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Closing Water Loops in Minerals Processing

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Circular hydrometallurgy: Close water loops

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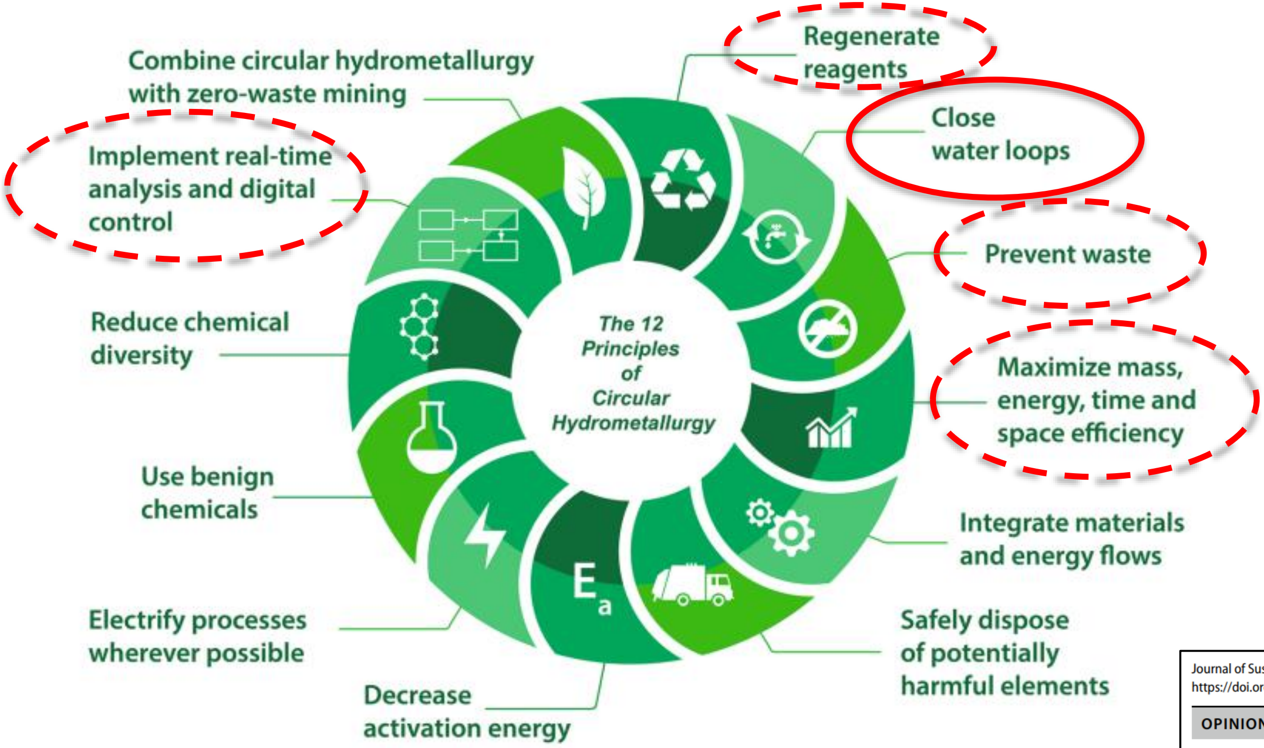
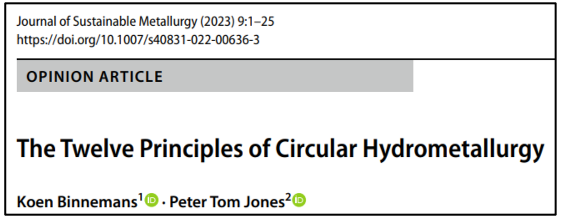



Journal of Sustainable Metallurgy (2023) 9:1–25
https://doi.org/10.1007/s40831-022-00636-3

OPINION ARTICLE

The Twelve Principles of Circular Hydrometallurgy

Koen Binnemans[1] · Peter Tom Jones[2]

Why to focus on water?

Every drop counts

VTT

- Water at the top of most urgent concerns of societies
- Rising demand for food and climate change could result in a global water deficit of 40% by 2030
- Many conflicts in mining are related to water
- Most water in mining used in minerals processing
- Not only recycling water, but minimizing the use of water
- E.g. AA dams account for 10-25% of total water lost
  - Creating water costs approximately US$200 million annually

Journal of Cleaner Production 278 (2021) 123640

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

ELSEVIER

Making or breaking social license to operate in the mining industry: Factors of the main drivers of social conflict

