Critical raw materials:

European perspectives and solutions including environmental impact

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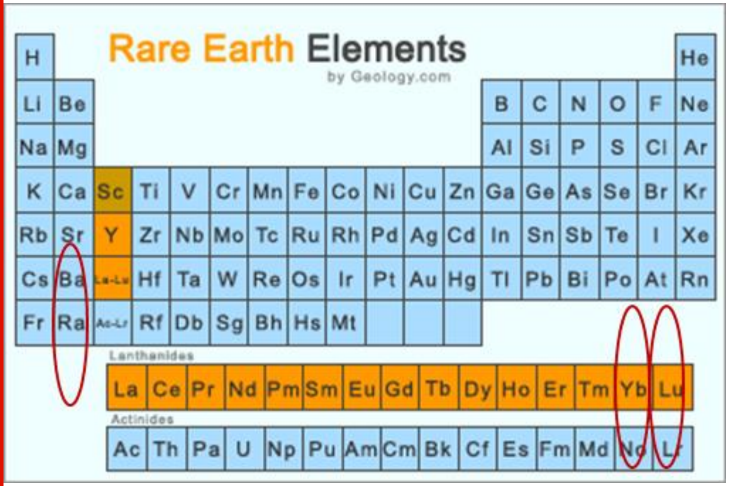
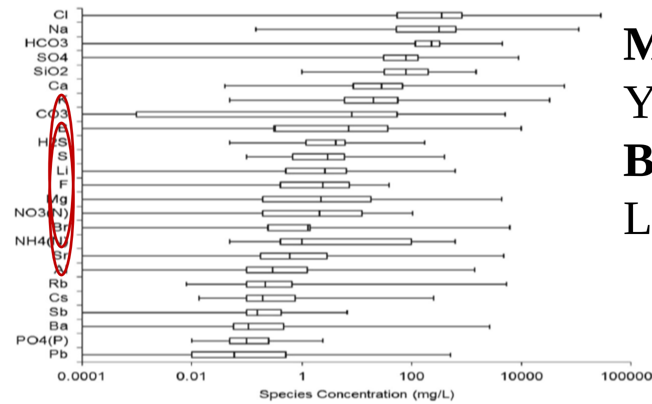
Introduction

- What are CRM's and why are they important
- Policy aspects
- (potential) Sources
- Extraction technologies
- CRM and environment

