

Bioaugmentation-Enhanced Chemical Reduction at a Brownfield Redevelopment Site

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Background/Objectives. Bioaugmentation enhanced in situ chemical reduction (ISCR) coupled with zero-valent iron (ZVI) were successfully implemented to remediate chlorinated volatile organic compounds (CVOCs) at a 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 as a voluntary cleanup in accordance with 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 4 feet per day would render this method infeasible, as soluble oxidants would potentially migrate out of the treatment area rapidly. As an alternative, emulsified vegetable oil and ZVI (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 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. Four performance monitoring events were completed between November 2015 and September 2016.

Results/Lessons Learned. The remedial outcomes are outlined below:

- At the source area, PCE concentrations were approximately 2,000 micrograms per liter (µg/L) before the injection of the highest dosage of ZVI. CVOCs were reduced to less than 5 µg/L within one year of the injection. The degradation was mainly via *beta*-elimination because daughter products were not produced and moderate levels of DHC were also detected.
- At the transitional area near the source area, CVOC concentrations were less than 1,000 µg/L before the injection of a moderate dosage of ZVI. CVOCs were reduced to less than 50 µg/L via mainly bio-mediated pathways that produced cis-1,2-dichloroethene (DCE), not vinyl chloride (VC), as the daughter product. The DHC population increased more than 5 orders of magnitude. Sulfate and dissolved iron levels increased significantly when CVOCs were reduced to below groundwater quality standards.
- At the plume perimeter, baseline CVOCs concentrations were up to 100 µg/L before injection and the lowest dosage of ZVI was applied. Limited reduction of PCE along with cis-1,2-DCE generation was observed. Additionally, a moderate increase of DHC, moderate decrease of sulfate, and lack of dissolved iron suggested that reductive dechlorination was not effectively enhanced.