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The rather unknown case of Technology Critical Elements (TCEs) In surface waters

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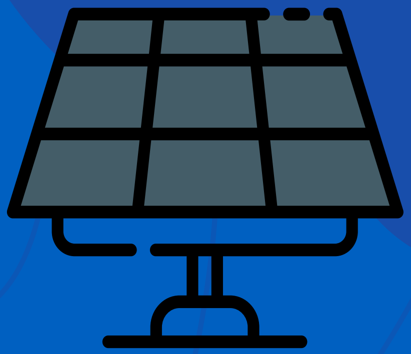
Introduction

2 Studies on same topic:

- Research by students of Utrecht University on the transfer routes of TCEs
- Research by students of University Siegen on the monitoring of TCEs

Both: literature-based report from 2022;
Cooperation with Deltares (Petra Krystek) and Rijkswaterstaat (Rob Berbee)

TCEs ... What are they?



- Technology critical elements
- Around 40 elements, including REEs and platinum group elements
- Modern technology; e.g., solar panels, mobile phones
- Critical because:
  - Few suppliers
  - Shortage could lead to large economic impacts

UU Research:
Transfer routes high-risk TCEs

- Socio-economic context
- Regulatory context
- High-risk TCEs
- Transfer to surface water

Socio-economic + regulatory context

Thresholds for 15 TCEs
3 substances of very high concern (ZZS stoffen): cobalt, beryllium, tellurium

