Successes and Challenges of Bioaugmentation DNAPL in a Low-Permeability Aquifer

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Background/Objectives. Two pilot injections, one full-scale injection, and one supplemental injection were conducted at a site located in northern New Jersey with tetrachloroethene (PCE) dense non-aqueous phase liquid (DNAPL) in the overburden, weathered bedrock, and fractured bedrock. The various remediation events that extended for 10 years significantly reduced contaminant concentrations and distribution. However, challenges including high contaminant concentrations and complex geology prevented complete source removal via bioremediation.

Approach/Activities. The previous remediations include injecting of Hydrogen Release Compound (HRC) and Slow Release Substrate (SRS) during two pilot studies in 2010. After the injection of organic substrates, PCE concentrations in groundwater decreased at the pilot study area temporarily, and the concentrations of the daughter products, cis-1,2-dichloroethene (DCE) and vinyl chloride (CV) had stalled. The full-scale remediation using EVO and bioaugmentation culture SDC-9 successfully remediated the area, except for the source area. Before the full-scale remediation, the concentration of PCE was 110 milligrams per liter (mg/L) in the source well. At the end of the performance monitoring for three years, cis-1,2-DCE was detected at 180 mg/L in the source well. To address the remaining source impact, a supplemental injection was completed in April 2018.

Results/Lessons Learned. Valuable lessons learned from the various bioremediation events conducted at the site.

- Bioaugmentation was shown to be effective and rapid when the contaminant initial concentrations were moderate (less than several mg/L). One injection event of EVO was able to reduce the CVOCs without rebound.
- EVO was approved to be an effective substrate for fractured bedrock. Although TOC reduced rapidly in the highly fractured bedrock, TOC levels maintained at approximately 15 mg/L between one and three years after the injection. The TOC level in the fractured bedrock maintained biodegradation and prevented rebound from occurring three years.
- In contrast, in the source area with DNAPL, bioaugmentation could not rapidly reduce contaminant concentrations and the cis-1,2-DCE stall had been prolonged.
    - Moderate substrate dosage may be more appropriate for biodegradation of DNAPL. Elevated TOC level (at approximately1,000 mg/L) and metabolic acids (more than 1,000 mg/L) that had been detected at the source may not be beneficial to DHC growth. DHC levels decreased more than three orders of magnitudes from the baseline level.
    - The iron-rich and sulfate-limited overburden soil also resulted in excessive iron reduction and iron reducing bacteria. After three years of active bioremediation, pH has decreased to 5.5 S.U. and soluble iron increased to approximately 700 mg/L.

The supplemental injection delivered DHC at a target concentration of 3×105 cell/ml and a mixture of diammonium phosphate and sodium bicarbonate into the source. This purpose of the injection was not to provide carbon substrate but to provide the optimal conditions for DHC growth. The first performance monitoring event of the supplemental injection will be conducted in October 2018.