Teaching Resources on the Sustainable Management of Critical Raw Materials

Trainer's Manual for
Responsible Mining

March 2020

Table of Contents

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

1 Context and Introduction to Training

This booklet is supplementing the teaching materials and the set of further supporting booklets that have been developed to support teachers in conducting training courses related to the sustainable management of critical raw materials.

SusCritMat aims to educate people from Master's student level up, both in industry and academia about important aspects of sustainable critical raw materials. In a novel concept, it introduces courses on these complex and interdisciplinary topics in a modular structure, adaptable to a variety of different formats and accessible to both students and managers in industry. These courses will develop new skills, which will help participants to better understand the impact and role of critical raw materials in the whole value chain; enabling them to identify and mitigate risks. Understanding the bigger picture and the interconnected nature of global business and society is increasingly necessary to and valued by industry.

SusCritMat is an EU-funded project that brings together the technical and pedagogical expertise of leading educational institutions and business partners. It uses and creates teaching materials which can be combined into different course formats.

This training kit presents the key messages related with the sustainable management of critical raw materials in three major sections:

- Introduction to criticality (including criticality assessment, global resource supply chains, geopolitical factors, and economics of metals)
- Analysis of criticality (including material flows, scenario planning, and life cycle assessment)
- Solutions (including responsible sourcing, circularity indicators, circular product design, and good practice examples)

In particular, the solutions part will be in the focus. The intention is to underline the possibilities that are available to approach and implement a circular economy for critical raw materials and the products bearing these. Doing so the concrete actions, i.e. the things that can be done, are highlighted, instead of only mentioning all sorts of associated problems or barriers in the context of CRMs.

The overall goal of the Summer School for Educators is to qualify the participants to teach the topics themselves. Therefore, the school does not only provide an introduction and improved insight into selected thematic issues, but to also deliver a set of teaching materials "ready-to-use".

- Learning targets that will be reached after having taught the courses
- Presentations on the specific topics including also notes on how to present the slides and key messages.
- Group work exercises including the task or question to work on, if applicable further reading on the methodology and the solutions in case of tasks requiring calculations.
- Assessment questions and the correct answers for each specific topic.
- Additional reading for each topic.

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1.1 Training Materials List

The *SusCritMat project* developed the following teaching materials:

Basics
Critical Resources for Emerging Technologies
Criticality
Supply Chain Resilience
Supply Risk Factors
Circularity
Circular Economy
Characterizing the Urban Mine
Circular Business Models
Waste Management and Recycling Potential
Closing Loops on Product Level
Governance
Geopolitical Aspects
Metals & CRM Scenarios
Restricted Substances Legislation
Impact on Society and the Environment
Sustainability Assessment
Responsible Mining
Responsible Sourcing / Certification
Environmental Aspects
Sustainable Materials Usage
CRM and Sustainable Development
Tools
MFA - Material Flow Management
Good Use of Data
LCA – Life Cycle Assessment
Process Models based on LCA

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1.2 Suggested timetable

The timetable contains a recommended timing for the lecture and exercises. However, depending on the pre-existing knowledge or group size the time can be extended.

- Responsible mining: 20 minutes
- Responsible sourcing: 40 minutes
- Group work exercise: 30 minutes
- Live quiz: 10 minutes
- Discussion quiz results: 15 minutes

1.3 Key Messages

- If demand for a metal is increasing, recycled metal cannot satisfy demand due to the time delay associated with the lifetime of products in the economy.
- Given our considerable appetite for mineral raw materials (MRMs), primary sources of MRMs (extracted from the ground), are unavoidable
- The key to responsible mining is good governance, covering economic, environmental and social issues and involving stakeholders from government, industry and civil society
- To be efficient, environmental & social management should be implemented all along the mine life cycle, from the exploration phase to the post-mining phase
- Mining waste is the Achilles' Heel of this industry
- With respect to acid mine drainage (AMD) formation, the question "are all ores worth mining?" is a valid question
- Given Europe's considerable appetite for certain metals, it would seem reasonable to develop Responsible Mining on European soil, rather than to simply import metals and outsource emissions.

