

Alkaline pH neutralisation and mineral weathering in Fe ore tailings driven by an acidophilic iron and sulfur oxidising bacterium, *Acidithiobacillus ferrooxidans*

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Billions of tons of iron (Fe) ore tailings are produced annually, creating challenges in mine site rehabilitation. Direct phytostabilisation of Fe ore tailings is typically unfeasible due to its harsh environment,[1] which includes strongly alkaline pH conditions, deficient available nutrients and organic matter and poor physical structure, hindering microbial and plant colonisation.[2] Eco-engineering Fe ore tailings into a soil-like substrate (or technosol) is an emerging technology to rehabilitate tailings landscapes sustainably, involving a suite of abiotic and biotic inputs (organic matter, functional microorganisms and pioneer plants). [3, 4] However, the extreme alkalinity and the lack of secondary Fe-rich minerals are critical barriers to transforming Fe ore tailings into soil.

Using a microcosm experiment amendment with elemental sulfur (S^0), *Acidithiobacillus ferrooxidans* demonstrated the capacity to generate acid that neutralised alkaline tailings and accelerated primary mineral weathering, i.e., technosol formation. The effects of biological S^0 oxidation on the weathering of alkaline Fe ore tailings were examined using several high-resolution micro-spectroscopic techniques, including synchrotron-based X-ray absorption fine structure spectroscopy (XAFS) and electron microscopy. It is found that: 1) *A. ferrooxidans* inoculum together with S^0 amendment facilitated fast neutralisation of the alkaline Fe ore tailings; 2) *A. ferrooxidans* activities induced Fe-bearing primary mineral (e.g., biotite) weathering and nano-sized secondary mineral (e.g., ferrihydrite and jarosite) formation; 3) the association between bacterial cells and tailing minerals were facilitated by extracellular polymeric substances (EPS). The behaviour and biogeochemical functionality of *A. ferrooxidans* in the tailings provide a fundamental basis for developing bacterial based technologies towards eco-engineering tailings into a soil-like substrate for sustainable mine site rehabilitation.

[1] Huang, Baumgartl & Mulligan (2012), Annals of Botany 110 (2), 223-238.

[2] Wu et al. (2019), Chemical Geology 523, 73-87.

[3] Li & Huang (2015), Critical Reviews in Environmental Science and Technology 45 (8), 813-839.

[4] Wu et al. (2019), Environmental Science & Technology 53 (23), 13720-13731.

