ADVENTUS

EHC™ for Tetrachloroethylene

Introduction

Adventus' newest bioremediation technology, EHC™, is a patented combination of controlled-release solid carbon and zero valent iron (ZVI) or other reduced metal particles. This unique combination stimulates reductive dechlorination of otherwise persistent organic solvents in groundwater and source zones. EHC is particularly effective for *in situ* treatment of subsurface environments impacted by chlorinated solvents such as tetrachloroethylene (PCE). Adventus has performed extensive testing of EHC for treatment of PCE and offers the technology for full-scale site remediation.

EHC™ material for *in situ* applications.

The problem with PCE

PCE is regulated by the EPA to 5 µg/L in groundwater. Exposure to PCE above the regulated level may result in damages to liver, kidney and the central nervous system. There is also some evidence that long-term exposures to PCE have the potential to cause cancer. PCE production has decreased in the United States, but was still as high as 405 million lbs in 1986. Approximately 50% of the PCE is utilized for dry cleaning and for textile processing. Other commonly impacted sites include organic chemical manufacturers and industrial metal cleaning facilities, such as electronics, aerospace, and automotive facilities, where the soil and groundwater have been impacted by the wastewater.

Limitations of Existing Treatment Strategies

Standard *ex situ* treatment strategies, such as pump-and-treat and soil excavation, are expensive and labor intensive. When applicable, passive *in situ* treatment systems are usually more efficient alternatives. Once the passive treatment systems are installed, the labor requirements are limited to monitoring.

When traditional carbon sources alone (*i.e.* lactate, vegetable oil or molasses) are provided for enhanced bioremediation, problematic catabolites are often produced as a result of the PCE degradation (Figure 1). In particular, the accumulation of DCE and/or vinyl chloride commonly requires additional treatment (*i.e.*, purchase and application of microbial inoculants) before site closure can be established. Therefore, when evaluating a treatment strategy for PCE, it is important to account for its degradation products as well.

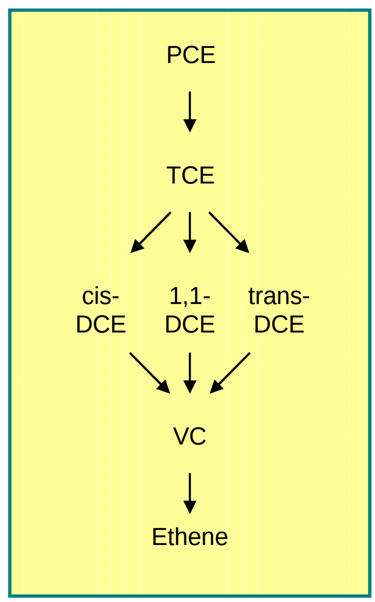

Figure 1. Anaerobic Degradation Pathway for PCE.

Zero-valent iron (ZVI) is a well-documented treatment strategy for chemical reductive dechlorination. ZVI degrades PCE and all of its degradation products. Typically, ZVI is installed into a permeable reactive barrier (PRB) at a minimum rate of 20% by mass. Since the reduction of contaminants using ZVI is a direct chemical reaction, direct contact with the contaminants is required. This makes the distribution of the ZVI into the subsurface more critical, compared to biologically induced treatment strategies. Therefore, depending on the application, biological treatment options can offer a more practical alternative.

Overview of EHC Technology

EHC technology causes destruction of contaminants through two primary mechanisms: (i) chemical reduction and (ii) enhanced biological degradation. EHC consists of solid-phase controlled-release carbon integrated with micro-scale ZVI or other metals (*e.g.*, zinc). Together these two components provide powerful reducing conditions (*e.g.*, < -550 mV), which result in complete destruction of many contaminants. In addition, natural attenuation processes in groundwater are enhanced through the release of dissolved organic carbon, as well as major, minor and micro-nutrients. As these compounds migrate through the treatment zone, they provide ideal conditions for growth of indigenous microorganisms. Because the rate of carbon release is controlled, the extent of biological colonization can also be managed, and flow rates can be maintained. This combined chemical and biological approach allows for more reliable and effective *in situ* treatment of targeted contaminants.

EHC Treatment Performance on PCE

EHC produces significantly lower redox potential and, therefore, minimizes the risk of the accumulation of problematic catabolites. Table 1 shows the results from a bench-study using flow-through columns. The system was sampled after 399 days of continuous operation.