REE's and critical raw materials





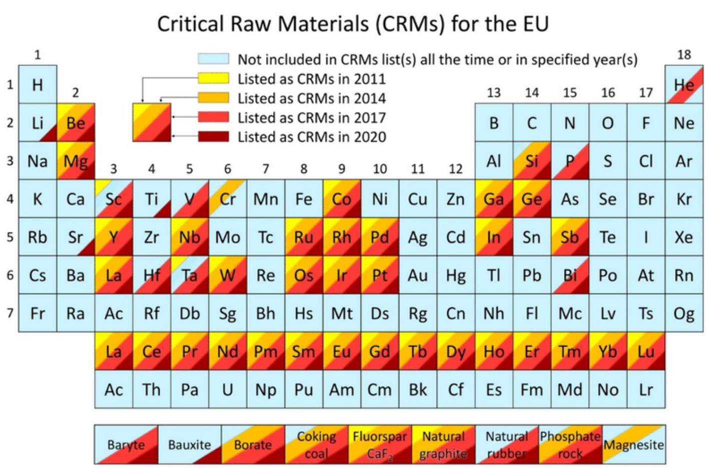
Medical

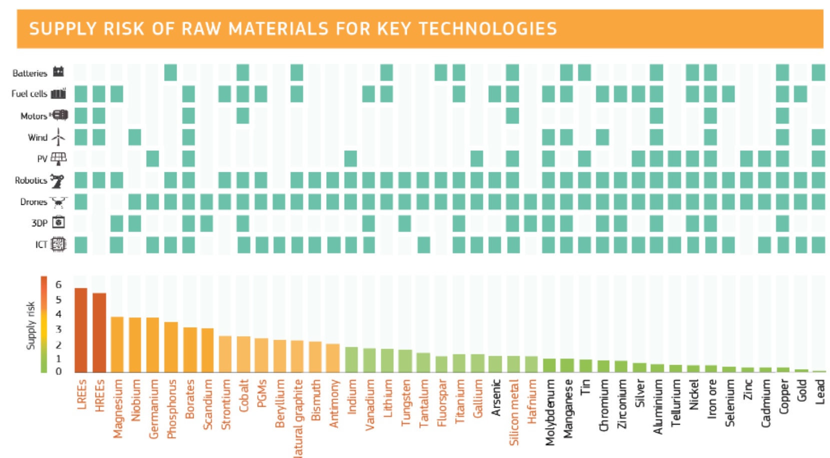
Yb, Lu, Ra

Battery Alliance

Li, Co, Ni, Nd

Geothermie water





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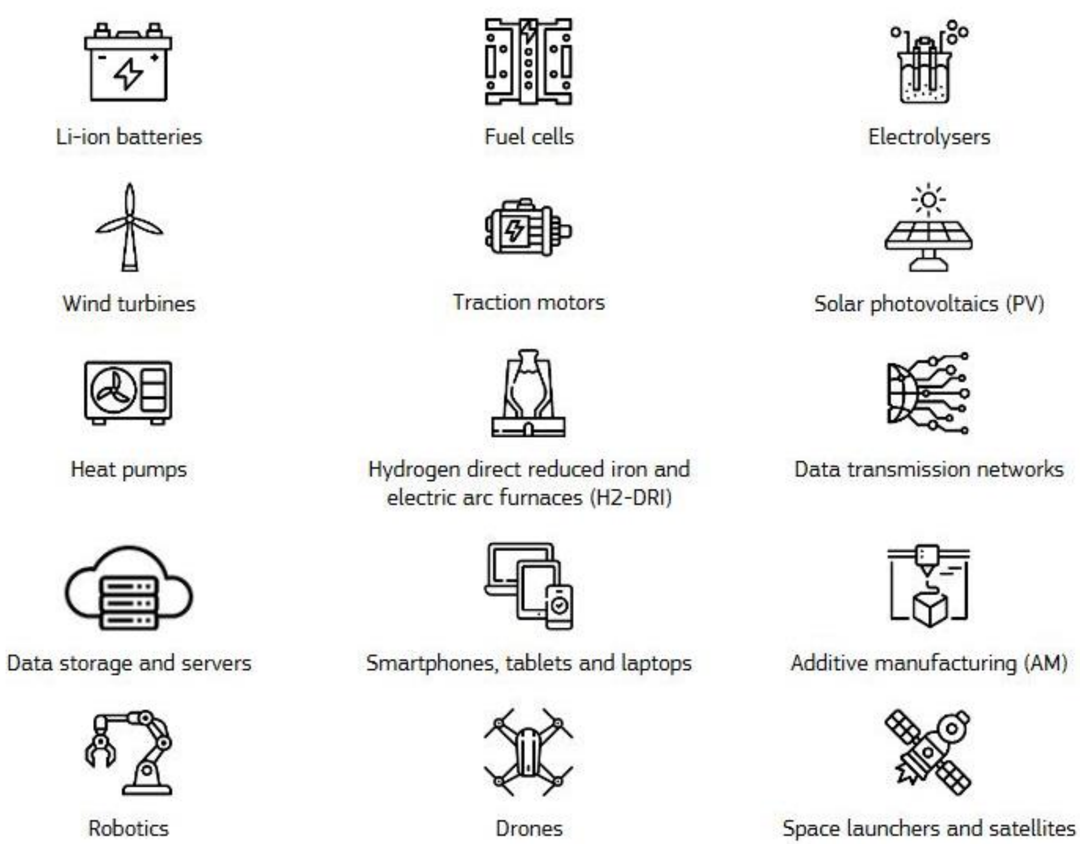
Applications



