Chlorinated Solvents Source Area Remediation: Combining Biotic and Abiotic Enhanced Reduction Approaches

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Background/Objectives. This case study presents remediation of soil and groundwater impacted with trichloroethene (TCE) beneath a former degreaser area in an active manufacturing plant located in southwest Michigan. The site aquifer was subdivided into two zones: an Upper-Middle Zone of moderately conductive fine- to medium-grained sand (15 to 27 feet below floor level - bfl), and a Lower Aquifer Zone characterized by less conductive, silty sand to silt (27 to 30 feet bfl). Most of the chlorinated volatile organic compound (CVOC) mass was adsorbed in the Lower Aquifer Zone. Both aquifer zones were initially remediated with enhanced reductive dechlorination (ERD) utilizing emulsified oil injections followed by inoculation with *Dehalococcoides*. Groundwater monitoring over 10 years showed dramatic (over 98%) reduction in CVOC concentrations in the impacted area; however, significant TCE concentrations persisted despite additional injections in the primary source area. It was suspected that TCE toxicity was impairing biologically-mediated reduction of TCE. Due to this apparent toxicity limitation for biological ERD, a new strategy was implemented in the source area. The objective of the work presented herein was to promote source area remediation by augmenting the existing treatment with injections to enhance abiotic pathways for CVOC reduction.

Approach/Activities. Supplemental ERD injections, composed of a combination of lecithin, ferrous sulfate, and a buffer, were selected in an attempt to form iron sulfide minerals *in situ* and establish an alternate abiotic reductive pathway in the source zone. This strategy was selected over ZVI injections because of the difficulty inherent in low pressure ZVI injections. Prior to the injection, bench testing was conducted using soil and groundwater collected from the source area to determine the amount of buffering agent needed to prevent a severe drop in pH that could adversely affect the biota present at the source area. A total of 226 gallons of the lecithin, ferrous sulfate, and groundwater solution, buffered with potassium bicarbonate, was directly injected into 6 direct-push locations surrounding the area with the greatest TCE concentrations. The solution was injected in the Lower Aquifer Zone, 30 to 40 feet bfl.

Results/Lessons Learned. Initial results have demonstrated a significant reduction of TCE in the primary source area (250,000 to 20,900 µg/L) has occurred since the injection 2.5 years ago with no significant alteration of pH. Acetylene, an indicator of potential abiotic reduction of chlorinated solvents, has been detected in the source area as well as cDCE and VC, which are intermediate products of biological reduction of TCE to ethene/ethane. These preliminary results indicate that both abiotic and biotic reductive pathways are relevant for TCE degradation in the source area. Although not always considered, abiotic degradation can contribute, at least in part, to chlorinated solvent remediation efforts.

Continued monitoring of these chemicals, as well as mass balance and statistical analysis will confirm the efficacy of combining biotic and abiotic enhanced reduction approaches to treat chlorinated solvents. In addition, future data will clarify which dechlorination mechanism is predominant at this site.