Quantification of Iron Reoxidation in Microbially Reduced FRC Sediments

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We are reporting preliminary results of a new project initiated in December of 2004 entitled "Reduction and Reoxidation of Soils During and After Uranium Bioremediation; Implications for Long-Term Uraninite Stability and Bioremediation Scheme Implementation." The proposed research focuses on the conditions and rates under which uranium will be remobilized after it has been precipitated biologically, and what alterations can be implemented to increase its long-term stability in groundwater after the injection of an electron donor has been discontinued. Furthermore, the proposed research also addresses short-term iron reoxidation as a mechanism to enhance/extend uranium bioremediation under iron reduction, without its remobilization.

Microbial reduction of iron has been shown to be important in the transformation and remediation of contaminated sediments. Reoxidation of microbially reduced iron may occur in sediments that experience cycles of oxidation and reduction and can thus impact the fate and extent of contaminant remediation, yet little research has been performed to quantitatively measure the rate of iron re-oxidation and changes in iron phases. The purpose of this initial phase of this research was to measure rates and extent of iron oxidation in a flow-through column filled with previously reduced sediment. In addition, the iron phases in the reoxidized sediment were compared to the original sediment as well as the biologically reduced sediment.

An unsaturated background FRC sediment containing both Fe(III)-oxides and silicate Fe(II)/Fe(III) was biologically reduced in phosphate-buffered (PB) medium at circumneutral pH utilizing the indigenous microbial population of the sediment in a long-term (500-day) column experiment in which acetate was supplied as the electron donor. Long-term iron reduction resulted in partial reduction of silicate Fe(III) and some goethite biotransformation, based on Mössbauer spectroscopy study. There was no evidence of vivianite formation, a ferrous phosphate. This reduced sediment was treated with an oxygenated PB solution in a flow-through column, resulting in the reoxidation of 38% of the biogenic Fe(II), mainly silicate Fe(II). Additional batch experiments show that the Fe(III) in the reoxidized sediment was more quickly reduced compared to the initial sediment, indicating that reoxidation of sediment not only regenerated Fe(III) but also enhanced iron reduction compared to the initial sediment and may be a viable method to extend iron-reducing conditions during in situ bioremediation scenarios.