Recovery of copper as “clean” nanoparticles of CuS from acid rock drainage and mine process water

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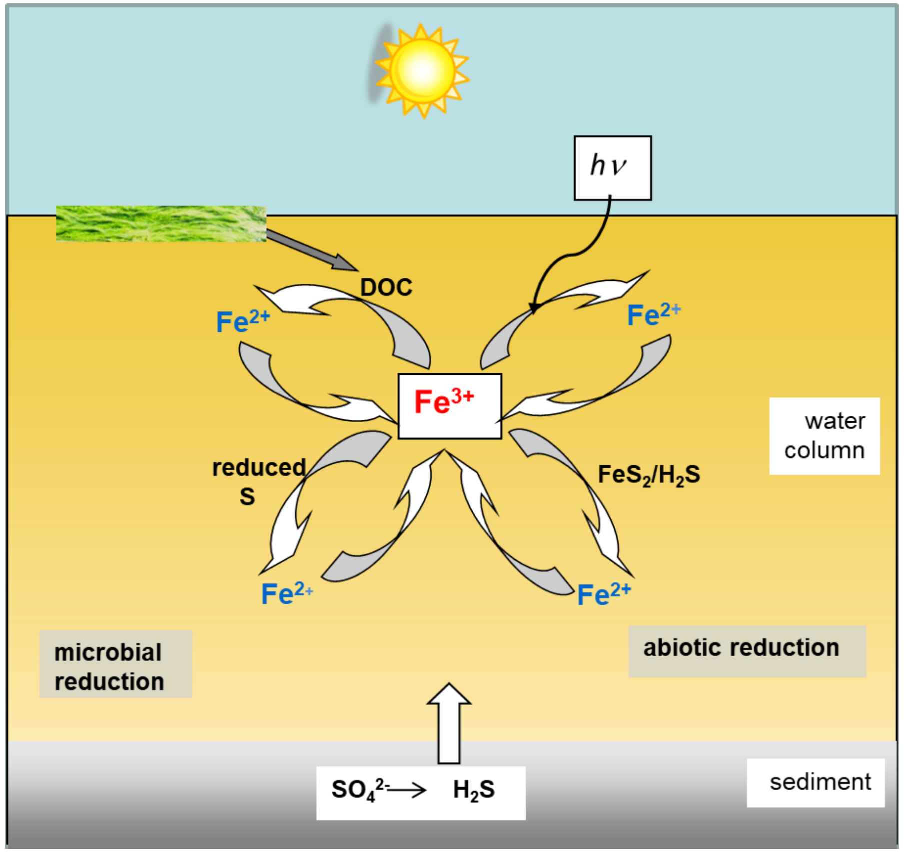
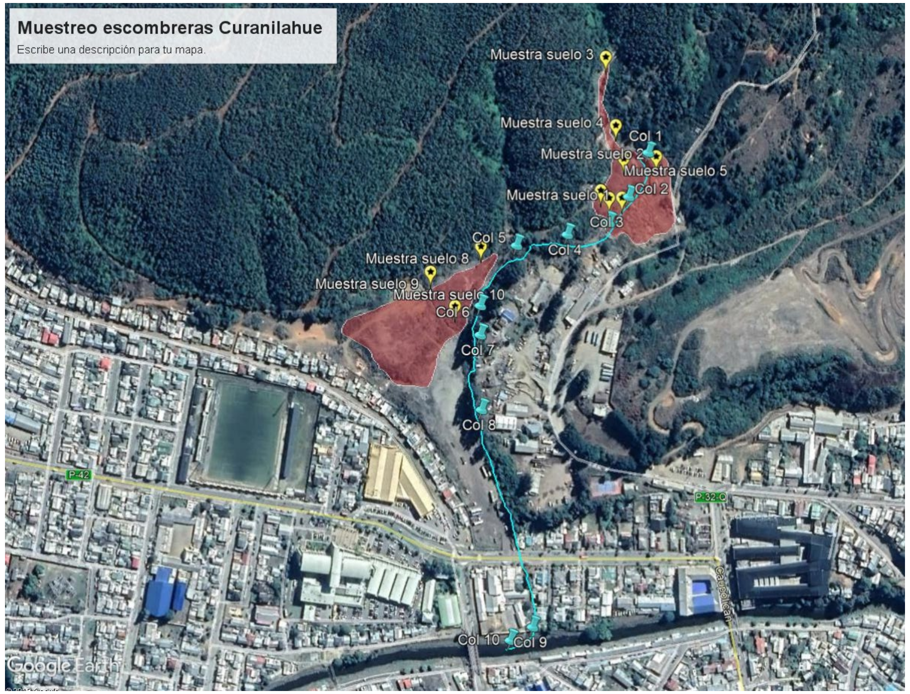
Cycling of iron in acidic enviroments has been widely studied, though:





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TAXONOMIC DESCRIPTION

González *et al.*, *Int. J. Syst. Evol. Microbiol.* 2020;70:3348–3354

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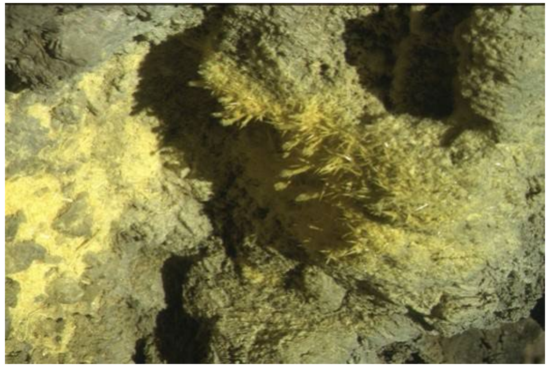
MICROBIOLOGY SOCIETY

Acidiferrimicrobium australe gen. nov., sp. nov., an acidophilic and obligately heterotrophic, member of the Actinobacteria that catalyses dissimilatory oxido-reduction of iron isolated from metal-rich acidic water in Chile

Daniella González[1], Katharina J. Huber[2], Brian Tindall[2], Sabrina Hedrich[3], Camila Rojas-Villalobos[4,5], Raquel Quatrini[4,5,6], M. Alejandro Dinamarca[7], Claudia Ibacache-Quiroga[7], Alex Schwarz[8], Christian Canales[1] and Ivan Nancucheo[1,*]

In contrast, although sulfur is usually very abundant in natural and man-made acidic environments, there have been relatively few studies on sulfur-cycling in these.