1.4 Learning Objectives

This session will help learners….

- Better understand of some key drivers behind our dependence on primary (extracted) raw materials
- Clarify the mine life cycle and the main concepts underlying responsible mining
- Highlight the importance of good mining waste management
- Reflect on Europe's demand for mineral raw materials

1.5 Additional Reading

Responsible mining (priority reads in bold):

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- **CEC, 2008. The raw materials initiative - meeting our critical needs for growth and jobs in Europe. Commission of the European Communities, COM 699, Brussels.**
- **Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries and amending Directive 2004/35/EC**
- Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries, in accordance with Directive 2006/21/EC; EUR 28963 EN; Publications Office of the European Union, Luxembourg, 2018; ISBN 978-92-79-77178-1; doi:10.2760/35297, JRC109657
- TAILSAFE, 2005. Tailings management facilities - Legislation, authorisation, management, monitoring and inspection practices. Sustainable Improvement in Safety of Tailings Facilities TAILSAFE - A European Research and Technological Development Project.
- **Goodland, R., 2012. Responsible Mining: The Key to Profitable Resource Development. Sustainability 2012, 4, 2099-2126; doi:10.3390/su4092099**
- IAPG Task Group, 2017. White Paper on Responsible Mining.
- **Example of shared governance and sustainability in mining:Kittila mine (Finland); www.euromines.org**
- Responsible Mining Index. Framework 2020. https://responsibleminingindex.org/en/foundation

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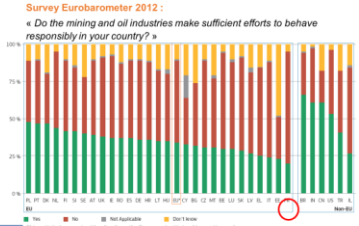
2 Slides

Course objectives • Better understand certain drivers behind our dependence on primary raw materials • Clarify the mine life cycle and the main concepts underlying responsible mining • Highlight the importance of good mining waste management • Reflect on Europe's demand for mineral raw materials	
Course objectives • Better understand certain drivers behind our dependence on primary raw materials • Clarify the mine life cycle and the main concepts underlying responsible mining • Highlight the importance of good mining waste management • Reflect on Europe's demand for mineral raw materials	
Contents 1. Responsible mining: why do we need it? 2. The mine life cycle and governance 3. A focus on mining waste 4. Take away messages 5. Discussion	
1. Responsible mining: why do we need it? Social License to Operate? 	Populations are increasingly opposed to the extractive industry. And yet mine production continues to increase, because of modern society's enormous demand for mineral raw materials.
1. Responsible mining: why do we need it? Survey Eurobarometer 2012 : « Do the mining and oil industries make sufficient efforts to behave responsibly in your country? » 	Interestingly, France which no longer has any metal mines (except overseas) is the most unfavourable to the extractive industry. This can spark a discussion on the underlying reasons. Typically, people will ask « what's in it for me? ». Populations that no longer benefit economically from the activity, will be opposed because they only have the downsides (environmental, …). While populations from Brazil, India, China, … see an economic interest for their livelihood.