Source: JRC elaboration based on flaticon.com

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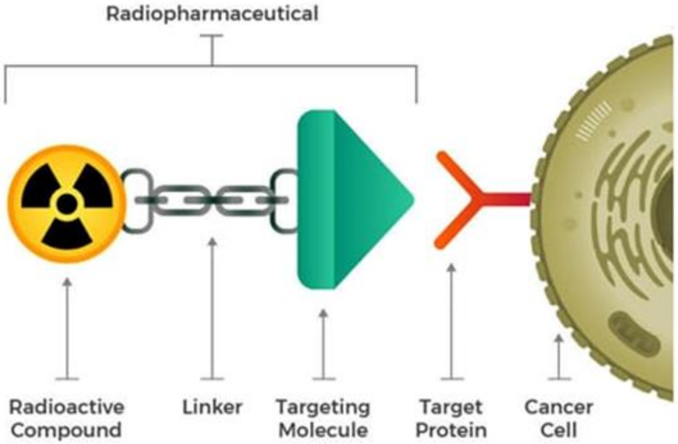
Targeted alpha theraphy

With the help of alpha radiation, it is possible to irradiate tumors selectively while sparing healthy tissues.

Alpha-emitters

Alpha particles have a high energy in the range of 5-9 MeV and at the same time a very short path length in human tissue below 0.1 mm, corresponding to less than 10 cell diameters. Alpha emitters allows for specific targeting of individual malignant cells, while minimizing the toxicity to surrounding healthy tissue



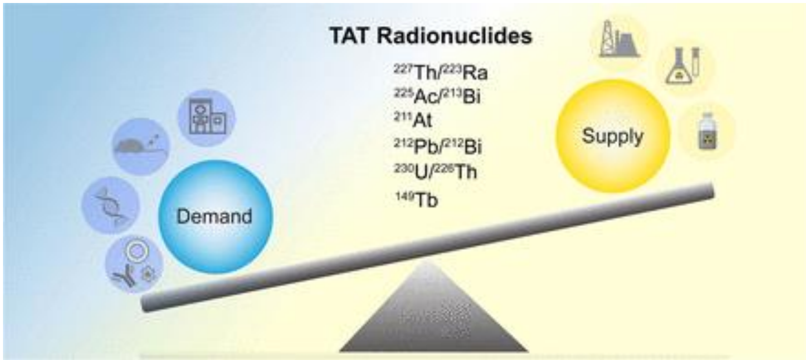
Targeted Alpha Therapy (TAT)

Effective cancer therapy by linking an alpha-emitter to a molecule that binds specifically to cancer cells. This so-called “targeting molecule” transports the alpha-emitter to the right location, preventing damage at other locations.

