Biostimulation of In Situ Uranium Reduction at the NABIR Field Research Center Using a Nested Recirculation Scheme and Aboveground Groundwater Conditioning

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This project is designed to assess the rate and extent of uranium reduction in a complex field environment under controlled conditions. Previously we characterized hydrogeology, geochemistry, and microbiology at a site in Area 3 of the NABIR Field Research Center at Oak Ridge, Tennessee. This site is adjacent to the S-3 pond cap and contains high levels of uranium (~30 mg/L in the water with 300–400 mg/kg on the soil), nitrate (8–10 g/L), aluminum (~0.5 g/L), low pH (~3.6), plus a range of other metals and volatile organics. We have installed two injection wells and two extraction wells along a line parallel to the direction of background groundwater flow, and have screened over a region of high flow. One well pair defines an outer flow cell. The second well pair defines an inner flow cell nested within the outer cell. The outer cell is connected to an aboveground treatment system that includes a vacuum stripper to remove volatile organics and dissolved gases, a two-step precipitation scheme to remove aluminum and calcium, and a fluidized bed reactor to remove nitrate.

Hydraulic conductivity and residence time distributions were determined from breakthrough profiles for a bromide tracer study. Rates of desorption of ions from the soil matrix were determined by modeling the rebound of ion concentrations after the tracer study. The treatment zone was then flushed with acidified tap water to displace aluminum and nitrate, and pH of the inner cell was adjusted to create an environment suitable for U(VI) reduction. Following pH adjustment, x stimulation of U(VI) reduction was initiated by intermittent addition of ethanol into the inner cell. This process is still ongoing. We expect to be able to alter rates of U(VI) reduction by manipulating biomass and carbonate concentrations.

To provide more unambiguous interpretation of our field results, we have performed batch and column microcosm studies, and we have evaluated U(VI) removal under a range of pH conditions. Experiments are ongoing to identify microorganisms responsible for U(VI) reduction, and to quantify rates of reduction and desorption.