Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.32062

Microbes in mine waste: The influence of microbial cycles on carbon storage and critical metal immobilization in a synthetic tailings pond

DECLA MCPARLAND[1], MINGER GUO[2], IAN M. POWER[2], CAROL J PTACEK[1] AND PROF. JENINE MCCUTCHEON, PHD[1]

[1]University of Waterloo
[2]Trent University

Mines hosted in ultramafic terranes, such as those mining Cu-Ni-platinum group elements or chrysotile ores, extract gigatons of CO_2 reactive material per year that are deposited as tailings. These sites are ideal targets for ex-situ carbon capture and storage (CCS) applications, including those mediated by microbial processes. Microorganisms in tailings ponds can sequester both atmospheric CO_2 and critical metals from solution, potentially providing a concurrent remedy for CSS and critical metal recovery. Microbes promote the precipitation of carbonate minerals through the metabolic generation of alkalinity and the production of extracellular polymeric substances (EPS) to which cations, such as those leached from ultramafic tailings, can bind. During mineral carbonation reactions, metals become incorporated into Mg-carbonate phases through substitutions within the crystal lattice. This research used a ~38 L bioreactor to simulate a synthetic mine tailings pond, containing microbial mats layered over sediment inoculated with sulfate-reducing bacteria. A medium reflective of ultramafic leachate containing Mn, Cr, Ni, and elevated concentrations of Mg (2500 mg L^{-1}) was introduced to the bioreactor. Diurnal water chemistry was monitored by microbial layer over 16 weeks, paired with monthly sampling of mineral precipitates. Photosynthetic bacteria facilitated CO_2 ingress into the system, making inorganic and organic carbon available for cycling in the mat. Alkalinity and dissolved inorganic carbon were highest at night, increasing on average, respectively, by 2005 mg L^{-1} $CaCO_3$ and 337 mg L^{-1} C in weeks 0–4 and by 1095 mg L^{-1} $CaCO_3$ and 230 mg L^{-1} C in weeks 4–16. Average metal removal efficiencies of 84%, 76%, 99%, 100% (weeks 0–4) and 100%, 76%, 96%, and 100% (remaining weeks) of Fe, Mn, Ni, and Cr respectively, were achieved. Mineralization was characterized using scanning electron microscopy, X-ray diffraction, and total inorganic carbon analysis, collectively providing insight into CO_2 sequestration and metal incorporation into carbonate mineral phases. These results contribute to the current understanding of metal mobility and attenuation during secondary carbonate mineral precipitation in association with microorganisms, with applications to mine site CCS and critical metal recovery.