



Evaluation of Fe(II) oxidation at an acid mine drainage site using laboratory-scale reactors

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Acid mine drainage (AMD) is a severe environmental threat to the Appalachian region of the Eastern United States. The Susquehanna and Potomac River basins of Pennsylvania drain to the Chesapeake Bay, which is heavily polluted by acidity and metals from AMD. This study attempted to unravel the complex relationships between AMD geochemistry, microbial communities, hydrodynamic conditions, and the mineral precipitates for low-pH Fe mounds formed downstream of deep mine discharges, such as Lower Red Eyes in Somerset County, PA, USA. This site is contaminated with high concentrations of Fe (550 mg/L), Mn (115 mg/L), and other trace metals. At the site 95% of dissolved Fe(II) and 56% of total dissolved Fe is removed without treatment, across the mound, but there is no change in the concentration of trace metals. Fe(III) oxides were collected across the Red Eyes Fe mound and precipitates were analyzed by X-ray diffraction, electron microscopy and elemental analysis. Schwertmannite was the dominant mineral phase with traces of goethite. The precipitates also contained minor amounts of Al_2O_3 , MgO , and P_2O_5 . Laboratory flow-through reactors were constructed to quantify Fe(II) oxidation and Fe removal over time at terrace and pool depositional facies. Conditions such as residence time, number of reactors in sequence and water column height were varied to determine optimal conditions for Fe removal. Reactors with sediments collected from an upstream terrace oxidized more than 50% of dissolved Fe(II) at a ten hour residence time, while upstream pool sediments only oxidized 40% of dissolved Fe(II). Downstream terrace and pool sediments were only capable of oxidizing 25% and 20% of Fe(II), respectively. Fe(II) oxidation rates measured in the reactors were determined to be between 3.99×10^{-8} and $1.94 \times 10^{-7} \text{ mol L}^{-1} \text{ s}^{-1}$. The sediments were not as efficient for total dissolved Fe removal and only 25% was removed under optimal conditions. The removal efficiency for all sediments decreased as residence time decreased and as water column depth increased. Control reactors with Co-60 irradiated sediments showed an increase in Fe concentration as a result of dissolution of the sediments; thus, it was concluded that Fe(II) oxidation in the reactors was a result of biological processes and not abiotic oxidation. It was also concluded that Fe(II) oxidation and removal rates were dependent upon geochemical gradients (pH, Fe(II) concentration) rather than depositional facies. Fluorescent in situ hybridization was also performed on field and reactor samples to determine which microbial communities were responsible for the highest Fe(II) oxidation rates.