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HELMHOLTZ-INSTITUT FREIBERG FÜR RESSOURCENTECHNOLOGIE

An Innovative bioleaching Approach for the Extraction of Valuable and Hazardous Elements from Mining Waste

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MSCA-ETN SULTAN

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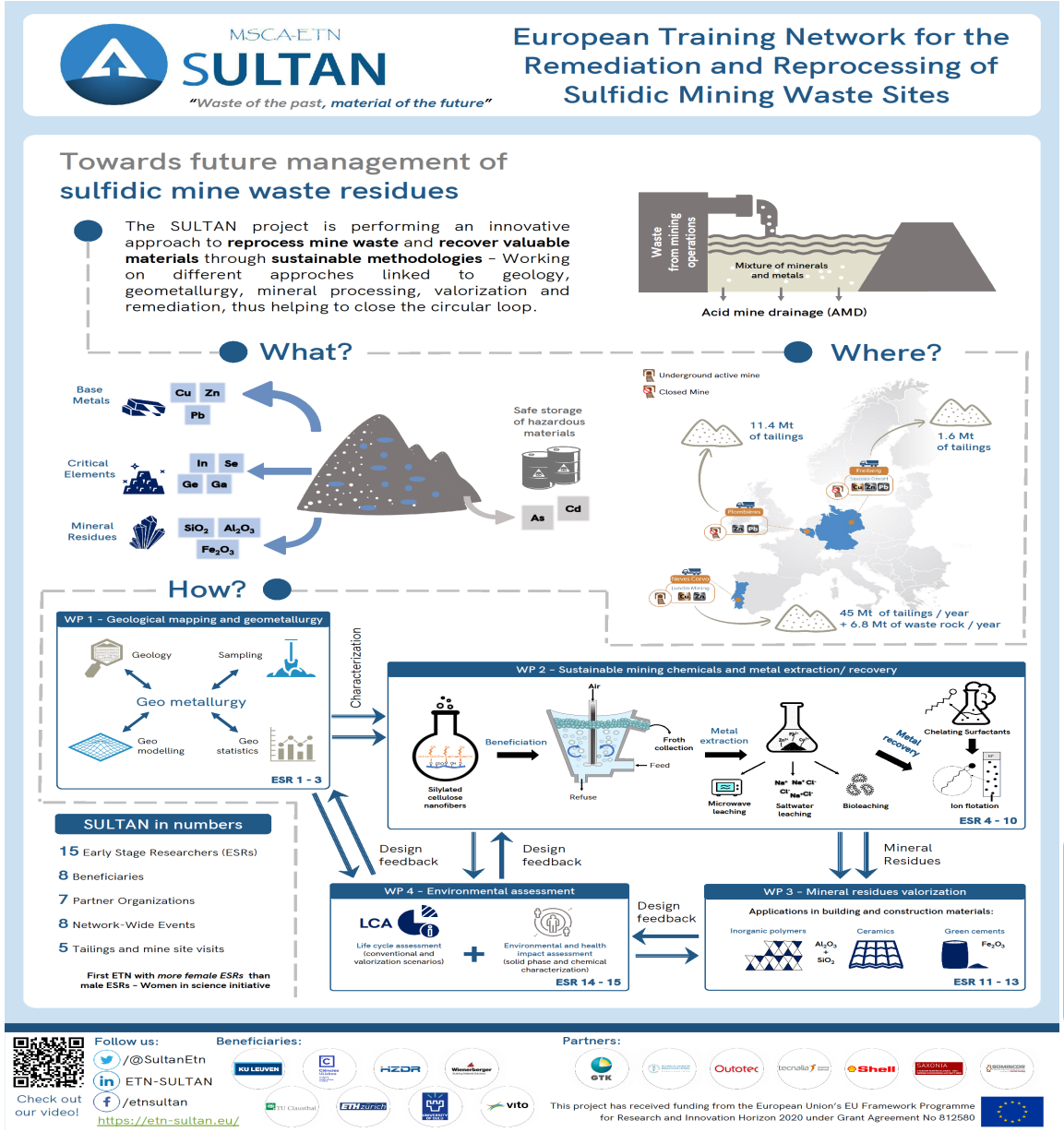
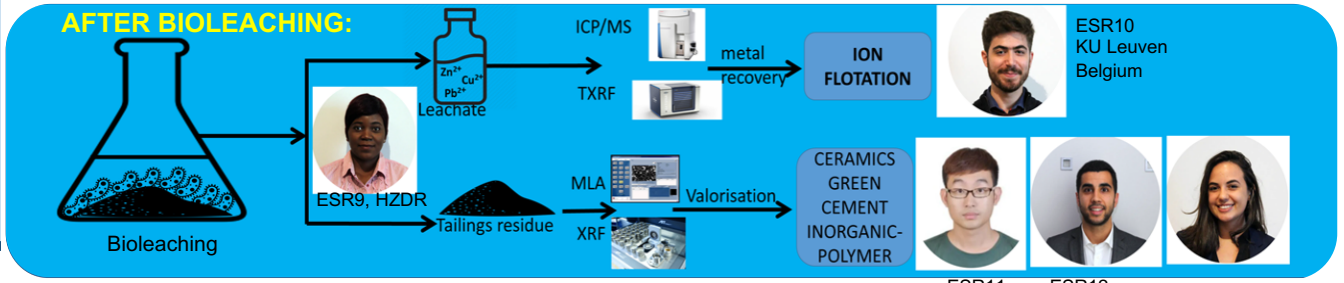
THE ETN-SULTAN PROJECT



