ENHANCED BIOLOGICAL REDUCTIVE DECHLORINATION AT A DRY CLEANING FACILITY

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ABSTRACT: A significant level of enhanced biological reductive dechlorination was demonstrated at a commercial dry cleaning facility in Orlando, Florida. Under the auspices of the Florida Department of Environmental Protection, and in accordance with the Dry Cleaning Solvent Cleanup Program, the upper and lower portion of the surficial aquifer at the site was treated with an experimental source of time-release hydrogen (HRC®, Regenesis Bioremediation Products, Inc.). The hydrogen, which is produced by fermentation from HRC derived organic acids, serves as an electron donor that mediates the reduction of chlorinated hydrocarbons.

The site was extensively characterized with state-of-the-art direct push diagnostic protocols. An area of approximately 14,600 square feet was found to be within the 1 mg/L isopleth for perchloroethylene (PCE); in some wells contamination levels approached 9 mg/L. As part of a pilot test conducted in 1999, approximately 6,810 pounds of HRC were injected into the area as described via 144 direct-push points spaced 10 feet on center. The total PCE contaminant mass was reduced by 96 percent after 152 days. This was calculated for a larger area that was bounded by wells which included both 1) a series of proximal up gradient wells and 2) a down gradient well series that could have been impacted by the advection and diffusion of the applied hydrogen releasing compound in the 152 days. This designated area, approximately 240' X 180', began with a mass of 19,183 g PCE and rose to 24,378 g by Day 43, presumably through physical desorption related to the injection activity. Subsequent to that point in time, mass was reduced to 17,925 g by Day 77, 12,869 g by Day 110 and then to 822 g by Day 152. Additionally, the daughter products trichloroethene (TCE), dichloroethene (DCE) and vinyl chloride all declined.

Due to the success of the pilot test, in August 2000, a secondary injection of HRC was conducted at the site. This included 128 injection points containing 2,550 lbs of HRC into the lower surficial aquifer, and an additional 50 injection points containing 7,500 lbs of HRC into the upper surficial aquifer. The points for the lower surficial aquifer were installed to a depth of 55 feet with continuous injection of HRC from 55 to 30 feet.

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Site Hydrogeology. The shallow subsurface generally consists of layers of tan to brown fine quartz sand to a depth of approximately 24 to 30 feet below land surface. The surficial sand is underlain by gray clay, which ranges in thickness from approximately 1 to 12 feet. Below this clay is a tan to white and gray silty sand and sandy clay unit which ranges in thickness from 20 to 25 feet. This is underlain by a pale to dark olive green sandy clay to clay with trace phosphate nodules at approximately 50 to 55 feet below land surface which represents the Hawthorne Group sediment. The groundwater seepage velocity of the aquifer systems ranged from 16 ft per year in the upper surficial aquifer, 2.6 ft per year in the lower surficial aquifer, and 5.8 ft per year in the intermediate aquifer.

HRC APPLICATION AND PERFORMANCE MONITORING

The application of HRC in the pilot test was designed to treat the upper surficial aquifer because the greatest concentrations of chlorinated solvents were observed in this part of the aquifer.

The treatment area for the secondary injection conducted in November 2000 was within an 80-ft by 160-ft grid, with injection points on 10-foot centers. During this application of HRC, the lower surficial aquifer was targeted for the most aggressive treatment, due to the lower level of contamination left in the upper surficial aquifer.

The effect of HRC on groundwater geochemistry and chlorinated solvent concentrations were determined by periodically sampling and analyzing groundwater from seven monitoring wells. Analysis included chlorinated solvents, dissolved oxygen, oxidation-reduction potential, pH, conductivity, temperature, ferrous iron, nitrate and nitrite, sulfate, methane, ethene, and ethane, manganese, and phosphorus. Groundwater samples were collected before the secondary injection, and every three months following the HRC application to monitor progress of the treatment. A pump and treat system was also installed after the secondary HRC injection was completed in order to control the migration of degradation products.

RESULTS AND DISCUSSION-INITIAL INJECTION

The initial application of HRC during the pilot test resulted in an observable change in the concentration of chlorinated solvents in the upper surficial. An area approximately 240 feet by 180 feet was affected by the HRC application. The mass of PCE and its dechlorination products before HRC application and at various time points after the initial application is listed in Table 1.

TABLE 1. Mass of chlorinated hydrocarbons at various times after HRC pilot application.

Compound	Initial (g)	43 Days (g)	77 Days (g)	110 Days (g)	152 Days (g)
PCE	19,183	24,378	17,925	12,869	822
TCE	2,548	1,261	1,108	1,222	1,254
Cis-1,2-DCE	6,309	3,144	3,946	3,705	4,012
Vinyl Chloride	2,350	1,287	670	572	1,016

The PCE mass increased from the initial mass to the mass estimated after 43 days. This change was presumably due to physical desorption related to the injection activity. Overall the PCE mass was reduced by 96 percent after 152 days of treatment. The TCE mass was reduced by approximately 51 percent. The cis-1,2-DCE mass was reduced by 36 percent and the vinyl chloride mass was reduced by 58 percent. The dramatic reduction in PCE mass and the less dramatic reduction in the mass of the lesser chlorinated ethenes suggest that the PCE was being dechlorinated to TCE, DCE, and vinyl chloride. Because these compounds were being formed and dechlorinated concurrently, the overall reduction in mass was not as great as that observed for PCE.

RESULTS AND DISCUSSION-SECONDARY INJECTION

The secondary injection monitoring results show an observable change in the concentration of chlorinated solvents in the upper surficial. Additional monitor well sampling will be conducted in May and a complete data evaluation will be presented in the final poster project at the remediation conference.

CONCLUSION AND COST SUMMARY

The overall results from the HRC application and continued monitoring indicate that HRC appears to be an effective remedial alternative for the restoration of groundwater impacted with chlorinated ethenes in some aquifers. The overall cost of the pilot project through planning, the initial site assessment, permitting, the HRC application, subcontracting, labor, and follow-up analytical and reporting was $127,000. HRC product cost was $27,197. The additional costs for the second application in the upper and lower aquifers were $98,000.

REFERENCES

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