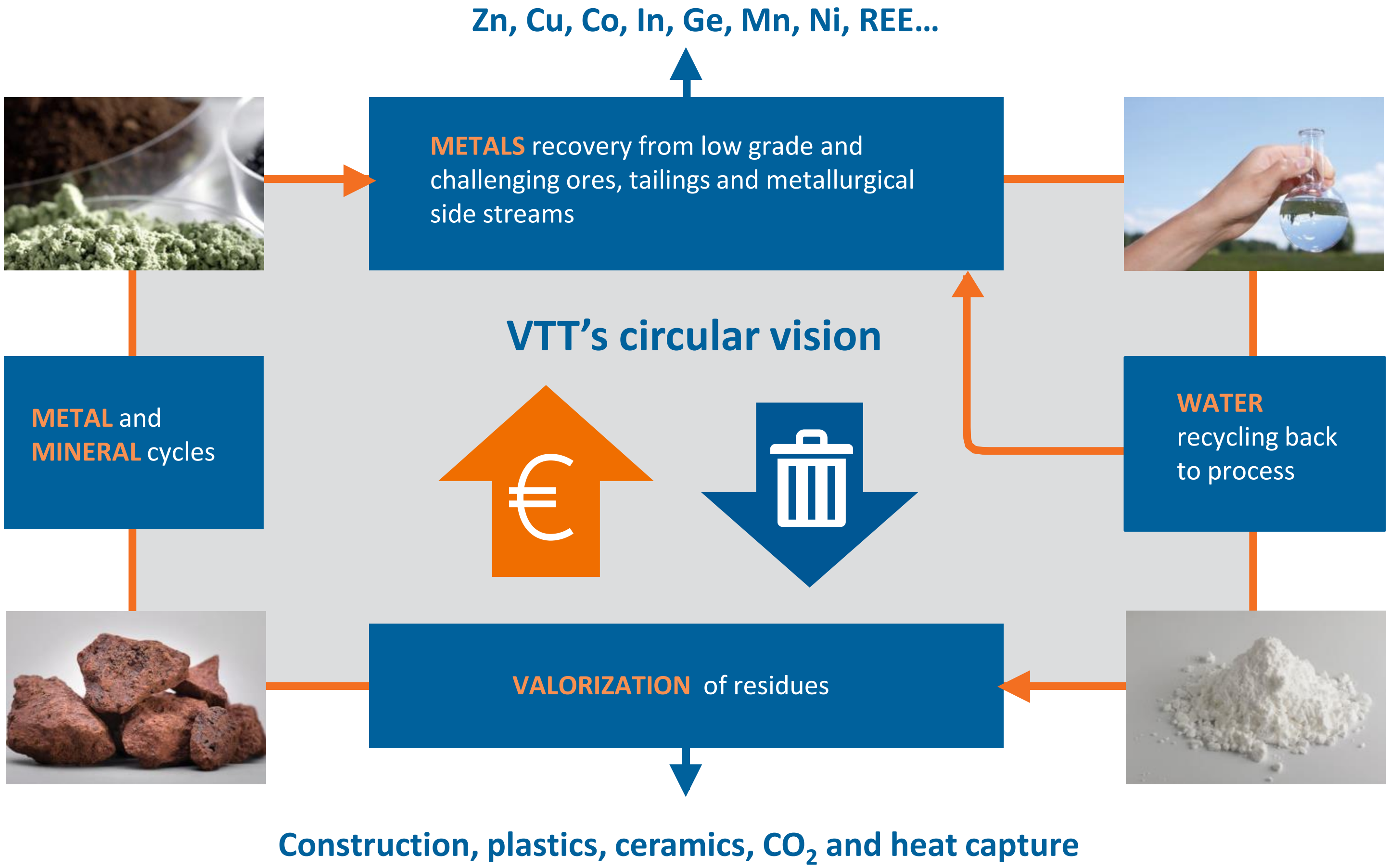
Saenz Cesar *, Ostos Jhony

WATER MANAGEMENT

Water in Mining: Every Drop Counts

How technology is helping the mining industry to address its dependence on water

By Carly Leonida, European Editor


Zn, Cu, Co, In, Ge, Mn, Ni, REE…
METALS recovery from low grade and challenging ores, tailings and metallurgical side streams
VTT's circular vision
METAL and MINERAL cycles
WATER recycling back to process
€
VALORIZATION of residues
Construction, plastics, ceramics, CO_2 and heat capture

Using less water

Closed loop recycling system

Water recycling

- Internal recycling
  - Chemicals can be recycled
- Direct recycling from the tailing dams
  - Mineral particles settle down in the tailing dam
  - Part of flotation reagents decompose gradually
  - Substances diluted owing to the inflow of rainwater and surface drainage
  - Some tailings excellent adsorbers for microorganisms
- Recycling after treatment
  - Physico-chemical methods
  - Biodegradation

Environmental Science
Water Research & Technology

ROYAL SOCIETY OF CHEMISTRY

TUTORIAL REVIEW

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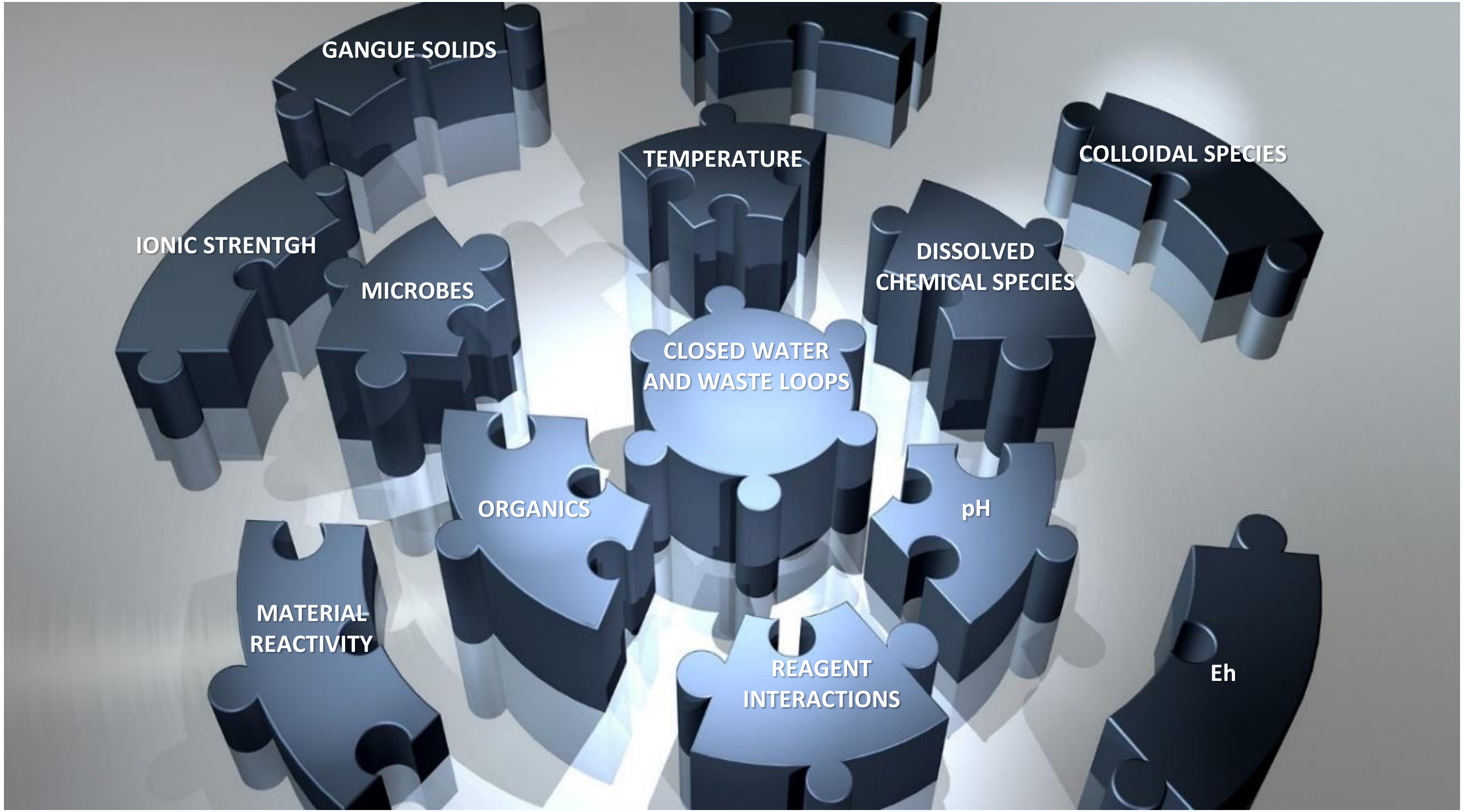
Cite this: *Environ. Sci.: Water Res. Technol.*, 2023, **9**, 1290

