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Cleanup Methods for Contaminated Soil and Groundwater

PDH Credits:

4 PDH

Course No.:

MCC101

Publication Source:

US EPA

"The Citizen's Guide Series – Superfund Cleanup Methods"

Pub. # EPA 542-F-01-020

Release Date:
Dec. 2001

1265 San Juan Dr. - Merritt Island, FL 32952
Phone: 321-501-5601

United States Environmental Protection Agency
Office of Solid Waste and Emergency Response (5102G)
EPA 542-F-01-020
December 2001
www.epa.gov/superfund/sites
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A Citizen's Guide to Activated Carbon Treatment

The Citizen's Guide Series

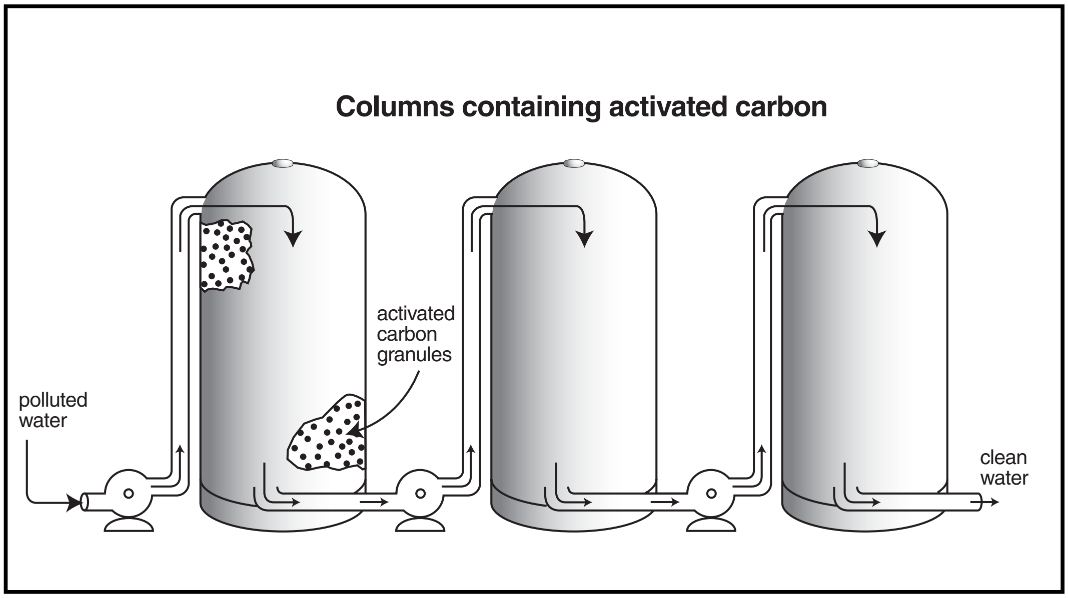
EPA uses many methods to clean up pollution at Superfund and other sites. If you live, work, or go to school near a Superfund site, you may want to learn more about these methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

What is activated carbon treatment?

Activated carbon is a material used to filter harmful chemicals from polluted air and water. It looks like tiny granules of black sand. As polluted water or air flows through an activated carbon filter, chemicals *sorb* or stick to the surface and within the pores of the granules. Most tap water filters and fish tank filters at home contain activated carbon and work the same way. Activated carbon filters are often used as part of a pump and treat system to clean up polluted groundwater (See *A Citizen's Guide to Pump and Treat* [EPA 542-F-01-025]).

How does it work?

An activated carbon filter generally consists of one or more containers or *columns* of granules. It is designed to sorb the specific hazardous chemicals found at a site. Water or air is usually pumped through a column from the top down, but upward flow also is possible. As the polluted water or air flows through the column, the chemicals sorb to the porous surface



of the granules. The water or air that exits the column is cleaner than the water or air that entered it. If the water or air isn't clean enough, it is pumped into another column or cleaned using another method.

When the available surface of the activated carbon fills up with chemicals, the carbon is said to be *spent*. Spent carbon must be replaced or cleaned so the filter can be reused. If spent carbon is replaced, the carbon and the sorbed chemicals are burned or disposed of in an approved landfill. Cleaning spent carbon involves heating the carbon and pumping clean air through it. The heat loosens the chemicals from the carbon, and the air sweeps them out of the column. Air pollution control equipment then collects the chemicals, which are disposed of or destroyed.

Is activated carbon treatment safe?

