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Harnessing Mn-Oxidizing Microorganisms in Passive Remediation Systems

GAITAN GEHIN[1], SOFIA FLORES BARRAGAN[2] AND JASQUELIN PEÑA[2]

[1]University of California Davis
[2]University of California, Davis
Presenting Author: ggehin@ucdavis.edu

Manganese (Mn) is a ubiquitous and redox-sensitive trace element that is generally present at low concentrations in soils and water. While essential as a trace nutrient across all domains of life, aqueous Mn can pose human and environmental health concerns at elevated concentrations. Dissolved Mn is challenging to remove from waste streams due to its slow oxidation kinetics in the absence of very high pH values or microbial activity. Microorganisms can enhance Mn oxidation rates by up to five orders of magnitude, rendering it an attractive and cost-effective method to remove Mn from water. However, little is known about the environmental conditions that allow Mn-oxidizing bacteria and fungi to thrive in natural environments. In this study, we isolated Mn-oxidizing bacteria and fungi from a Mn-impacted industrial site. Using metagenomics and classic isolation methods, we aim to identify the Mn-oxidizing members within the microbial community and determine their growth requirements and Mn-oxidizing capacity, both in pure culture and artificial communities. Initial results show that Mn-oxidizing bacteria and fungi are naturally present in the topsoil. Isolated bacteria strains were bio-stimulated by the addition of amino acid-rich carbon sources, whereas the fungal isolates preferred a glucose-rich growth medium. The isolated bacteria were able to oxidize up to 200 µM Mn within 24 h, whereas the isolated fungi oxidized up to 10,000 µM Mn within 2 weeks. Mn(II) removal by bacteria increased from 200 to 4000 µM when Mn(II) was added in increments, mimicking the mass transport of a passive water treatment system. The incremental addition of Mn(II) resulted in the formation of highly redox-active Mn oxides that support autocatalytic oxidation of Mn(II). This work shows that microorganisms can be leveraged as powerful bioremediation agents that can effectively remove Mn(II) from solution through combined biotic (i.e., enzymatic oxidation of Mn) and abiotic (i.e., surface-mediated oxidation) processes. Additionally, the findings from this effort will be used to develop a bio-augmentation and bio-stimulate scheme for field-scale implementation of Mn bioremediation.