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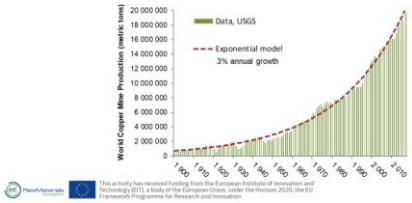
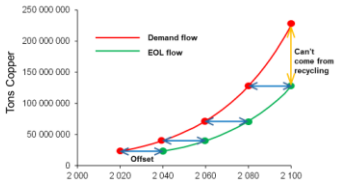
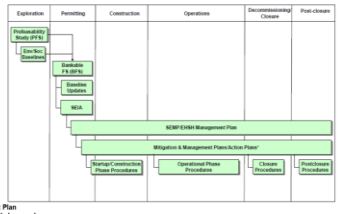
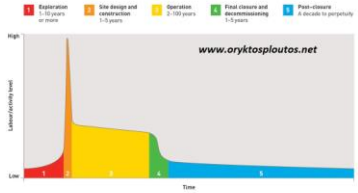
1. Responsible mining: why do we need it? And yet we need the extractive industry because if demand for a metal is increasing (e.g. exponentially), recycling cannot satisfy demand  	Emphasize the incredibly good match between an exponential growth curve and observed copper production since more than a century. Can mention that there is little indication that such growth will subside any time soon, as the energy transition absolutely needs copper (one of the best conductors of electricity that exists). If we NEED THE STUFF, we must make the extractive industry more environmentally and socially friendly.
1. Responsible mining: why do we need it? • Assume growth rate = 3% and average life time of products in economy = 20 years • Because of this offset, the contribution of 2ary copper to the production of new copper cannot exceed 56% (assuming « *ideal* » recycling rate of 100%...)  	A recycling rate of 100% is also completely unrealistic. Due to collection rates, losses, entropy, etc., recycling rates are often lower than 50% in the best of cases
2. The mine life cycle  	Definitions for resources and reserves are provided in the course on criticality concepts
2. The mine life cycle • Environmental & social management should be implemented all along the mine life cycle  FS = feasibility study SEIA = Social & Environmental Impact Assessment SEMP = Social & Environmental Management Plan EHSH = Environmental Health & Safety Management Plan * = includes regularly updated decommissioning and closure plan	All of these phases are documented by standardized procedures and regulations. But which differ from one country to another. The mining industry tries to harmonize in order to promote a level playing field.
2. The mine life cycle • Notion of time in the mine life cycle  	Emphasize that duration of period 3 is highly variable. Also emphasize the discrepancy between time scale of metal price variations (daily) and time scale of mine development (10-15 years)

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2. The mine life cycle • Coalition of governance = key to successful transformation of mineral raw materials into benefits for all society Institutional Governance Corporate Governance Civil Society Governance  Source : Thomas et al., 2013 doi.org/10.1016/j.cities.2012.12.002	Today we need to rely more on the collective intelligence. Which implies more transparency (next slides)
2. The mine life cycle • Governance : the **extractive industry value chain**  Accountability all along the value chain Source : World Bank	Transparency all along the value chain
2. The mine life cycle EITI Extractive Industries Transparency Initiative ✓ A **global standard** to promote the open and accountable management of oil, gas and mineral resources ✓ Requires the disclosure of **information** along the extractive industry value chain from the point of extraction, to how revenues make their way **through the government**, and how they **benefit the public** ✓ Seeks to strengthen public and corporate governance, promote understanding of natural resource management, and provide the data to inform reforms for greater **transparency and accountability** in the extractive sector ✓ In each of the 51 implementing countries, the EITI is supported by a **coalition of government, companies, and civil society.**	This is a tool for promoting transparency.
2. The mine life cycle • Key facts: ✓ 51 implementing countries ✓ 2,4 trillion US$ revenues disclosed in EITI Reports ✓ 394 fiscal years covered in EITI reporting 	Note that globally, there are still many countries that have not joined the EITI.
3. A focus on mining waste • A mining project is, to a large extent, a waste management project… Fortaleza Nickel mine (Brazil)  	Mining waste is the extractive industry's Achilles's Heel. Despite centuries of activity, mining waste management is often failing.

