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Reduction of Uranium (VI) in Sediments with Complex Organic Electron Donors

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Abstract:
In situ bioremediation of a highly uranium-contaminated aquifer was conducted in the US DOE ERSP IFC site, Oak Ridge, TN. In order to achieve sustainable uranium(VI) reduction and long-term stability of the reduced area, slowly degrading, complex organic electron donors were tested for U(VI) reduction. Microcosm tests were performed to study the feasibility under anaerobic, ambient temperature conditions using long-chain fatty acid, oleate or emulsified vegetable oil as electron donor in comparison with ethanol. Uranium contaminated sediments from the IFC site were used for the tests. The tests also examined the impact of concentrations of calcium and sulfate on U(VI) reduction. Both oleate and the oil were degraded by indigenous microorganisms with acetate as a major product but at a much slower rate in comparison with ethanol. The rapid removal U(VI) from the aqueous phase was correlated with acetate production and sulfate reduction. U(VI) reduction to U(IV) was confirmed by X-ray near-edge absorption spectroscopy (XANES) analysis. The extent of U(VI) reduction in the solid phase was influenced by the presence of calcium ions and bicarbonate in the aqueous phase. Higher calcium concentrations resulted in a higher fraction of calcium uranyl carbonate which was resistent to reduction and a relatively lower U (VI) reduction efficiency. Initial sulfate concentration (5 vs. 9 mM) influenced residual aqueous U concentration but more U(VI) in sediments was reduced with higher initial sulfate. Methane production was observed. Based on the microcosm test results, field tests with the emulsified vegetable oil are being conducted at the IFC Oak Ridge site. Analysis of bacterial populations in microcosms using 16S rRNA gene libraries showed a significant increase in *Deltaproteobacteria* compared to unamended controls. A 16S clone type similar to several *Desulforegula* spp. prevailed in recovered clones in the libraries originating from both oleate- and oil-amended sediments. Iron reducers such as *Geobacter* spp. were also present, but in much lower abundances.
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