Using CSIA to Verify Effectiveness of Coupling Synthetic Iron Sulfide Injections with Bioaugmentation to Address a Trichloroethylene Plume

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Background/Objectives. A low cost, green, and sustainable remediation approach was required to address a plume of chlorinated solvents in groundwater in northern New Jersey. When adequate redox conditions, microbial communities and/or minerals are present, trichloroethylene (TCE) is known to undergo natural degradation. The proposed site management strategy replicated these mechanisms through the injection of specialized amendments coupled with specialized monitoring tools.

Approach/Activities. The remedial approach required constructing a conceptual site model (CSM) through subsurface geochemical and geological characterization that helped describe the fate and transport mechanisms of TCE and select strategic treatment areas where conditions were modified to allow for the degradation of TCE. $d^{13}C$ and $d^{37}Cl$ isotope analysis of TCE (i.e., compound-specific isotope analysis, or CSIA) coupled with qPCR quantifying DNA of *Dhc*, *vcrA*, *bvcA*, *tceA* (i.e., molecular biology analysis) was utilized as the performance monitoring tool to understand the potential mechanisms for TCE transformation. Products used to transform the subsurface conditions included a self-emulsifying vegetable oil that acted as a source of carbon, an electron donor, along with a Mackinawite-structured iron sulfide suspension replicating the mineralogy capable of abiotic reductive dechlorination of TCE. The injection program included inoculating with a *Dehalococcoides*-rich culture grown from a site where TCE underwent complete dechlorination. The amendments injected in the subsurface also included a source of nutrients and labile organic carbon mixed with sodium bicarbonate to accelerate the conditioning to an anaerobic, microbially rich, aquifer while keeping pH conditions neutral.

A 1,500-square feet treatment area using eight injection points targeted the highest TCE concentrations acting as a source to the downgradient plume. A downgradient permeable reactive front acted as a barrier to mitigate further plume migration by injecting amendments through 36 points. Both areas required injecting chemicals through a 12-foot vertical contaminant plume span (from 3 to 15 feet below ground surface).

Results/Lessons Learned. Baseline characterization using CSIA allowed recognizing natural degradation of TCE and degradation product cis-1,2-dichloroethylene (cis-1,2-DCE); however, a vinyl chloride (VC) stall was observed. The remedial injections resulted in a significant decrease in the concentrations of the targeted compounds of concern. Groundwater samples were collected from three monitoring wells (MW-68S, MW-69S and MW-70S) within the injection radius of influence four months after completion of the injection process. The results showed either a 78% decrease in TCE concentration (MW-68S) or a decrease to levels below the laboratory detection limits (MW-69S and MW-70S). Similarly, the concentration of cis-1,2-DCE decreased by 94%, 99% and 92% in MW-68S, MW-69S and MW-70S, respectively. The concentration of VC also decreased by 96% and 50% in MW-68S and MW-70S respectively, and below the laboratory detection limit in MW-69S. Should conditions change after the injection event, CSIA and molecular diagnostic tools will serve to describe the main process responsible for the changes in the concentrations.