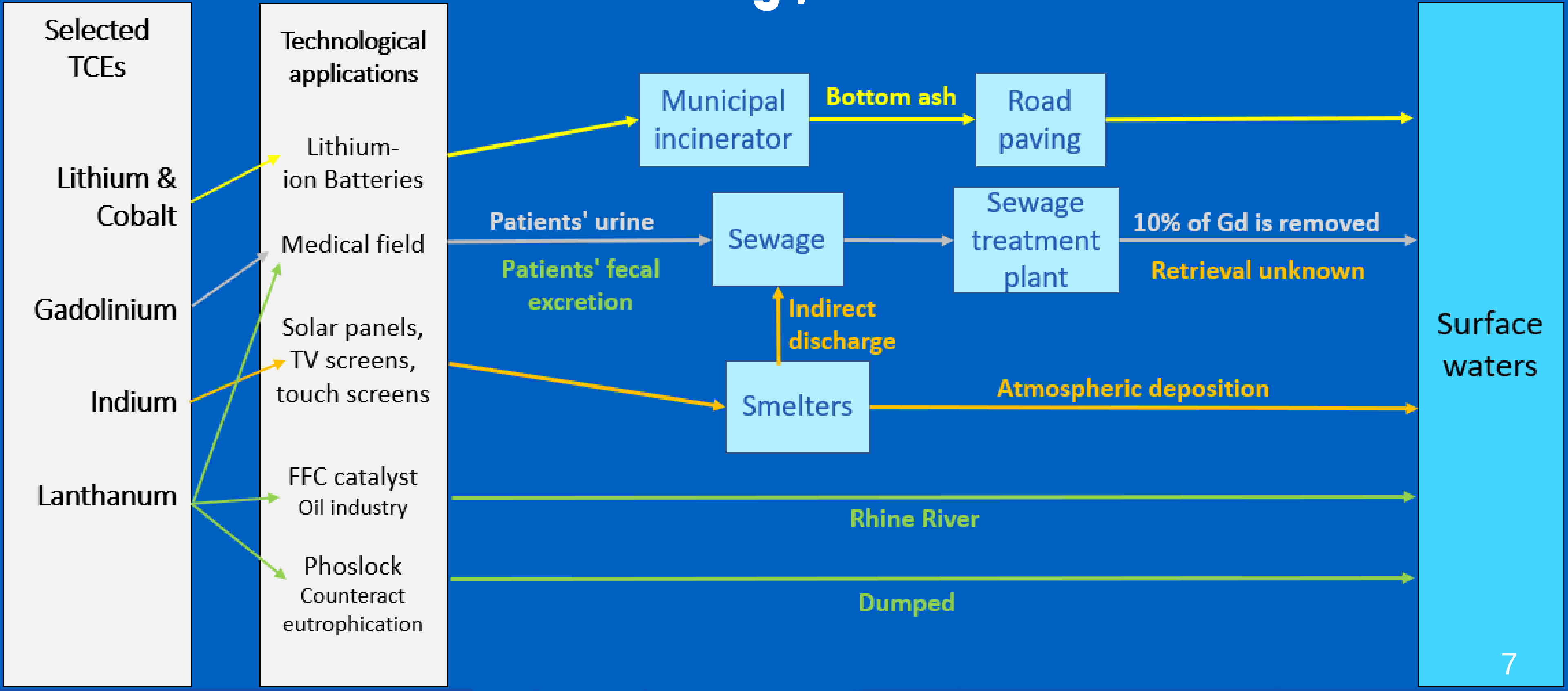
High-risk TCEs

TCE	Explanation
Lithium (Li)	High concentration in Rhine + high anthropogenic input[1]
Cobalt (Co)	Considerably high concentration in Rhine + toxic in aquatic environment[1,2]
Gadolinium (Gd)	Rapid increase of concentrations in Rhine[1,3]
Indium (In)	Significant anthropogenic input in Rhine + high concentration in sediment[3]
Lanthanum (La)	Significant anthropogenic input in Rhine + high concentration in sediment[3]

[1] De Jonge, J.A. et al., *Jaarrapport 2021 de Rijn* (2022)
[2] ECHA, *Search for chemicals* (n.d.)
[3] Klein, O., et al. *Science of The Total Environment* (2022)

Transfer routes

From e.g., the Rhine



Conclusion

- TCE consumption strongly related to energy transition
- Different routes to water bodies, probably only a small part of the whole picture
- Extending knowledge on toxicity and presence in Dutch surface waters will be useful to determine risks

Uni. Siegen research:

Six rather unknown TCEs

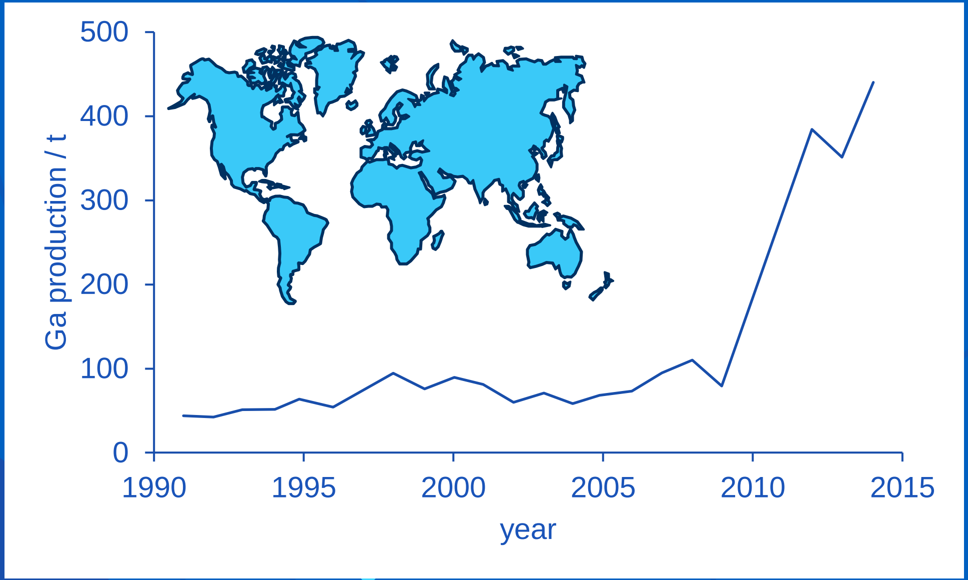
In the River Rhine and entering the Netherlands

Less studied TCEs

TCE		Where are they mainly used?
Niobium	41 Nb	High strength low alloy steel (cars, pipelines, bridges, etc.)[1,2]
Tantalum	73 Ta	Powder in capacitors, and in metal products[1]
Gallium	31 Ga	Integrated circuits, optoelectronic devices and solar cells[1]
Indium	49 In	Flat panel displays, solders and photovoltaics[1,3]
Germanium	32 Ge	Fiber optics systems, infrared optics[1]
Tellurium	52 Te	Solar cells and theroelectric devices[1]

[1] Filella, M., et al. *Chemosphere* (2017)
[2] https://www.edisongroup.com/edison-explains/ferroniobium-and-hsla-steel/ (accessed 22/11/2022)
[3] Brun, N.R., et al. *Science of The Total Environment* (2016)