Recent advances in the treatment and recycling of mineral processing wastewater

Gaogui Jing,[abc] Xiangsong Meng,[abc] Wei Sun,[abc] Przemyslaw Boguslaw Kowalczuk[d] and Zhiyong Gao*[abc]

What happens, when water is recycled?

Accumulation of everything



Seasonality in flotation

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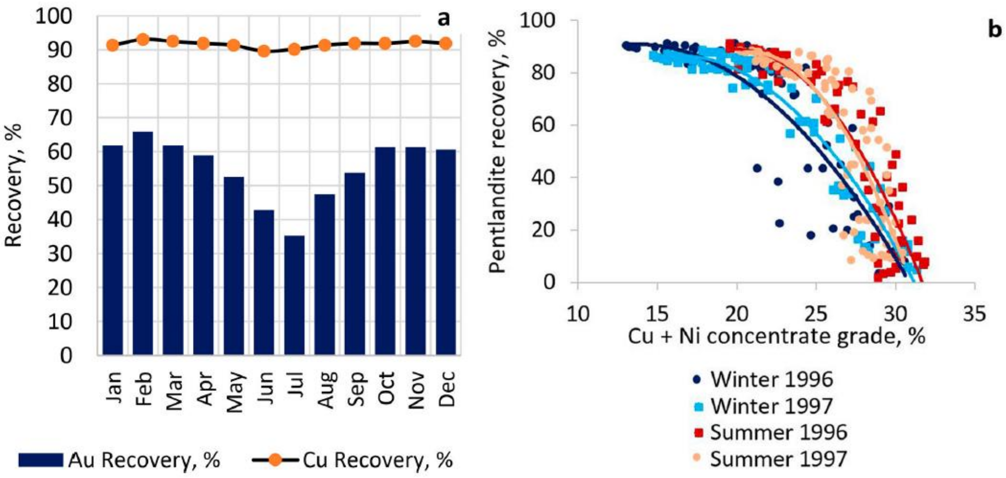

Figure 1. Examples of seasonal drop: (a) in gold recovery on Hudson Bay Mining and Smelting, 2000–2003; (b) in Cu + Ni grade on Clarabelle mill, adapted from Refs. [28,63].

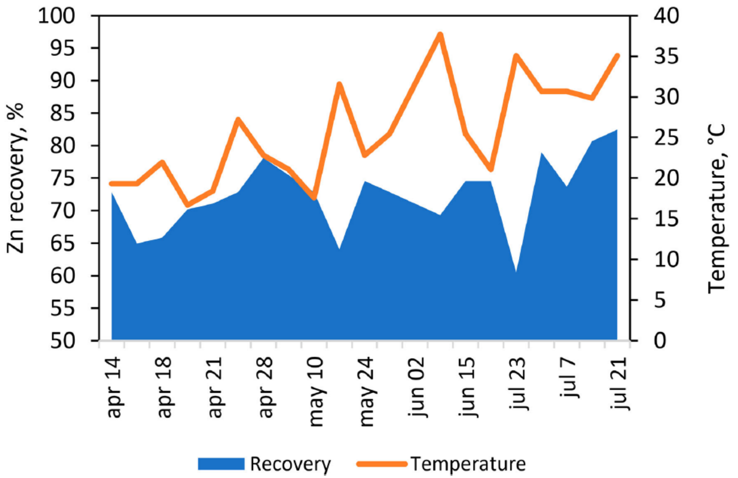

Figure 8. Zinc recovery at the Neves-Corvo zinc plant in relation to the daily temperature, adapted from Ref. [132].

CANADIAN METALLURGICAL QUARTERLY
2023, VOL. 62, NO. 3, 511–548
https://doi.org/10.1080/00084433.2022.2127788

MetSoc CIM ICM | Taylor & Francis, Taylor & Francis Group

OPEN ACCESS | Check for updates

Temperature and climate-induced fluctuations in froth flotation: an overview of different ore types

Dzmitry Pashkevich, Ronghao Li and Kristian Waters

ITERAMS project:
Some lessons learned

NEW ROLE OF WATER AND WASTE IN MINING

- From water handling cost minimization
- to taking care of water properties and optimizing these properties for each process step. New water reuse concepts.

- From depositing waste rock and tailings
- to utilizing waste rock and tailings for added revenue as hardening mine fill or products. New ways of safe depositing of remaining tailings.

Do we know?

- How closed water loops impact contaminants?
- How contaminants affect process performance?
- Which contaminants are the most critical to process performance?
- How sealing water in a reservoir (no evaporation) will impact water quality?
- How to measure contaminants of interest in real-time, on-line, and at reasonable cost?

No we don’t,

but we should.

