Sustained Anaerobic Bio-Augmentation via In Situ Bioreactors

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Background/Objectives. The study updates the use and performance of an in situ bioreactor (ISBR) in promoting reductive dechlorination of trichloroethylene (TCE) in a bedrock monitoring well. The remediation has been ongoing for two years and has recently been expanded from one well to three, including an experimental ISBR design. The study also presents the testing of the initial remediation well after the ISBR was removed once the well was inoculated however biodegradation processes have been sustained.

Approach/Activities. The study site is a former chemical distribution facility where a deep, fractured aquifer had been impacted predominately by TCE (1,230 μg/L). An ISBR unit was initially installed in an existing monitoring well to promote reductive dechlorination. The ISBR was deployed in an existing monitoring well at a depth of 60 ft BGS. Groundwater samples were routinely obtained at a depth of 140 ft to determine whether ISBR operation affected contaminant concentrations and geochemical conditions throughout the depth of the saturated zone. Bio-Trap® samplers were also deployed at depths of 60, 85, 105 and 140 ft BGS. After one year, the inoculated ISBR was moved to a new well, and two new ISBR remedial units were installed at the site. One of the new reactors was an experimental design to assess if nitrogen sparge gas (for circulation purposes only) could be removed.

Results/Lessons Learned. Prior to the initial ISBR deployment, all data confirmed reductive dechlorination processes were limited under existing conditions. For example, cis-1,2-dichloroethylene (cDCE) was detected (133 μg/L) but vinyl chloride and ethene concentrations were below detection limits suggesting. Consistent with historical groundwater monitoring, *Dehalococcoides* concentrations were low (10^0 cells/mL) and vinyl chloride reductase genes were not detected. After approximately 6 months of operation, geochemical monitoring at 140 ft. BGS demonstrated sulfate consumption and methanogensis. After 9 months of operation, the *Dehalococcoides* concentration at 140 ft. BGS had increased by four orders of magnitude, surpassing 1 million cells/mL. After five quarters, all chlorinated solvents were nondetect. The inoculated ISBR was relocated to a new well and similar mass reductions and elevated microbial populations were observed. Most interesting, biodegradation processes remained elevated in the initial well, even after the removal of the ISBR. Overall, the results conclusively demonstrated that the ISBR successfully enhanced anaerobic bioremediation throughout the saturated thickness of the monitoring well and indicated that ISBRs can be an effective remediation approach even in a deep, fractured bedrock aquifer.