Environmental Solutions

EHC® Reagent
Case Study

Use of EHC® Reagent for the Treatment of CVOCs at Former Solid Waste Management Unit in Ohio

Project

Application: EHC PRBs Injected into Existing Gravel Collection Trenches
Site: Former Unregulated Solid Waste Management Unit, Ohio
COCs: TCE, 1,2-DCE, VC
Consultant: Hull & Associates, Inc.

Summary

Groundwater at a former unregulated solid waste management unit is impacted by various chlorinated volatile organic compounds (CVOCs), mainly chlorinated ethenes. Groundwater collection trenches totaling approximately 330 ft in length were previously constructed downgradient of the suspected source areas. In February 2006, EHC® Reagent was injected into the gravel trenches to convert them into permeable reactive barriers (PRBs). A microbial culture of Dehalococcoides species (KB-1® inoculant; SiREM) was also applied to the main trench. Subsequent field monitoring showed that trichloroethene (TCE) and cis-1,2-dichloroethene (cis-DCE) decreased below the detection limit within the trenches after just 6 months, without the accumulation of recognized catabolites, such as vinyl chloride (VC). Continued monitoring has shown that the PRBs remain active for over 3 years and that the concentration of total chloroethenes is decreasing downgradient of the center of the PRB (over 97% removal since November 2006). A positive correlation between the presence of EHC breakdown products (TOC and dissolved Fe), Dehalococcoides count and removal rates has been observed downgradient of the PRB.

Challenge

Site groundwater proximal to a known area is impacted by TCE (maximum of 750 ppb; remedial objective = 5 ppb) and its recognized anaerobic daughter products 1,2-DCE (maximum of 5,200 ppb; remedial objective = 70 ppb) and VC (maximum of 630 ppb; remedial objective = 2 ppb). In an effort to mitigate transport of groundwater CVOCs, collection trenches measuring approximately 250 ft long were previously installed along the southern and western boundaries of the former unregulated solid waste management unit. Another collection trench measuring approximately 80 ft long was installed inside of a building (**Figure 1** – red lines). The goal of this current project was to turn these existing collection trenches into permeable reactive barriers (PRBs) to passively treat the

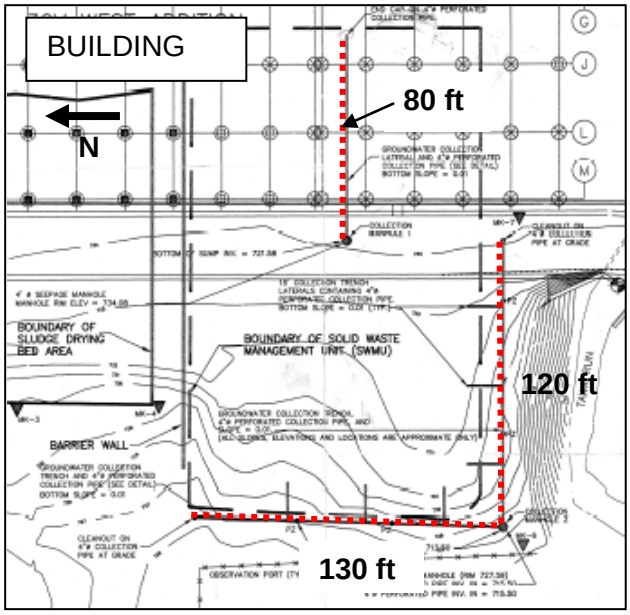

Figure 1: Collection trenches shown in red

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groundwater as it flowed through the newly created reactive treatment zones. The groundwater table is generally at 6 ft below ground surface (bgs) and the trench extends down to approximately 12 ft bgs. The trenches measures 2 ft wide and are filled with washed river gravel up to a foot above the groundwater table.

Solution

Using conventional direct push technology, 11,850 lbs of EHC were injected into the gravel zone to form a reactive zone thus creating an in situ PRB that would treat the groundwater as it flows through the reactive zone (injections conducted by Superior Environmental, **Figures 2 and 3**). The EHC product was delivered as a dry powder and consisted of solid organic carbon and zero-valent iron at 42%. The EHC powder was mixed with water on site into a slurry containing approximately 20 to 25 percent solids using a grout mixer. The injection points were spaced 10 ft apart, resulting in a total of 30 injection points. A total of 400 lbs of EHC (ca 200 USG of slurry) was designed for each injection point. Immediately following the EHC injections, KB-1 inoculant was added to the major trench along the property line to accelerate removal of cis-1,2-dichlorethylene DCE. No inoculants were added at the trench inside the building.

