# Selective removal of metal ions from aqueous solutions using a biosurfactant, surfactin

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## Background

- Mining activities result in water contaminated with various metal ions.[1]
- Both the water and the metals in the water have potential value.
- Valorisation of the metals and water is possible through efficient separation.
- This work follows on the ion flotation work from Schlebusch (2023)[2], who showed surfactin can be used as a chelating agent in ion flotation.
- Surfactin is a biosurfactant and a possible alternative to synthetic surfactants for environmental remediation.[3]

## Aim and Objectives

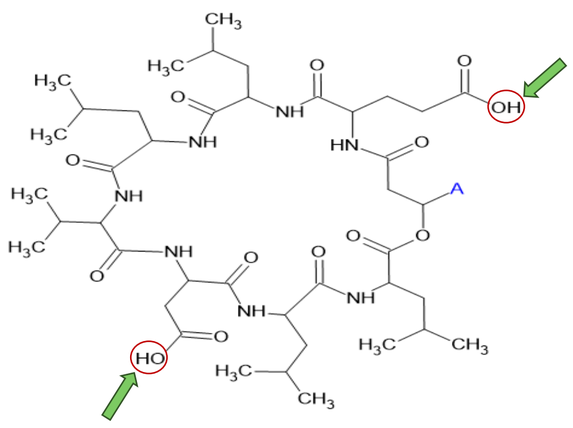
**Aim:**

Determine the applicability of biosurfactant, surfactin as a chelating agent for the selective removal of metal ions from aqueous solutions with flotation.

**Objectives:**

- Investigate the coordination of surfactin and monovalent cations.
- Determine best conditions to use surfactin as chelating agent through variation of temperature, pH and concentration of surfactin.
- Determine the effectiveness of using surfactin as a chelating and foaming agent in ion/precipitation flotation
- Determine the feasibility of using surfactin to selectively remove metal from mine wastewater.
- Investigate the potential to reuse surfactin after use in flotation.

## Surfactin Structure




+ $Co^{2+}$

*Figure: Structure of surfactin with carboxyl groups where metal cations potentially bond indicated. The blue (A) indicated the varying length carbon chain tail. Bonmatin, et al. (2024)[4] showed that surfactin takes on a horse saddle-like shape with the carboxylic groups binding with the cations in a claw-like formation.*

## Ion Flotation Equipment

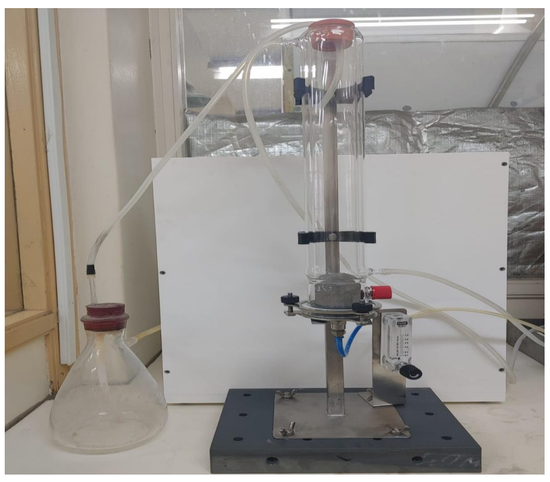


*Figure: Ion/Precipitation flotation column with heating jacket and additional vacuum pump and beaker for froth removal.*

## Results

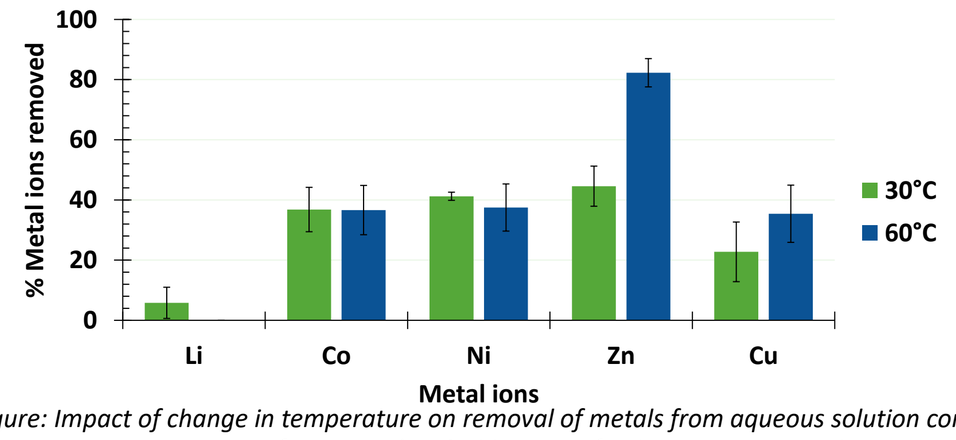



*Figure: Impact of change in temperature on removal of metals from aqueous solution containing 100 mM of one metal and 100 mM surfactin at constant pH 6.*