Ore sorting decreases water use

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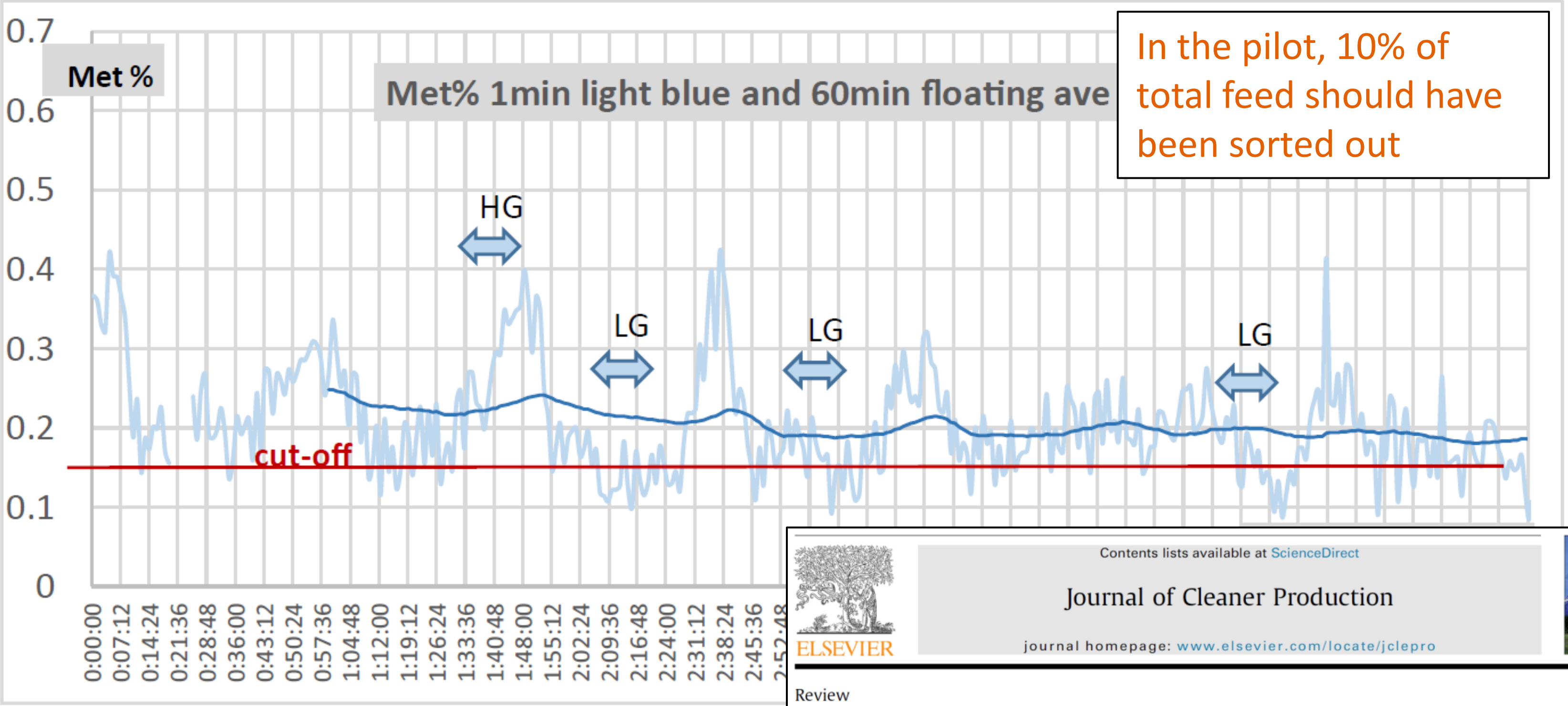

In the pilot, 10% of total feed should have been sorted out

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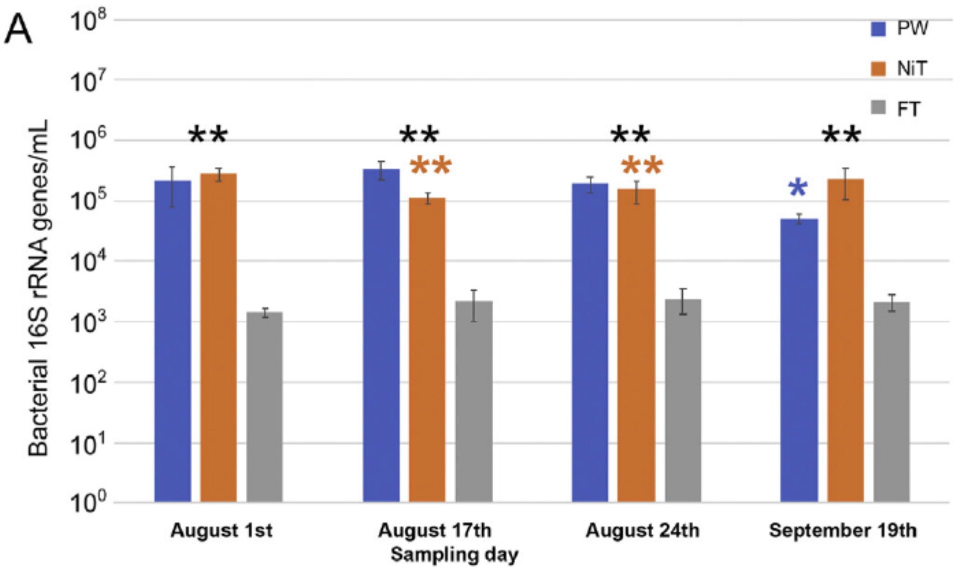
ELSEVIER

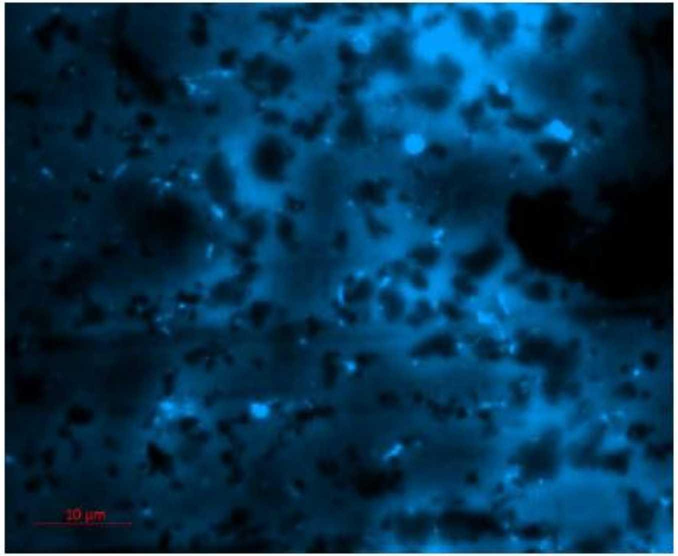
Review

Review of closed water loops with ore sorting and tailings valorisation for a more sustainable mining industry

