What Are the Key Data Needs to Demonstrate Effective In Situ Bioremediation of Chlorinated Solvents?

Laurie LaPat-Polasko (llapat@matrixneworld.com)
(Matrix New World Engineering, Phoenix, AZ, USA)
Georgia Waters (Matrix New World Engineering, Phoenix, AZ, USA)

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 in the source area. The groundwater contains elevated concentrations (> 10 milligrams per liter) of various chlorinated volatile organic compounds (cVOCs): tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), and 1,1-dichloroethene. Elevated levels of 1,4-dioxane have also been observed in some areas of the site. The site is located in a groundwater discharge zone where groundwater moves not only laterally along fractures and bedding planes but also upward from depth.

Approach/Activities. A pair of recirculation wells was installed in two different plumes to inject carbon sources and microbial consortium into the groundwater. The injection amendments included: 1. biostimulation with EOSQR and an emulsified oil substrate, EOS100 to sustain the microbial population for several years and support reductive dechlorination, and 2. bioaugmentation with *Dehalococcoides* microbial consortium (BAC-9) to promote complete reductive dechlorination of the chlorinated ethenes. A monitoring program was developed to evaluate the effectiveness of the treatment system, which included field parameters, cVOCs, key microbial populations and genes, geochemistry and compound specific isotope analysis (CSIA). Dissolved oxygen (DO) and oxidation reduction potential (ORP) were monitored to determine when bioaugmentation should be applied.

Results/Lessons Learned. Within one week after injecting the carbon substrates, an increase was observed in the conductivity of groundwater in downgradient wells. Oil retention in the fractured rock was over-estimated, which resulted in the carbon substrate impacting wells further downgradient than was anticipated based on current knowledge of the hydrogeologic conditions. Within two months after the EOSQR and EOS100 injection, a significant decline in DO levels to less than 0.5 mg/L was observed along with a corresponding decrease in ORP levels to less than -150 millivolts in the recirculation and downgradient impacted wells in the eastern portion of the plume. The *Dehalococcoides* population and corresponding key enzymes (e.g., tceA reductase, vcrA reductase) markedly increased in downgradient wells following the bioaugmentation event.

The groundwater geochemistry indicated that competing electron acceptors (oxygen, nitrate, iron and sulfate) were considerably reduced and therefore conditions were appropriate for reductive dechlorination. This was demonstrated by more than a one to three order of magnitude decrease in concentrations of PCE, TCE and cis-1,2-DCE in downgradient wells post-biostimulation and bioaugmentation. Likewise, concentrations of ethene, the environmentally harmless end product of PCE dechlorination, are increasing in downgradient wells. This presentation will identify the key monitoring parameters to evaluate for an ISB system and how to effectively make adjustments to maximize biodegradation rates in groundwater.