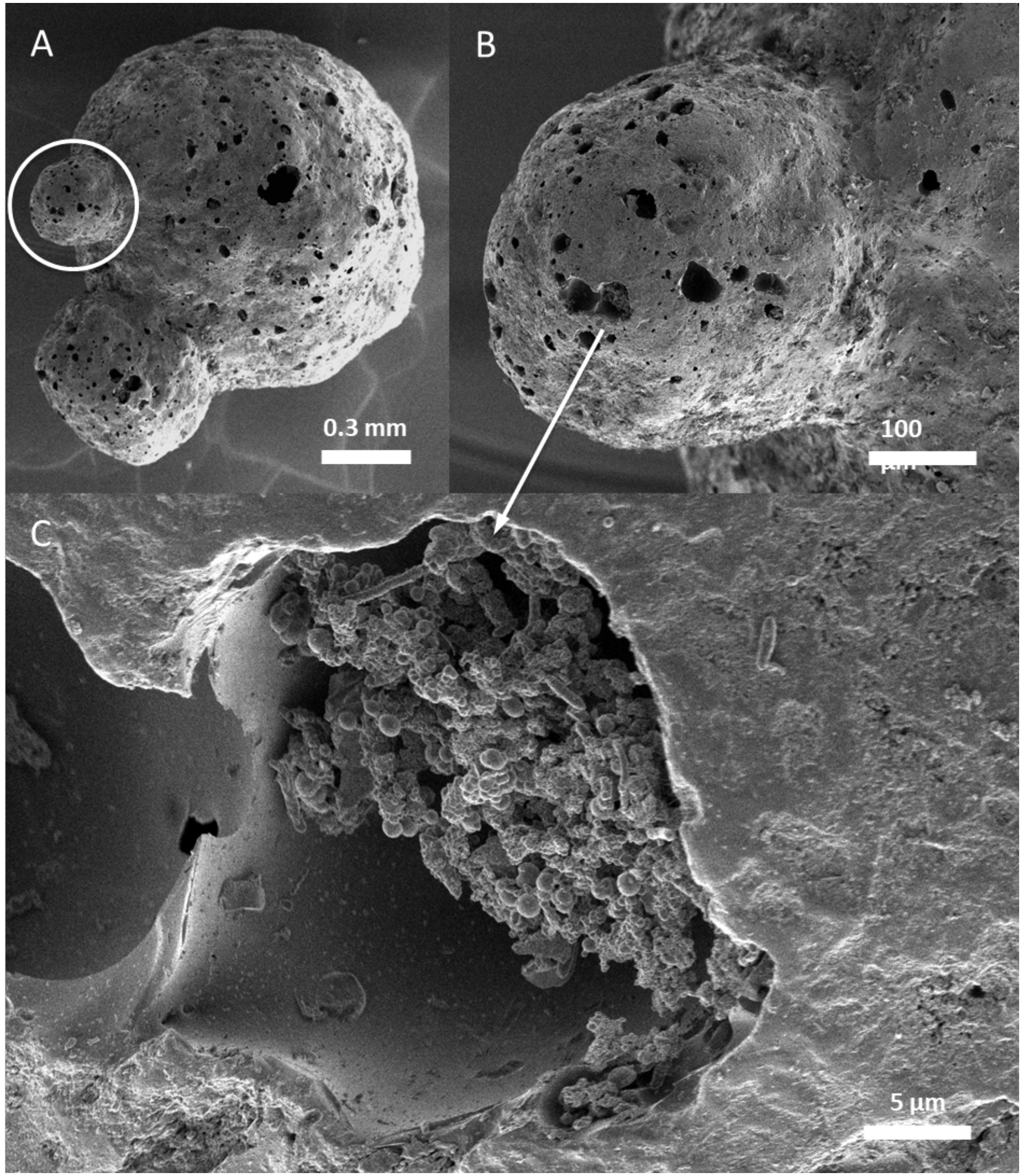


Acidophilic iron-oxidisers +
Acidophilic iron-reducers +
Acidophilic sulfur-oxidisers +
Acidophilic sulfate-reducers ?


AMAZONAS
ACRE
Perú
RONDONIA
Cercado de Lima
Cusco
Arequipa
La Paz
Bolivia
Cochabamba
Santa Cruz de la Sierra
Antofagasta
Paraguay
Salta
San Miguel de Tucumán
Asunción
Chile
Google

*** Río Azufre; a small, abandoned sulfur mine; pH~ 2,3**


HANNA
301.8 mVpH
11.37 mS/cm
1.60 pH
0.0001 MΩ·cm
484.5 ORP
7877 mg/L
56.8 %DO
9.24 PSU
3.69 mg/L DO
0.2 FNU
15.75 mS/cm
10.37 °C
Registrar
Menu
HI 9829
Multiparameter
ESC
HELP