- European Training Network for the Remediation and Reprocessing of Sulfidic Mining Waste sites (**ETN-SULTAN**)
- **Motivation** for SULTAN
  - Discarded extractive waste residue: 29% of EU-28's current waste output
  - significant environmental hazard
  - sulfidic tailings prone to acid mine drainage
  - contains valuable metals
- **Purpose** of SULTAN
  - mitigate environmental risks
  - economically recover valuable raw materials
- **WP1**: resource potential of European main tailings
- **WP2**: ecofriendly metal extraction/recovery methods
- **WP3**: valorize clean(ed) tailing residue into high-added value applications
- **WP4**: novel environmental assessment methodology



Brief Background of Biomining

Biomining definition:

- Biological systems (mainly prokaryotic microorganisms)
- Expedite the extraction and recovery of metals
- From ores or waste materials

Global production using biomining technology

- 15% of Copper
- 5% Gold
- Smaller amounts of other metals

Biomining

- Bio-oxidation
- Bioleaching

Bio-oxidation (biological pre-treatment)

- remove minerals that obstruct target metals
- target metal is then made accessible and solubilised in a second process

Bioleaching

- Target metal is solubilised during bioprocessing

Conventional microorganisms used in bioleaching

- Consortia of obligate acidophiles (e.g *Acidithiobacillus ferrooxidans*)
- Grow autotrophically by oxidising
  - reduced forms of sulphur
  - ferrous iron (Fe^{2+})
  - hydrogen
- Catalyses mineral dissolution
- pH ≤ 2

Advantages of biomining

- Eco-friendly (smaller carbon footprints)
- Atmospheric pressure, low temperature
- Cost-effective for low grade ores
- For sulphide ores with high concentration of Arsenic

Disadvantages of biomining

- Slow
- At full-scale, limited to low grade ores
- Mistrust about robustness/reliability
- Previous failures or linked to environmental problems