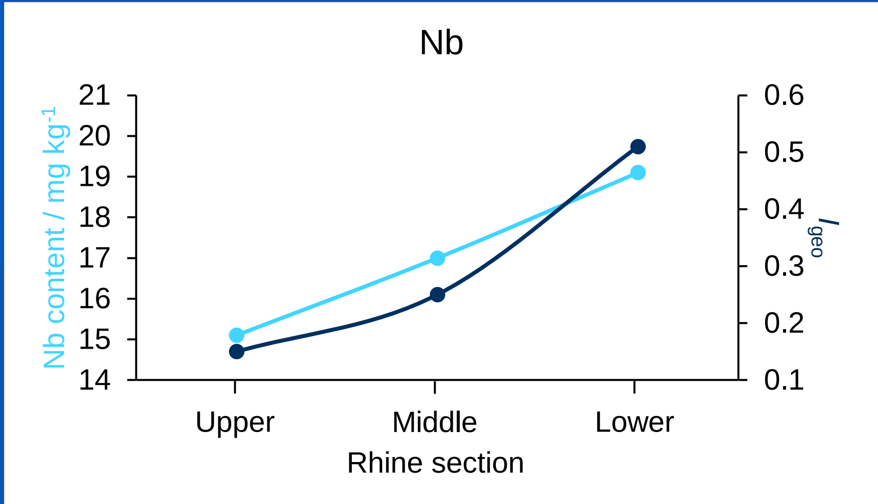
Worldwide increase of production, without equally increasing monitoring!



Example: Worldwide gallium production
Graphic adjusted from: Filella, M., et al. *Chemosphere* (2017)

Geoaccumulation along the river Rhine

$$I_{geo} = \log_2\left(\frac{X_i}{1.5\ X_1}\right)$$



Example: Content (mg/kg) of Nb in Rhine sediments and its geoaccumulation.

Map of German part of Rhine and definition of the different sampling sites

Klein, O., et al. *Science of The Total Environment* (2022)

Geoaccumulation along the Rhine

$$I_{geo} = \log_2\left(\frac{X_i}{1.5\,X_1}\right)$$

Element	Increase along the Rhine	Rhine section
Niobium (Nb)	++	Whole river
Tantalum (Ta)	-	-
Gallium (Ga)	+	Upper – middle
Indium (In)	+	Upper – middle
Germanium (Ge)	++	Whole river
Tellurium (Te)	+	Middle – lower

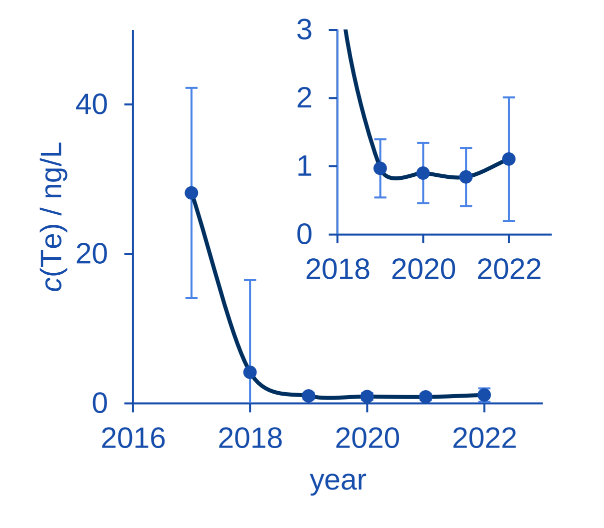
- No increase, + increase, ++ strong increase

Map of German part of Rhine and definition of the different sampling sites.

Klein, O., et al. *Science of The Total Environment* (2022)

Passing Lobith and entering the Netherlands

- Only 3 of 6 LSTCEs are monitored (Ga, Nb and Te)
- Problem of possible interferences in the measurement
- Ga and Nb are mostly present attached to suspended solids, while Te is mostly dissolved in water
- Over the last 5 years, the concentration of all three elements decreased



Mean concentrations of Tellurium dissolved in water from 2017 to 2022 (September), filtered (0.45µm).

Data measured by Rijkswaterstaat at Lobith

Conclusion

Sediment data

- Nb and Ge showed highest geoaccumulation index → should be observed carefully
- Geoaccumulation of Ga, In and Te also increased
- No accumulation seen for Ta

→ Main focus should lie in **sediment** analysis

Water data

- No significant increase over the past five years

THANKS!

DO YOU HAVE ANY QUESTIONS?