German Environment Agency

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Environmental Criticality of Raw Materials

Some facts & findings for policy-makers

1 What is Environmental Criticality?

Mining and processing of minerals and metals often have far reaching consequences for local and regional environments, including the people living in and close to mining areas.

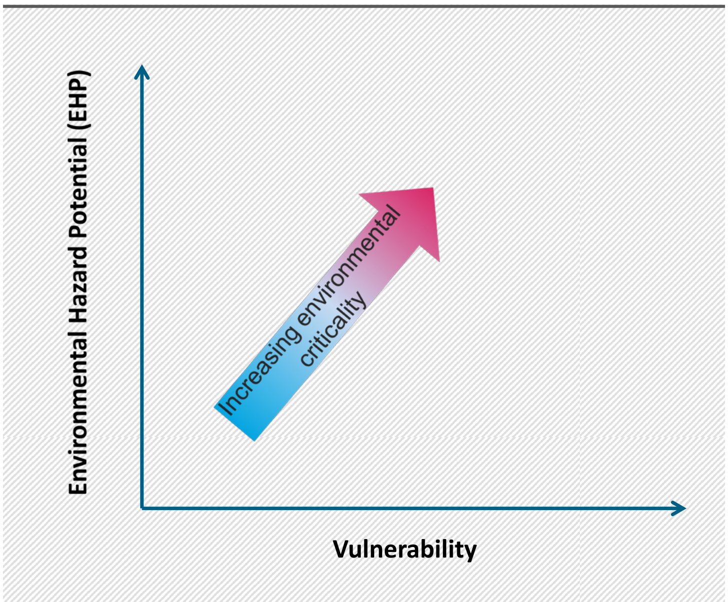
As most minerals and metals are globally traded commodities, many of our industries and products are – via its supply chains – connected to mining activities in diverse world regions.

Environmental Criticality is a concept that brings together two dimensions:

- The Environmental Hazard Potential of Raw Materials (mining and processing phase)
- The dependency of products, industries and economies on individual raw materials (importance, substitutability, ability to innovate, susceptibility).

In conventional criticality analyses, the second dimension is also referred to as "economic importance" or "vulnerability to supply restriction" and is mapped against a "supply risk" dimension. In environmental criticality this dimension could be referred to as "vulnerability to reputation damage" or "vulnerability to future supply restriction".

Figure 1: 2-dimension concept of environmental criticality



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Raw Materials which are essential for a certain product sector or economy and which are – at the same time – associated with a high environmental hazard potential in their mining and processing phase, are considered to have a high environmental criticality (see Figure 1).

1 Why is it relevant for Policy Makers?

Many industrialized countries are heavily dependent on imports of minerals and metals – partly as ores or concentrates, partly in the form of semi-finished goods.

Such import dependencies are often connected with supply risks: A shortage in supply can have strong effects on prices and availability affecting large industry segments.

To identify and being able to mitigate such risks, various studies analysed both, supply risks and the related vulnerabilities of sectors, countries and world regions. The outcomes of these studies are lists of 'critical raw materials' that guide policy-makers to focus policy-action on the right raw material streams and related sectors. As an example, the new EU Waste Framework Directive (EU Directive 2018/851) prioritizes sound management and recycling of waste streams that contain significant amount of critical raw materials in order to ensure security of supply of those raw materials.

Next to the issues around supply risks, raw materials are also subject to various environmental issues and it is well known that mineral mining and processing are often associated with far-reaching environmental consequences affecting local population and ecosystems. These impacts also have implications for downstream users:

- ► Environmental impacts in upstream supply chains are increasingly becoming a corporate reputation risk for downstream manufacturing industries;
- ► A negligence of environmental issues is likely to spike widespread opposition against mining, which drastically increases mid- and long-term supply risks (e.g. closure of existing mines, no granting of new concessions) and thus jeopardizes raw material policy goals;
- ► Circular economy and resource efficiency policies aim at reducing environmental impacts by using less primary raw materials.

Despite these implications, environmental concerns of primary raw material production are not commonly integrated in criticality assessments. The environmental dimension of raw material criticality helps to determine raw material flows and supply chains with a particular high likelihood for environmental shortcomings and where current raw material prices are likely not to represent the full production costs, including cost related to environmental impacts. It should therefore become an integral part of criticality assessment schemes aiming to support foresighted raw materials, circular economy and resource efficiency policies.

2 How can the issue be addressed in practice?

The OekoRess Project developed a methodology to assess and compare raw material specific Environmental Hazard Potentials (EHPs) of primary raw material production. The outcomes of this assessment are available for a large number of raw materials and can be used to quantify one dimension of Environmental Criticality Assessments (see table 1). Depending on the scope of a criticality assessment (e.g. individual company, sector or economy), the other dimension can be added by using respective data that adequately reflects the dependency on certain raw materials. Other relevant information (e.g. on recycling) can be added if needed.