Päivi Kinnunen [a, *], Robert Obenaus-Emler [b], Jukka Raatikainen [c], Sylvain Guignot [d], Jordi Guimerà [e], Andreas Ciroth [f], Kari Heiskanen [g]

Microorganisms in process waters





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First insights to the microbial communities in the plant process water of the multi-metal Kevitsa mine

Malin Bomberg [a,*], Hanna Miettinen [a], Benjamin Musuku [b], Päivi Kinnunen [c]

minerals

Review

Review of Potential Microbial Effects on Flotation

Päivi Kinnunen [1,*], Hanna Miettinen [2] and Malin Bomberg [2]

Seasonal variation

Received: 1 December 2023 | Accepted: 30 April 2024
DOI: 10.1111/1758-2229.13284

RESEARCH ARTICLE

ENVIRONMENTAL MICROBIOLOGY REPORTS

Seasonal variation in metabolic profiles and microbial communities in a subarctic ore processing plant

Malin Bomberg[1] | Hanna Miettinen[1] | Päivi Kinnunen[2]

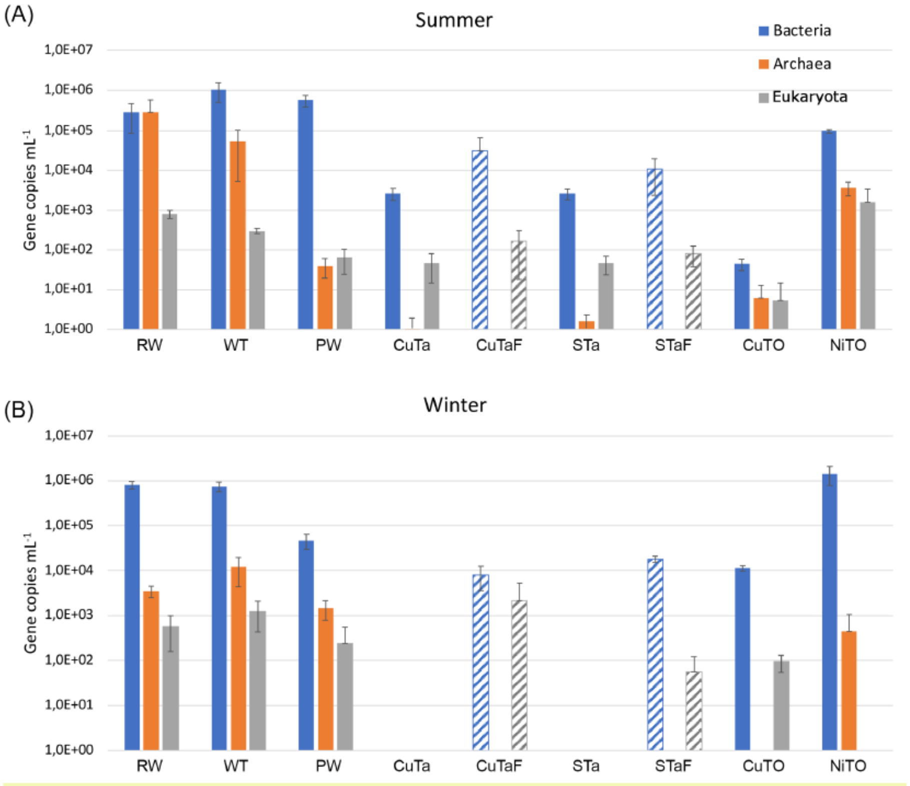

FIGURE 2 The number of bacterial (blue) and archaeal (orange) 16S rRNA gene copies and eukaryotic (grey) 5.8S rRNA gene copies ml^{-1} in the (A) summer and (B) winter samples. The striped columns of CuTaF and STaF indicate the phenol-extraction protocol. Each column is the average of three replicate qPCR reactions from two or three replicate samples ($n = 6–9$) and the error bars show standard deviation.

