In Situ Chemical Oxidation followed by Enhanced Reductive Dechlorination for Treatment of Chlorinated Solvents in Groundwater

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Background/Objectives. Chlorinated solvents can be oxidized by chemical oxidants and can be reduced by chemical or biological reduction. Oxidation results in carbon dioxide, chloride ions and water while reduction successively removes chlorine atoms until a non-chlorinated end product is reached. Chemical oxidation raises the oxidation-reduction potential (ORP) of the area while biological reductive dechlorination can occur only under highly reducing conditions. Chemical oxidation with sodium persulfate causes elevated sulfate concentrations. Sulfate can act as a competing electron acceptor and inhibit reductive dechlorination. Based on these facts it would seem that chemical oxidation and reductive dechlorination are opposing processes and could not be applied at the same site, however a successful in situ chemical oxidation (ISCO) treatment was performed followed by polishing by enhanced reductive dechlorination (ERD).

Chlorinated solvents were present at a former oil recycling processer site in both the bedrock and overburden aquifers. In situ treatment was performed on both aquifers. This presentation focuses on the treatment performed in the bedrock aquifer with transport primarily through secondary porosity (i.e., fractures, joints).

Approach/Activities. Following the completion of a successful laboratory treatability study, ISCO was selected for treatment of the bedrock aquifer. ISCO was selected due to the low natural oxidant demand of the bedrock and the fact that an aqueous chemical oxidant could be injected into bedrock fractures. Sodium hydroxide (NaOH) activated sodium persulfate was injected quarterly into the bedrock injection wells for 3 years. Prior to the last injection, natural attenuation parameter data were collected from the bedrock monitoring wells. Based on these data the ISCO injections were discontinued, and after a period of 6 months to allow oxidizing conditions to dissipate, enhanced reductive dechlorination treatment was initiated by the injection of sodium lactate into the bedrock injection wells. Monitoring was performed and treatment was assessed.

Results/Lessons Learned. ISCO treatment resulted in a reduction in the mass of chlorinated solvents present in the treatment areas with many of the compounds reduced to below the Site-specific remediation goals. Natural attenuation data collected before the last ISCO injection event showed that complete dechlorination of volatile organic compounds (VOCs) to ethene and ethane was occurring in the bedrock wells, and when not affected by the oxidant injections, conditions appeared to be anaerobic. This suggested that ERD treatment would work with, rather than against, the natural conditions present in the bedrock aquifer. There was an initial concern that elevated sulfate concentrations detected in the bedrock injection wells previously used for ISCO injections would inhibit ERD. However, sulfate concentrations decreased rapidly after lactate was injected reaching non-detect levels in some of the wells; therefore, the effect of the sulfate on ERD appeared to be temporary at most. Monitoring data suggest that after the lactate injection anaerobic conditions were enhanced in the bedrock zone. Decreased concentrations of VOCs were observed in all injection wells that still contained VOCs after the ISCO injections. Rebound that occurred after discontinuing the ISCO injections was also treated. A radius of influence of 200 feet from the injection wells was observed in monitoring wells with VOCs with treatment of VOCs observed in all monitoring wells that still contained

VOC concentrations above groundwater remediation goals. These data show that biological treatment can be enhanced successfully as little as 6 months after ISCO treatment with means that facultative and anaerobic bacteria were not killed by the ISCO injections.