A
B
0.3 mm
100
C
5 µm

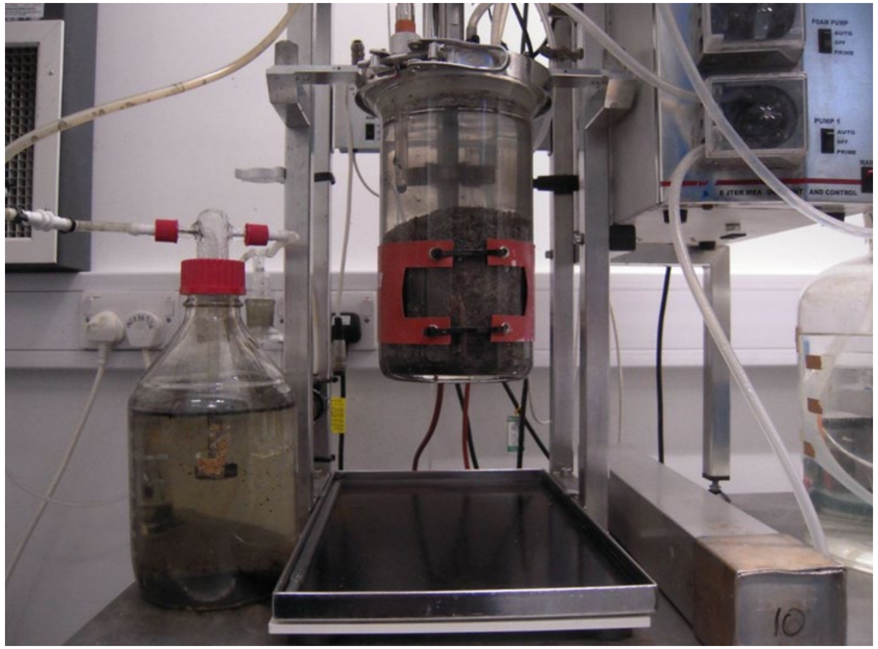
moving from this……….to this

mixed metal sludge

copper

zinc

iron

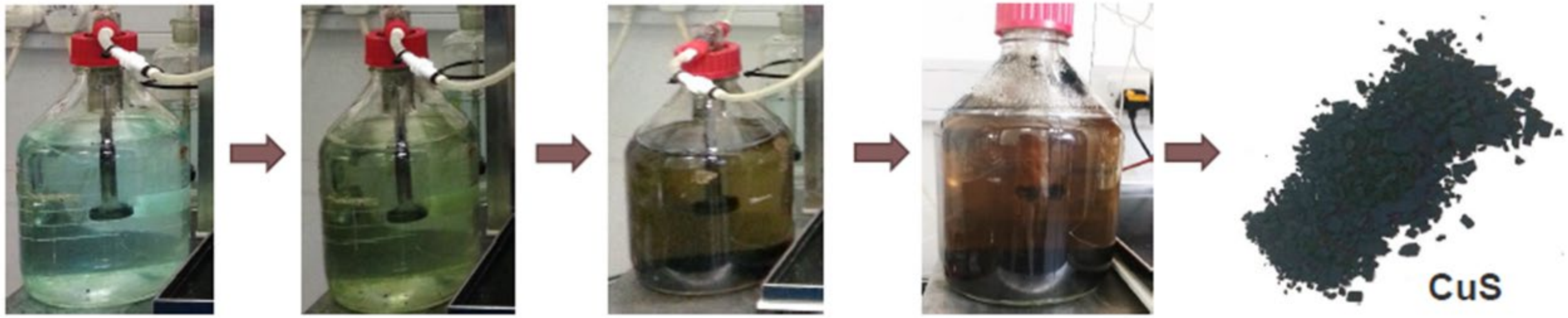


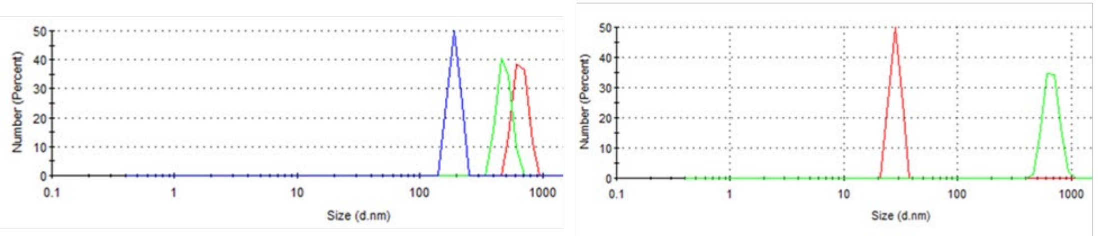
metals

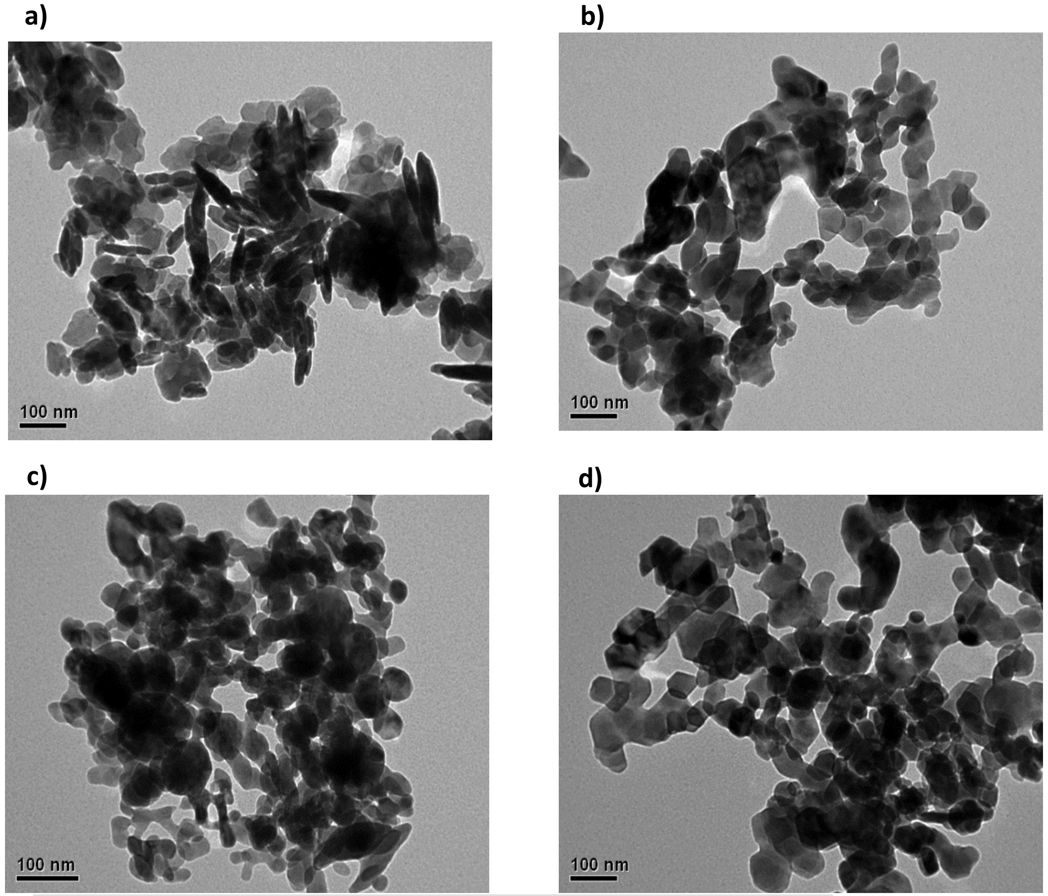
Article

Covellite (CuS) Production from a Real Acid Mine Drainage Treated with Biogenic H_2S

Patricia Magalhães Pereira Silva [1], Adriano Reis Lucheta [1], José Augusto Pires Bitencourt [2], Andre Luiz Vilaça do Carmo [1], Ivan Patricio Ñancucheo Cuevas [3], José Oswaldo Siqueira [2], Guilherme Corrêa de Oliveira [2,*] and Joner Oliveira Alves [1,*]







Contents lists available at ScienceDirect

Journal of Environmental Chemical Engineering

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

Covellite nanoparticles with high photocatalytic activity bioproduced by using H_2S generated from a sulfidogenic bioreactor