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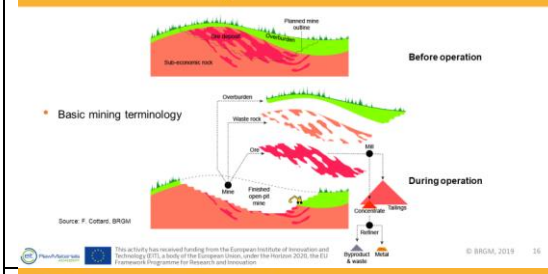
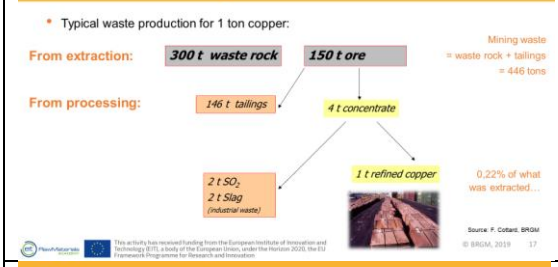
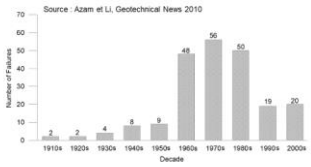
3. A focus on mining waste  	Need to distinguish between rock that goes into a process (grinding, flotation, flocculation, …) and rock that doesn't. The latter lead to waste rock while the former lead to tailings.
3. A focus on mining waste  	The Slag and SO2 emissions are not Mining Waste, but Industrial Waste (not the same legal status)
3. A focus on mining waste  	Here the talings are in the form of a slurry, but their water content may be reduced (paste tailings or even dry tailings). This costs money, but reduces the risks.
3. A focus on mining waste Tailings ponds are often the component of a mining operation that generate the highest liabilities They may generate short and long-term risks for health and the environment Unfortunately, the global performance of the extractive industry with respect to tailings pond management is not very satisfactory According to SRK: on average each year there are 2 major tailings pond failures somewhere in the world srk consulting	Achilles' Heel analogy
3. A focus on mining waste Evolution of accidents related to tailings dam failures  However: most probably severely underestimated	The graphic show that there were far more accidents in the 3 decades 60s, 70s, 80s, before stricter rules were enforced in the extractive industry regarding Health & Safety. On the other hand, the graphic says nothing of the number of casualties: there may be less accidents in a decade but with more casualties.

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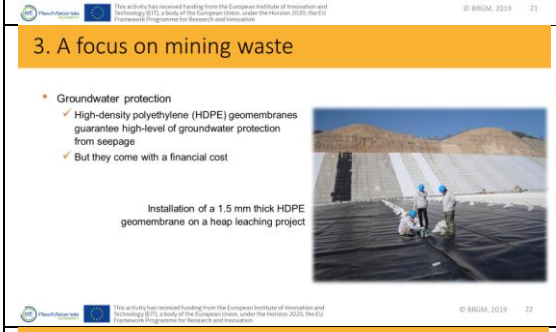
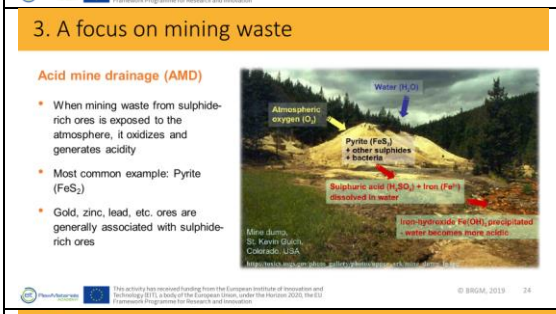
	The video is amazing and well worth finding a Wifi connexion..
	In advanced economy countries, these geomembranes are compulsory at the base of tailings ponds.
	Best Available Technology documents provide the reader with a synthesis of current state-of-the-art.
	Water acidity is measured by pH. In acid mine drainage, values are typically as low as 2 (nothing lives in water at pH 2…).
	