Microbial metabolism in flotation samples

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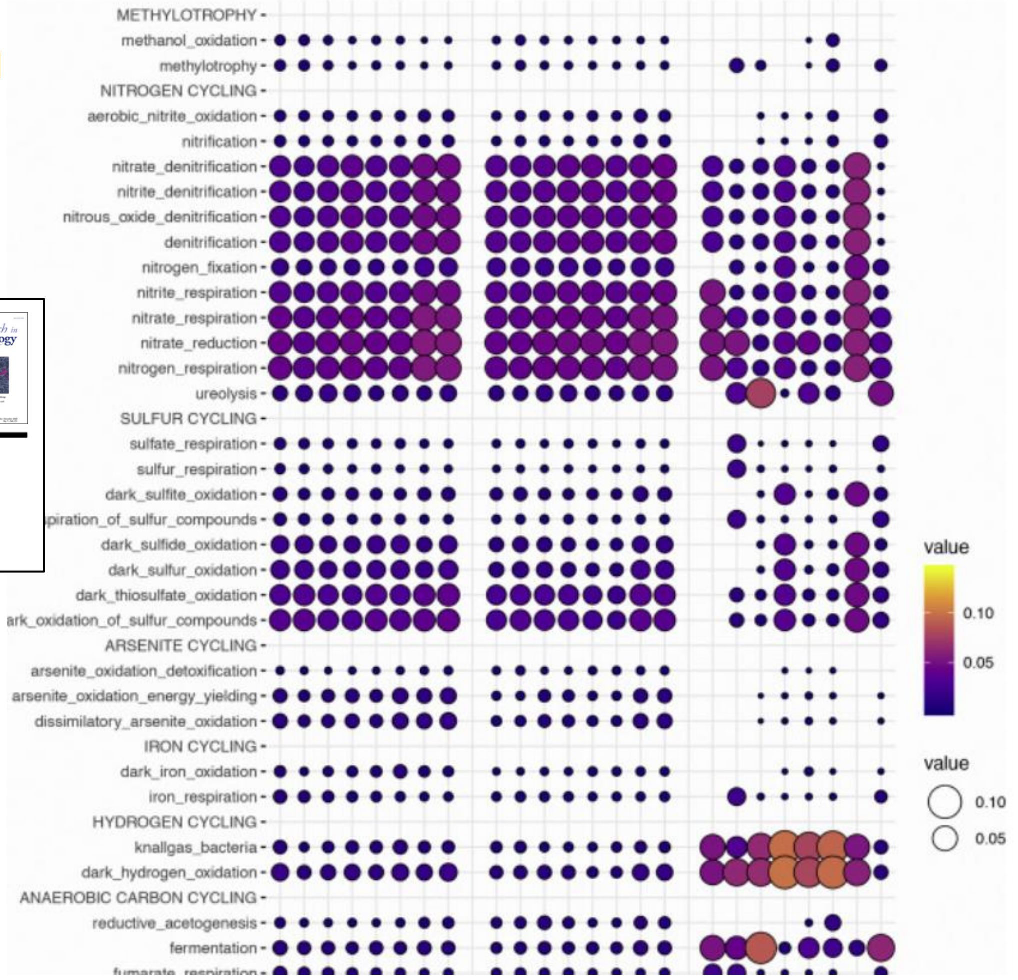
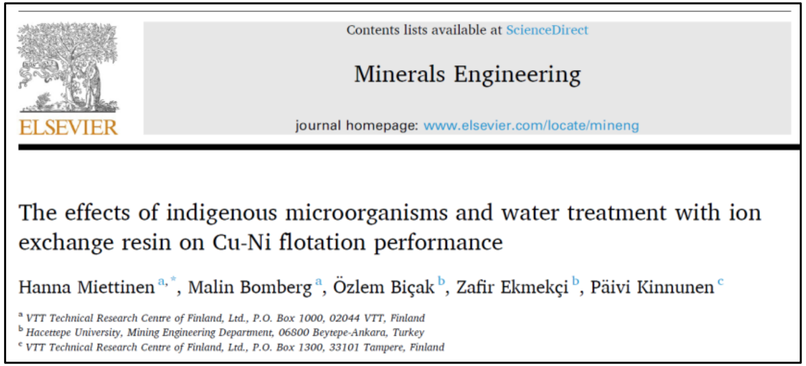


Impact on performance



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ELSEVIER

The effects of indigenous microorganisms and water treatment with ion exchange resin on Cu-Ni flotation performance

Hanna Miettinen [a,*], Malin Bomberg [a], Özlem Biçak [b], Zafir Ekmekçi [b], Päivi Kinnunen [c]

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[b] Hacettepe University, Mining Engineering Department, 06800 Beytepe-Ankara, Turkey
[c] VTT Technical Research Centre of Finland, Ltd., P.O. Box 1300, 33101 Tampere, Finland

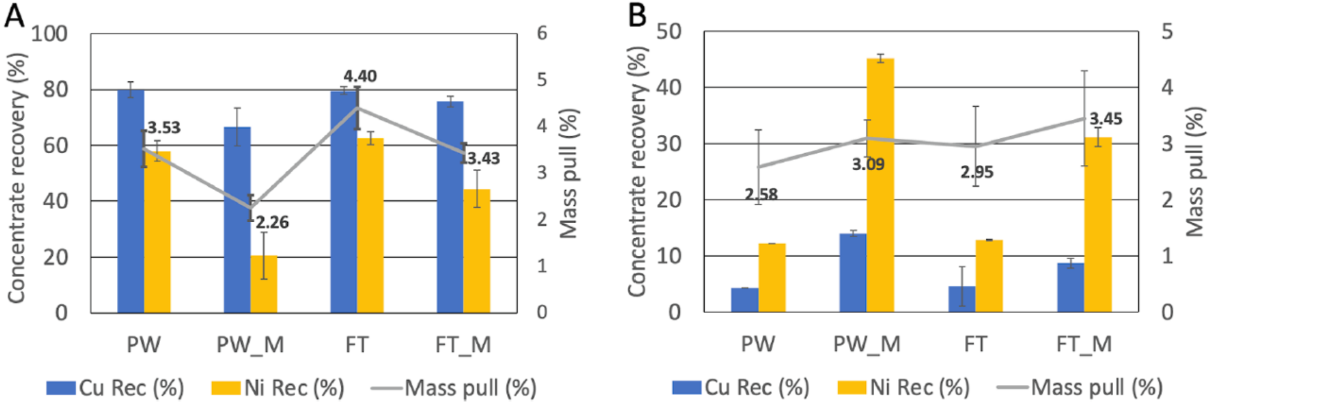
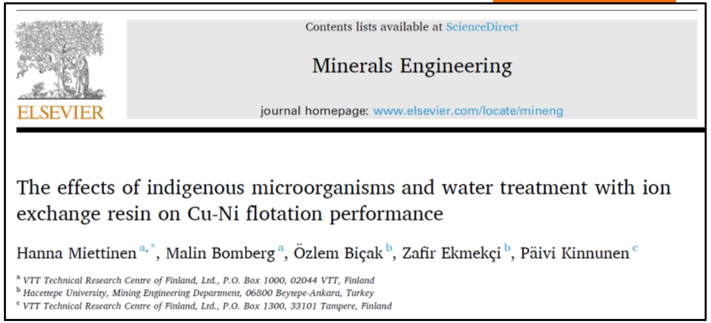


Fig. 3. Recovery of Cu and Ni concentrates in Cu (A) and Ni (B) flotations and mass pull with process water (PW) and final tailings (FT) with (M) and without microorganisms from duplicate experiments.