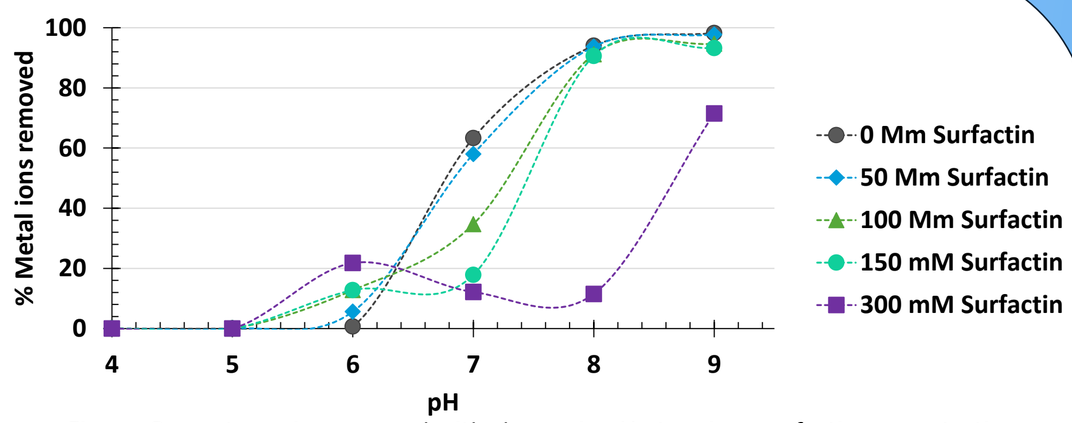



*Figure: Percentage zinc removed with change in pH at various surfactin concentrations*

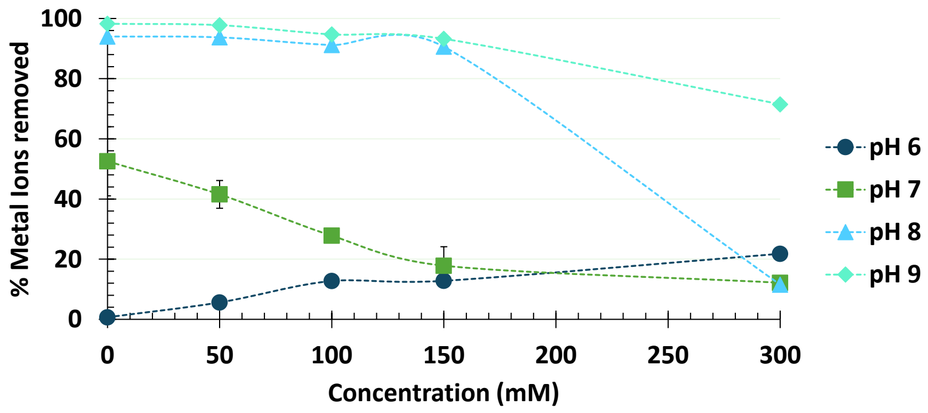



*Figure: Percentage zinc removed against changes in surfactin concentration at various pH*

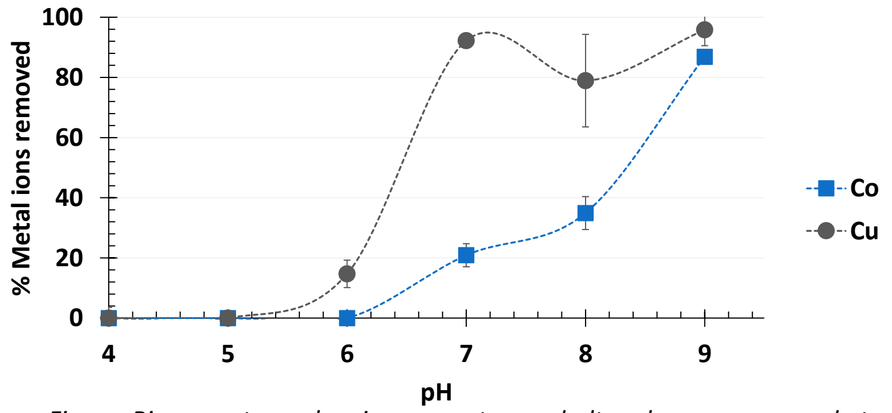



*Figure: Binary systems showing percentage cobalt and copper removed at various pH and a 1:1 surfactin to metal ratio*

## Insights

1. Changes in temperature only significantly increase removal of zinc from aqueous solutions.
2. Surfactin and lithium does not react to produce a precipitate.
3. Micellization could potentially play a role in the removal of metals during ion flotation.

## Future Work

1. Flotation experiments investigating efficiency using surfactin as frothing agent chelating agent
2. Determine whether surfactin metal complexes are insoluble
3. Investigate the efficiency of removal of metals from actual mine water containing various components

[1] R. P. Van Hille, G. A. Boshoff, P. D. Rose, and J. R. Duncan, "A continuous process for the biological treatment of heavy metal contaminated acid mine water," *Resources, Conservation and Recycling,* vol. 27, no. 1-2, pp. 157-167, 1999, doi: 10.1016/s0921-3449(99)00010-5.
[2] I. D. Schlebusch, "The application of the lipopeptide Surfactin in heavy metal extraction from mine wastewater," 2023.
[3] C. N. Mulligan, R. N. Yong, and B. F. Gibbs, "Removal of Heavy Metals from Contaminated Soil and Sediments Using the Biosurfactant Surfactin," *Journal of Soil Contamination,* vol. 8, no. 2, pp. 231-254, 2010, doi: 10.1080/10588339991339324.
[4] J. M. Bonmatin, M. Genest, H. Labbe, and M. Ptak, "Solution three-dimensional structure of surfactin: a cyclic lipopeptide studied by 1H-NMR, distance geometry, and molecular dynamics," *Biopolymers,* vol. 34, no. 7, pp. 975-86, Jul 1994, doi: 10.1002/bip.360340716.