Activated carbon treatment is quite safe to use. The columns are equipped with detectors that alert cleanup workers 1) if leaks occur; and 2) when it is time to replace the activated carbon. The columns are cleaned or replaced with care to avoid releasing chemicals. Larger filters are often preferred because they do not have to be replaced as often as small ones.

How long will it take?

The time it takes to complete activated carbon treatment depends on several factors:

- amount of polluted water or air
- type and amounts of harmful chemicals present
- size and number of columns

Depending on the site, cleanup can take just a few days or as long as many years. Since activated carbon treatment is often used with other cleanup methods, the length of time may depend on how fast the other methods work.

Why use activated carbon treatment?

Activated carbon treatment can provide good results for a wide range of chemicals like fuels, PCBs, dioxins, and radioactive wastes. It also can remove some types of metals, if they are present in small amounts.

Activated carbon treatment can be cheaper than other cleanup methods. However, activated carbon does not destroy chemicals. The chemicals and spent carbon eventually must be disposed of in a landfill or removed from the carbon and destroyed by other methods.

For more information

write the Technology Innovation Office at:

U.S. EPA (5102G)
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EPA 542-F-01-016
December 2001
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EPA

A Citizen's Guide to Air Stripping

The Citizen's Guide Series

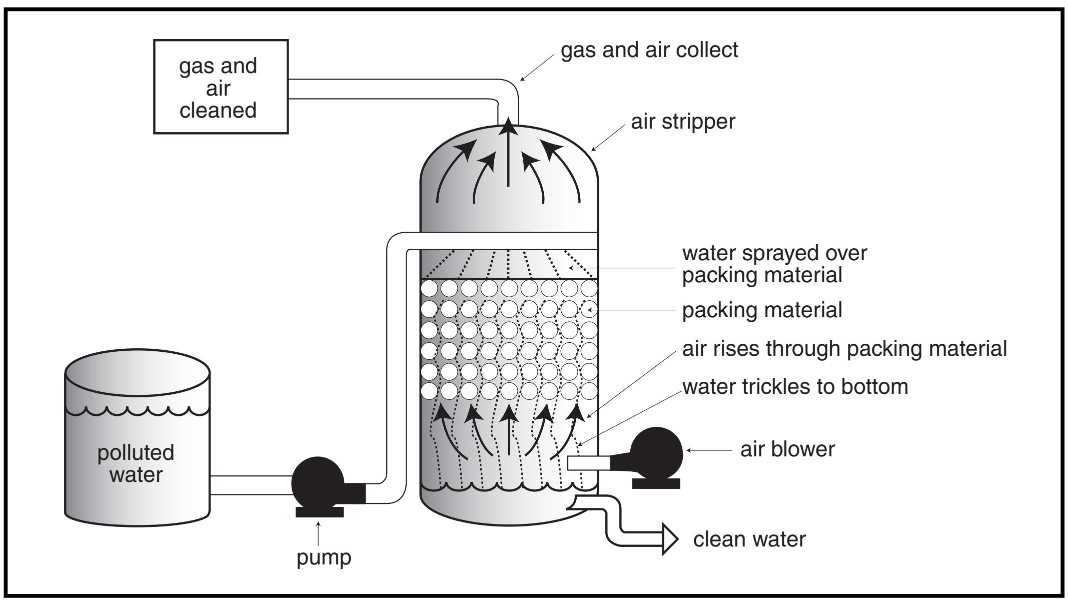
EPA uses many methods to clean up pollution at Superfund and other sites. If you live, work, or go to school near a Superfund site, you may want to learn more about these methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

What is air stripping?

Air stripping is the process of forcing air through polluted groundwater or surface water to remove harmful chemicals. The air causes the chemicals to change from a liquid to a gas (evaporate). The gas is then collected and cleaned. Air stripping is commonly used to treat groundwater as part of a pump and treat remedy. (See *A Citizen's Guide to Pump and Treat* [EPA 542-F-01-025].)

How does it work?

Air stripping uses equipment called an *air stripper* to force air through polluted water. An air stripper usually consists of a large tank filled with a packing material, made of plastic, steel, or ceramic. The polluted water is pumped into the tank and sprayed over the packing material. The water trickles down through the spaces between the packing material toward the bottom of the tank. At the same time a fan at the bottom blows air upward. As the air passes upward through the trickling water, it causes the chemicals to evaporate. The air



carries the evaporated chemical gases to the top of the tank where they are collected and cleaned (see *A Citizen's Guide to Activated Carbon Treatment* [EPA 542-F-01-020]). By spreading the water over the packing material, the rising air can reach more of the polluted water and evaporate more of the harmful chemicals. As water trickles to the bottom of the tank, it is collected and tested to make sure it is clean. If chemicals are still present, the water may be passed through the same or another tank, or cleaned up using a different method.