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3. A focus on mining waste • With acid mine drainage, the focus is generally on mine tailings (mining waste that has been through a process (grinding, flotation, flocculation, etc., to obtain a concentrate) • But what about acid mine drainage from waste rock in the case of sulphidic ores? Example: "Montagne d'Or" project in French Guyana. The question is currently under investigation  Source : Modified after « Compagnie Montagne d'Or » © BRGM, 2019 27	The Montagne d'Or project proposes geomembranes at the base of the tailings pond, but none at the base of the mine waste rock storage facility. This could be a problem because mine waste rock contains variable amounts of sulphides that may oxidize and generate acidity
4. Some takeaway messages • Given our considerable appetite for mineral raw materials (MRMs), primary sources of MRMs (extracted from the ground), are unavoidable • The key to responsible mining is good governance, covering economic, environmental and social issues and involving stakeholders from government, industry and civil society • To be efficient, environmental & social management should be implemented all along the mine life cycle, from the exploration phase to the post-mining phase • Mining wastes are the Achilles' Heel of this industry • With respect to acid mine drainage (AMD) formation, the question "are all ores worth mining?" is a valid question © BRGM, 2019 28	
5. Discussion • Since Europe needs the MRMs, shouldn't Europe develop resources from European sources (2nd pillar of the Raw Materials Initiative), rather simply importing (and delocalizing emissions)? Discuss pros and cons  © BRGM, 2019 29	
Selected references ✓ **CEC, 2008. The raw materials initiative - meeting our critical needs for growth and jobs in Europe. Commission of the European Communities, COM 699, Brussels.** ✓ **Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries and amending Directive 2004/35/EC** ✓ Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries, in accordance with Directive 2006/21/EC; EUR 28963 EN; Publications Office of the European Union, Luxembourg, 2018; ISBN 978-92-79-77178-1; doi:10.2760/35297, JRC109657 ✓ TAILSAFE, 2005. Tailings management facilities - Legislation, authorisation, management, monitoring and inspection practices. Sustainable Improvement in Safety of Tailings Facilities TAILSAFE - A European Research and Technological Development Project. ✓ **Goodland, R., 2012. Responsible Mining: The Key to Profitable Resource Development. Sustainability 2012, 4, 2099-2126; doi:10.3390/su4092099** ✓ IAPG Task Group, 2017. White Paper on Responsible Mining. ✓ **Example of shared governance and sustainability in mining:Kittila mine (Finland); www.euromines.org** ✓ Responsible Mining Index. Framework 2020. https://responsibleminingindex.org/en/foundation © BRGM, 2019 30	References in bold can be read in priority

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3 Exercises

Exercise is a debate at the end of the lecture on European dependence regarding primary mineral raw materials.

4 Assessment Questions

Include 5 multiple choice quiz questions and 4 possible answers here. Mark the correct answer(s) by putting “correct” in brackets behind it (see example).

Why do we need responsible mining?
Answer 1: Because our demand for certain metals is increasing and therefore it cannot be covered by recycling / reuse alone. (correct)
Answer 2: To supply our industries
Answer 3: To reduce our dependence on metal imports
Answer 4: To increase our exports and improve our commercial balance

In order to be effective, environmental management should be implemented.
Answer 1: From exploration to post-closure (correct)
Answer 2: During the post-closure phase
Answer 3: From operations to decommissioning
Answer 4: From permitting to decommissioning

One of these wastes is not classified as mining waste
Answer 1: Slag (correct)
Answer 2: Tailings
Answer 3: Waste rock
Answer 4: Overburden

What is acid mine drainage?
Answer 1: Water that has been in contact with mining waste and has a very low pH (correct)
Answer 2: A drainage system on a sulphuric acid mine
Answer 3: Rainwater that flows as runoff on certain mining waste dumps
Answer 4: Groundwater in sulphide-bearing ore materials

What type of mining governance is promoted by regulatory bodies?
Answer 1: Private-Public-People (correct)
Answer 2: Private-Public-Academic
Answer 3: Public-Corporate-Social
Answer 4: Economic-Environmental-Social

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6 Citation

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7 Disclaimer

The teaching materials within the SusCritMat project have been prepared with great care and experienced several revisions. Nevertheless, the consortium assumes no liability for the topicality, completeness and correctness of the content provided.

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In case you have suggestions or other feedback how to improve the materials, we value your opinion: Please contact us via the project webpage https://suscritmat.eu/contact/.

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