Figure 2: EHC injections at trench along property lines.

Figure 3: EHC injections inside building

Monitoring Program

Following the installation of the EHC PRB, the groundwater was sampled for CVOCs on a quarterly basis at the following locations **(Figure 4)**:

- Manholes (CB-1 and CB-2),
- Downgradient wells (MK-5 and MK-6),
- Sidegradient well (MK-7), and
- Downgradient piezometer (P5).

In addition, groundwater quality field parameters including pH, DO, temperature, water level, and ORP have been collected monthly. Nine months following the installation of the PRBs, the groundwater was analyzed for total iron,

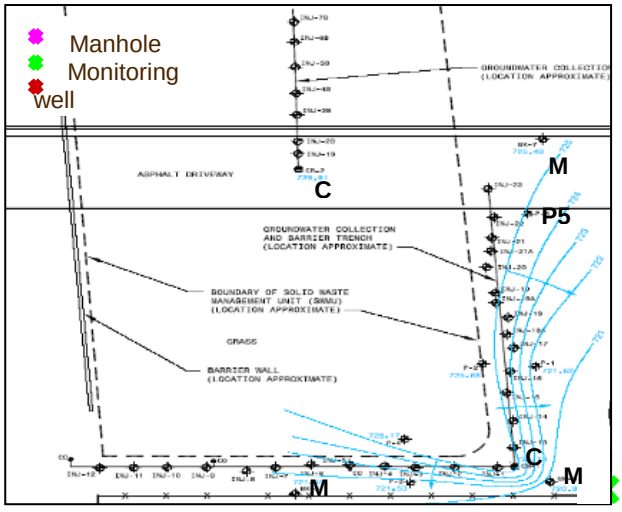

Figure 4: Monitoring

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ferrous iron, and TOC to verify which sampling locations are within the EHC zone of influence. Samples from MK-5, MK-6 and P5 were also analyzed for Dehalococcoides species.

Result

Figure 5 and **Figure 6** show the concentration of total chloroethenes in groundwater collected from the collection manholes at the downgradient end of the trenches. The first round of performance monitoring (May 2006) was conducted approximately three months after the EHC injections and did not show any discernible response. However, subsequent monitoring conducted over a three year period post EHC injection showed almost complete removal of all CVOCs, ***without the accumulation of catabolites***. In the latest monitoring event, conducted in February 2009, total CVOCs decreased by >99.9% at the trench along the property line (from 2,700 to 1 ppb) and 99.5% at the building trench (from 1,950 to 9 ppb) compared to the initial concentrations measured in September, 2004.

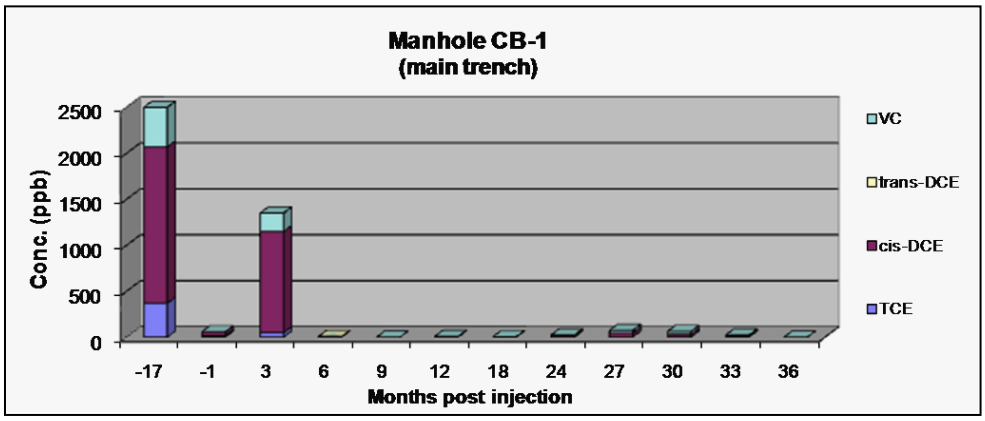

Figure 5: Influence of EHC injections on concentrations of chloroethenes in groundwater at collection manhole CB-1.

