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Evaluation of Multiple Innovative Approaches for Accelerating Low VOC Concentration Plume Attenuation

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Background/Objectives. Beginning in 2013, CH2M has conducted pilot studies to evaluate various bioremediation technologies to accelerate modest natural attenuation rates and reduce long-term monitoring (LTM) periods at multiple low concentration volatile organic carbon (VOC) plumes at a military facility in North Carolina. These studies included the installation and operation of a solar-powered subgrade biogeochemical reactor (SBGR), injection of emulsified vegetable oil (EVO) with a bioaugmentation culture (with and without the addition of red yeast rice [RYR] as a methane inhibitor), and use of sulfate and/or a carbon-iron amendment to promote degradation of multiple contaminants of concern (COCs) in a mixed VOC plume.

Approach/Activities. For the first study, a 625 square foot SBGR was installed to 6 feet below ground surface (bgs) and comprised 60 percent mulch, 40 percent gravel, and 230 gallons of soy bean oil to assess its effectiveness in stimulating reductive dechlorination of trichloroethene (TCE) in shallow groundwater. An infiltration gallery within the SBGR and downgradient extraction well were installed to recirculate groundwater with TCE concentrations up to 50 micrograms per liter (µg/L). The extraction well was fitted with a downhole pump and connected to a solar panel source.
The objective of the second study was to assess the effectiveness of EVO for stimulating reductive dechlorination of 1,1,2,2-tetrachloroethane (TeCA) concentrations up to 9 µg/L and the ability of a commercial RYR product for suppressing methane generation. This study consisted of two areas, each with two injection locations targeting the 30 to 40 feet bgs interval and three monitoring wells installed 4, 6, and 8 feet from the injection locations. Direct push technology (DPT) was used to inject a 3 percent EVO solution and one liter of a bioaugmentation culture into each location. In one of the areas, 7.5 pounds of the RYR product was also added via DPT.
For the third evaluation, a laboratory study was conducted to identify the substrate mix that could promote oxidative remediation of benzene, toluene, ethylbenzene, and xylenes (BTEX) and reductive dechlorination of chlorinated ethenes. During Phase 1 of the study, microcosms with site soil and groundwater were amended with either Epsom salt or a carbon-iron substrate. Phase 2 included amendment of the Phase 1 reactors with either sodium lactate or a dechlorinating culture to stimulate the sulfate-reducing and dechlorinating reactions, respectively. A field-scale study was then implemented based on the results of the laboratory study.

Results/Lessons Learned. Downgradient of the SBGR, TCE concentrations decreased 85 percent within 9 months of installation and conditions remain favorable for continued reductive dechlorination after 15 months. During the EVO injection study, 1,1,2,2-TeCA and TCE decreased 50 and 80 percent in some of the monitoring wells, but overall effectiveness appeared to be limited by substrate distribution and low starting VOC concentrations. Furthermore, it appears that the RYR did not have a discernable impact on methane suppression when comparing the dual injections. Finally, the laboratory study concluded that the addition of sulfate did not boost BTEX degradation but dechlorination of the chlorinated ethenes could be substantially accelerated at the site with just the addition of a dechlorinating culture. The presentation will review implementation, costs, a detailed analysis of the results of each evaluation, and their influence on the duration of the LTM program.