EnviroFacts
Environmental Management Directorate, Hill Air Force Base, Utah
October 1998

Monitored Natural Attenuation

As more sites move from the investigation stage to the cleanup stage, new cleanup technologies and methods are receiving more attention than ever. Among these new technologies is one called monitored natural attenuation.

Essentially, natural attenuation means allowing contaminants in the soil or groundwater to degrade naturally without treatment.

This approach to cleanup has been met with some skepticism. Critics argue that this approach will cause the contamination to be forgotten and never really cleaned up. However, supporters say natural attenuation, when properly applied, can effectively clean up contaminated soil and groundwater. In so doing, it saves millions of dollars in cleanup costs without putting anyone at any additional risk.

Biological and chemical

There are two types of natural attenuation: biological and chemical. Biological natural attenuation has been used for years. It is frequently called bioremediation. Bioremediation—along with enhanced variations, like bioventing—has been successfully applied at petroleum-contaminated sites for years. Living organisms, such as bacteria, use the petroleum as a food source. By "eating" the chemical, they break it down into simpler, harmless compounds.

Chlorinated solvents like trichloroethene (TCE) are another matter. For years, scientists studied how TCE and similar chemicals degrade naturally. Their research showed that in certain conditions, chlorinated solvents break down, but since bacteria do not seem to have a taste for TCE, they didn't know why it was happening. Until they knew why, there would be no way to successfully use it as a cleanup technology.

After years of research, scientists found their answers. They discovered bacteria also play an important role in chemical natural attenuation. But instead of "eating" the chemicals, the bacteria use parts of the TCE molecule to help them eat their food. In the process, the TCE molecule is broken down into simpler components.

Chemists call the TCE molecules "electron acceptors." Simply put, as the bacteria break down their food (similar to the way our bodies digest food), they must find a place to put the excess electrons created in the breakdown process. TCE molecules become this place, trading a chlorine atom for another ion (usually hydrogen). With fewer chlorine atoms, the chemical is no longer TCE, but something else (usually dichloroethene). This process of losing chlorine atoms continues until all the chlorine is gone and the compound has broken down into carbon dioxide and water.

Just as with biological natural attenuation, chemical natural attenuation does not work everywhere. For this process to work effectively, aquifer conditions must be just right. In some aquifers, the proper conditions exist naturally. But even if aquifer conditions are less than ideal, they can sometimes be enhanced.

In addition to these processes, dispersion and dilution occurs in all aquifers. As a chemical moves away from its source, it dissolves into more and more water, reducing its concentration until it can no longer be detected. A chemical may also stick to soil particles, which also removes it from the groundwater.

Regulatory approval

The U.S. Environmental Protection Agency, initially skeptical of natural attenuation, has extensively researched the technology. EPA agrees that natural attenuation works, given the right site conditions. However, the agency has issued strict guidelines for using natural attenuation as a cleanup method.

EPA is quick to point out that natural attenuation is not a "no action" cleanup method, nor should it be considered a "presumptive" remedy. (Presumptive remedies are methods EPA has approved and recommended for use in certain site conditions or

Natural attenuation information available online

More information on natural attenuation can be found on the internet at the following locations:

EPA's Web Site:
www.epa.gov/swerffrr/chlorine.htm

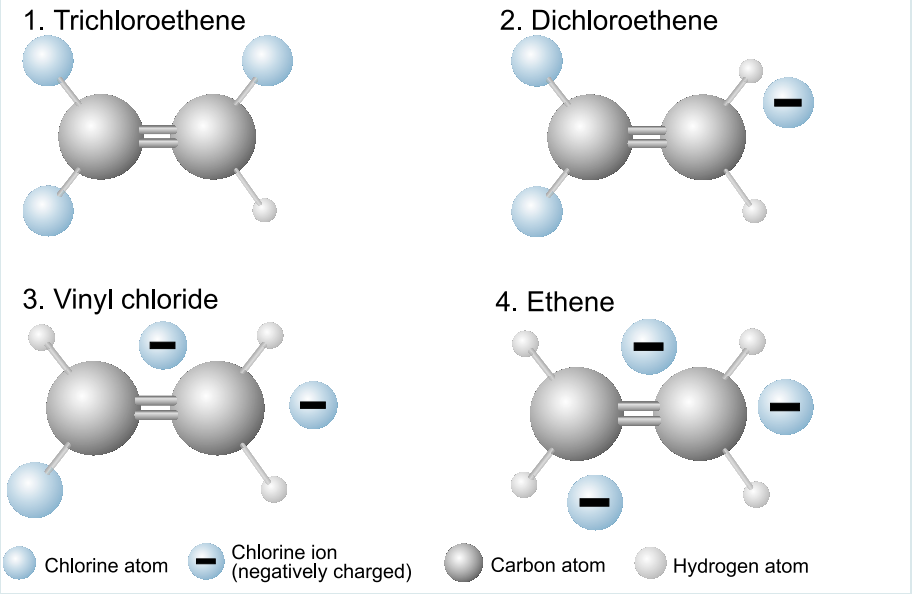
Groundwater Currents:
www.clu-in.com/gwc/gwcchlrs.htm
www.clu-in.com/gwc/gwcnatt.htm