Air strippers vary in size and structure. Some force air across the tank, rather than up through it. Others do not use forced air. Instead, they simply rely on the water trickling through the air in the tank to evaporate the chemicals. Air strippers are designed specifically for the types and amounts of harmful chemicals in the water found at a specific site.

Is air stripping safe?

Air stripping is safe to use. Air strippers can be brought to the site so polluted water does not have to be transported to a cleanup facility. The polluted water is contained throughout cleanup so there is no chance for coming into contact with the water. The polluted gases that are produced by the air stripping are cleaned up and tested by EPA. The clean water can be returned to the site.

How long will it take?

The time it takes to clean up groundwater or surface water using air stripping depends on several factors:

- amount of polluted water
- types and amounts of harmful chemicals present
- rate that water can be pumped
- number of air strippers used

Depending on the site, it can take many years to complete a cleanup.

Why use air stripping?

Air stripping works best on water containing chemicals that evaporate easily (like fuels and solvents). Air stripping can remove about 99% of these chemicals when it is designed properly. Air stripping cannot remove metals, PCBs, or other chemicals that do not evaporate. Air strippers are simple to construct at a site and easy to maintain. They have been used to clean up polluted water at hundreds of sites.

For more information

write the Technology Innovation Office at:

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EPA 542-F-01-001
April 2001
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EPA

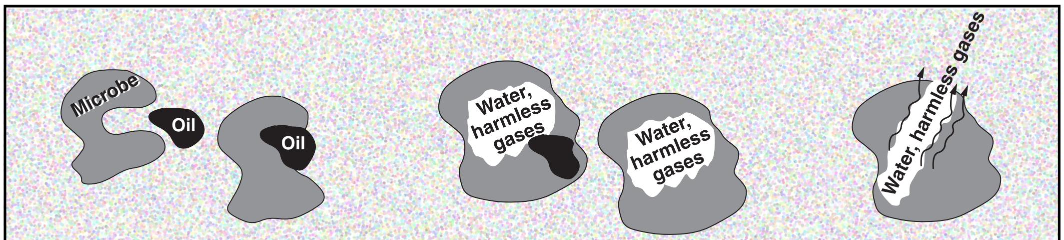
A Citizen's Guide to Bioremediation

The Citizen's Guide Series

EPA uses many methods to clean up pollution at Superfund and other sites. Some, like bioremediation, are considered new or *innovative*. Such methods can be quicker and cheaper than more common methods. If you live, work, or go to school near a Superfund site, you may want to learn more about cleanup methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

What is bioremediation?

Bioremediation allows natural processes to clean up harmful chemicals in the environment. Microscopic "bugs" or *microbes* that live in soil and groundwater like to eat certain harmful chemicals, such as those found in gasoline and oil spills. When microbes completely digest these chemicals, they change them into water and harmless gases such as carbon dioxide.



Microbe eats oil

Microbe digests oil and changes it to water and harmless gases

Microbe releases water and harmless gases into soil or groundwater

How does it work?

In order for microbes to clean up harmful chemicals, the right temperature, nutrients (fertilizers), and amount of oxygen must be present in the soil and groundwater. These conditions allow the microbes to grow and multiply—and eat more chemicals. When conditions are not right, microbes grow too slowly or die. Or they can create more harmful chemicals. If conditions are not right at a site, EPA works to improve them. One way they improve conditions is to pump air, nutrients, or other substances (such as molasses) underground. Sometimes microbes are added if enough aren't already there.

The right conditions for bioremediation cannot always be achieved underground. At some sites, the weather is too cold or the soil is too dense. At such sites, EPA might dig up the soil to clean it above ground where heaters and soil mixing help improve conditions. After the soil is dug up, the proper nutrients are added. Oxygen also may be added by stirring the mixture or by forcing air through it. However, some microbes work better without oxygen. With the right temperature and amount of oxygen and nutrients, microbes can do their work to "bioremediate" the harmful chemicals.