Contents lists available at ScienceDirect

Science of the Total Environment

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

Bio-recovery of CuS nanoparticles from the treatment of acid mine drainage with potential photocatalytic and antibacterial applications

Iván Nancucheo [a], Aileen Segura [a], Pedro Hernández [a], Christian Canales [a], Noelia Benito [b], Antonio Arranz [c], Manuel Romero-Sáez [d], Gonzalo Recio-Sánchez [a,*]

minerals

Article

Synthesis of Copper Sulfide Nanoparticles Using Biogenic H_2S Produced by a Low-pH Sulfidogenic Bioreactor

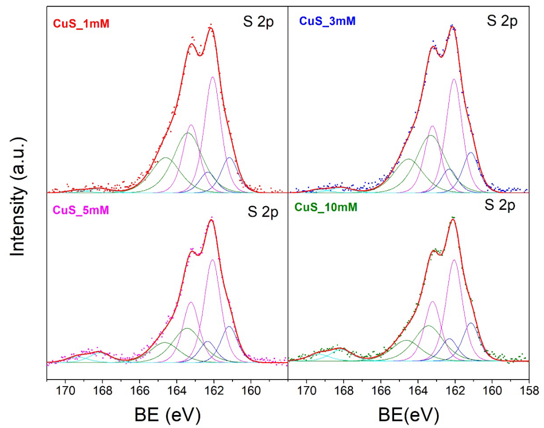
Camila Colipai [1], Gordon Southam [2], Patricio Oyarzún [1], Daniella González [1], Víctor Díaz [1], Braulio Contreras [1] and Ivan Nancucheo [1,*]

nanomaterials

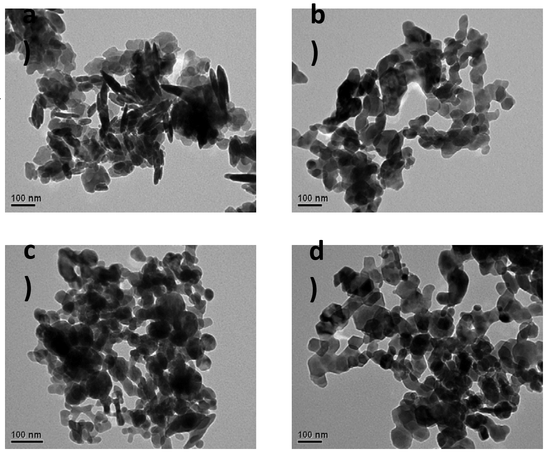
Article

Sulfidogenic Bioreactor-Mediated Formation of ZnS Nanoparticles with Antimicrobial and Photocatalytic Activity