Air Force Center for Environmental Excellence:
www.afcee.brooks.af.mil/events/erworkshop/agenda/presentations/techinia/natural/tsld001.htm

Remedial Technologies Development Forum:
www.icubed.com/rtdf/html/private/bioremed/docs.html

a.k.a.

Monitored natural attenuation is also known by other names, including intrinsic remediation, passive remediation, reductive dechlorination, assimilative capacity and natural restoration.



Step 1. *TCE is a molecule made up of two carbon atoms, three chlorine atoms (tri-chloro) and one hydrogen atom.*

Step 2. *As bacteria in the aquifer eat other molecules as food, TCE is used to help them break down the food. In the process, a chlorine atom is stripped off the TCE molecule, leaving DCE molecule and a chlorine ion.*

Step 3. *The process continues. DCE is reduced to vinyl chloride, a highly toxic chemical. However, vinyl chloride quickly breaks down to ethene.*

Step 4. *Once all the chlorine atoms have been stripped away, the ethene molecule breaks down into harmless carbon dioxide and water.*

for cleaning up specific types of contamination.)

For EPA to approve using natural attenuation at a site, there must be clear evidence the process is occurring at a rate reasonably comparable to using active cleanup systems. Remediation by monitored natural attenuation must also be accepted by the affected community. In addition, the site must be carefully monitored to ensure the process continues to work and that the cleanup goals are being met. EPA also strongly recommends that natural attenuation be used in conjunction with other active remedial options that control or clean up source areas. They also recommend a backup plan, in case conditions change unexpectedly.

Putting pieces together

Cleaning up a hazardous waste site is much like assembling a puzzle. At Hill, most cleanup plans are complex and employ several different cleanup methods and technologies. Like a puzzle, each piece of the plan integrates with other pieces to achieve the cleanup goals. And like a puzzle, each piece is important to the overall success of the cleanup.

For example, at Operable Unit 1, natural attenuation has been approved by state and federal regulators as one of several cleanup methods that will be used to clean up the site. Active technologies such as pump-and-treat and containment will be used in the heavily contaminated areas on base. In some of the the less-contaminated off-base areas, monitored natural attenuation will be used instead of a massive and expensive pump-and-treat system that would have otherwise been required.

However, merely declaring that a site will be allowed to naturally attenuate does not mean that work at the site is over. As specified in EPA regulations, the Air Force must specify realistic cleanup goals for the site. Then the site must be carefully monitored to ensure the process is working and that the cleanup goals are being met. This monitoring must continue until the site has been restored.

Mutually beneficial

While monitored natural attenuation can be significantly cheaper than conventional cleanup methods, cost is not its only advantage. For example, the Air Force invests millions of dollars every year designing, and operating pump-and-treat systems to clean up large areas of contaminated groundwater. While these systems are somewhat effective, they may not work significantly better than natural attenuation would, given the proper conditions.

Yes, natural attenuation may take longer to clean up an area than would active treatment, but it offers one distinct advantage—property owners can continue to use their land during the cleanup.

Active treatment systems are often very intrusive. They usually require several extraction wells installed in the ground which are connected by hundreds of feet of pipe and electrical wiring, severely limiting the usefulness of the affected area.

Natural attenuation, on the other hand, requires only a few relatively unobtrusive monitoring wells, with very little impact on land use.

Hill AFB: Environmental Research Lab

For many years, Hill AFB has been used by the world's top environmental scientists as a field laboratory for testing and researching cleanup and investigative technologies. The list includes innovative capping methods, bioventing, soil flushing, various experimental *in situ* treatment methods, and the list goes on. While only a few of these methods are ever permanently implemented at Hill or anywhere else, the lessons learned are invaluable to researchers trying to find the best way to clean up environmental contamination.

Monitored natural attenuation at Hill AFB

Monitored natural attenuation is part of cleanup plans at OU-1, OU-6 and the Patriot Hills petroleum spill site. The Air Force plans to propose natural attenuation in future cleanup plans, as well.

For more information

For more information on Natural Attenuation or any other environmental issue at Hill, contact the Environmental Public Affairs Coordinator:

Charles Freeman
(801) 775-6951

e-mail: freemach@hillwpos.hill.af.mil