Biological Reduction and Chlorinated Contaminant Partitioning through the use of an Innovative Electron Donor

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PROJECT BACKGROUND

A chlorinated solvent plume had formed within the subsurface environment as a result of dry cleaning operations at a commercial site in Newport News, Virginia. The contaminant plume migrated 200 feet downgradient extending toward the property boundary. Near the source area, groundwater concentrations of tetrachloroethene (PCE) and trichloroethene (TCE) had reached 7,600 parts per billion (ppb) and 1,500 ppb, respectively (Table 1). The remediation goal endpoint was established at U.S. EPA Drinking Water Maximum Contaminant Levels (MCLs) of 5 ppb for PCE and TCE, 70 ppb for cis-1,2-dichloroethene (cis-DCE) and 2 ppb for vinyl chloride (VC). A soil vapor extraction system was originally installed and operated for nearly 3 years. However, the system was shut down as it was no longer effective in reducing groundwater concentrations to MCLs. Shortly thereafter, an in-situ, enhanced bioremediation approach was implemented using a highly distributable, electron donor substrate called 3-D Microemulsion (3DMe)™. Enhanced bioremediation can be particularly effective at eliminating low-level contaminant concentrations that mechanical systems cannot efficiently treat.

Table 1. Source Area Concentrations Prior to Treatment and Cleanup Goals (ppb)

Contaminant	Pre-Remedial Concentrations MW-7	Pre-Remedial Concentrations OB-1	Cleanup Goals
PCE	1,800	7,600	5
TCE	360	1,500	5
cis-DCE	5,200	500	70
VC	350	0	2

3-D Microemulsion (3DMe)™

3-D Microemulsion (3DMe)™ is a unique and highly distributable electron donor material, composed of free lactic acid, controlled-release lactic acid (polylactate) and certain fatty acid components. These three components support a highly desirable, staged fermentation process which supplies an immediate, mid-range, and very long-term controlled-release supply of hydrogen to fuel the reductive dechlorination process. Additionally, 3DMe is applied as a highly mobile microemulsion which can migrate significant distances in the subsurface and well beyond its initial emplacement distribution limits. Unlike emulsified vegetable oils that tend to immediately sorb onto soil surfaces limiting distribution, 3DMe moves significant distances in the subsurface and can be applied using relatively wide injection and/or well spacing.

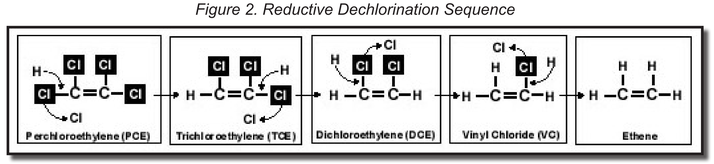
Figure 1. 3DMe and Water Microemulsion

REMEDIATION STRATEGY & METHODS

In-Situ Enhanced Anaerobic Bioremediation

Enhanced anaerobic bioremediation is the practice of adding a source of hydrogen (electron donor) into the subsurface to increase the number and vitality of indigenous microorganisms performing bioremediation (reductive dechlorination). Because of specific conditions, and the relatively low concentrations of COC's at this site, this approach was deemed most suitable and appropriate for reaching the specified remediation goals (MCLs).

Figure 2. Reductive Dechlorination Sequence



3-D Microemulsion (3DMe) Applications

A total of 3,600 pounds of 3DMe were applied in a grid layout through 40 direct-injection points targeting treatment in the source area and downgradient plume (Figure 3). Sampling was performed following the application to monitor performance.

Approximately 1 year later, an additional 3DMe application was performed close to the initial application to target a previously unidentified source of contamination emanating from beneath the dry cleaning facility. A total of 510 pounds of 3DMe were applied through 18 direct-injection points (Figure 4). Sampling was performed 9 months later to monitor performance.