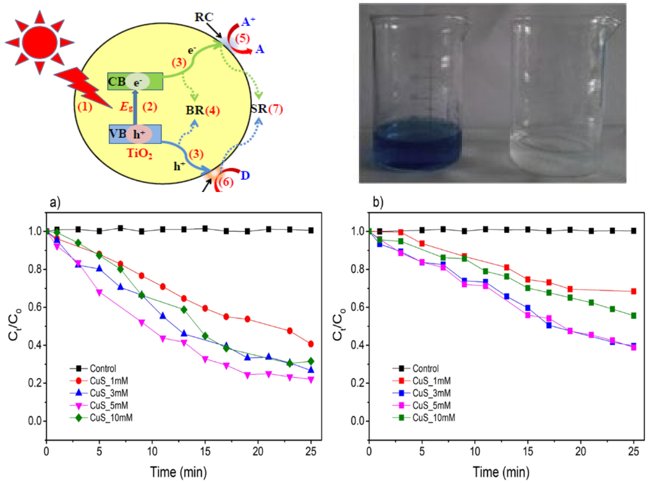
Chemical properties



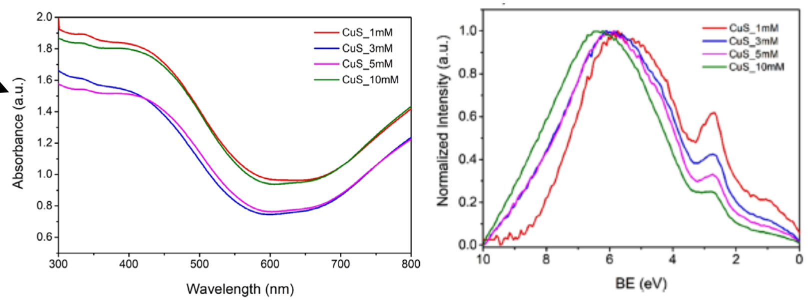
Antibacterial activity



Photocatalytic properties



Optoelectronic Properties



Direct and indirect band gap obtained from Tauc plot.

Sample	Direct band gap (ev)	Indirect band gap (ev)
CuS_1mM	2.12	1.11
CuS_3mM	2.14	1.09
CuS_5mM	2.14	1.09
CuS_10mM	2.12	1.11

For pregnant leaching solution????

- A widely used technology for processing low-grade sulfide copper deposits involves (bio) leaching the ore in heaps or dumps. The leach solution migrates through a fixed bed of ore particles to facilitate the copper dissolution

- Subsequently to bioleaching of low-grade ores, the copper is recovered from the leach liquors (Pregnant leaching solution; PLS) using solvent extraction and electro-winning (SE-EW) which is a highly energy consuming process and involves the use of high amounts of organic solvents

- Different transition metals can precipitate as sulfide minerals and since their have different solubilities, they can be selectively precipitated by fine-tuning the pH of the liquor, which controls the sulfide concentration

- This strategy is used at full scale in the Talvivaara mine in Finland, where transition metals (e.g., copper and zinc) are selectively recovered from their PLS using chemically generated H_2S

- In this study, we describe the synthesis of CuS nanostructure by feeding biogenic H_2S generated by a SRB bioreactor to a bioleach liquor containing copper.

Methodology

- The low-grade copper-bearing sulfide ore was obtained from a copper mine currently active in the Coquimbo Region in north-central Chile. The main transition metals based on the chemical composition were (i) Cu 0.79% and (ii) Fe 1.35%

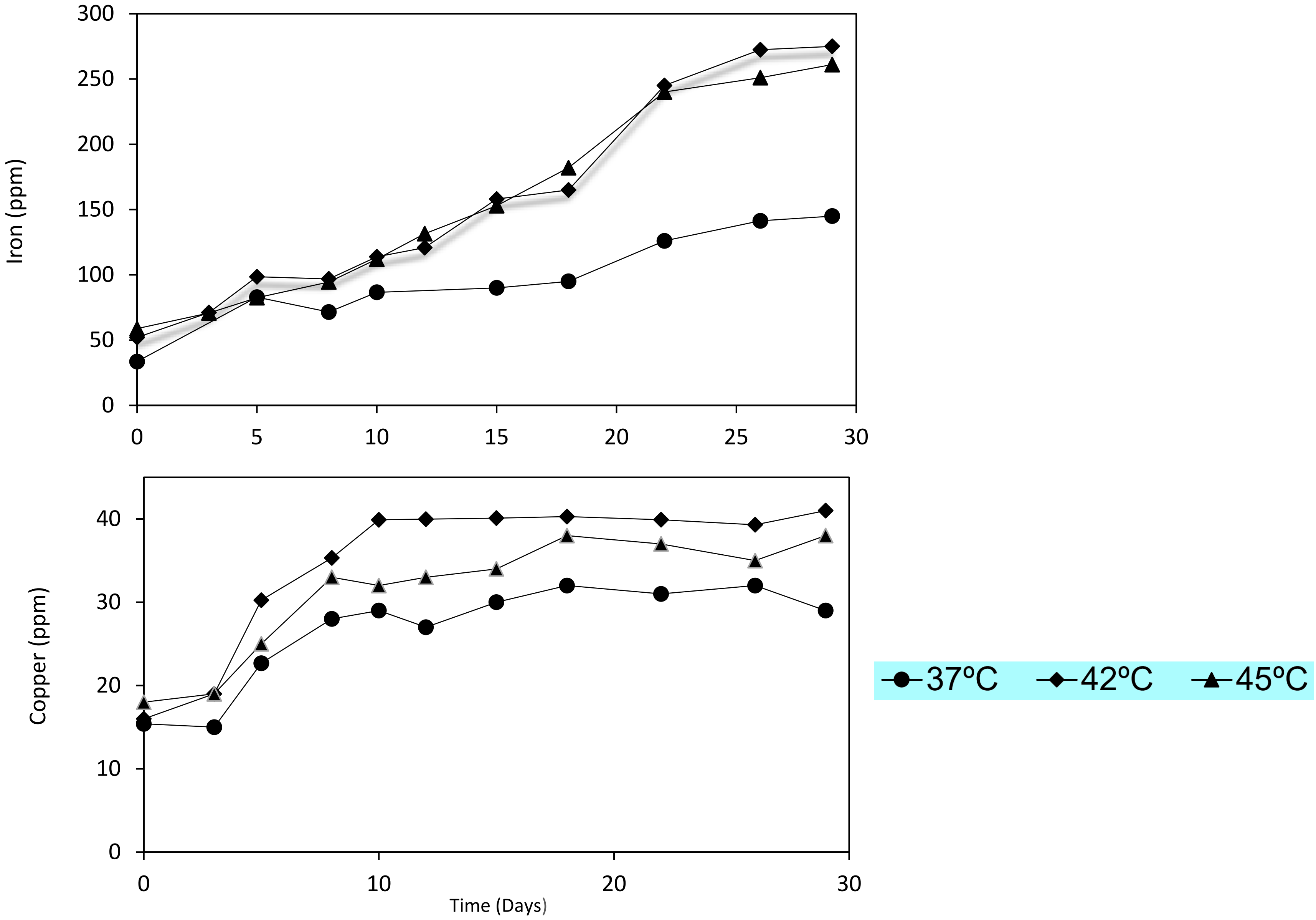
- Bioleaching experiments (1% pulp density) were carried out between 37-45 ^{o}C using a moderately thermophilic acidophilic consortium at pH 1.8, aerobically and under batch conditions