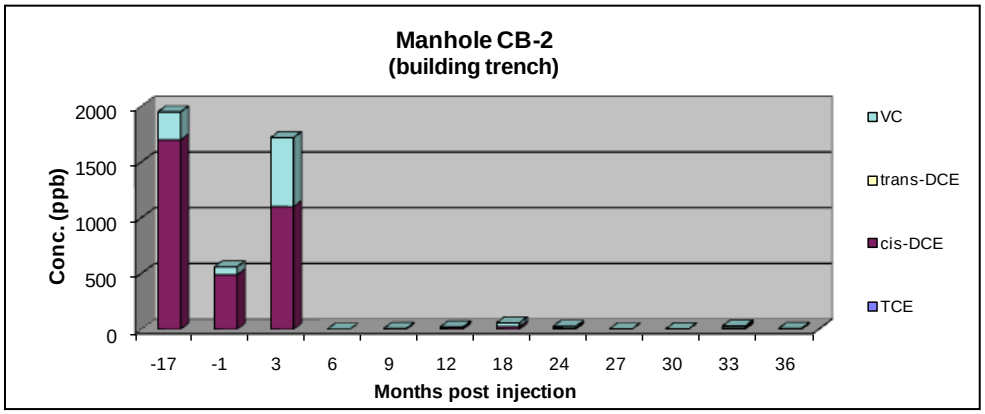

Figure 6: Influence of EHC injections on concentrations of chloroethenes in groundwater at collection manhole CB-2.

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In addition, a steady decline in CVOCs was observed at monitoring well MK-6, which is located 13 ft downgradient from the center of the trench **(Figure 7)**. Eighteen months following the EHC injections total CVOCs had decreased by 99.7%; TCE decreased from 370 ppb to ND (<1 ppb), DCE from 2,800 to 4.5 ppb, and VC from 510 ppb to 4.8 ppb. Subsequent measured removal rates have remained between 96.6 and 99.0% for over 3 years of PRB operation.

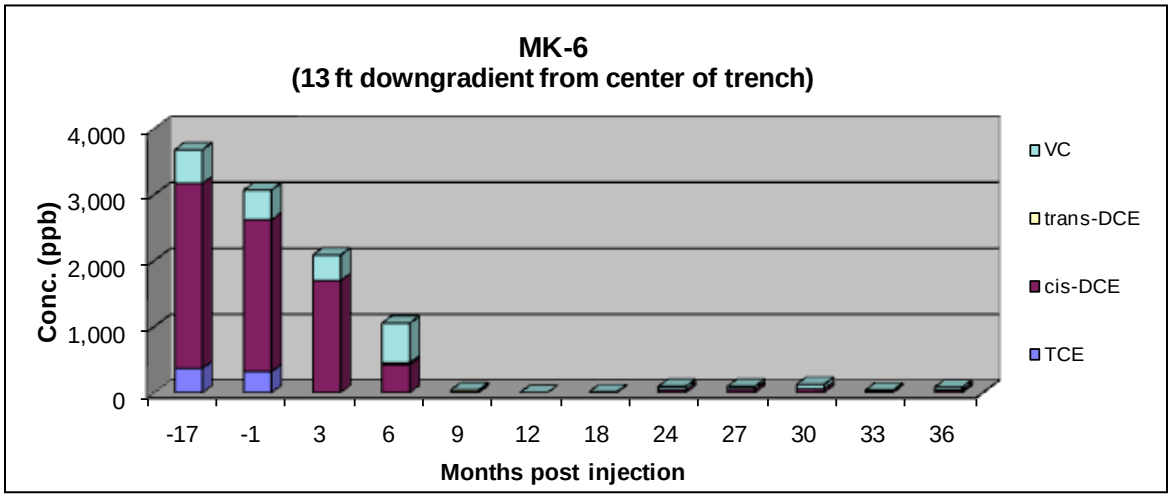

Figure 7: *Influence on total chloroethenes measured 13 ft downgradient from EHC PRB.*

No consistent CVOC removal has been observed in the other monitoring locations outside of the trench (MK-6 and P5). To verify whether these points were within the direct zone of influence of the EHC, the groundwater was sampled for TOC and total and ferrous iron nine months following the injections. Following the injection of EHC into the subsurface a significant increase would be expected in these parameters within and directly downgradient of the injection zone. The extent of the zone with elevated levels of EHC breakdown products will depend on the linear groundwater velocity and direction.

