Laboratory and In-Situ Biostimulation of Uranium Reduction and Immobilization using Long Chain Fatty Acids-containing Organics

as Sustained Release Electron Donors at the Oak Ridge IFC site

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INTRODUCTION

Microbial bioremediation of U(VI) in DNAPL (dense non-aqueous phase liquid) contaminated sites remains a major challenge. In situ biostimulation (SRS) and bioaugmentation can be used to enhance microbial reduction of U(VI) in situ. Both SRS and bioaugmentation are dependent on electron donor (ED) concentrations. The objective of this study is to develop a SRS strategy which can stimulate microbial reduction of U(VI) using long-chain fatty acid ED.

OBJECTIVES OF THE STUDY

- Selection of appropriate electron donor using microcosm tests.
- Characterization of bioreduction process and microbial communities involved.
- Geophysical characterization of test site using borehole tracer, GPR and field test in situ biostimulation by injection of electron donor.

SITE AND BACKGROUND OF THE TESTS

SRS has been injected to the subsurface. Reduction of nitrate, Fe(III), sulfate and U(VI) occurred sequentially. U(VI) reduction to U(IV) was confirmed by XANES analysis. Filtered groundwater and surcharged sediment samples have been taken over the full time-course.

SLOW RELEASE ELECTRON DONOR SOURCE

Oleate and emulsified vegetable oil (SRS) were selected as a slow release electron donor source for microcosm test for comparison with ethanol. Oleate is a long- chain fatty acid (C18:1, MW 282.26) with low water solubility and a density of 0.916 g/cm3. Under anaerobic conditions, oleate is degraded via β-oxidation to H2 and CO2, with low water solubility and a density of 0.916 g/cm3. The high groundwater calcium concentrations are less favorable for U(VI) reduction.

MICROBIOLOGICAL TEST AND COMMUNITY ANALYSIS

Microcosm tests were conducted under ambient temperature condition with sediment (350 mg U/kg) and groundwater (initial sulfate concentration 1.0 mM, pH 6.9, calcium 2.2 mM) from Area 2. All three electron donor supported U(VI) reduction with similar total reduced U(VI)/U(IV) concentrations observed during tracer test. Higher bromide concentration observed during tracer test. The background of geochemistry and microbiology has been investigated. The results of in situ test have been confirmed with the understanding flow path experiments (Figure 10), and the design for in-situ SRS biostimulation.

COLUMN EXPERIMENTS FOR SRS ADSORPTION

Adsorption tests were conducted starting after two week incubation. High sulfate concentration resulted in high groundwater calcium concentrations. The background of geochemistry and microbiology has been investigated. The results of in situ test have been confirmed with the understanding flow path experiments (Figure 10), and the design for in-situ SRS biostimulation.

FIELD BIOSTIMULATION FOR U(VI) REDUCTION

Field test was conducted on Feb 3, 2006 SRS was injected to 35% solution and 35% emulsified vegetable oil. U(VI) reduction occurred within one week and sulfate concentration decreased after 4 weeks. Active bacterial communities were observed after 4 weeks. Sediment samples were taken from several downgradient monitoring wells and analyzed via XAS. Later, the analyses confirmed U(VI) reduction to U(IV). Filtered groundwater and surcharged sediment samples have been taken over the full time-course.

SUMMARY

- Slow release electron donor: oleate and emulsified vegetable oil (SRS) support U(VI) reduction in GEMICC sediment at significantly slower rate relative to ethanol. The reactors rate of SRS was slower and was sustained longer than oleate.
- Microbial communities related U(VI) reduction were stimulated by electron donor sources. Microbial communities developed depend on electron donor source and sulfate concentration. Highly diversified community was found with SRS.
- Column test showed electrical conductivity increase related to SRS injection as well as degradation. The sediments of GEMICC Area 2 were shown to have high affinity for SRS. The hydrology of test area has been characterized using bromide tracer and surface electrical methods. The background of geochemistry and microbiology has been investigated.
- SRS has been injected to the subsurface. Reduction of nitrate, sulfate and U(VI) was observed sequentially. U(VI) reduction to U(IV) was confirmed by XAS analysis.