Figure 3. Initial 3DMe Application Grid

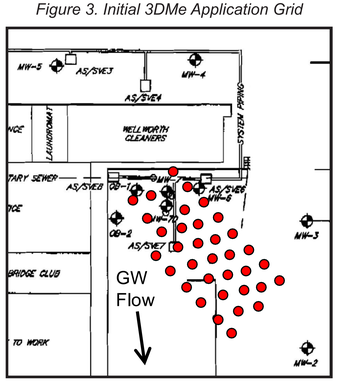
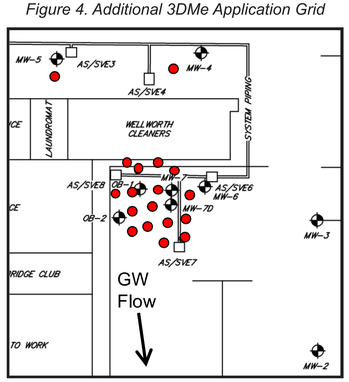


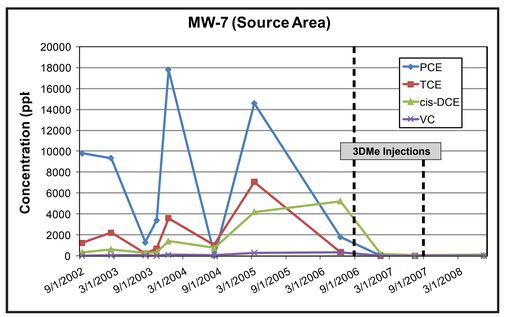
Figure 4. Additional 3DMe Application Grid

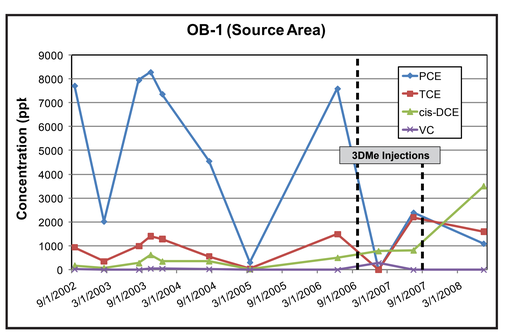


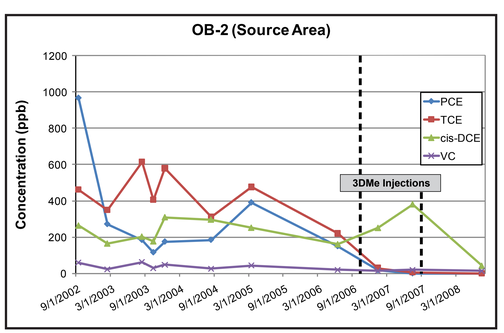
RESULTS AND CONCLUSIONS

Following the initial 3DMe application, sampling results indicated a significant decline in chlorinated solvents over the majority of the source area. PCE and TCE concentrations in source area wells OB-1, OB-2 and MW-7 were reduced by 87% - 99% within four months of 3DMe injection. A slight increase in cis-DCE was observed in OB-1 and OB-2 and typical for reductive dechlorination treatments. In well MW-7, a simultaneous decline in PCE, TCE and cis-DCE was observed suggesting that contaminant partitioning may be occurring in this area. During partitioning, aqueous-phase chlorinated solvents can be transferred into a non-aqueous phase material such as an electron donor, in this case 3DMe.

At 10 months following the initial 3DMe application, an influx in PCE and TCE concentrations was observed in well OB-1 as levels rose to more than 2,000 ppb. A previously unidentified source area was discovered beneath the building and an additional 3DMe treatment was applied targeting this area. Sampling conducted after the additional 3DMe application indicated a decreasing trend in PCE and TCE and an increase in cis-DCE in well OB-1. In well OB-2, PCE and TCE remained at non-detect levels and cis-DCE concentrations were reduced by 89%. Vinyl chloride concentrations ranged from approximately 20-290 ppb in the source area throughout the monitoring period.







Conclusions

Overall, the results at this site look promising and based on the sampling data it appears that both enhanced reductive dechlorination and partitioning have occurred as a result of the 3DMe applications. Historical fluctuations in PCE concentration were significant and had reached almost 18,000 ppb. Following the 3DMe injection, PCE concentrations no longer fluctuated but also declined considerably across the site with the exception of OB-1. PCE and TCE concentrations in well OB-1 and elevated concentrations of daughter products are expected to continue to decline over the next 6 to 18 months.