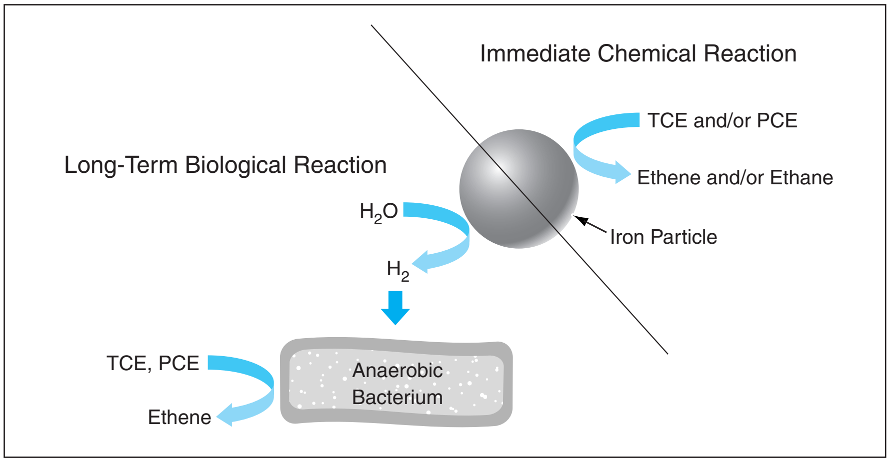
Using Iron To Treat Chlorohydrocarbon-Contaminated Soil

Prompt chemical remediation is followed by longer-term enhanced bioremediation.

John F. Kennedy Space Center, Florida

A method of *in situ* remediation of soil contaminated with chlorinated hydrocarbon solvents involves injection of nanometer-size iron particles. This method should not be confused with a similar method, involving injection of emulsified iron particles, reported in "Treatment To Destroy Chlorohydrocarbon Liquids in the Ground" (KSC-12246), *NASA Tech Briefs*, Vol. 27, No. 6 (June 2003), page 56. Like that method, this method is implemented in a process that is safe, yields environmentally benign end products, takes less time and costs less than do traditional pump-and-treat processes, and is both less expensive and less environmentally disruptive than are cleanup processes that involve excavation, transport to facilities for incineration or other treatment, and reburial in landfills.



An **Injected Iron Particle** causes the reduction of chlorinated hydrocarbons (especially TCE and PCE). These compounds are converted to hydrocarbons along two reaction pathways: an immediate chemical reduction and a long-term biological reduction.

In a related prior method of bioremediation of soil con-taminated with trichloroethylene (TCE) or perchloroethylene [(PCE), also known as tetrachloroethylene], electron donors and nutrients are supplied to contaminated soil so that anaerobic bacteria naturally present in the soil can use the electron donors in breaking down chlorohydrocarbon molecules in their metabolic pathways. In the metabolic process in question, denoted reductive dechlorination or dehalorespiration, one or more chlorine atom(s) are removed from each chlorinated hydrocarbon molecule and replaced with hydrogen atoms.

The present method exploits a combination of prompt chemical remediation followed by longer-term enhanced bioremediation (see figure) and, optionally, is practiced in conjunction with the method of bioremediation described above. Newly injected iron particles chemically reduce chlorinated hydrocarbons upon contact. Thereafter, in the presence of groundwater, the particles slowly corrode via chemical reactions that effect sustained release of dissolved hydrogen. The hydrogen serves as an electron donor, increasing the metabolic activity of the anaerobic bacteria and thereby sustaining bioremediation at a rate higher than the natural rate.

Wells for injecting the iron particles are installed in a contaminated site in locations such that the particles become entrained in the underground plume of groundwater and contaminants flowing from the site. The particles are small enough that they can be transported through compact soil and thereby become dispersed throughout a large volume.

The effects of choosing various locations for injection wells and of injecting various amounts of iron are assessed by a technique in which helium, used as a tracer gas, is injected into the ground via the wells. Helium was chosen as the tracer gas because of its low background concentration in the atmosphere, low rate of diffusion in water, moderate solubility in water, non-toxicity, chemical inertness, and the similarity of its physical characteristics to those of hydrogen. The decrease in the concentration of helium with distance from the point of injection is taken as an approximate indication of the abiotic component of the loss of dissolved hydrogen; the difference between decrease in the concentration of hydrogen and that of helium is then taken as an approximate indication of the biotic component of the loss of dissolved hydrogen. Monitoring by use of this technique can provide information that helps to determine the minimum amount of iron that must be injected to remediate the contaminated site.

This work was done by G. Duncan Hitchens, Dalibor Hodko, Heekyung Kim, Tom Rogers, Waheguru Pal Singh, Anthony Giletto, and Alan Cisar of Lynntech, Inc., for **Kennedy Space Center**.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

Jinseong Kim
Lynntech, Inc.
7610 Eastmark Drive
College Station, TX 77840
E-mail: jinseong.kim@lynntech.com

Refer to KSC-12299, volume and number of this NASA Tech Briefs *issue, and the page number.*