Elevated levels of TOC and iron were measured within the trenches and at MK-6, directly downgradient from the lowest point of the trench which correlates with the CVOC removal achieved at these locations. No significant increase of EHC breakdown products was observed at the remaining sampling locations and it could therefore be assumed that the EHC PRB has not directly impacted those

Figure 8: Approximate location of gravel trench, manhole CB-1

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locations yet. This could possibly be explained by the flow-pattern created by the gravel trenches installed into the low-permeability clayey soil; the groundwater would be expected to be directed through the gravel collection trenches (as designed) and to be primarily released at the lowest point by collection manhole CB-1. This would also be supported by the significant and fast removal of CVOCs at MK-6 directly downgradient from manhole CB-1 (**Figure 8**).

Nine months after the EHC injections, the groundwater was also analyzed for *Dehalococcoides* at MK-5, MK-6 and P5. There appeared to be a positive correlation between the presence of EHC breakdown products, *Dehalococcoides* levels and CVOC degradation (**Table 1** and **Figure 9**).

Table 1: *TOC, iron and Dehalococcoides measured in groundwater and corresponding CVOC removal rates nine months following the injection of EHC and KB-1.*

	Total Iron (ug/L)	Ferrous Iron (ug/L)	TOC (mg/L)	Fraction Dehalococcoides[a]	Dehalococcoides Count[b]	CVOC Removal[c]
MK-5	5400	0.14	7	2-4%	9 x 10^6 per Liter	61% increase
MK-6	162000	101	1100	11-28%	4 x 10^8 per Liter	99% decrease
P5	3560	0.14	10	2-7%	3 x 10^7 per Liter	86% decrease

a. Calculated by dividing the number of Dehalococcoides by the total number of bacteria
b. Dehalococcoides assumed to contain one rRNA gene copy per organism; number interpreted to represent the number of Dehalococcoides present in sample.
c. Change in concentrations of total chloroethenes nine months following injections.

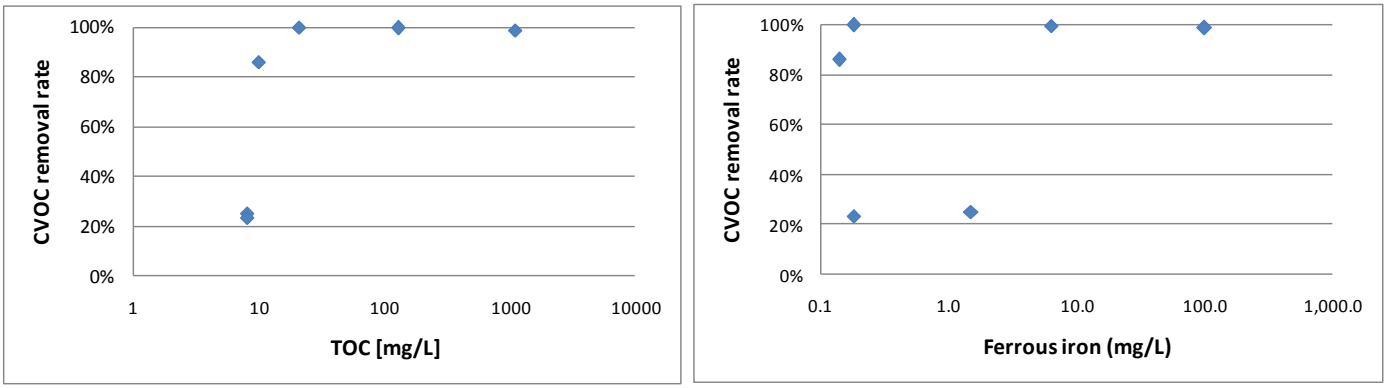

Figure 9: *Correlation between CVOC removal rates and TOC / ferrous iron in collection manholes and downgradient sampling locations.*

Cost

The material cost of using EHC was \$12/ft^2 (\$129/m^2) of PRB cross-section (a total of 11,850 lbs of EHC Reagent injected into PRBs measuring a total of 330 ft long x 6 ft deep on average).

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