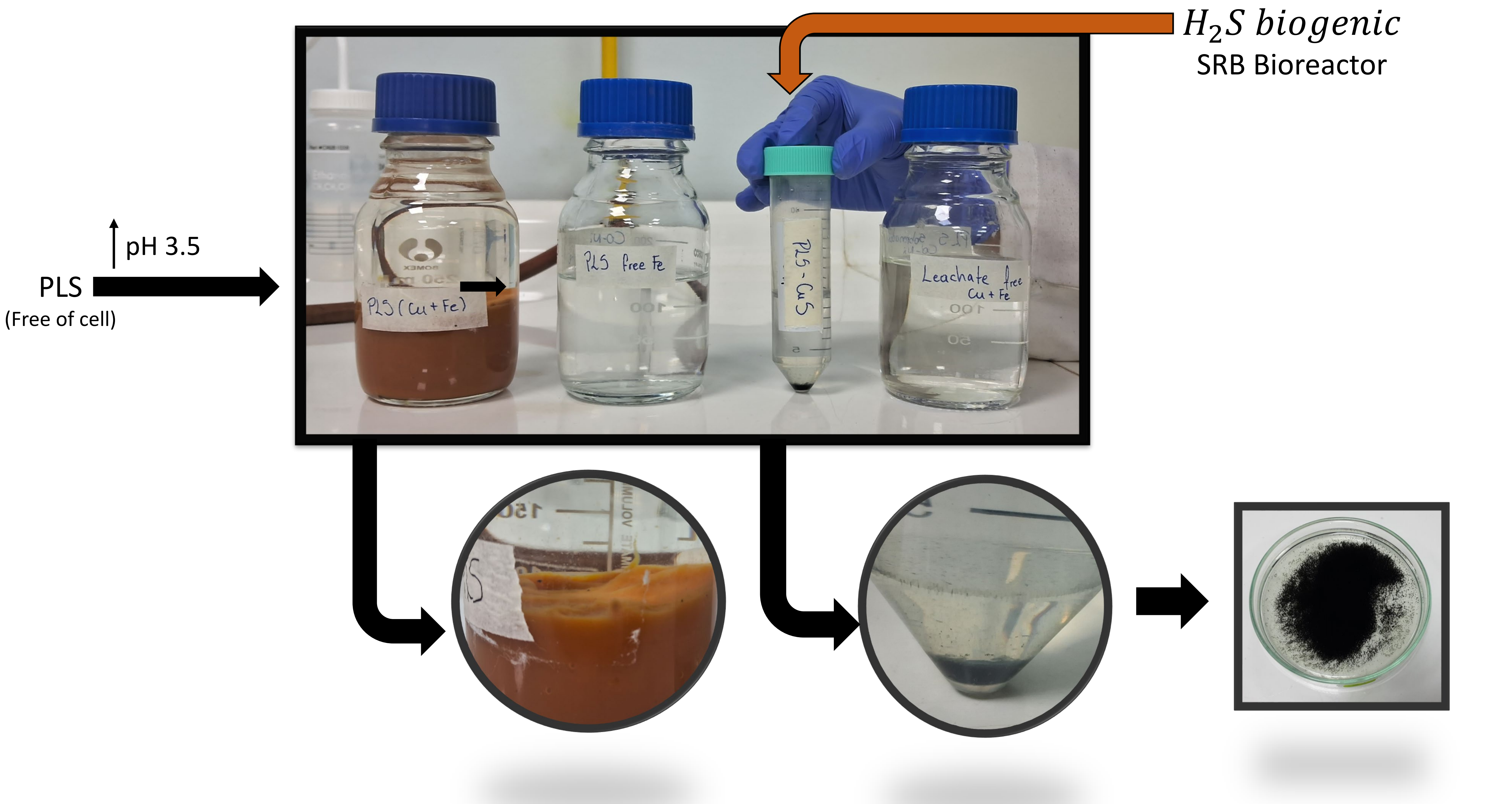
- PLS was filtered and transferred into a second vessel to increase the pH to 3.5 with NaOH to promote the precipitation of ferric iron. The iron-free PLS was contacted with biogenic H_2S produced by a low pH sulfidogenic bioreactor

- Total soluble copper and iron were determined in filtered and acidified samples using AAS. Metal sulfides produced were analyzed by SEM-EDS and XPS.

