCA of abrasives in bearings manufacturing



Abrassives preparation

- Minerals minnnig and processing
- Final product storage & transport



Abrasives application

- grinding, polishing, furbishing

Waste

- Used abrrasive mixed with cooling/carrying liquids collection, sludge processing and dispoasal

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Thank you..