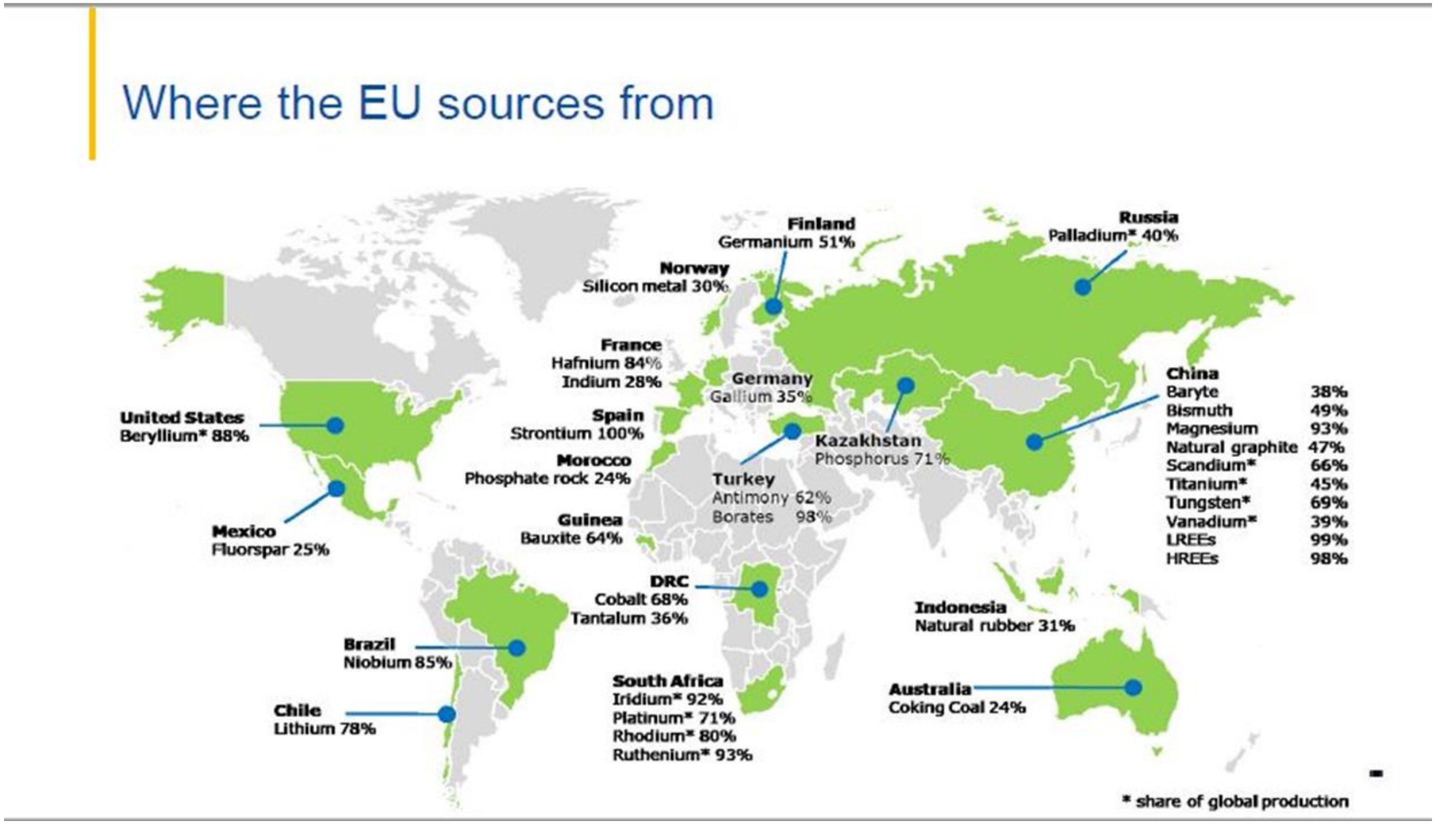
Sustainable radium sourcing

Developing a sustainable source of Ra-226 is one of the challenges to ensure long term supply of TAT isotopes**.**

- TAT radionuclides include Ac-225, Bi-213, At-211, Pb-212, Ra-223, Th-227
- One of the main challenges limiting the wide application of TAT is the production and supply of suitable these radionuclides.
- Ra-226 is a key raw material in the production of TAT radionuclides
- At present most radium originates from legacy sources available at universities and institutes. A sustainable solution is needed.