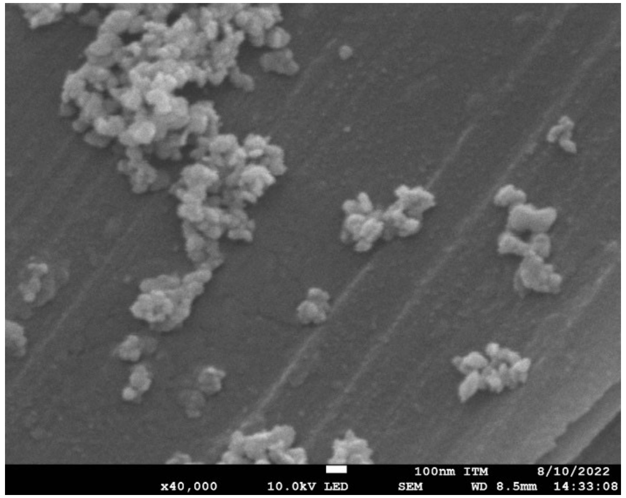
Results

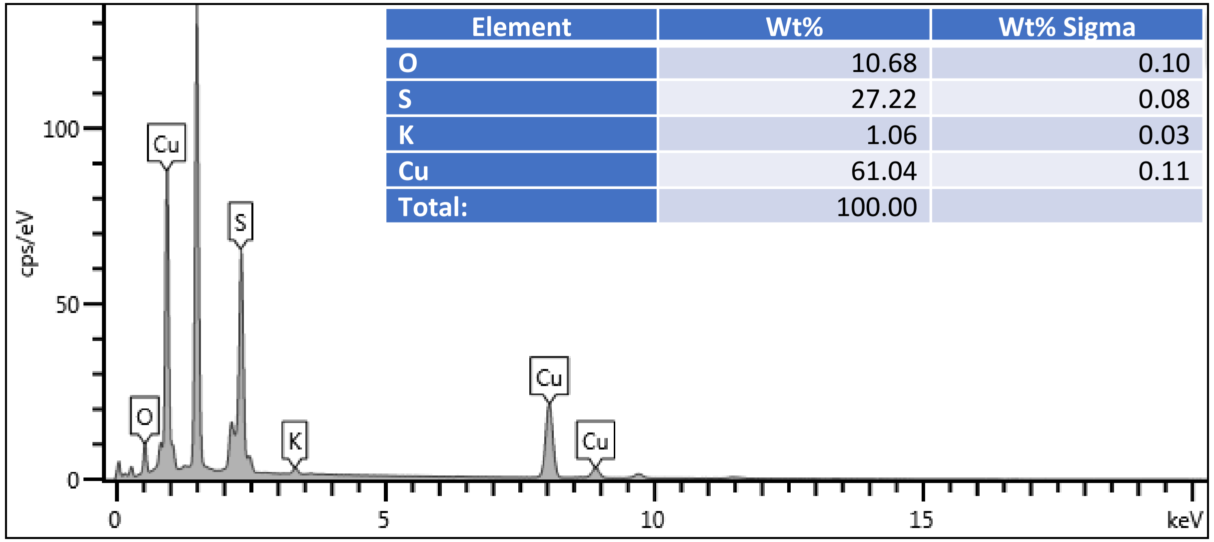
Bioleaching experiments



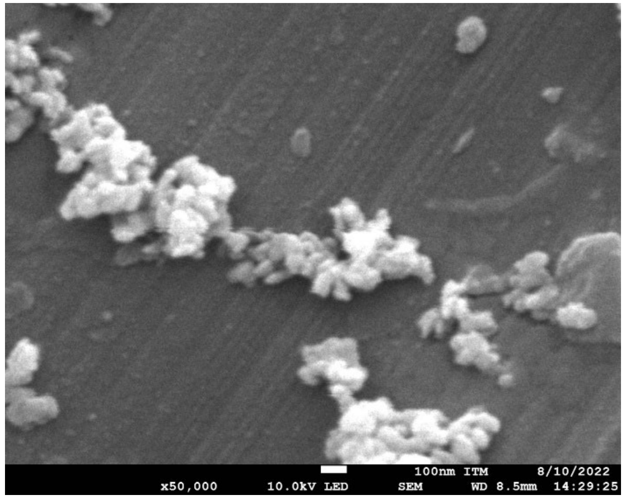


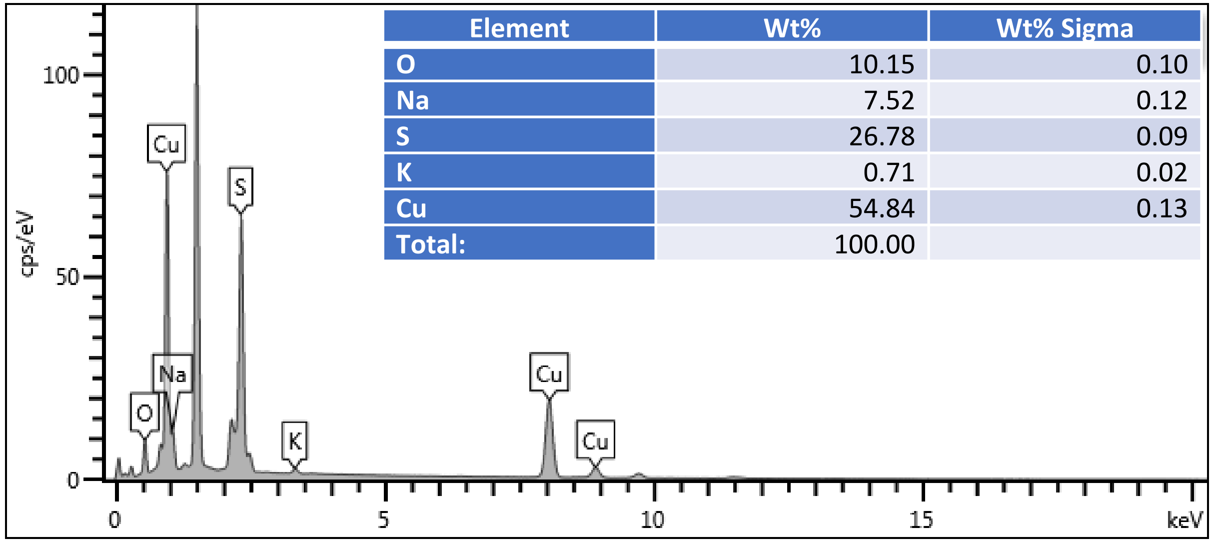
H_2S biogenic
SRB Bioreactor
pH 3.5
PLS
(Free of cell)
PLS (Cu + Fe)
PLS free Fe
PLS - CuS
Leachate free Cu + Fe