Project goals and Methodology

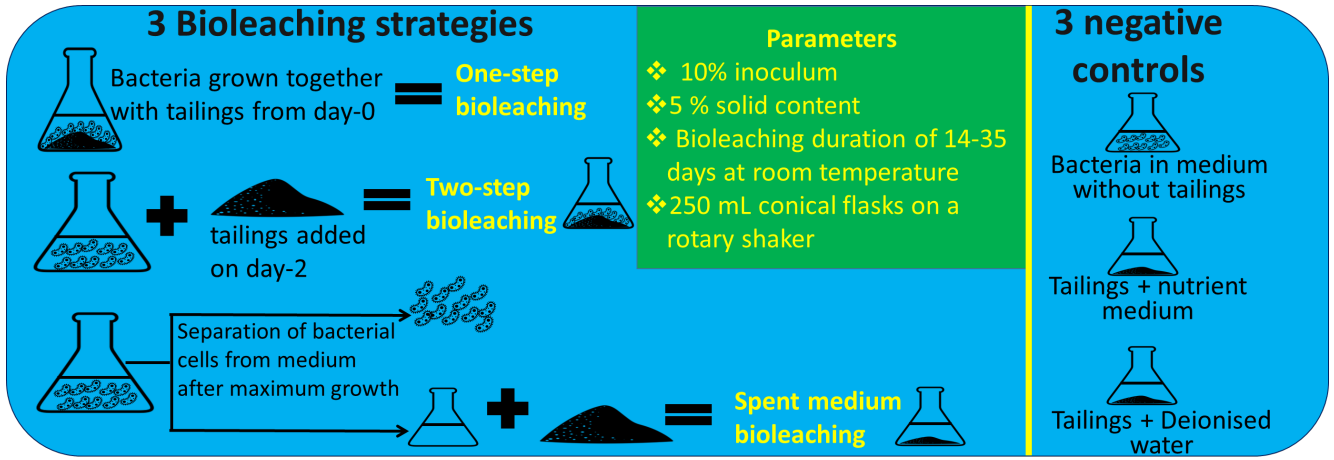
Goal: to develop alternative bioleaching processes for treating mining waste (tailings & waste rock) at less acidic (pH>2) to neutral conditions.

Objectives of project

- investigate bioleaching potentials of (halo) alkaliphilic and/or marine sulphur-oxidising microorganisms
- study the interactions of selected promising bacteria with minerals

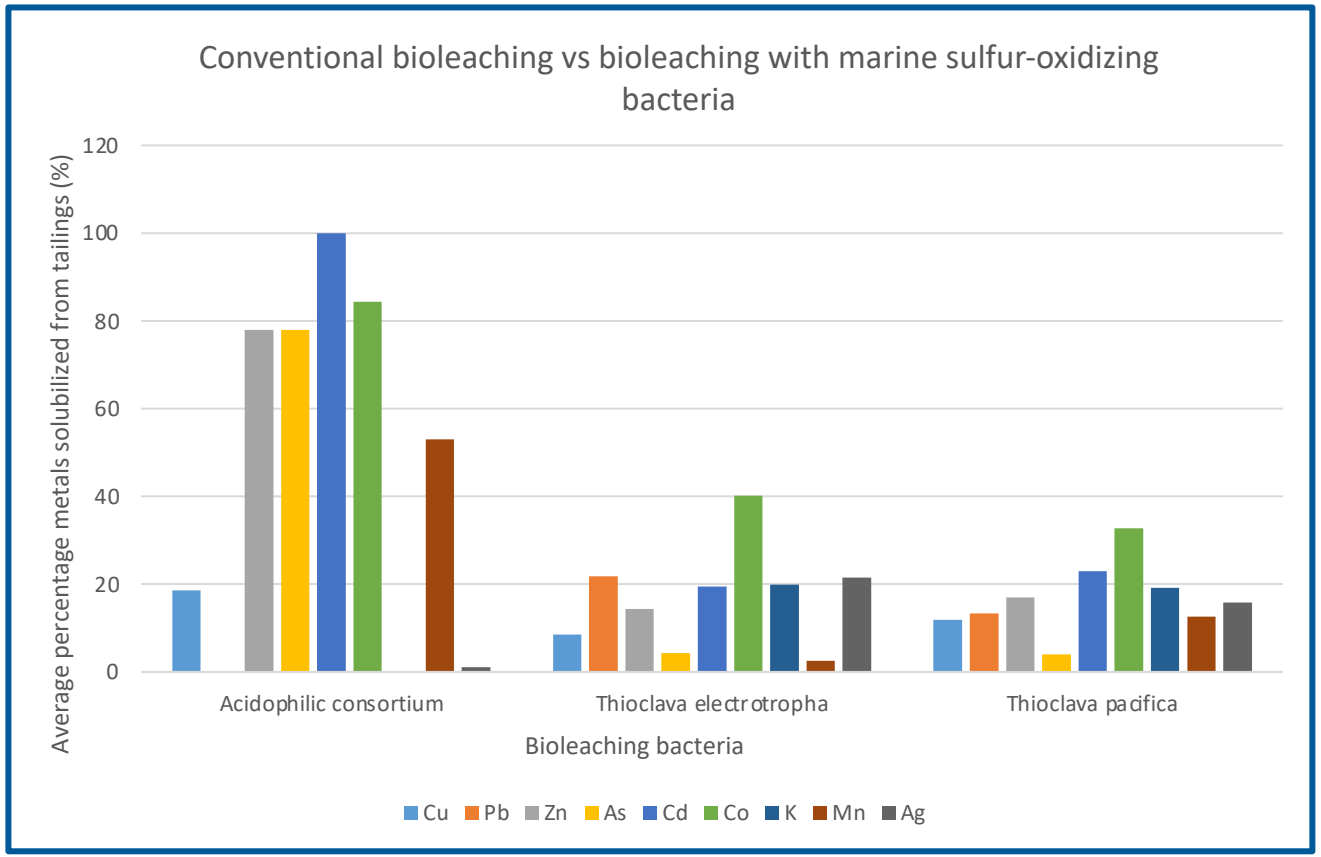
Benefits of project:

- Novel approach in biomining
- Leaching at higher pH unlike acidophilic bacteria - prevents the acidification of the environment
- Leaching at high Cl concentration - applicable in sea water, saves fresh water



S/N	Bacterial strains tested	Reason for choosing	Results/ conclusion
1.	*Thioclava electrotropha* DSM-103712	moderately halophilic sulfur-oxidising bacteria	Promising for leaching at higher pH and high Cl concentration
2.	*Thioclava pacifica* DSM-10166		
3.	*Thiomicrorhabdus chilensis* DSM-12352	moderately halophilic sulfur-oxidising bacteria	Not promising for leaching at higher pH and high Cl concentration
4.	*Thiomicrospira cyclica* DSM-14477		
5.	*Thiohalobacter thiocyanaticus* DSM-21152		
6.	*Thiobacillus thioparus* DSM-505	less acidophilic sulfur-oxidising bacteria	
7.	*Alicyclobacillus acidiphilus* DSM-14558	less acidophilic bacterium	
8.	*Marinobacter sp.* DS40M6	siderophore-producing	
9.	*Brevundimonas sp.* DSM-21112T	present in microbial community of recycled PEG spray system (Preston, Smith et al. 2014)	
10	Chemolithoautotrophic acidophilic bacterial consortium	Bioleaching positive control	Efficiently leached metals at low pH and low Cl concentration

Results: Conventional bioleaching VS bioleaching with marine sulphur-oxidizing bacteria (*Thioclava electrotropha and Thioclava pacifica*)



% metals solubilized = $\frac{\text{Amount of metal } \textit{solubilised}}{\textit{Initial amount of metal in waste sample}} X\ 100\%$

Average % solubilized = Average of duplicate samples with RSD < 30%

Other marine sulphur oxidising bacteria screened:

1. *Thiomicrorhabdus chilensis*
2. *Thiomicrospira cyclica*
3. *Thiohalobacter thiocyanaticus*

All not promising

Sample: fresh waste rock (<100 µm particle size) from Neves Corvo mine, Portugal	Metal content (mg/kg)
Cu	1840
Pb	826.3
Zn	3560
As	766.7
Cd	9
Co	84.7
K	14466.7
Mn	724.3
Ag	5.7

	Conventional bioleaching	Bioleaching with marine sulfur oxidizing bacteria	
	Acidophilic consortium	Thioclava electrotropha	Thioclava pacifica
Final pH at the end of bioleaching	1.7 – 1.8	4.2 – 4.6	4.6 - 4.7

Conclusion / Future plans

- ❖ New bioleaching approach likely feasible
- ❖ *Thioclava electrotropha* and *Thioclava pacifica* seem promising for treating mining waste at pH > 4
- ❖ method requires process optimization
  - adaptation of bacteria to high metal concentrations
  - use of bacterial consortium
- ❖ Screen more marine sulphur-oxidizing bacteria for potential bioleaching activities

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Thank you for your attention

Questions/Suggestions?

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