H2020 ITERAMS project. Sustainability of a portfolio of solutions for water and tailings management in mining

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Major issue in mining (I) water use

- Freshwater intake
- Water discharge
- Environmental limits/water quality
- Environmental limits/water quantity
- Water recycling
- Costs/water pumping
- Costs/waste water treatment
Major issue in mining (II) tailings disposal

- Land use
- Emissions to freshwater
- Acid Mine Drainage (AMD)
- Conflicts with local communities
- Risk of ecological disasters, e.g. dam failure
- Costs/tails management
- Wet tailings disposal will probably be banned in the future
H2020 ITERAMS project | Figures

- Integrated Mineral Technologies for More Sustainable Raw Material Supply
- 3 years: 1.6.2017 – 31.5.2020
- 7.9 M€ budget
- 16 partners
- 3 validation sites

Finland
Portugal
South Africa
H2o2o ITERAMS project: closing the water loop

• Closure of water cycles at each process stage
• Isolation of process waters from other water systems

How does this affect…

• process water quality?
  Water temperature increases $\rightarrow$ bacterial growth

• water treatment effort?
  Electricity, chemicals

• process stability?
  Closed water cycle $\rightarrow$ thermodynamic and kinetic instability

• plant performance?
  Concentrate grade, recovery rate
H2020 ITERAMS project: tailings valorization

• Use tailings/waste rocks to create new mineral phases
  -> Geopolymers to be used as:

- Backfill material for underground mining
- Cover material for surface deposits (to avoid AMD)

How to assess ITERAMS sustainability

Can the sustainability of mining operations be enhanced with ITERAMS? And how can we evaluate it?

• A comparative sustainability assessment of impacts and risks with and without the implementation of the novel technologies

The comparison is not straightforward!
Why the comparison is not straightforward

• Plant performance and output change over time and are likely to be affected by the novel technologies
• Functional unit definition
• Every mine site is different

There will not be one “block” of technologies, but a portfolio of technologies adapted to each site:

• Different water cleaning technologies
• Different ways to create geopolymers
Every mine site is different – example water quality

Water availability

Freezing climate

Low residence time of process water in tailings area

Poor process water quality

Fine solids

Bacteria

Water stress

Save as much water as possible: paste thickener

Low residence time of process water in tailings area

Poor process water quality

Sulphate

Thiosalts

Water stress

Use of sewage water

Poor process water quality

Fine solids

Bacteria

FINLAND

PORTUGAL

SOUTH AFRICA
A portfolio of ITERAMS solutions

• A simple “black and white” comparison (“with or without” “the” ITERAMS solution) is not realistic

• …nor useful

→ We assess the sustainability of a portfolio of ITERAMS solutions for water and tailings management in mining
Modelling the ITERAMS portfolio | hotspots

- Starting with insights from a previous hotspots screening and qualitative ITERAMS modelling

**Article**

Environmental and Social Pressures in Mining. Results from a Sustainability Hotspots Screening

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**Abstract:** In recent years, increased interest and actions have been taken to better understand, and mitigate, sustainability impacts of mining activities, by both industry and policy. The present work reports on a sustainability hotspots screening performed for the EU Horizon 2020 “Integrated Mineral Technologies for More Sustainable Raw Material Supply” (ITERAMS) project, which foresees a more efficient water recycling, tailings valorization, and minimization of environmental footprint. The focus of this paper is on social and environmental issues in mining. Different methodologies were explored, starting from a qualitative causal loop modelling. Afterwards, an environmental and social LCA screening was performed using well-accepted databases and methods, thus completing results with a literature research. The main findings related to the importance of the supply chain, the vulnerability of local communities, and the toxic emissions from tailings offer a starting point to reflect on the specific social, socio-economic, and environmental context which may influence these issues. A better understanding of the environmental and social pressures associated with mining is not only crucial to orient the sustainability assessment foreseen for the ITERAMS project, but also to contribute in terms of methodology to the challenges tackled by policy and research worldwide towards a more sustainable mining.