Ion exchange



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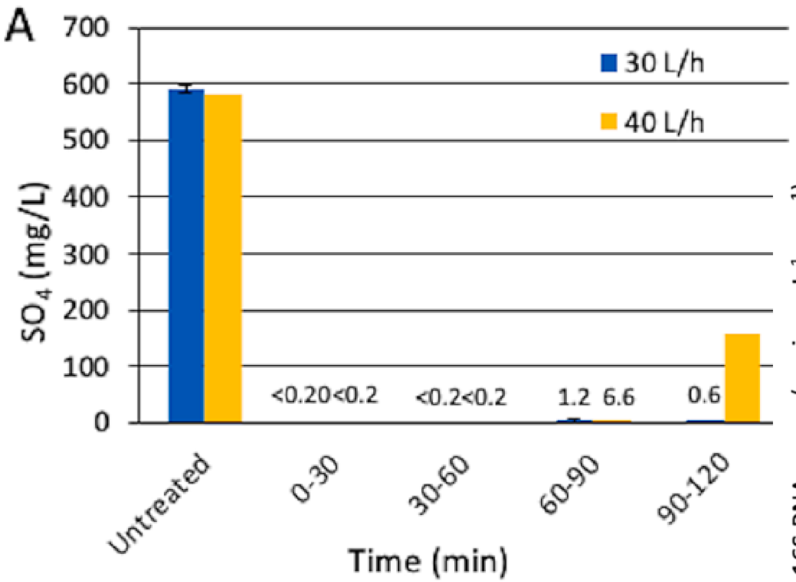
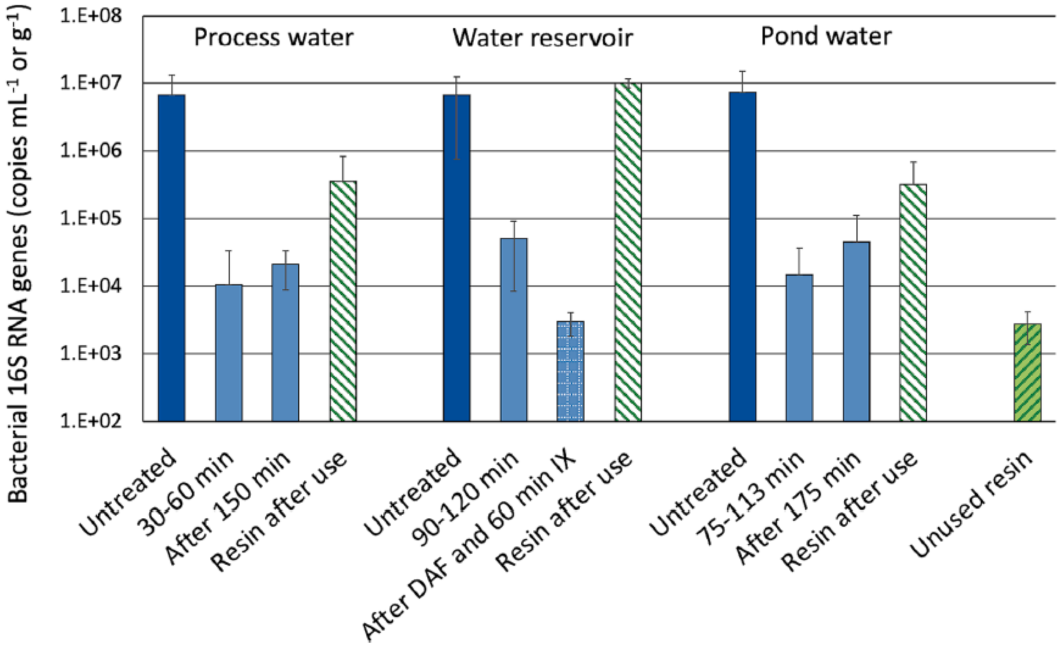
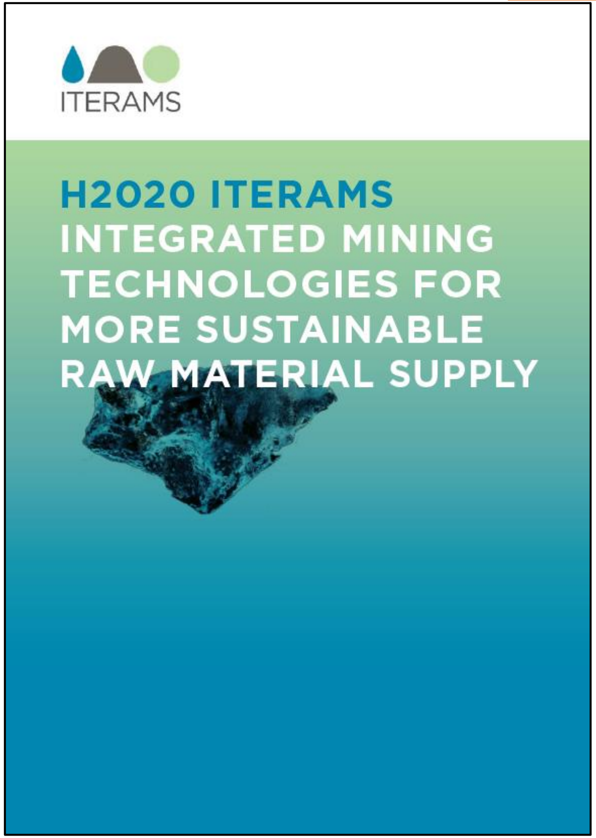