Sometimes mixing soil can cause harmful chemicals to evaporate before the microbes can eat them. To prevent these chemicals from polluting the air, EPA mixes the soil inside a special tank or building where chemicals that evaporate can be collected and treated.

Microbes can help clean polluted groundwater as well as soil. To do this, EPA drills wells and pumps some of the groundwater into tanks. Here, the water is mixed with nutrients and air before it is pumped back into the ground. The added nutrients and air help the microbes bioremediate the groundwater. Groundwater can also be mixed underground by pumping nutrients and air into the wells.

Once harmful chemicals are cleaned up and microbes have eaten their available "food," the microbes die.

Is bioremediation safe?

Bioremediation is very safe because it relies on microbes that naturally occur in soil. These microbes are helpful and pose no threat to people at the site or in the community. Microbes themselves won't hurt you, but never touch the polluted soil or groundwater—especially before eating.

No dangerous chemicals are used in bioremediation. The nutrients added to make microbes grow are fertilizers commonly used on lawns and gardens. Because bioremediation changes the harmful chemicals into water and harmless gases, the harmful chemicals are completely destroyed. To ensure that bioremediation is working, EPA tests samples of soil and groundwater.

How long will it take ?

The time it takes to bioremediate a site depends on several factors:

- types and amounts of harmful chemicals present
- size and depth of the polluted area
- type of soil and the conditions present
- whether cleanup occurs above ground or underground

These factors vary from site to site. It can take a few months or even several years for microbes to eat enough of the harmful chemicals to clean up the site.

Why use bioremediation?

EPA uses bioremediation because it takes advantage of natural processes. Polluted soil and groundwater can be cleaned at the site without having to move them somewhere else. If the right conditions exist or can be created underground, soil and groundwater can be cleaned without having to dig or pump it up at all. This allows cleanup workers to avoid contact with polluted soil and groundwater. It also prevents the release of harmful gases into the air. Because microbes change the harmful chemicals into water and harmless gases, few if any wastes are created.

Often bioremediation does not require as much equipment or labor as most other methods. Therefore, it is usually cheaper. Bioremediation has successfully cleaned up many polluted sites and is being used at 50 Superfund sites across the country.

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EPA 542-F-01-022
December 2001
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A Citizen's Guide to Capping

The Citizen's Guide Series

EPA uses many methods to clean up pollution at Superfund and other sites. If you live, work, or go to school near a Superfund site, you may want to learn more about these methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

What is capping?

Capping involves placing a cover over contaminated material such as the waste buried at a landfill. Such covers are called "caps." Caps do not clean up the contaminated material. They just keep it in place so it will not come into contact with people or the environment.

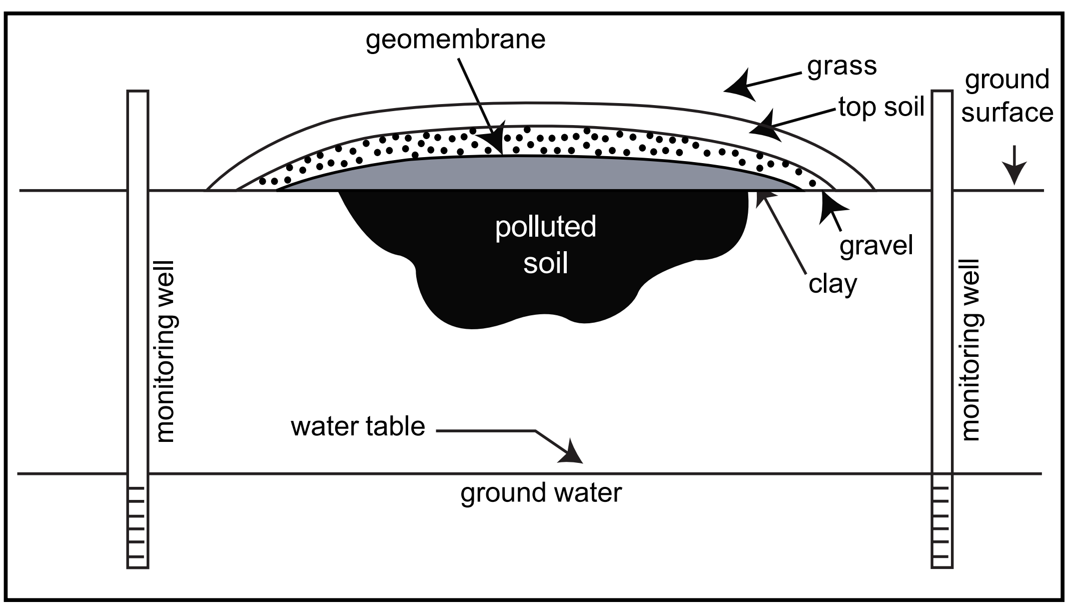
How does it work?

