Opportunities and Limitations of DNAPL Treatment via Injectable ZVI/Carbon: Results of Bench- and Field-Scale Tests

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Background/Objectives. Carbon tetrachloride (CT) is present as the primary constituent of a DNAPL-source that is related to former storage tanks and a historic waste conveyance system at the Hercules LLC site, Parlin, New Jersey. The DNAPL material resides at a depth of 15-20 feet within a channel deposit (sandy gravel) of the Magothy aquifer and overlies a locally continuous clay unit. Given saturated soil concentrations on the order of up to 10,000 mg CT/kg, source material unevenly dispersed and potentially present underneath existing structures, and challenging groundwater flow conditions, various options to address the source materials were evaluated, including soil excavation, electric resistivity heating, soil stabilization, and in-situ treatment options.

Approach/Activities. Based on cost forecasts and prior experience, an in situ chemical reduction option was selected and three ZVI-based products (with or without carbon) were tested in the initial bench-scale study. The objective of the bench study was to identify the effectiveness of the iron-based remediation products, also in light of the potential for generating recalcitrant daughter products. At the conclusion of the bench study, a ZVI-impregnated carbon product was selected for the subsequent field-pilot test. During the characterization of the test area, it became apparent that the success of the pilot-scale application of the selected amendment (CAT-100™) might be limited by the ability to inject an adequate mass of ZVI-carbon relative to the volume / mass of the DNAPL source materials (CT mass was estimated to be locally up to 1.1 lbs/cf). The field-pilot test commenced in early 2017 with the successful injection of 3,600 gallons of injectant (carrying 4,650 lbs of ZVI carbon), and utilized 38 injection locations that were systematically distributed across the 750 sf pilot-test area. Prior to the injections, a monitoring network was established and baseline groundwater and biological data (quantArray Chlor) were collected. Monitoring wells within the injection area were installed after the subsurface delivery of the injectable carbon. Remediation progress samples have been collected at approximately monthly intervals (on-going).

Results/Lessons Learned. Across the portion of the test area that had little or no apparent DNAPL source material, the progress groundwater data indicated rapid decreases of CT (baseline 300 mg/L to less than 1 mg/L), with no apparent generation of methylene chloride (MC). In contrast, the CT concentration in the DNAPL-rich portion of the test area were little changed. Outside the injection area, post-injection sampling revealed a gradual increase in pH (to about 5.5 or greater), a trend toward lower ORP (from +200 mV to about -50 mV), and a lowering of CT concentrations of approximately one order of magnitude. Biological activity inside and immediately adjacent to the test area increased by 3-4 orders of magnitude relative to baseline, but not always of the desired type (e.g., *dehalobacter* is not present). Although complicated by variable groundwater gradients across the test area, the rate of decrease of CT concentrations adjacent to the test area suggests the mixing of rapidly treated (abiotic?) groundwater in the non-DNAPL portion with recalcitrant source material in the DNAPL-rich portion of the test area.