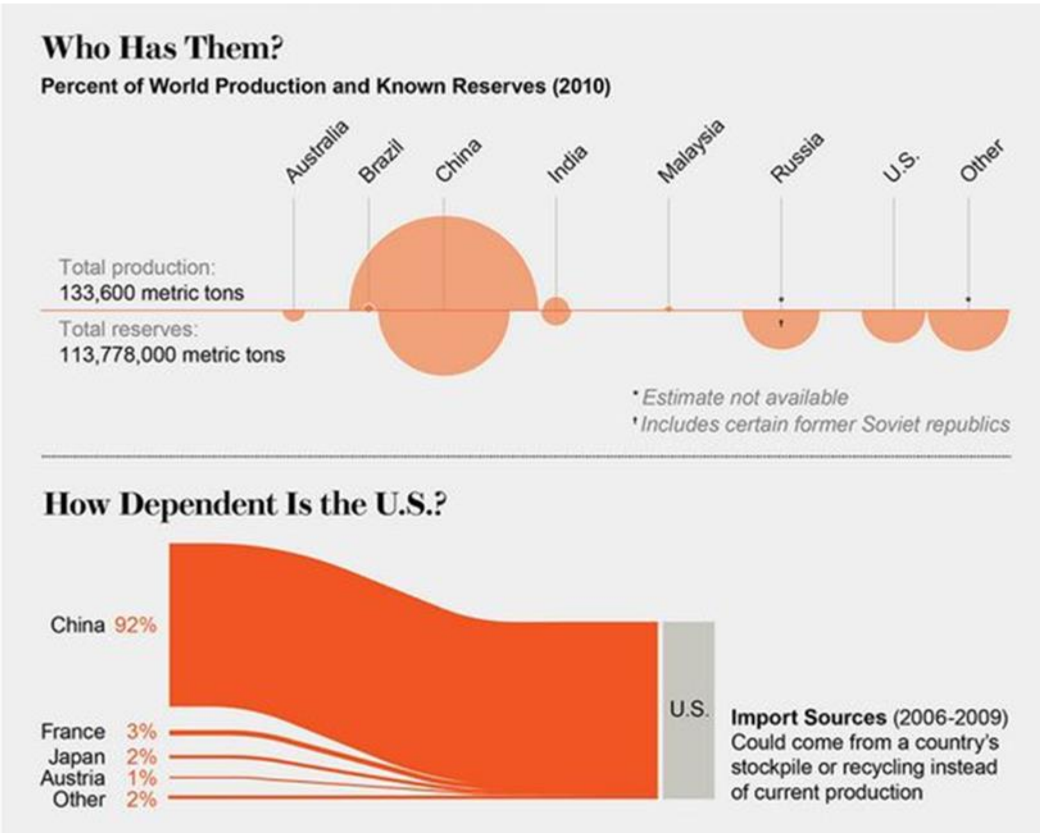


Current situation



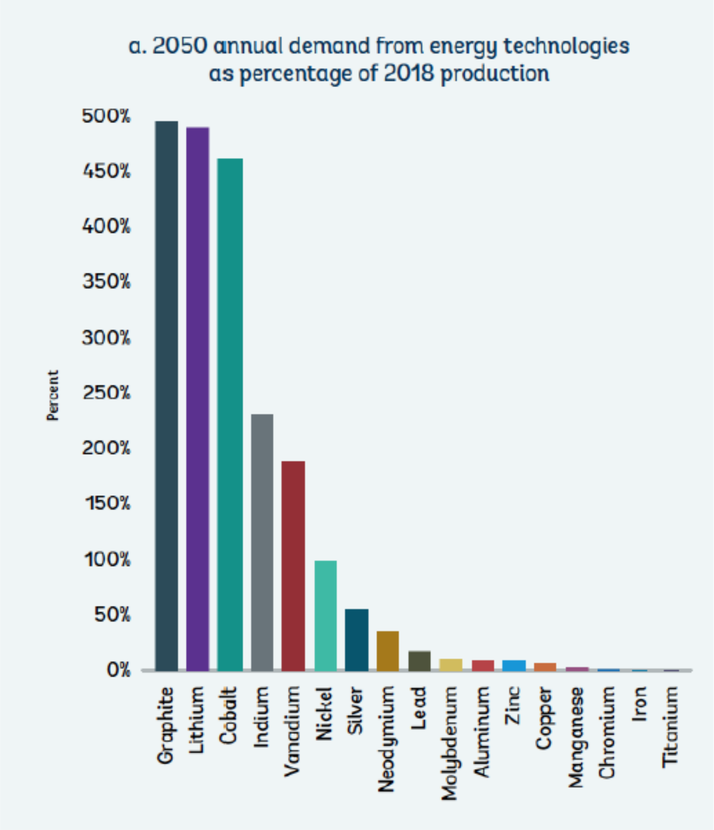
Source: EC EIP on raw materials/ Raw materials Scoreboard)

Previous (?) situation USA



Originally produced for the October 2011 issue of *Scientific American*. Credit: Jen Christiansen. Source: Mineral Commodity Summaries 2011. *U.S. Department of the Interior* and *USGS*

Increase annual demand



Source:Geologists, Inc. Munk et al. (2016) Chapter 14: Lithium brines: A global perspective, Reviews in Economic Geology

EU policy on critical minerals

2008: Raw Materials Initiative adopted by EC

- 3 pillars:

i) Fair & sustainable supply of raw materials from global markets

ii) Sustainable supply of raw materials within EU

iii) Resource efficiency & **supply of secondary raw materials through recycling**

2015: Circular Economy Action Plan (COM/2015/614)

2020: Action plan on critical raw materials

2023: Proposal of European Critical Raw Material Act

Recovery from landfills and mining waste ?

