Community Guide to Bioremediation

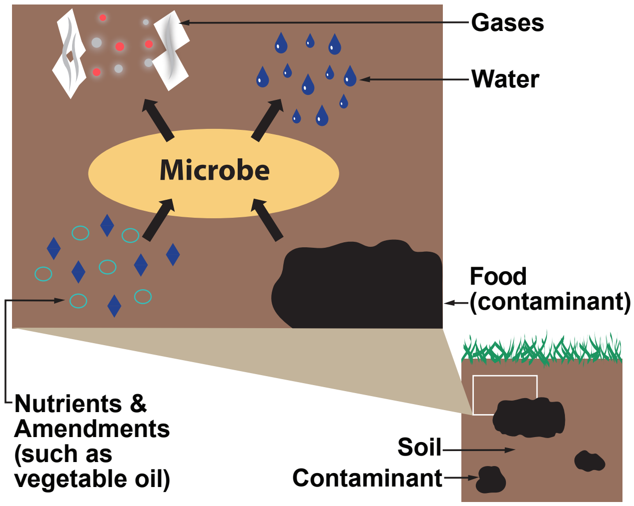
What Is Bioremediation?

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 gases like carbon dioxide and ethene. When soil and groundwater do not have enough of the right microbes, microbes are added. This process is 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. Adding "amendments" may improve conditions. 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).



In bioremediation, microbes consume nutrients and contaminants, and release gases and water.

The conditions necessary for bioremediation in soil cannot always be achieved in situ. 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" (aboveground) on a pad or in tanks. The soil may be heated, stirred or mixed with amendments to improve conditions.

Sometimes mixing soil causes 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 are collected and treated.

Is Oxygen Always Needed?

Some contaminants can be bioremediated only in an aerobic environment — one that contains oxygen — because the microbes need oxygen to grow. Other contaminants can be bioremediated only in an anaerobic (without oxygen) environment. 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 aboveground tanks. The water is mixed with amendments before it is pumped back into the ground. An alternative is to pump the amendments directly underground. The amendment-enriched groundwater allows microbes to bioremediate the rest of the contaminated groundwater underground. Groundwater also can be pumped into an aboveground "bioreactor" for ex situ treatment as part of a "pump and treat" system. (See *Community Guide to Pump and Treat*.) 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 underground or discharged to surface water or to the public sewer system.

How Long Will It Take?

It may take a few months or even years to bioremediate a site, depending on several factors that vary from site to site. For example, bioremediation will take longer where:

- Contaminant concentrations are high, or contaminants are trapped in hard-to-reach areas, like rock fractures or dense soil.
- The contaminated area is large or deep.
- 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 your community. Microbes added for bioaugmentation typically die off once contaminants and proper conditions are gone. The chemicals added to stimulate bioremediation also are safe. For example, the nutrients added to make microbes grow are commonly used on lawns and gardens. To ensure that bioremediation 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 your community or the site. You may notice increased truck traffic as equipment comes to the site. You also might hear the operation of pumps, mixers and other construction equipment used to add amendments or improve site conditions to begin the bioremediation process.

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 transport them elsewhere for treatment. Because microbes change the harmful chemicals into small amounts of water and gases, few if any waste by-products are created.

Injection of vegetable oil underground to improve conditions for bioremediation.

Bioremediation has been selected for use at hundreds of Superfund sites and other cleanup sites across the country.

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Example

Anaerobic bioremediation is being used to clean up groundwater at a portion of Dover Air Force Base in Delaware. Previous industrial activity and storage of hazardous waste contaminated an area approximately 2,800 feet long and 650 feet wide with solvents. Remediation began in 2006 with the injection of more than 100,000 gallons of a solution of vegetable oil and sodium lactate. The solution was injected in 49 locations to depths of 5 to 30 feet underground. In 2012, a second source of contamination several hundred feet from the original source area was detected. An additional 140,000 gallons of solution were injected in 20 new locations. Routine groundwater monitoring shows that concentrations have decreased to below cleanup levels in all monitoring wells, with occasional small fluctuations above cleanup levels in a few wells.

For More Information

- About this and other technologies in the Community Guide Series, visit: https://clu-in.org/cguides or https://clu-in.org/remediation/
- About use of cleanup technologies at a Superfund site in your community, contact the site's community involvement coordinator or remedial project manager. Select the site name from the list or map at http://www.epa.gov/superfund/sites to view their contact information.