Bioremediation and Enhanced Chemical Reduction via EZVI at an Active Brownfield Redevelopment Site

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Background/Objectives. A combination of bioaugmentation, use of emulsified vegetable oil and zero-valent iron (EZVI) was successfully implemented to remediate chlorinated volatile organic compounds (CVOCs) at an active brownfield redevelopment site in Brooklyn, New York. The site was a former automotive repair facility that was demolished to make way for a 12-story mixed-use residential and commercial building in Brooklyn's Park Slope neighborhood under voluntary participation in the New York State Brownfield Cleanup Program (NYSBCP).

Approach/Activities. A bench-scale treatability study showed that oxidation could effectively degrade the CVOCs, but elevated groundwater velocities up to four feet per day would render this method infeasible, as soluble oxidants would potentially migrate rapidly out of the treatment area. As an alternative, EZVI (along with bioaugmentation) was implemented because ZVI, once emplaced, does not migrate as quickly in groundwater. In July and August 2015, 3,000 gallons of EZVI solution and 60 liters of SDC-9 biological culture were injected via direct-push technology (DPT) to depths of 35 to 45 feet below surface grade. The target treatment area was divided into three zones, according to contaminant level and groundwater flow conditions. To further complicate matters, DPT injections were completed at the base of a 15-foot excavation during ongoing earthwork and footing installation. The site construction was complete in November 2015, and replacement monitoring wells were installed shortly thereafter. Seven performance monitoring events have been completed to date. VOCs, geochemical and biological parameters were collected during all seven performance monitoring events.

Results/Lessons Learned. The in situ EZVI remediation was successfully implemented in a dense urban environment. An active system, such as an air sparge/soil vapor extraction system, would have required additional building space and ongoing O&M. Because various EZVI dosages were applied at different areas of the site, valuable lessons for effective EZVI field dosing were obtained. The interaction of biotic and abiotic pathways was also investigated under different aquifer conditions. The remedial outcomes and evaluation will aid in future implementation of in-situ bioremediation and chemical reduction. A few key observations are listed below.

- For the EZVI remediation at the site, the dosage of ZVI determined the dominant path. At the source area, where a larger dosage of ZVI was applied, b-elimination reduced PCE concentrations from 2,000 to less than 5 micrograms per liter (µg/L), without daughter product accumulation. At the other areas, where lower dosages of ZVI were applied, reductive dechlorination sequentially reduced CVOCs to ethene and ethane.
- Because *dehalococcoides* (DHC) levels in all monitoring wells were measured in seven events, the extensive microbial results established DHC growths in the aquifer under different conditions. DHC proliferation had been significantly impacted by the level of ZVI and EVO. At the source area where TOC levels were higher than the levels at the downgradient area, DHC levels were lower than those at the downgradient area because ZVI may likely interfere the DHC growth. However, the low level of ZVI seemed to enhance DHC growth, as DHC at near 108 cells per milliliter (cell/ml), a level commonly seen in bioaugmentation culture, was observed at the low EZVI dosed area.

- The EZVI treatment showed fast kinetics and longevity. The kinetic and longevity of biotic and abiotic pathways did show significant differences. Further, the influences of other electron acceptors seemed to be different at the source area and other areas.