JRC report:

- ➢ Landfill mining ☹
  - ▪ No good example of successful landfill raw material extraction activity
  - ▪ Poor likelihood of finding significant quantities of CRM in landfills
- ➢ Recovery from mining waste ☺
  - ▪ historic extractive wastes = potential resource for critical metals
  - ▪ Recovery should not focus on a specific material alone
  - ▪ Energy demand required for material separation = main challenge for full recovery of critical metals


European Commission

JRC SCIENCE FOR POLICY REPORT

Recovery of critical and other raw materials from mining waste and landfills

State of play on existing practices

Blengini, G.A.; Mathieux, F.; Mancini, L.; Nyberg, M.; Viegas, H.M. (Editors)

2019

Joint Research Centre

EUR 29744 EN

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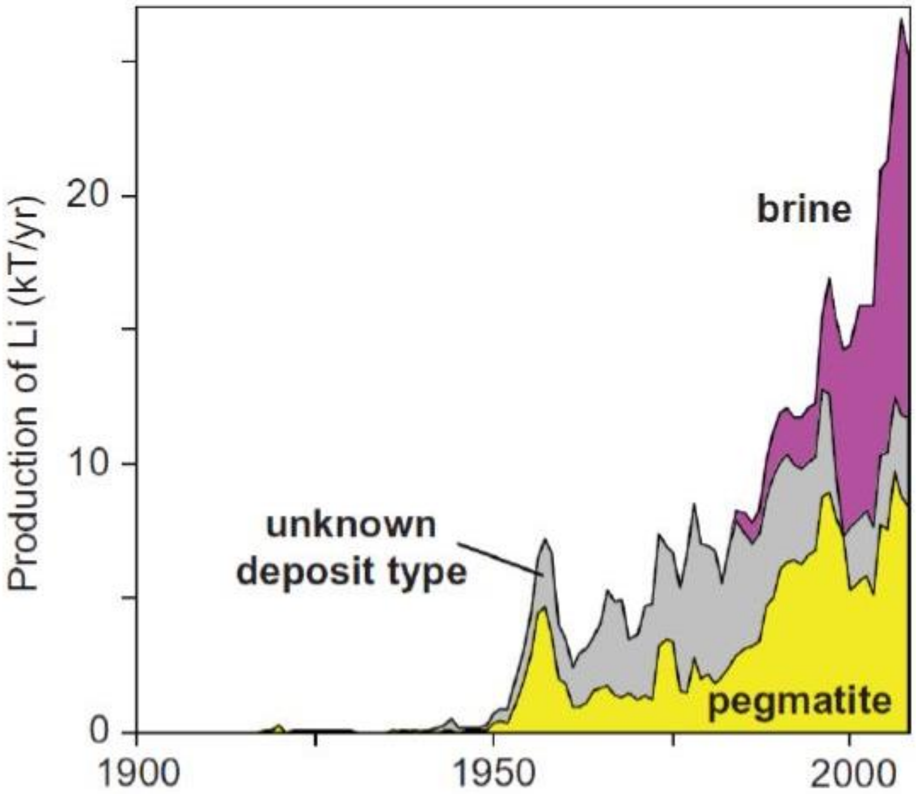
Li production



Source:Geologists, Inc. Munk et al. (2016) Chapter 14: Lithium brines: A global perspective, Reviews in Economic Geology

Concentration of CRM in Oil&Gas production water

ENA European NORM Association

Element	Concentration (mg/l)
Barium	ND -1740
Beryllium	ND – 0.004
Chromium	ND – 3,71
Cobalt	N.D. 0.01
Lithium	N.D. - 235
Manganese	N.D. -175
Molybdeen	N.D. – 0.448
Nickel	N.D – 9.2
Selenium	N.D. – 1,27
Silver	N.D. - 7
Vanadium	N.D. – 0.29
Zink	0.01 - 35

