A Citizen's Guide to Bioremediation

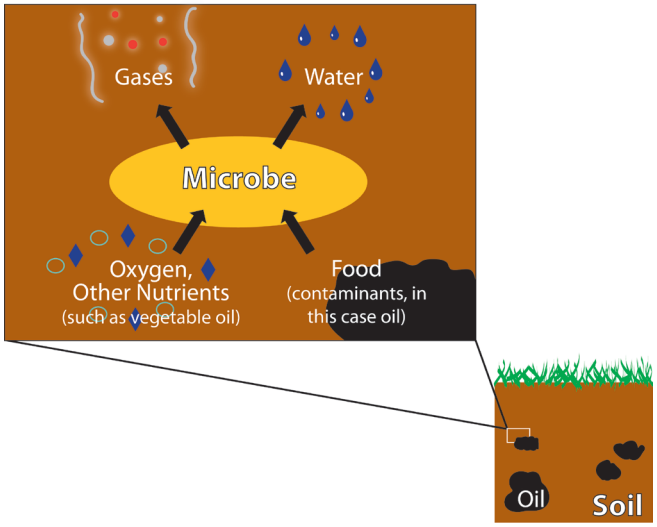
What Is Bioremediation?

Bioremediation is the use of microbes to clean up contaminated soil and groundwater. Microbes are very small organisms, such as bacteria, that live naturally in the environment. Bioremediation stimulates the growth of certain microbes that use contaminants as a source of food and energy. Contaminants treated using bioremediation include oil and other petroleum products, solvents, and pesticides.

How Does It Work?

Some types of microbes eat and digest contaminants, usually changing them into small amounts of water and harmless gases like carbon dioxide and ethene. If soil and groundwater do not have enough of the right microbes, they can be added in a process called "bioaugmentation."

For bioremediation to be effective, the right temperature, nutrients, and food also must be present. Proper conditions allow the right microbes to grow and multiply—and eat more contaminants. If conditions are not right, microbes grow too slowly or die, and contaminants are not cleaned up. Conditions may be improved by adding "amendments." Amendments range from household items like molasses and vegetable oil, to air and chemicals that produce oxygen. Amendments are often pumped underground through wells to treat soil and groundwater in situ (in place).



Microbe takes in oil, oxygen, and nutrients and releases gases and water.

The conditions necessary for bioremediation in soil cannot always be achieved in situ, however. At some sites, the climate may be too cold for microbes to be active, or the soil might be too dense to allow amendments to spread evenly underground. At such sites, EPA might dig up the soil to clean it "ex situ" (above ground) on a pad or in tanks. The soil may then be heated, stirred, or mixed with amendments to improve conditions.

Sometimes mixing soil can cause contaminants to evaporate before the microbes can eat them. To prevent the vapors from contaminating the air, the soil can be mixed inside a special tank or building where vapors from chemicals that evaporate may be collected and treated.

Is Oxygen Always Needed?

Some contaminants can only be bioremediated in an aerobic environment—one that contains oxygen. Others can only be bioremediated in an anaerobic environment without oxygen. Anaerobic microbes do not need oxygen to grow.

To clean up contaminated groundwater in situ, wells are drilled to pump some of the groundwater into above ground tanks. Here, the water is mixed with amendments before it is pumped back into the ground. The groundwater enriched with amendments allows microbes to bioremediate the rest of the contaminated groundwater underground. Groundwater also can be pumped into a "bioreactor" for ex situ treatment. Bioreactors are tanks in which groundwater is mixed with microbes and amendments for treatment. Depending on the site, the treated water may be pumped back to the ground or discharged to surface water or to a municipal wastewater system.

How Long Will It Take?

It may take a few months or even several years for microbes to clean up a site, depending on several factors. For example, bioremediation will take longer where:

- Contaminant concentrations are high, or contaminants are trapped in hard-to-reach areas, like rock fractures and dense soil.
- The contaminated area is large or deep.

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- Conditions such as temperature, nutrients, and microbe population must be modified.
- Cleanup occurs ex situ.

Is Bioremediation Safe?

Bioremediation relies on microbes that live naturally in soil and groundwater. These microbes pose no threat to people at the site or in the community. Microbes added to the site for bioaugmentation typically die off once contamination and the conditions needed for bioremediation are gone. The chemicals added to stimulate bioremediation are safe. For example, the nutrients added to make microbes grow are commonly used on lawns and gardens, and only enough nutrients to promote bioremediation are added. To ensure that the treatment is working and to measure progress, samples of soil and groundwater are tested regularly.

How Might It Affect Me?

Bioremediation often occurs underground and does not cause much disruption to the site or surrounding community. Contaminated soil and groundwater stay onsite, reducing truck traffic, compared with some other cleanup methods. However, area residents and businesses may hear the operation of pumps, mixers, and other construction equipment used to add amendments or improve site conditions to begin the bioremediation process. Excavation and pumping also will occur for ex situ bioremediation. (See a *Citizen's Guide to Excavation of Contaminated Soil* [EPA 542-F-12-007].)

Why Use Bioremediation?

Bioremediation has the advantage of using natural processes to clean up sites. Because it may not require as much equipment, labor, or energy as some cleanup methods, it can be cheaper. Another advantage is that contaminated soil and groundwater are treated onsite without having to dig, pump, and transport them elsewhere for treatment. Because microbes change the harmful chemicals into small amounts of water and gases, few if any waste byproducts are created.

Bioremediation has successfully cleaned up many polluted sites and has been selected or is being used at over 100 Superfund sites across the country.

Injection of vegetable oil underground to improve conditions for bioremediation.

Example

Bioremediation is cleaning up groundwater contaminated with dry cleaning solvent at the Iceland Coin Laundry Superfund site in New Jersey. To improve the conditions at the site for bioremediation, amendments were added. A solution of vegetable oil and baking soda was injected into the groundwater in an area of particularly high contaminant concentrations. Bacteria also were added to increase the existing population of microbes. The treatment area is about 1800 feet long, 500 feet wide and extends 40 feet below ground.

Preliminary testing of the groundwater has shown that bioremediation is working and contaminant concentrations are decreasing. The objective is to continue to reduce the concentration of contaminants from 10 or more parts per billion to less than 1 part per billion.

For More Information

For more information about this and other technologies in the Citizen's Guide Series, visit:

www.cluin.org/remediation
www.cluin.org/products/citguide
www.cluin.org/bioreactor
www.cluin.org/bioremediation

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