Sometimes digging up and removing contaminated material can be difficult or expensive. Instead, a cap will be placed over it to keep it in place. A cap works in three main ways:

1) It stops rainwater from seeping through the hazardous material and carrying the pollution into the groundwater, lakes or rivers.

2) It stops wind from blowing away the hazardous material.

3) It keeps people and animals from coming into contact with the contaminated material and tracking it off the site.



Constructing a cap can be as simple as placing a single layer of asphalt on top of the contaminated material. More often, however, caps are made of several layers. The top layer at the ground surface is usually soil with grass or other plants. Plants take up rainwater with their roots and help prevent it from soaking down into the next layer. They also keep the topsoil from eroding. The second layer down drains any water that comes through the first layer. It is usually constructed of gravel and pipes. A third layer may be added to control gasses that come from the hazardous material. The bottom layer lies directly on the contaminated material. It is usually made of clay. The clay is covered by a sheet of strong synthetic material called a *geomembrane*. Together the clay and the geomembrane help stop further flow of water downward.

Is capping safe?

When properly built and maintained, a cap is a safe method for keeping contaminated material in place. A cap will continue to work safely as long as it is not broken or eroded. Regular inspections are made to make sure that the weather, plant roots or some human activity have not damaged the cap. Also, groundwater monitoring wells are placed around the edges of the cap so that any leakage from the site can be found and fixed.

How long will it take?

Building a cap can take a few days up to several months.

The length of time depends on several factors that vary from site to site:

- size of the area
- thickness and design of the cap
- availability of clean topsoil and clay

Caps can be effective for many years as long as they are properly maintained.

For more information

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Why use capping?

Caps have been used at hundreds of sites because they are an effective method for keeping wastes contained. Caps are usually only part of a cleanup remedy. Often they are used with pump and treat systems (See *A Citizen's Guide to Pump and Treat* [EPA 542-01-025]). The pumping and treating cleans up polluted groundwater, while the cap prevents contaminated materials from reaching the groundwater.

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EPA 542-F-01-010
October 2001
www.epa.gov/superfund/sites
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A Citizen's Guide to Chemical Dehalogenation

The Citizen's Guide Series

EPA uses many methods to clean up pollution at Superfund and other sites. Some, like chemical dehalogenation, are considered new or *innovative*. Such methods can be quicker and cheaper than more common methods. If you live, work, or go to school near a Superfund site, you may want to learn more about cleanup methods. Perhaps they are being used or proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

What is chemical dehalogenation?

Chemical dehalogenation removes *halogens* from harmful chemicals, making them less toxic. Halogens are a class of chemical elements that includes chlorine, bromine, iodine, and fluorine. Many harmful chemicals contain halogens. The presence of halogens can be one of the main reasons such chemicals are toxic. Chemical dehalogenation is most often used to remove chlorine from PCBs and dioxins contained in polluted soil, sludge, or sediment.

How does it work?

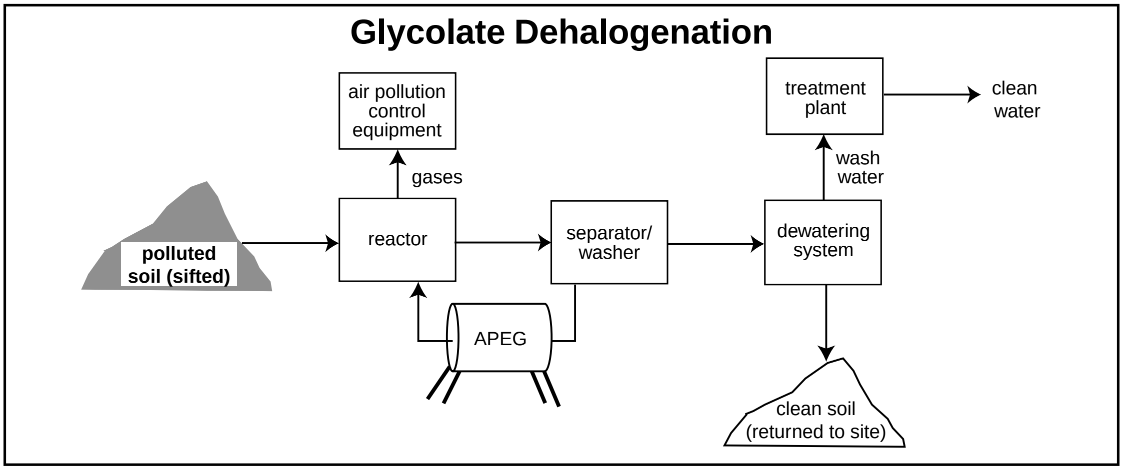
Before using chemical dehalogenation the soil must be dug from the polluted area to be treated. The soil is sifted and crushed to remove large objects, like rocks and debris. The sifted soil is then mixed with chemicals and heated in a large container called a *reactor*. During mixing and heating, a chemical reaction occurs which changes the harmful chemical. The reaction involves removing the halogens and replacing them with less toxic chemicals. Chemical dehalogenation can also work by evaporating the harmful chemicals, which changes them to gases. The gases are then destroyed.

