Advancing Urban Site Remediation Using In Situ Bioaugmentation for Chlorinated Aliphatic Hydrocarbons in Groundwater

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Background/Objectives. Chlorinated aliphatic hydrocarbons (CAHs) historically released in urban areas from dry cleaners or former industrial manufacturing processes require innovative strategies to achieve remedial goals and site closure. Traditionally, it is thought that CAHs are treated most effectively via reductive dechlorination technologies such as anaerobic dehalogenating bacteria (e.g., Dehalococcoides; DHC) or through chemical reduction via zero valent iron (ZVI). However, aerobic cometabolic processes have the ability to effectively treat CAHs while using the site's geochemical conditions to our advantage.

Urban site settings are complex in nature because utilities, buried structures, foundations, historic fill material, and nearby mixed-use buildings present significant challenges from an access perspective and to achieving remedial goals. Selection of an effective remedial technology can be limited further by contaminant type, commingled plumes, aquifer characteristics, and difficult soil types that are too often common in densely populated areas. As a result, conventional remedial alternatives using excavation, mechanical/electromechanical equipment, or other more invasive methods are often infeasible, disrupt neighbors, and are cost prohibitive despite premiums placed on urban redevelopment. This presentation is meant to show that there are other biological aerobic processes that can be utilized to address CAH impacts.

Approach/Activities. Direct push technology (DPT) to deliver low volumes of aerobic microbes consisting of a consortium of *Pseudomonas* and *Burkholderia cepacian species,* oxygen supplements, and simple-chain sugar substrate has been used by the author effectively in many urban settings. This consortium of microbes produces monooxygenase, dioxygenase, and/or hydroxylases enzymes that have been proven to cometabolically degrade CAHs. This consortium has a wide metabolic diversity with the ability to transfer plasmid encoded enzymes between species. As a result, this consortium of microbes thrives in many subsurface environments under a variety geochemical conditions.

Results/Lessons Learned. This presentation summarizes the aerobic cometabolic and injection approaches that were used for two sites in Massachusetts. Aerobic bioaugmentation was selected based on the preapplication geochemical conditions, and DPT was selected given the space constraints at these sites. The preapplication geochemical conditions were primarily aerobic (i.e., dissolved oxygen concentrations ranged from 1 to 4 milligrams per liter [mg/L], and oxidation-reduction potential (ORP) was greater than +50 millivolts [mV]) with a generally neutral pH (6-8 pH units). This presentation will also summarize the analytical results from years of remedial monitoring activities and describe how this approach was completed with fewer safety concerns (e.g., chemical exposure to environmental team, breakout of harmful chemicals inside buildings, and structural integrity of surrounding buildings) and reduced concerns from residential neighbors because long-term operation of mechanical and electromechanical systems was eliminated as a remedial strategy. This presentation will also touch on how this remedial strategy generally complies with USEPA's Greener Cleanups Initiative, MassDEP Greener Cleanups Guidance document WSC14-150, and ASTM Standard E2893-16E01.