

In Situ Chemical Reduction using EHC in Trench and Excavation

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ABSTRACT

EHC™ was installed into a trench and open excavation for treatment of a range of chlorinated solvents in groundwater through *in situ* chemical reduction processes. The constituents of interest (COIs) included tetrachloroethylene (PCE), trichloroethylene (TCE), cis-1,2-dichloroethylene (cis-1,2-DCE), trans-1,2-DCE, 1,1-DCE, and vinyl chloride (VC) at concentrations generally less than 3,000 ppb. COI mass in the soil was removed at the source area by excavation. Following the removal of soil from the suspected source area, EHC was placed into the bottom of the excavation to address the impacted groundwater. In addition, EHC was placed into a downgradient trench to form a permeable reactive barrier (PRB), designed to treat the dissolved plume migrating from the upgradient source zone through a thin permeable sand layer overlying bedrock at approximately 12 feet below ground surface (bgs).

EHC MODE OF ACTION

EHC™ is a patented combination of controlled-release carbon and zero valent iron (ZVI) particles used for stimulating reductive dechlorination of otherwise persistent organic compounds in groundwater. Following placement of EHC into the subsurface environment, a number of physical, chemical and microbiological processes combine to create very strong reducing conditions (as low as -600 mV) that stimulate rapid and complete dechlorination of organic solvents and other recalcitrant compounds. First, the organic component of EHC (fibrous organic material) is an ideal support for growth of bacteria in the groundwater environment. As the indigenous heterotrophic bacteria grow on the EHC particle surfaces they consume dissolved oxygen thereby reducing the redox potential in groundwater. In addition, as the bacteria grow on the organic particles, they ferment carbon and release a variety of volatile fatty acids (acetic, propionic, butyric) which diffuse from the site of fermentation into the groundwater plume and serve as electron donors for other bacteria, including dehalogenators and halorespiring species. Finally, the small ZVI particles (<5 to 45 µm) provide substantial reactive surface area that stimulates direct chemical dechlorination and an additional drop in the redox potential of the groundwater via chemical oxygen scavenging.

EHC hence supports a number of treatment mechanisms:

1. Biological degradation from consumption of the carbon,
2. Direct chemical reduction by the ZVI, and
3. Enhanced thermodynamic destruction by the low redox conditions created.

INSTALLATION OF TRENCH PRB



A construction and consulting company installed EHC in a trench and an open excavation. The PRB was constructed with an excavator by digging a 3-foot wide trench down to the top of the bedrock, followed by filling the bottom foot with a mixture of 10% EHC and 90% sand by mass. Only the bottom foot required treatment because the groundwater table was less than a foot above the bedrock, and the permeable sand unit was also at this depth. The remainder of the PRB was backfilled with pea gravel.

Figure 1. Placement of EHC and sand mixture into excavation trench.

PLACEMENT OF EHC INTO EXCAVATION

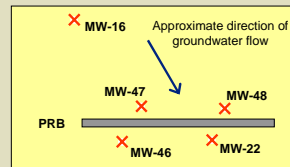
In a separate area, impacted soil was removed from a source zone, and the same mixture of EHC and sand was placed in the bottom 2 to 3 ft of the open excavation.

Figure 2. Placement of EHC and sand mixture at bottom of excavation to treat impacted groundwater following excavation of source area soil.



PERFORMANCE MONITORING

The installation was completed in late February of 2004, and samples were taken 1, 4, 7, and 11 months after the installation. Samples were collected from the excavation area and



from a set of monitoring wells upgradient and downgradient of the trench PRB (Figure 3). The wells are located approximately 6 to 10 ft from the trench, which constitutes approximately 6 to 10 days in terms of groundwater travel time.

Figure 3. Locations of monitoring wells at PRB.

TREATMENT RESULTS

All COIs were below the detection limit at the excavation area following the EHC placement (Figure 4). Note that excavation of the impacted soil occurred on day -5. EHC placement occurred on day 0, prior to backfilling.

The set of monitoring wells assessing the effectiveness of the trench PRB also showed good COI reductions (Figure 5). Concentrations of PCE steadily declined in the downgradient well, while concentrations of cis-1,2-DCE initially increased in concentration, but subsequently declined to even lower levels than the upgradient well, most likely due to the colonization of the PRB and area immediately downgradient of the PRB with dechlorinating bacteria. By month 11, 1,300 ppb of PCE was being reduced by 93% to 92 ppb, TCE was being reduced by 87%, cis-1,2-DCE by 71% and the effluent VC concentration was only 2 ppb. This observation, combined with the steady decrease in PCE, suggests that at least part of the treatment mechanism is due to biostimulation of native microorganisms.

Figure 4. Conc. of COIs in groundwater at excavation following EHC treatment.

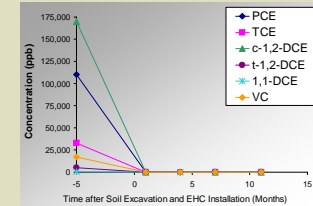
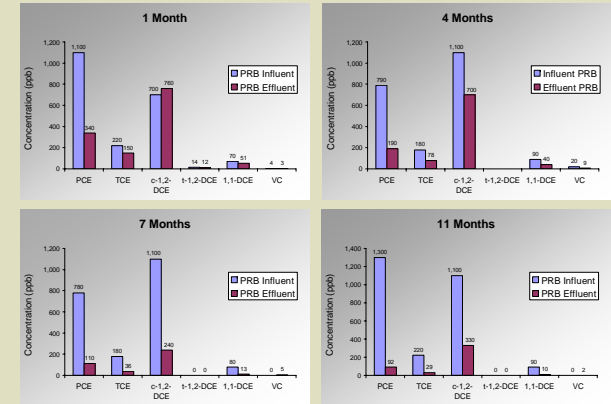


Figure 5. Concentration of COIs in groundwater upgradient and downgradient of EHC PRB 1, 4, 7, and 11 months following the installation.



CONCLUSIONS

Estimation of the half-life of PCE from the field data indicate that the value is decreasing over time, and is in a range of 1.5 to 7 hours (Figure 6). This value is in line with laboratory studies on the treatment of PCE with EHC. The decline of the half-life over time also supports the hypothesis that the native microorganisms continue to become better acclimated to the carbon source and reduced conditions created by EHC over time.

Figure 6. Modeled half life compared to actual field observations.