There are two common types of chemical dehalogenation: glycolate dehalogenation and base-catalyzed decomposition.

Glycolate dehalogenation adds a combination of two chemicals called "APEG" to soil in the reactor. During mixing and heating, one chemical combines with the halogens to form a non-toxic salt. The other replaces the halogens to form other non-toxic chemicals. The heat in the reactor can cause some of the chemicals in the soil to evaporate. The gases are treated by air pollution control equipment at the site.

The soil is then placed in a *separator/washer* where the excess APEG is removed from the soil. Any remaining APEG is removed from the soil with water. The APEG can be reused in the cleanup of more soil. The wash water is removed from the soil and treated. When the soil is clean, it can be placed back on the site. If the soil still contains chemicals in harmful amounts, it is placed back in the reactor to repeat the process.

Base-catalyzed decomposition adds a chemical called "sodium bicarbonate" to soil in the reactor. The sodium bicarbonate allows the harmful chemicals in the soil to evaporate at a low



Glycolate Dehalogenation

temperature. Once the chemicals evaporate, the cleaned soil can be returned to the site. The gases produced during evaporation are changed into liquids. These liquids are then mixed with other chemicals, such as sodium hydroxide and heated again. A chemical reaction occurs that removes the halogens from some of the chemical and replaces them with hydrogen. This produces a non-toxic salt and a non-toxic chemical. The resulting mixture is then treated using other cleanup methods and recycled.

Is chemical dehalogenation safe?

Chemical dehalogenation can be quite safe to use, but there are potential hazards. Chemical reactions can result in flammable and even explosive conditions in the reactor. Proper design and operation must be followed to avoid these conditions. Some of the chemicals used are corrosive, which means they can wear away certain materials and burn the skin. Therefore, workers must wear protective clothing. During digging and cleanup, air pollution equipment must be used to control dust and gases. Chemicals are rarely released from the reactor, but EPA tests the air to make sure that chemicals are not released in harmful amounts. EPA also tests the soil to be sure it is clean before it is placed back on the site.

How long will it take ?

The time it takes to clean up a site using chemical dehalogenation depends on:

- the amount of polluted soil
- the condition of the soil (Is it wet or dry? Does it contain a lot of debris?)
- type and amounts of harmful chemicals present.

Cleanup can take just a few weeks at sites with small amounts of polluted soil.

Why use chemical dehalogenation?

Chemical dehalogenation has been used at several sites to remove halogens from PCBs, dioxins, and certain pesticides. It works best for small amounts of polluted soil or polluted soil that has small amounts of harmful chemicals. Chemical dehalogenation can be conducted at the site, which avoids the costly transport of soil to a cleanup facility. It also can be cheaper to operate and maintain compared to other methods that cleanup similar harmful chemicals. And the cleanup time is relatively short.

