How Much Carbon and Bioaugmentation Are Needed for Effective Reductive Dechlorination?

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Background/Objectives. The purpose of the in situ bioremediation (ISB) system was to promote biodegradation of chlorinated ethenes in groundwater via biostimulation in combination with bioaugmentation. The groundwater has displayed elevated concentrations (> 1 milligram per liter) of total chlorinated volatile organic compounds (cVOCs) including: tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), and 1,1-dichloroethene. Background concentrations of total organic carbon are low, less than 3 milligrams per liter (mg/L) and dissolved oxygen ranges from anaerobic to aerobic conditions.

Approach/Activities. A series of injections were performed in three separate locations, which showed elevated cVOC concentrations. A major benefit of the injection system was to optimize and repurpose various site wells. The injection amendments included: biostimulation with a quick release carbon substrate and an emulsified oil substrate to sustain the microbial population for an extended time period and support reductive dechlorination, and bioaugmentation with *Dehalococcoides* microbial consortium to promote complete reductive dechlorination of the chlorinated ethenes. A buffer was also injected to mitigate pH reduction in groundwater. A monitoring program was developed to evaluate the effectiveness of the treatment system, which included field parameters, cVOCs, geochemical parameters and key microbial populations and genes.

Results/Lessons Learned: Within less than 4 months after injecting the carbon substrates and *Dehalococcoides*, there was a one to three order of magnitude increase in total organic carbon (TOC) in the impacted groundwater, which corresponded to a decrease in oxidation reduction potential (ORP) to as low as -354 millivolts. The carbon substrate impacted areas showed ORP less than -243 mV. The competing electron acceptors, oxygen, nitrate and sulfate were reduced to less than 1.3 mg/L, 0.7 mg/L and non-detect (<10 mg/L), respectively, demonstrating that conditions were now appropriate for reductive dechlorination. TCE was decreased by more than 85% in two of the areas and more than 65% in the third area. In addition to the TCE reduction, there was also a significant reduction in cis-1,2-DCE and vinyl chloride (VC) in one area. However, in two other areas there was a major increase in cis-1,2-DCE and VC. The pH of the groundwater ranged from 5.8 to 6.5 and may need further buffering to provide amenable conditions for *Dehalococcoides*.

This presentation will discuss the varying hydrogeologic, microbiological, nutrient, and geochemical conditions of the site groundwater over time and how these challenges were addressed to maximize biodegradation of the chlorinated ethenes in groundwater.