Bioaugmentation for Enhanced Anaerobic Degradation of a Mixed cVOC Plume on a Commercial Property

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Background/Objectives. An in situ bioremediation program addressed groundwater contaminated with a mixture of chlorinated volatile organic compounds (cVOCs) at a former manufacturing facility in northern New Jersey. This coating facility applied polyester and cellulose substrates utilizing both solvent-based and water-based materials. The contaminants of concern (COC) were 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethane (1,1-DCA), and 1,1-dichloroethene (1,1-DCE), in addition to a localized petroleum hydrocarbon (toluene) plume. The former facility operated twelve underground storage tanks (USTs) to store chemicals including 1,1,1-TCA, methyl ethyl ketone, methyl isobutyl ketone, denatured ethanol, ethyl alcohol, toluene, xylene, and various solvent wastes. Currently, the property houses a medical services building. In 2009, two monitoring wells within a presumptive source area had cVOC concentrations well above groundwater quality standards (GWQS). A natural attenuation remediation approach was deemed unviable, and an active remediation project was initiated in 2017.

Approach/Activities. A laboratory treatability study assessed the potential to biodegrade target cVOCs in site groundwater. The microcosm study showed that cVOCs can be rapidly transformed to non-toxic end products by adding a combination of a nutrient-rich yeast fermentation byproduct, a soybean oil-based electron donor and a culture of organohalide respiring bacteria rich in *Dehalobacter* and *Dehalococcoides*. Parameters obtained from the bench-scale test were used in design of the full-scale site remediation.

After the initial design and remedial action work plan submittal, the design and implementation of the full-scale injection program was modified based on review of groundwater monitoring data from newly installed wells and discussions with the property manager and owner. Specifically, given the sensitivity of onsite medical operations, and high pedestrian traffic, the injection scope was modified to maximize targeted injections in a condensed timeframe and also minimize permanent injection wells and multiple mobilizations. The approach consisted of injecting amendments, selected and optimized in the bench-scale test, through 27 temporary injection points first addressing chlorinated solvents in the aquifer. The hydrocarbon contamination will be addressed through future remediation efforts.

Results/Lessons Learned. Groundwater sampling 3 and 6 months after amendment injections revealed that cVOC concentrations in source area groundwater actually increased, with a record 1,1,1-TCA concentration of 140 mg/L measured in a new well in the source area 9 months post-injections. These findings suggest that injections disturbed and desorbed an unaccounted-for contaminant mass in the matrix and that electron donor demands were underestimated. Fortunately, geochemical and biological data indicated a highly reducing environment with abundant anaerobic bacteria, including *Dehalobacter*; which was still propagating 12 months post-injections. Temporal changes in volatile fatty acids has demonstrated that electron donors are favorably fermenting, yet the carbon source is depleting faster than anticipated. Additional substrate injections may be a required to complete the dechlorination process. Although dissolved concentrations of 1,1,1-TCA initially increased, the increases in degradation

byproducts, including chloroethane and ethene, are positive indications that a fast and complete reductive dechlorination pathway has been established with this bioremediation event.