	Influent [ppb]	Effluent [ppb]
PCE	1,278	ND
TCE	ND	ND
cis-DCE	ND	ND
VC	ND	ND

Table 1: Result from EHC bench-study on PCE degradation products.

EHC has also proven to achieve higher removal of PCE than lactate in a bench study where equal volumes of each material were placed in flow-through columns under identical conditions. Two different EHC products were evaluated and both had a higher treatment performance than lactate and achieved faster mass removal (Figure 2).

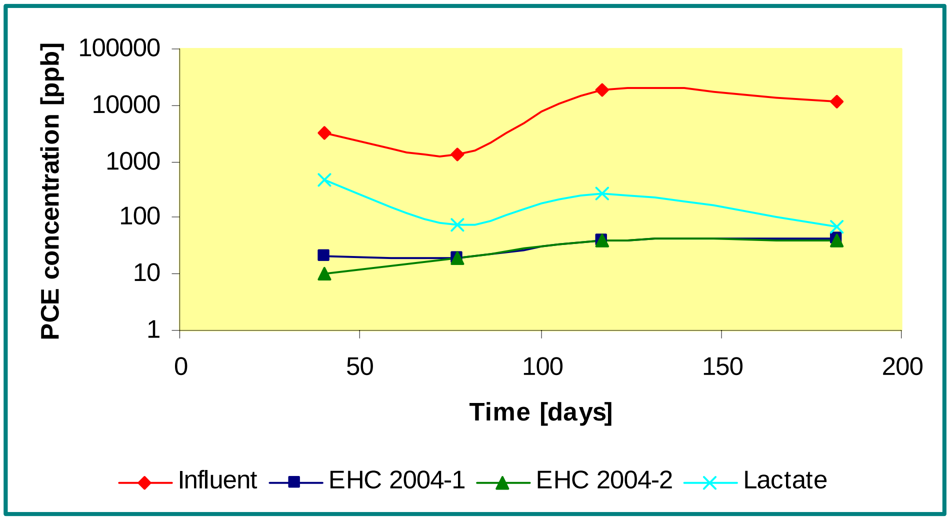

Figure 2. Results from bench-study on PCE degradation comparing EHC and lactate.

Benefits of Using EHC

It is generally accepted that under anaerobic conditions PCE can be degraded by indigenous bacteria. However, even though bacterial populations (*Dehalococcoides)* reducing cis-DCE and VC were found in 75% of the aquifers in a study by SERDP, the bacterial communities were not uniformly distributed, which helps explain why traditional bioremediation methods often fail to reduce PCE completely. The combined mechanisms following EHC placement into the soil creates extremely low redox potential at which the PCE is chemically unstable and will physically degrade. Hence, the technology is biologically based in that we rely on indigenous microbes to biodegrade the EHC carbon, but we do not recommend the addition of unique bacteria for complete and effective remediation.

The EHC materials can be applied using various construction techniques. Because EHC releases a zone of dissolved organic carbon and low redox conditions, the targeted contaminants do not need to come into direct contact with EHC to be treated. Thus, EHC may be injected into the subsurface at an *in situ* application rate that is sufficiently low to be very cost effective (typical range from 0.1 to 1% mass). Also, EHC can take the form of pellets, granules, flowable powders, or slurries. Therefore, methods such as hydraulic fracturing, pneumatic fracturing and direct injection can be used, depending on site hydrogeology. The material may also be placed in a trench using conventional or modified PRB techniques.

Another benefit of EHC is found in its adaptability to site conditions, including contaminant concentrations and groundwater flow rates. A range of EHC products is available, and each product has its own carbon and nutrient release and buffering characteristics. This allows product characteristics to be tailored to meet site-specific needs. Through appropriate selection of EHC products, the longevity, redox conditions and pH can be controlled. This protects the downgradient treatment area from large shifts in pH that can hinder enhanced natural attenuation.

Cost Benefits of EHC™ Technology

Data indicate that EHC will remain active for a period of at least 12 to 60 months in the subsurface, depending on the product used and hydrogeological conditions. This is longer than many other organic carbon based treatment materials. The price of EHC depends on both type and volume, but will generally range from $1.75/lb to $3/lb. **EHC is a leading treatment technology in terms of both cost and performance.**

REFERENCES

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