E3B The Elements of Bioremediation, Biomanufacturing & Bioenergy Metals in Biology

Durham University · University of Kent · Manchester 1824 The University of Manchester · UKRI Biotechnology and Biological Sciences Research Council

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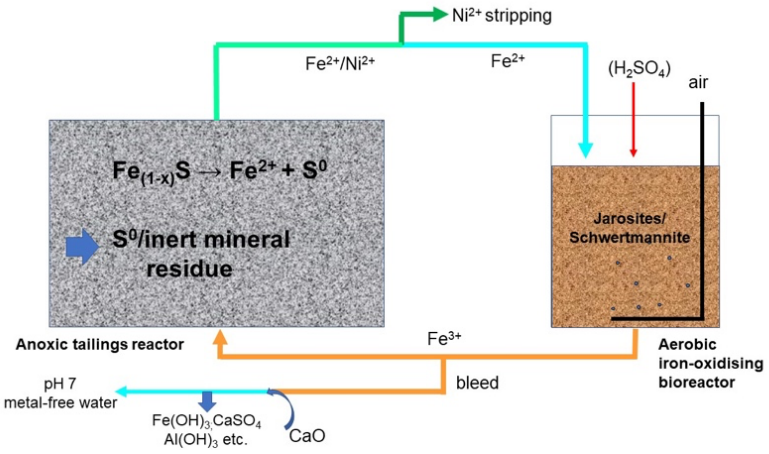
Development of a biotechnological protocol for extracting and recovering nickel from pyrrhotite waste and generating an environmentally benign solid residue

"The work done under this research project has proven that it is possible to biomine and bioleach mine tailings and release nickel in a leach solution that is amenable to nickel recovery. The work … paves the way for interesting follow-up, to demonstrate the two process variants at pilot scale."

PROJECT AIMS: Mining of metals produces waste by-products, an increasing environmental issue. This project will develop an indirect bio-processing protocol to recover nickel from historic mine wastes in Ontario, Canada that limits acid production. The project aims to develop a lab-scale protocol for indirect bio-oxidation of the nickel-bearing mineral, pyrrhotite, which would result in the target metal being released and the sulfide mineral only partially oxidised to minimise acid production. This new protocol will be compared with a conventional complete bio-oxidation protocol.



The integrated system developed in this project for indirect bioleaching of tailings, recovery of nickel and mitigation of waste waters.

RESULTS:

- Two species of acidophilic bacteria that can accelerate the oxidative dissolution of sulfide minerals (*Sulfobacillus thermosulfidooxidans* and a *Leptospirillum* sp.) were isolated from tailings samples and purified *in vitro*.
- Experiments carried out in shake flasks confirmed that the tailings were amenable to microbiological processing using defined cultures of acidophilic prokaryotes (including the indigenous strain of *Sb. thermosulfidooxidans*).
- An indirect bioleaching protocol was established for bioprocessing the tailings, aimed at limiting acid-generation while facilitating metal extraction. This involved producing an acidic solution of ferric sulfate in an aerated ferric iron-generating bioreactor, which was used to oxidise the tailings in an oxygen-free second vessel.
- Experiments were carried out in stirred aerated bioreactors that facilitated the complete oxidation of the tailings. When pH was not controlled, there was substantial accumulation of secondary ferric iron mineral deposits within the bioreactor. When the pH was maintained at about 1.6, most of the ferric iron was retained in solution. This method was particularly effective at solubilising both nickel and copper.
- The relative costs and values of metals obtained by bioleaching the tailings under fully oxidative conditions in pH-controlled and non-controlled conditions were compared.
- Potential scenarios for recovering metals and mitigating waste liquors and solids produced by bioleaching the Sudbury tailings were formulated.

Change in technology readiness level: 2 to 3

OUTCOMES & NEXT STEPS:

- Further research and future collaborations may continue via the PI's new institution, the Natural History Museum.