# The Environmental Corner

*By: Steve Henshaw*

## In Situ Bio-Remediation Of Perc From Syrup To Cheese Whey

For years, environmental scientists and engineers have been promoting the notion of using microorganisms to degrade chlorinated volatile organic compounds (e.g. perc and associated breakdown products) and petroleum hydrocarbons (e.g. gas, diesel, oil, etc.) This technology falls under a general term called bio-remediation. One may recall video of the Valdez oil spill in Alaska, when cleanup crews sprayed microorganisms onto the oil laden shoreline. The idea was that the microorganisms would literally consume the oil as their food source. This same phenomenon has been observed in aquifers contaminated with gasoline and oil, whereby the leading edge of the contamination plume is often consumed by naturally occurring microorganisms, while the center of the contamination plume does not have sufficient oxygen for the microorganisms to grow. The breakdown of petroleum hydrocarbons can be summed up as needing an oxygen rich environment, also known as an aerobic environment, where oxygen is needed to aid in the consumption of the petroleum hydrocarbons. The result is that gasoline and diesel contaminated plumes are relatively small in length. As the concentration of gasoline and diesel compounds decrease from the source area, the amount of oxygen increases and the bugs' population, in turn, adjusts to the lower concentration food source.

So why is the same not true for perc contaminated groundwater plumes? Why do we see some perc plumes extend thousands of feet from the source area? The reason is that the breakdown of chlorinated hydrocarbons, such as perc, requires an oxygen depleted or anaerobic environment.

Typically, bacteria that are involved in the biodegradation of chlorinated hydrocarbons, more

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specifically known as chlorinated aliphatic hydrocarbons (CAH), in the subsurface are chemotrophs (bacteria that derive their energy from chemical redox reactions) and use organic compounds as electron donors and sources of organic carbon (organoheterotrophs).

To aid in the degradation, a carbon source must be introduced into the contaminated aquifer to act as a substrate and a food and energy source for the bacteria. During the microbial metabolic process, the carbon source is fermented releasing hydrogen, which acts as a preferred electron donor and bacteria reduce electron acceptors such as CAH resulting in release of chlorine atoms. The carbon source can be any number of products from commercially made specialty products to commercial grade corn syrups, molasses, vegetable oil and even cheese whey. Really, the source is more dependent on what part of the world the contaminated site is located and what available product is cheapest. If a site is located in the south, corn syrup or molasses may be cheapest. If the site is located near dairy farms, cheese why might be cheapest.

To understand if your site is suitable for in situ bio-remediation, the groundwater has to be analyzed for concentrations of key chemical parameters and bacterial population. Such chemical parameters include the concentrations of CAHs and daughter products (e.g. perc, TCE, cis-DEC, vinyl chloride), oxygen content, pH, redox potential, iron, sulfates and nutrient concentrations. These parameters provide information about the baseline contamination and water quality at the site, to support biodegradation, and whether and how much intrinsic biodegradation (without enhancements) may be occurring at the site. Bacterial analysis further assists in assessing potential for reductive dechlorination. Redox potential is being monitored to determine whether the subsurface environment is more reducing or more oxidizing.

In addition to the chemical testing, the sites most suitable to in situ bio-remediation are going to have an aquifer that is transmissive, where water flows relatively easily and the formation is not tight. Think of a sandier environment verses a tight clay environment. If the aquifer is too tight, the injected material cannot penetrate very far into the aquifer, which results in the need for more injection points to get the material evenly across the aquifer.

The advantages to using in situ bio-remediation are that the material can be injected into the subsurface with minimal business interruption, there may be no need for an active treatment system involving pumps, compressors and treatment tanks, there are no electrical costs, and there are no costs for routine operation and maintenance. Other advantages to using in situ bio-remediation are that the product is relatively inexpensive, readily available and it is safe and easy to handle.

The downside to in situ bio-remediation can be that depending on what material is being injected into the aquifer the reaction of turning the aquifer from an aerobic (oxygen rich) environment to an anaerobic (oxygen deficient) environment can be very slow. Products such as cheese whey and syrups act very rapidly, but they tend to be consumed rapidly also, which may require several additional injections before the concentrations of the CAHs are to acceptable levels for site closure. Conversely, vegetable oil and other specialty products can take a considerable time to convert the aquifer, but may last a longer amount of time in the aquifer. Other disadvantages is as the perc is broken down to the sister products such as TCE, DCE etc., the rate of dechlorination may reduce requiring more time to attain the desired concentration. Vinyl chloride, which is considered a carcinogen, is formed as the last chlorinated compound in this breakdown process and requires aerobic environment and aerobic bacteria to degrade to non-hazardous constituents. Finally, some of the products tend to smell like rotten eggs (e.g. cheese whey)

If you or your consultant are considering in situ bio-remediation, you may want to have a small scale test or pilot study conducted to make sure all above issues are properly studied to conclude that this technical approach is suitable for the specific site.