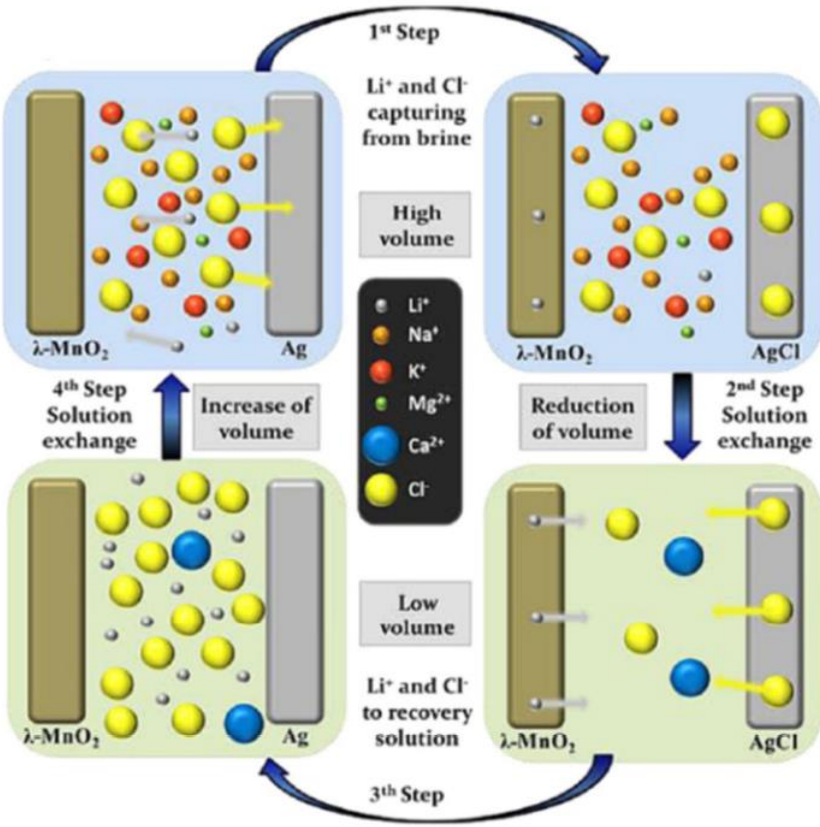
Source: Guerra K., Dahm K., Dumdorf S.; "Oil and Gas produced water management and beneficial use in the Western United States", US Department od the Interior (2011)

Available extraction technologies

In developement (partially based on existing technologies):

- Micro filtration (nano-membranes)
- Electro chemical
- Specific adsorption (Li with modified mineral matrix such as zeolites)
- Biological (absorption by micro organisms…. e.g. diatoms)

Electro chemical



Source: A review on lithium recovery using electrochemical capturing systems Sifani Zavahir

Diatoms

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End-of-Waste criteria

EU Waste Framework Directive (2008/98/EC)

Art. 6 : “**<u>End-of-waste” criteria</u> => specify when a waste become a secundary raw materials**

⇒ “The criteria shall include **limit values for pollutants** where necessary and shall take into account any possible adverse environmental effects of the substance or object”

⇒ **«end-of-waste » certificate delivered by national or regional waste authority upon application by waste producer**

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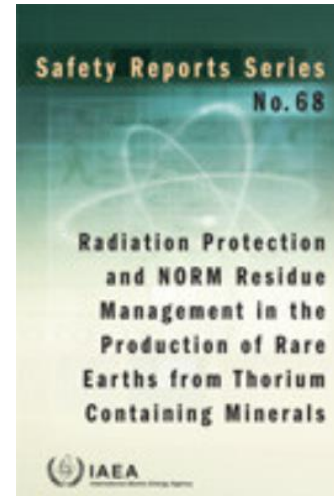
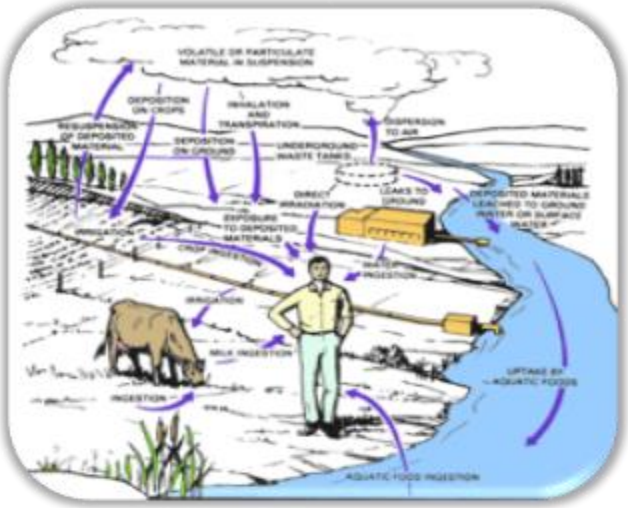
CRM & NORM

