Combined Remedy Enhancements to Treat a Groundwater TCE Plume Commingled with Cr(VI) via In Situ Chemical Reduction and Enhanced Anaerobic Bioaugmentation

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Background/Objectives. Site groundwater was impacted by a trichloroethene (TCE) plume with concentrations up to 1,000 micrograms per liter (μg/L), commingled with a hexavalent chromium (Cr[VI]) plume with concentrations up to 250,000 μg/L. The remedial goal was to reduce the mass of TCE in the source area to the extent practicable and minimize further migration of the TCE groundwater plume. High Cr(VI) concentrations inhibit the biodegradation of TCE; therefore, to effectively treat TCE by bioremediation, the elevated Cr(VI) concentrations required reduction first. The proposed remedy employed sequential applications of in situ chemical reduction (ISCR) with calcium polysulfide (CPS) to reduce Cr(VI) concentrations followed by the implementation of ISCR using ferrous lactate to further reduce Cr(VI) concentrations to below 5 mg/L such that TCE could be degraded abiotically through the ISCR application and biotically via enhanced anaerobic bioremediation (EAB). Calcium precipitation is common during CPS injections resulting in adverse impacts to soil permeability, injection equipment, well screens, and injection radius of influence, which would have negatively impacted the subsequent ferrous lactate and EAB injections. Parsons developed and implemented methods to reduce calcium precipitation and support favorable environmental conditions for the following enhanced bioremediation to degrade the mixed plume.

Approach/Activities. Parsons performed bench-scale development of pH-adjusted CPS injectate and field implementation of the modified CPS to reduce unacceptable secondary impacts to soil permeability and groundwater geochemistry. The subsequent ISCR and EAB injection for TCE treatment started two months after the CPS injection when Cr(VI) concentrations had declined to below 5 mg/L and when pH, dissolved oxygen, and oxidation-reduction potential data indicated that favorable anaerobic conditions had been reached. A mixture of ferrous lactate, bioremediation substrate, pH buffer, and makeup water was injected into 15 treatment area wells in the TCE plume core, and a 20 or 25 ft radius of influence of each injection well was achieved. After the injection of the amendment mixture was complete, a bioaugmentation culture with anoxic water were injected to emplace a microbial population that was capable of complete dichlorination of TCE two non-toxic ethene.

Results/Lessons Learned. The commingled Cr(VI) and TCE plume required a unique sequential remedy. The implemented remedy had to overcome the inhibitory effect of Cr(VI) on TCE biodegradation while also preventing unacceptable secondary impacts to soil permeability and groundwater geochemistry. The pH-adjusted CPS injection reduced the elevated Cr(VI) concentrations, eliminated the common negative impacts following injection, and provided favorable environmental conditions for subsequent ISCR and EAB. TCE was successfully reduced to below background concentrations across the treatment zone. Over four years later, geochemistry remains in the pH-neutral anoxic range conducive to biotic and abiotic degradation, the microbial population is stable, and substrate refresh has not been required. Overall, the pH-adjusted CPS approach reduced negative impacts typical of this remedial technology and allowed the full remedy to be successfully completed in a shorter timeframe.