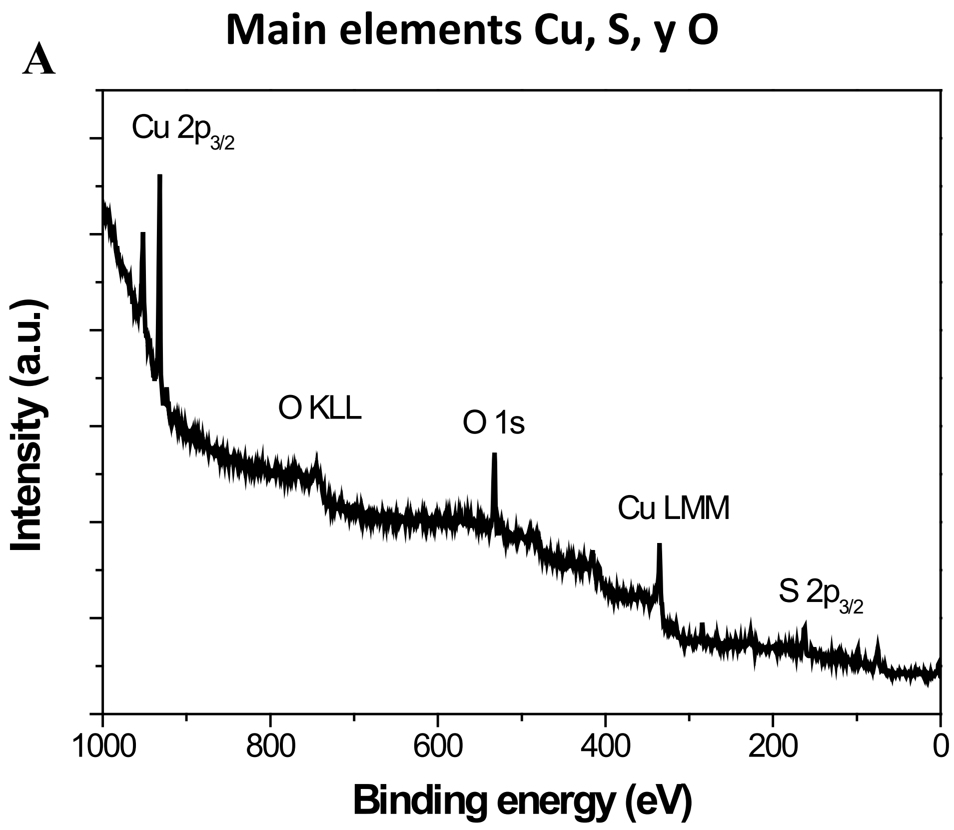
Element	Wt%	Wt% Sigma
O	10.68	0.10
S	27.22	0.08
K	1.06	0.03
Cu	61.04	0.11
Total:	100.00	

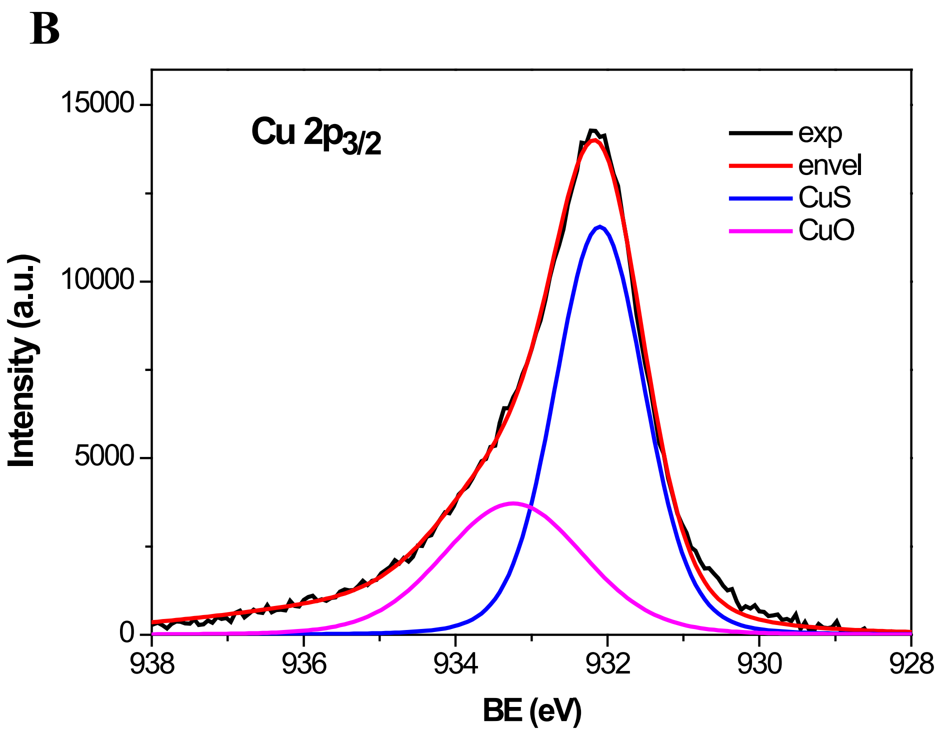




Element	Wt%	Wt% Sigma
O	10.15	0.10
Na	7.52	0.12
S	26.78	0.09
K	0.71	0.02
Cu	54.84	0.13
Total:	100.00	

SEM images of the recollected CuS precipitates, show nanoparticles with a spherical-like shape, a mean diameter of 60 nm, with tendency to agglomerate





XPS characterization was also performed to identify the kind of copper sulfide obtained (A, B). Figure B shows the Cu $2p_{3/2}$ band, in which the main contribution appears at 932.1 eV of binding energy, corresponding to CuS bonds

Conclusion

This study provides a proof of concept of an approach for recovering copper as nanoparticles from different mine water sources using biogenic H_2S. This product can be made in a scalable way free of bacterial cells harnessing a continuous sulfidogenic process to generate H_2S.

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