3 Some important findings

The analysis of OekoRess shows, that antimony, bismuth, cobalt, copper, germanium, gold, indium, lead, light rare earths, molybdenum, nickel, palladium, phosphate rock, platinum, rhenium, rhodium, selenium, silver, tellurium, vanadium and zinc have high aggregated Environmental Hazard Potentials (aEHPs). This means that these are raw materials where geological conditions, applied mining technologies and the conditions in the natural environment combine into situations in which severe environmental degradation is more likely than for other raw materials of that list – presupposing that all mines apply comparable levels of mitigation strategies. The list also shows aggregated information on the environmental governance situation of production countries (EGov) and indicators on the global size of material and energy flows (GSMEF) from mining to smelting. Raw materials with high ratings in these fields are those which have – from a global perspective – the highest impacts in terms of excavated ore-mass and required energy for extraction, processing and smelting.

Beyond these aggregated results, the study includes also detailed raw material profiles that indicate the more specific environmental hazard potentials in relation to pollution risks, impacts on ecosystems, natural accident hazards, competition over water use and the total extent of global impacts. Generalised information on these aspects can be found in the left part of table 1 (EHP-indicators 1-8, SMF, SEF). The detailed raw material profiles (not part of this paper) can be used as an entry point for further investigation and targeted action.

4 Further reading

Methodological background reports of the OekoRess project can be downloaded from https://www.umweltbundesamt.de/publikationen/eroerterung-oekologischer-grenzen-der

The full raw material-related evaluation will soon be available at

https://www.umweltbundesamt.de/publikationen (in German)

https://www.umweltbundesamt.de/en/publications (in English)

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Table 1 Raw material specific OekoRess results

EHP Indicators								GSMEF		Raw materials	Results			Supplementary information		
1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**SMF**	**SEF**		**aEHP**	**EGov**	**GSMEF**	**M/B/C**	**ASM**	**AR**
										Aluminium				M		< 1%
										Antimony				M+B+C	**ASM**	< 1%
										Bauxite				M		< 1%
										Beryllium				M+B	**ASM**	< 5%
										Bismuth				B		< 1%
										Borates				M		0%
										Chromium				M	**ASM**	0%
										Cobalt				M+B	**ASM**	< 5%
										Coking coal				M		0%
										Copper				M		< 5%
										Fluorspar				M	**ASM**	0%
										Gallium				B		< 1%
										Germanium				B		< 10%
										Gold				M+B	**ASM**	< 5%
										Graphite				M	**ASM**	< 5%
										Gypsum				M	**ASM**	0%
										HREE				M+C		< 1%
										Indium				B		< 1%
										Iron				M		< 1%
										Iron ore				M		< 1%
										Kaolin clay				M		0%
										Lead				M+C		< 1%
										Lithium				M		0%
										LREE				M+C		< 5%
										Magnesite				M		0%
										Magnesium				M		0%
										Manganese				M	**ASM**	0%
										Molybdenum				M+B		< 1%
										Nickel				M		< 15%
										Niobium				M		< 1%
										Palladium				C+B		< 30%

EHP Indicators								GSMEF		Raw materials	Results			Supplementary information		
1.	2.	3.	4.	5.	6.	7.	8.	SMF	SEF		aEHP	EGov	GSMEF	M/B/C	ASM	AR
										Phosphate rock				M		< 5%
										Platinum				M+B+C		< 10%
										Potash				M		0%
										Rhenium				B		< 5%
										Rhodium				C+B		< 20%
										Scandium				B		< 10%
										Selenium				B		< 5%
										Silica sand				M		0%
										Silver				M+C+B	**ASM**	< 5%
										Tantalum				C	**ASM**	0%
										Tellurium				B		< 5%
										Tin				M	**ASM**	< 1%
										Titanium				M		< 1%
										Tungsten				M	**ASM**	< 5%
										Vanadium				M+**B**		< 5%
										Zinc				M		< 1%

1. Preconditions for acid mine drainage (AMD)
2. Paragenesis with heavy metals
3. Paragenesis with radioactive substances
4. Mining method
5. Use of auxiliary substances
6. Accident hazards due to floods, earthquakes, storms, landslides
7. Water Stress Index (WSI) and desert areas
8. Designated protected areas and Alliance for Zero Extinction (AZE) sites

SMF Size of material flow
SEF Size of energy flow
EGov Environmental governance
EHP Environmental hazard potential
aEHP Aggregated environmental hazard potential
EGov. Environmental governance
GSMEF Global size of material and energy flows
M/B/C Main (M), co- (C) or by (B)-product. **Fat** and underlined represents the largest share (e.g. **B**). '+' indicates that the raw material is mined as M, B, and/or C

ASM Artisanal and small-scale mining
AR Share of mining sites in the arctic region
HREE Heavy rare earth elements
LREE Light rare earth elements

High EHP
Medium to high EHP
Medium EHP
Low to medium EHP
Low EHP