PhD Thesis Defense
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"Microbially-mediated nitrate-dependent iron oxidation for selenium bioremediation"

ABSTRACT

Selenium and nickel are widespread contaminants released by industrial activities such as mining and coal combustion. Remediation of selenium and nickel could be accomplished by nitrate-dependent iron oxidation (NDFO), a novel mechanism for microbial bioremediation of metal(loid) contaminants due to their propensity for sorption to iron minerals produced during NDFO, and, for some contaminants, the possibility of concurrent bioreduction. Selenium is one of the latter contaminants; native microbial communities commonly have the capability of reducing the toxic oxyanions selenate and selenite to insoluble elemental selenium. At the same time, the iron minerals produced by NDFO could aid selenium removal by sorbing selenite, and to a lesser extent selenate; coprecipitating with selenium; and catalyzing reduction of selenite to Se(0). The research presented in this dissertation investigated selenium removal by microbial reduction and selenium and nickel removal by NDFO.

The impact of site conditions on microbial selenium reduction was tested by constructing laboratory microcosms using biofilm and groundwater collected from four monitoring wells screened in three distinct stratigraphic units near fly ash disposal ponds in southeastern Montana. Glycerol, methanol, and molasses were tested as carbon amendments. Selenium removal was significantly impacted by stratigraphic unit, with microcosms from alluvial wells removing more total selenium than those from coal and interburden wells. Microbial community composition was correlated with site, carbon amendment, and nitrate and selenium removal. Site, carbon amendment, and microbial community were all found to potentially impact remediation efficacy.

Waste rock and influent water from a subsurface bioreactor treating mining wastewater were used to construct batch bioreactors, which were amended with either Fe(II) or methanol to test contaminant removal in NDFO vs. heterotrophic microbial communities. On average, NDFO removed more selenium than heterotrophic bioreduction. Addition of Fe(II) after carbon depletion also resulted in near-complete removal of selenium; Fe(II) addition could potentially be used to "cap" reactors with iron minerals during decommissioning in order to remove any remaining selenium and to capture remobilized selenium. Microbial taxa known to be key players in environmental NDFO enrichments were increased in NDFO reactor communities. To the best of my knowledge, this is the first research to investigate NDFO for selenium remediation.