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Performance of Thermally-Enhanced Bioremediation for Targeted DNAPL Source Treatment

Neil Smith (CDM Smith, Denver, CO, USA)
Tamzen Macbeth (CDM Smith, Helena, MT, USA)
Dominic Giaudrone (CDM Smith, Bellevue, WA, USA)
Randa Chichakli (CDM Smith, Carlsbad, CA)
Christopher Cora and Kira Lynch (U.S. Environmental Protection Agenc, Seattle, WA, USA)
Thomas Powell (TRS Group Inc., Longview, WA, USA)

Background/Objectives. A multi-component remedy, including in situ thermal remediation (ISTR) and enhanced anaerobic biodegradation (EAB), has been implemented at the Well 12A Superfund Site in Tacoma, Washington. The goal of the ISTR and EAB source remedies is to reduce mass discharge from the source areas by 90 percent. EAB was implemented over a large area of the site containing a thin silt unit with residual chlorinated solvent mass, which acts as a secondary source of contamination to groundwater. Amendments injected during the full-scale EAB remedy consisted of emulsified vegetable oil delivered using shear-thinning fluids to optimize amendment delivery adjacent to and into the silt unit. During implementation of EAB, two localized areas were observed to contain dense non-aqueous phase liquid (DNAPL) predominantly composed of 1,1,2,2-tetrachloroethane (PCA) and trichloroethene (TCE), above the silt unit. After amendment injections and establishment of reducing conditions, dissolved-phase concentrations of site contaminants increased in the DNAPL areas due to enhanced dissolution. Reductive dechlorination products also increased, but at a slower rate than desired to achieve the mass discharge reduction goal in a reasonable timeframe.

Approach/Activities. In the two identified DNAPL areas, low-temperature thermal enhancement was implemented utilizing electrical resistance heating (ERH). The thermal enhancement was designed to increase the rate of dissolution of the DNAPL and to increase the biodegradation kinetics, degrading the dissolved-phase contamination at a faster rate while minimizing volatilization of contaminants to the vadose zone. The ERH treatment zone was created using an array of three electrodes surrounding each DNAPL area, with temperature monitoring in the center of each array. The electrodes were installed to target heating within and immediately above the silt unit where DNAPL is present. The target temperatures in each array were maintained between approximately 45 and 50 degrees Celsius (°C) during operation, following the initial startup period. The ERH system has operated for 12 months to date.

Results/Lessons Learned. The ERH system has been maintained at a target temperature between 45°C and 50°C throughout most of the 12-month operational timeframe. Monitoring data indicate that the smaller DNAPL source had been substantially depleted during the first six months of operation, while the larger DNAPL source has exhibited declining concentrations after 12 months of operation but is not yet depleted. Monitoring data indicated that DNAPL dissolution was enhanced in the target treatment area at temperatures between 45 and 50°C , but only minimal biodegradation occurred at the DNAPL-impacted locations. Rapid reductive dechlorination occurs in areas immediately surrounding the electrode array, where temperatures were slightly lower and more favorable for enhanced biological degradation. Degradation rates in areas with temperatures below 40°C were significantly higher than rates observed in other areas at the Site where EAB was implemented. Since implementation of the ERH remedy, PCA and TCE concentrations in the DNAPL source wells have declined between 80 and 99 percent.