

The Nature of the Chlorinated Aliphatic Hydrocarbons (CAHs)

Chlorinated Aliphatic Hydrocarbons (CAHs), a family of compounds that are commonly used as chlorinated organic solvents, are increasingly being detected in soil and groundwater. The most prevalent of these CAHs are perchlorethylene (PCE), trichloroethylene (TCE), and trichloroethane (TCA), shown in Figure 1. Since the 1960s, these solvents have been used primarily for degreasing in the dry cleaning, electronics, industrial manufacturing and machine maintenance industries. Due to leakage of these CAHs from storage tanks and machinery, dissolved phase PCE, TCE, and TCA are now appearing in groundwater at concentrations which have been proven unhealthy and even carcinogenic.

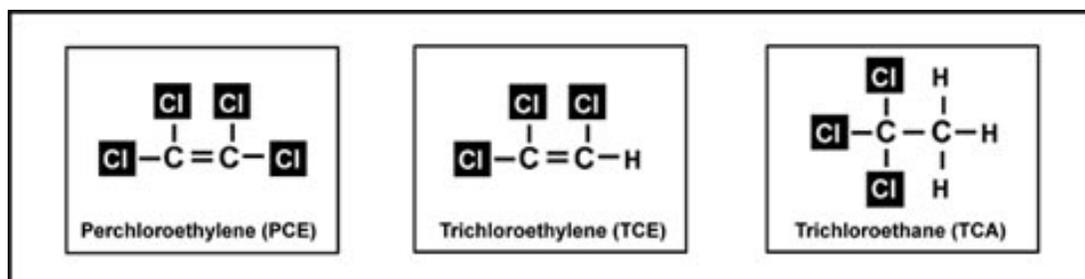


Figure 1

Unlike petroleum products, CAHs are more dense than water and can exist as Dense Non-Aqueous Phase Liquids (DNAPLs) which are not stopped at the water table and flow through the saturated zone to the aquitard. Their ability to exist as DNAPL makes CAHs much more difficult to clean up compared to petroleum hydrocarbons. Once in the saturated zone, CAHs form “fingers” which can lead to the collection of large amounts of solvent in one or more pools on top of less permeable layers (see Figure 2). In the past, it was believed that CAHs would vaporize due to their high volatilities before they could enter the saturated zone, thus negating any concern over groundwater contamination. Unfortunately, any CAHs that do not vaporize are transported into the saturated zone and form fingers that become too difficult to locate for conventional mechanical remediation methods to be effective.

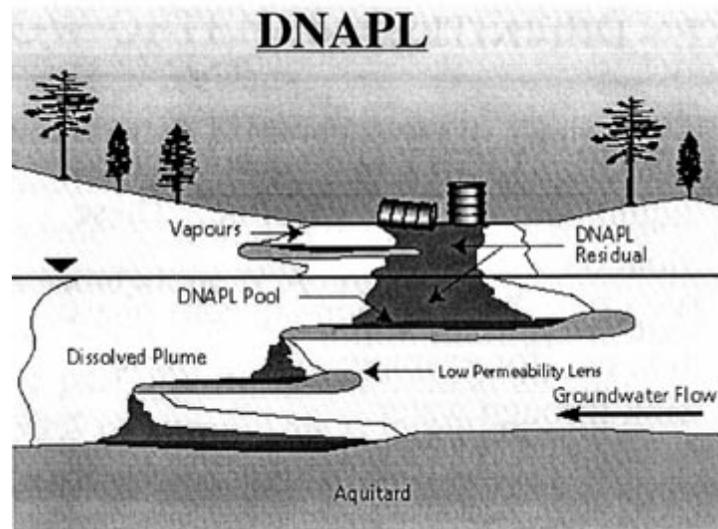


Figure 2

Several other factors have led to extensive groundwater contamination by CAHs, making them difficult to remove via mechanical methods (1):

- The relatively low viscosity of CAHs allows rapid downward movement in the subsurface.
- The low interfacial tension between liquid CAHs and water allows the CAHs to enter easily into small fractures and pore spaces which can lead to deep penetration into the subsurface.
- The high relative solubilities of CAHs mean that a spill can cause groundwater contaminate concentration to reach levels that are harmful to human health.
- The low partition coefficient of CAHs from aqueous phase to soil materials means that they will bind weakly to soil and rock, in both the unsaturated and saturated zones. Due to this poor sorption, soils will not significantly retard the movement of a chlorinated solvents, and contaminant plumes can advance much further than petroleum hydrocarbon contaminated plumes.

Since mechanical methods commonly used for the clean up of petroleum hydrocarbons are costly and can be ineffective in CAH remediation, the focus has turned to bioremediation. Through a biological process called reductive dechlorination, anaerobic microorganisms indigenous to the aquifer can use hydrogen to remove the chlorine atoms from CAHs resulting in non-toxic end products such as ethene (see HRC technical bulletin #1.1.2 for detailed information on reductive dechlorination). The fact that hydrogen is a limiting factor in the process of reductive dechlorination is the basis for the application of Hydrogen Release Compound, HRC. HRC is an environmentally safe, food quality, high viscosity, polylactate ester specially formulated for the slow release of lactic acid upon hydration. The lactic acid released from HRC is metabolized by indigenous microbes to produce the hydrogen necessary for reductive dechlorination to occur. Given the insidious nature of CAH/DNAPL contamination, bioremedial solutions based on these principles hold great promise.

References

1. Pankow, J.F. and J.A. Cherry. 1996. Dense Chlorinated Solvents and Other DNAPLs in Groundwater. Waterloo Press.