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EPA 542-F-01-005
April 2001
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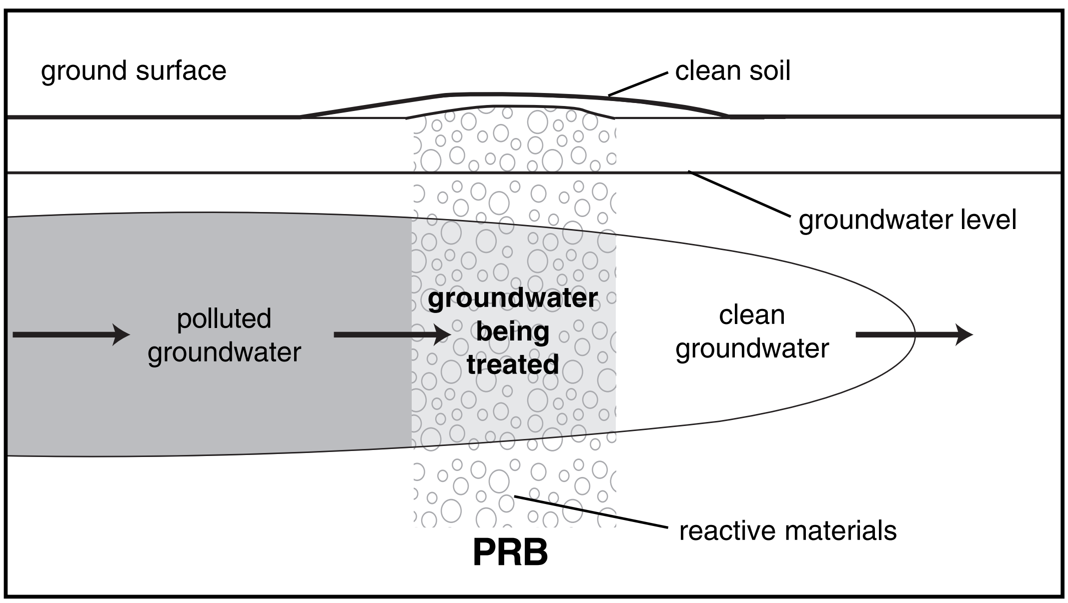
A Citizen's Guide to Permeable Reactive Barriers

The Citizen's Guide Series

EPA uses many methods to clean up pollution at Superfund and other sites. Some, like permeable reactive barriers, are considered new or *innovative*. Such methods can be quicker and cheaper than more common methods. If you live, work, or go to school near a Superfund site, you may want to learn more about cleanup methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

What are permeable reactive barriers?

A permeable reactive barrier or *PRB* is a wall built below ground to clean up polluted groundwater. The wall is *permeable,* which means it has tiny holes that allow groundwater to flow through it. *Reactive* materials in the wall trap harmful chemicals or change the chemicals into harmless ones. Clean groundwater flows out the other side of the wall.



How do they work?

A PRB is built by digging a long, narrow trench in the path of the polluted groundwater. The trench is filled with a reactive material that can clean up the harmful chemicals. Iron, limestone, and carbon are common types of reactive materials that can be used. The reactive materials may be mixed with sand to make it easier for water to flow through the wall, rather than around it. At some sites, the wall is part of a funnel that directs the polluted groundwater to the reactive part of the wall. The filled trench or funnel is covered with soil, so it usually cannot be seen above ground.

The material used to fill the trench depends on the types of harmful chemicals in the groundwater. Different materials clean up pollution through different methods by:

- Trapping or *sorbing* chemicals on their surface. For example, carbon has a surface that chemicals sorb to as groundwater passes through.
- *Precipitating* chemicals that are dissolved in water. This means the chemicals settle out of the groundwater as solid materials, which get trapped in the wall. For example, limestone can cause dissolved metals to precipitate.
- Changing the chemicals into harmless ones. For example, iron can change some types of solvents into harmless chemicals.
- Encouraging tiny bugs or *microbes* in the soil to eat the chemicals. For example, nutrients and oxygen in a PRB help the microbes grow and eat more chemicals. When microbes completely digest the chemicals, they can change them into water and harmless gases such as carbon dioxide. (*A Citizen's Guide to Bioremediation* [EPA 542-F-01-001] describes how microbes work.)

How long will it take ?

Cleaning groundwater with a PRB may take many years. The time it takes depends on two major factors that vary from site to site:

- type and amount of pollution present in the groundwater
- how fast the groundwater moves through the PRB

Groundwater may move a few inches to hundreds of feet per year. Its speed varies from site to site.

Are PRBs safe?

PRBs have a good safety record. Once built, they have no moving parts, equipment, or noise. The reactive materials placed in the PRB trench are not harmful to the groundwater or to people. The polluted groundwater is cleaned underground so cleanup workers can avoid contact with it. Some soil, which may be polluted, must be removed when digging the trench. EPA makes sure that the polluted soils are handled safely. For example, they cover loose soil to keep dust and harmful gases out of the air.