**Keywords:** mining; social impacts; environmental impacts; hotspots; social risks; supply chain; LCA; screening

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Modelling the ITERAMS portfolio | FU

• Copper equivalent as functional unit

\[ \text{CuEq.\%} = \text{Cu\%} + \left( \sum_i R_i V_i G_i \right) / \left( V_{\text{Cu}} R_{\text{Cu}} \right) \]

where,

- \( R \) is the metallurgical metal recovery rate
- \( V \) is the metal price
- \( G \) is the metal grade in percent of concentrate

*Copper equivalent means the percentage of marketable metals or minerals contained in mineralized material*

https://www.lawinsider.com/dictionary/copper-equivalent
Modelling the ITERAMS portfolio | current situation

- Model of the “current situation” on site for the 3 locations:
  - Primary data from the mining companies for the **foreground** models
  - Link with **background** data from LCA databases
Modelling the ITERAMS portfolio | modules (I)

• Use the LC model for the current situation on site as the basis for a second system where ITERAMS technologies are added
  - for each site and
  - in a modular way with process modules

• To reflect the plant layouts
• To adapt the model to different cases and over time
• To adapt the model to different locations
Step by step modular modelling

- Identification of **site-specific** processes (current situation)
Step by step modular modelling

- Identification of **sector-specific** processes

Ore mining - Comminution

Comminution - Flotation

Cu Comminution

Cu flotation

Tailings pumping

Copper filtration

Backfilling

Tailings management

Ore mining underground

WRD management

Ore mining - Waste rock management

Flotation - Tailings pumping
Step by step modular modelling

- **Sector-specific** processes become connecting processes (CP) for **site-specific** processes

- Ore mining-Comminution
- Mining-WR management
- Pit dewatering
- WRD water management
- Comminution-Flotation
- Flotation-Filtration
- ...
- Waste water treatment
- Process water
Step by step modular modelling

- Connecting modules are used to link site-specific process in a flexible way
Step by step modular modelling

- Shaping connecting processes (modules)

**Ore mining underground**
- INPUT
  - Resource in nature
  - Energy
  - Backfill
- OUTPUT
  - Ore mined
  - Waste rock
  - Pit dewatering

**CP1**: Ore mining - Comminution
- INPUT
  - Ore mined
  - Energy
- OUTPUT
  - Ore mined
  - Cu Ground ore Dust

**Cu ore comminution**
- INPUT
  - Ore mined
  - Energy
- OUTPUT
  - Cu Ground ore Dust

**Ore mining open pit**
- INPUT
  - Resource in nature
  - Energy
- OUTPUT
  - Ore mined
  - Waste rock
  - Pit dewatering

**CP1**: Ore mining - Comminution
- INPUT
  - Ore mined
  - Energy
- OUTPUT
  - Ore mined
  - Cu + Ni Ground ore Dust

**Cu+Ni ore comminution**
- INPUT
  - Ore mined
  - Energy
- OUTPUT
  - Cu + Ni Ground ore Dust
Step by step modular modelling

- Following the same logic, the ITERAMS technologies can be added at any point in the model and differently for each site.
Modelling the ITERAMS portfolio | DAF technology

- Dissolved Air Flotation (DAF) for the Finnish site

**Issue:** Fine solids in Ni flotation circuit

**Cause:** Short circuiting of recycled water flow due to freezing

**Solution:** DAF

**Effects on Ni flotation**

- Freshwater intake
- Chemicals
- Recovery rate
- Electricity

Implementation of process modules in openLCA
Modelling the ITERAMS portfolio | modules (II)

• The ITERAMS portfolio is affected by and affects local conditions, e.g. water availability and indigenous presence

• These “background situations“ are also studied in a modular way
A portfolio of background situations

Categories:

• Vulnerability of local communities
  indigenous populations, employment

• Conflicts with other economy sectors
  tourism, reindeer farming

• Local resources
  water availability and quality, groundwater

• National and sub-national risks
  energy supply, natural disasters

• Importance of the sector for the national and local economy
  share of the sector in the GDP
Background situations as modules

Background situation

Alternatives

ITERAMS effect

ITERAMS technologies
Background situations as modules - examples

- **Water availability**
  - Water positive areas
    - Effect on water quality rather than availability
  - Water negative areas
    - Reduced water stress

- **Electricity availability**
  - Constant
    - Increased electricity use
  - Fluctuating
    - Malfunctioning of WWT
Conclusions

• A system than can evolve from time to time with the specific nature of the system under study
Conclusions and further outlook

• When assessing the sustainability of new technologies in mining, it is often unrealistic to consider a “unique block of new solution”

• How to include background situations in the LC model?

• How to include risks in the LC model?

• Test the modular approach for other cases, also beyond the mining sector
Thank you!

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