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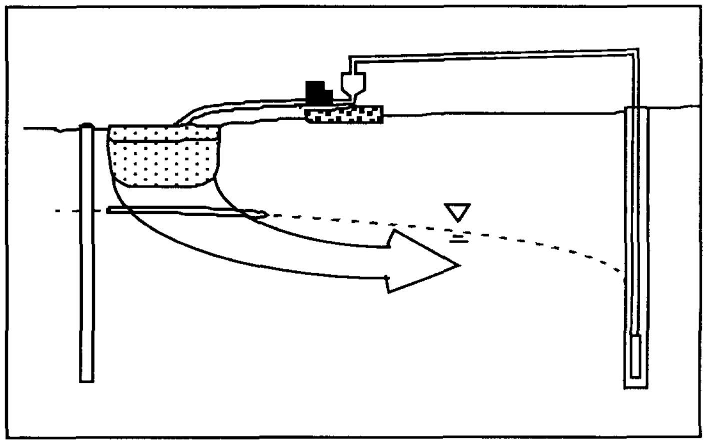
EPA Summary Paper

In-Situ Bioremediation of Ground Water



Introduction

The Robert S. Kerr Environmental Research Laboratory (RSKERL) has developed a number of *Issue Papers* and *Briefing Documents* which are designed to exchange up-to-date information related to the remediation of contaminated soil and ground water at hazardous waste sites. In an attempt to make the content of these documents available to a wider audience, RSKERL is developing a series of *Summary Papers* which are condensed versions of the original documents.

There are a number of techniques that may potentially be used for dealing with problems resulting from the contamination of ground water with organic compounds. These include physical containment using slurry walls or grout curtains, or hydraulic controls using pumping wells or interceptor systems to manipulate the hydraulic gradient; free product recovery techniques; or the extraction of contaminated ground water followed by treatment at the surface. Also, ground water can sometimes be treated in place using chemical or biological processes. *In-situ* chemical treatment, for example, may involve the neutralization, precipitation, oxidization, or reduction of contaminants by injecting reactive materials into the subsurface.

Bioremediation Concepts

An emerging technology for the *in-situ* remediation of ground water is the use of microorganisms to degrade contaminants which are present in aquifer materials. Although *in-situ* bioremediation has been used for a number of years in the restoration of ground water contaminated with petroleum hydrocarbons, its application to other classes of contaminants is relatively recent.

Most biological *in-situ* treatment systems are carried out by stimulating indigenous microorganisms to degrade those organic contaminants dissolved in ground water and attached to aquifer solids. The process, which is an adaptation of earlier attempts to remediate gasoline-contaminated aquifers, involves the circulation of oxygen and nutrients through a contaminated aquifer using extraction and injection wells. The placement of the wells depends on the size and configuration of the affected area, and the hydraulic conductivity of the ground-water formation.

Research is under way to test the use of nitrate instead of oxygen during *in-situ* treatment systems to promote the anaerobic degradation of organic contaminants. Investigations into additional methods to enhance *in-situ* bioremediation include the addition of a readily degradable substrate to aid in the degradation of more recalcitrant molecules, and the addition of a non-toxic substitute for a specific contaminant in order to induce degradative enzyme activity that will affect both the substitute and the specific contaminant.

In addition to the stimulation of indigenous microbial populations to degrade organic compounds in a contaminated aquifer, another technique, which has not been fully demonstrated, is the addition of microorganisms with specific metabolic capabilities. These microbial populations have been altered to degrade specific compounds by enrichment culturing or genetic manipulation. Enrichment culturing involves exposure of microorganisms to increasing concentrations of a contaminant. Genetic manipulation is accomplished by exposure of organisms to a mutagen, followed by enrichment culturing, or by the

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use of DNA recombinant technology to change the genetic structure of the microorganism. It is important to note that the inoculation of specialized microbial populations into the subsurface may not result in degradation for a number of reasons including the concentration of the contaminant, geochemistry of the formation, or other organisms that are toxic or inhibitory to the inoculated organisms.

There are a number of advantages to the use of *in-situ* bioremediation. Unlike other aquifer remediation techniques, it can often be used to treat contaminants that are sorbed to aquifer material or trapped in pore spaces. The time required using *in-situ* bioremediation can often be faster than extraction and treatment processes. For example, a gasoline spill was remediated in 18 months using *in-situ* bioremediation, while pump-and-treat techniques were estimated to require 100 years. *In-situ* bioremediation often costs less than other remediation options.
There are also disadvantages to *in-situ* bioremediation. Many organic compounds are resistant to degradation as are heavy metals. In addition, organic compounds that otherwise might be subject to degradation may be toxic or inhibit the growth of microorganisms at concentrations often found at contaminated sites. Injection wells may also become clogged from profuse microbial growth resulting from the addition of nutrients and oxygen.

In-situ bioremediation is difficult to implement in low permeability aquifers that do not permit the transport of adequate supplies of nutrients and electron acceptors to active microbial populations. Aquifers with hydraulic conductivities of 10^{-4} cm/sec (100 ft/yr) or more are usually considered good candidates for *in-situ* bioremediation.

This *Summary Paper* has been developed from the *Ground-Water Issue Paper* titled "*In-Situ* Bioremediation of Contaminated Ground Water." EPA/540/S-92/003, February 1992.

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