- IAEA Safety Report 68 “Radiation Protection and NORM residue management in the production of RE from Thorium Containing Minerals”
  - Activity concentration Th-232 in RE tailings (China, Australia): **1.7 – 2.2 Bq/g**
  - Activity concentration in RE-rich tin mining residues (Indonesia, Malaysia,…): up to **200 - 370 Bq/g** Th-232
  - Ra-226 activity concentration in brines from oil & gas industry: up to **1200 Bq/litre** (see e.g. IOGP report “Managing NORM in oil & gas industry)



Environmental impact

- Workers and members of the public might be exposed to radiation from NORM containing waste streams.
- Exposures include: γ-radiation, inhalation of resuspended dust and ingestion
- Some indirect pathways include e.g. consumption of crops through irrigation and dust deposition



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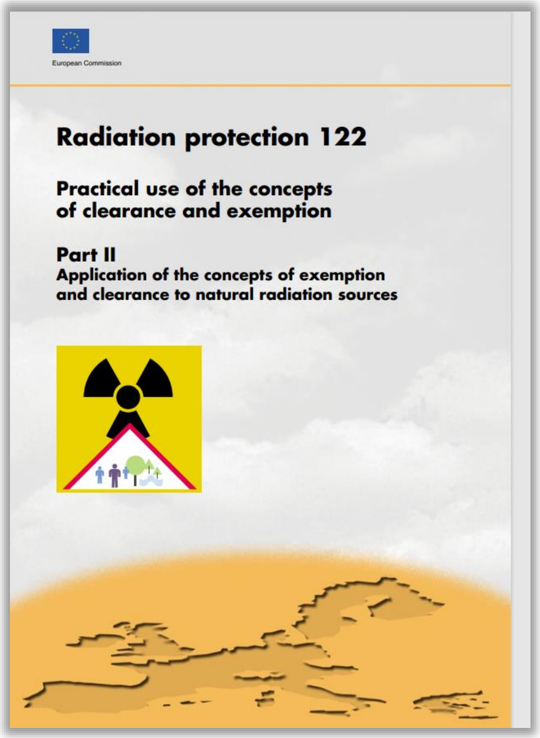
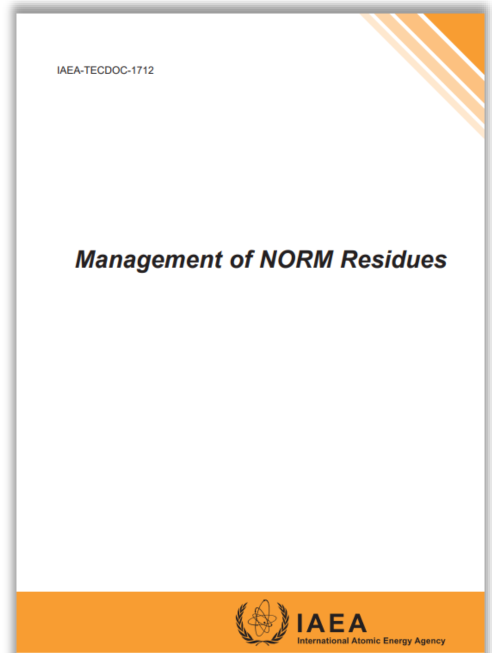
Protection of workers and public

- Protection of workers and public through compliance with regulatory requirements on the use of NORM
- Implementation of EC and IAEA guidelines on NORM handling.





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Conclusions

- CRM's are increasingly important for the energy transition as well as an important aspect of the circular economy
- CRM's can be found in a wide spread of sources amongst which (industrial) waste materials
- There is a need for the development of separation techniques to obtain CRM's from these wastes
- As well as there are many initiatives using all kinds of technologies to development these techniques
- In many cases NORM is involved and should be addressed together with the other environmental aspects.