ITERAMS book

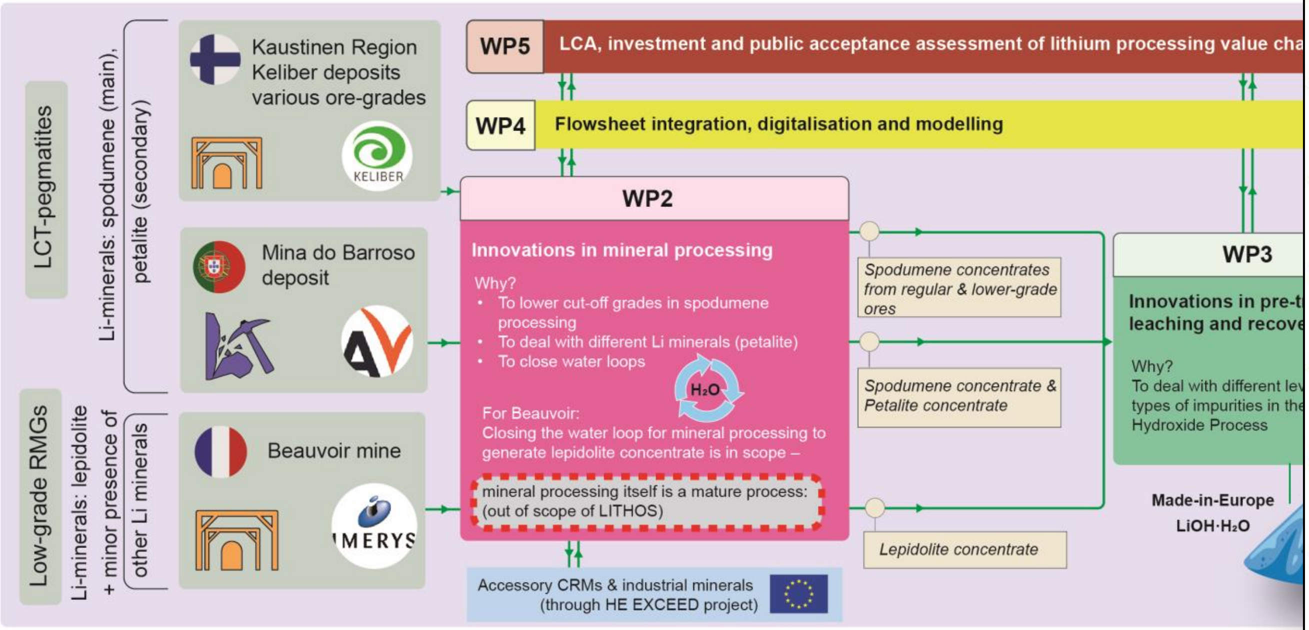
THE FINAL PROTOCOL IS A COMBINATION OF 7 SUB-PROTOCOLS:

1 Sub-protocol for evaluating water quality in relation to plant performance
2 Sub-protocol for identifying adverse components and their limit
3 Sub-protocol for evaluating the effect of bacteria
4 Sub-protocol for predicting the variation of water quality and its impact on flotation
5 Sub-protocol for implementing water treatment solution
6 Sub-protocol for monitoring and controlling water quality
7 Sub-protocol for implementing water management in plant design



http://www.iterams.eu/Content/PublicArea/ITERAMS_Shortbook_201217.pdf

LITHOS closed water loops



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3	[KUL]	KU Leuven	
4	[EUROMINES]	European Association of Mining Industries. Metal Ores / Industrial Minerals AISBL	
5	[BRGM]	Bureau de Recherches Geologiques et MIniers	
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8	[TUC]	Polytechneio Kristis	
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10	[Imerys]	Imerys SA	

https://lithos-horizon.eu/

Other water treatment examples

Multidisciplinarity: chemistry – separation technologies – bioprocesses – modelling

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Sulphate removal from mine water with chemical, biological and membrane technologies

Päivi Kinnunen, Hanna Kyllönen, Tommi Kaartinen, Jarno Mäkinen, Juha Heikkinen and Ville Miettinen

ABSTRACT

Chemical, physical and biological technologies for removal of sulphate from mine tailings pond water (8 g SO_4^{2-}/L) were investigated. Sulphate concentrations of approximately 1,400, 700, 350 and 20 mg/L were obtained using gypsum precipitation, and ettringite precipitation, biological sulphate reduction or reverse osmosis (RO) after gypsum pre-treatment, respectively. Gypsum precipitation can be widely utilized as a pre-treatment method, as was shown in this study. Clearly the lowest sulphate concentrations were obtained using RO. However, RO cannot be the only water purification technology, because the concentrate needs to be treated. There would be advantages using biological sulphate reduction, when elemental sulphur could be produced as a sellable end product. Reagent and energy costs for 200 m^3/h tailings pond water feed based on laboratory studies and process modelling were 1.1, 3.1, 1.2 and 2.7 MEur/year for gypsum precipitation, ettringite precipitation, RO and biological treatment after gypsum precipitation, respectively. The most appropriate technology or combination of technologies should be selected for every industrial site case by case.

Key words | biological sulphate reduction, ettringite, gypsum, membrane, sulphate

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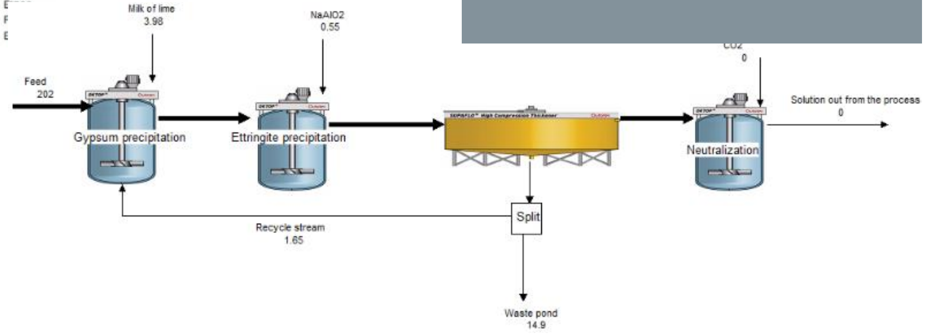


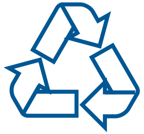
CUSTOMER REFERENCE: AGNICO-EAGLE

”VTT evaluated four process options for sulphate removal. Process models and cost calculations were very useful, and we were able to choose the best process”
Pasi Kreivi, Agnico Eagle

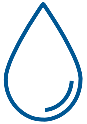
Reducing costs and CO_2 footprint by recycling sodium sulphate waste effluents

Finnish Minerals Group (FMG) partnered with VTT to find a circular economy solution for treating sodium sulphate wastewater. Instead of just getting rid of sodium sulphate, FMG wanted to make the most of the side stream. Using electrodialysis, the team developed a solution with which sodium sulphate can be regenerated into new, product-quality chemicals, thus reducing environmental impacts and the need to purchase new chemicals. Next, in collaboration with Adven, FMG is moving ahead with a plant-scale project.

Proof-of-concept data through tailored pilot runs



Circular economy solution



A cost-effective way to turn sodium sulphate wastewater from an additional cost to a raw material

"Our long-term collaboration with VTT has been one of the key elements paving the way towards industrial applications."

Jani Kiuru
Senior Vice President of Raw Materials
FMG

Beyond the obvious

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