EPA tests the air to make sure that dust and gases are not released. If the soil is polluted, it may be cleaned using another cleanup method. Or the soil is disposed of properly in a landfill. The groundwater is tested regularly to make sure the PRB is working.

Why use PRBs?

PRBs work best at sites with loose, sandy soil and a steady flow of groundwater. The pollution should be no deeper than 50 feet. PRBs clean up many types of pollution underground. Since there is no need to pump polluted groundwater above ground, PRBs can be cheaper and faster than other methods. Very little waste needs to be disposed of in a landfill, which also saves money. There are no parts to break, and there is no equipment above ground so the property can be used while it is being cleaned up. There are no energy costs to operate a PRB because it works with the natural flow of groundwater. PRBs have been installed at more than 40 sites in the United States and Canada.

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EPA 542-F-01-006
April 2001
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A Citizen's Guide to Soil Vapor Extraction and Air Sparging

The Citizen's Guide Series

EPA uses many methods to clean up pollution at Superfund and other sites. If you live, work, or go to school near a Superfund site, you may want to learn more about cleanup methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

What are soil vapor extraction and air sparging?

Soil vapor extraction or *SVE* removes harmful chemicals, in the form of *vapors*, from the soil above the water table. Vapors are the gases that form when chemicals evaporate. The vapors are extracted (removed) from the ground by applying a vacuum to pull the vapors out.

What is the Water Table?

The water table is the level of groundwater below the ground surface.

Air sparging uses air to help remove harmful vapors from polluted soil and groundwater below the water table. When air is pumped underground, the chemicals evaporate faster, which makes them easier to remove. Like SVE, a vacuum then extracts the vapors. Certain chemicals—like solvents and fuel—evaporate easily. SVE and air sparging work best on these types of chemicals. SVE and air sparging are often used at the same time to clean up both soil and groundwater.

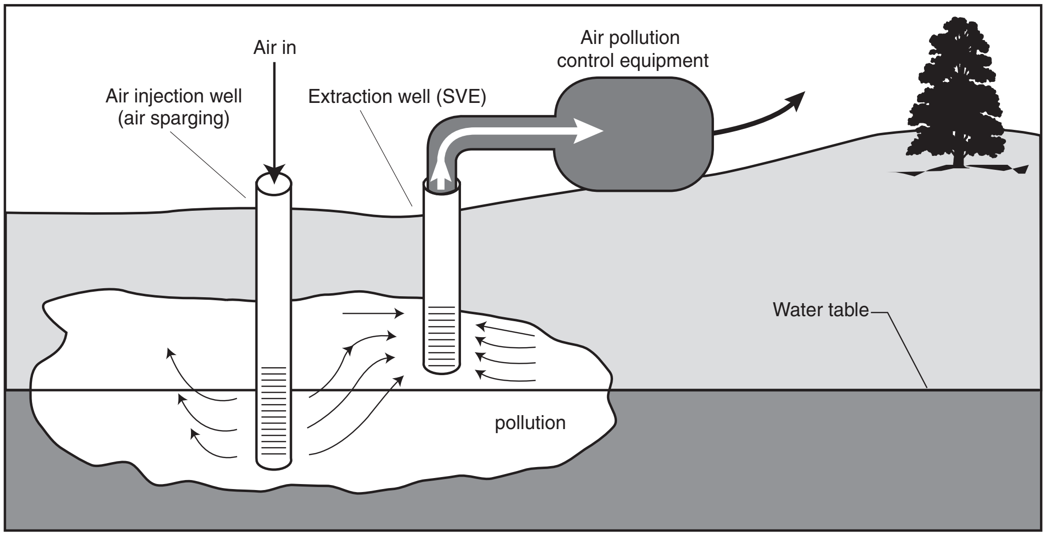
How do they work?

SVE requires drilling *extraction wells* within the polluted area. These wells are drilled into the soil, but not the groundwater. Attached to the wells is equipment that creates a vacuum, which pulls air and vapors through the soil and up to the surface.

Air injection wells can be drilled to help the cleanup. Air injection wells pump air into the ground. The air causes the pollution to evaporate faster. Sometimes air vents are used instead of air injection wells. Air vents don't pump air, but provide a passage for fresh air to enter the ground. The number of air injection and extraction wells can range from one to hundreds, depending on the size of the polluted area.

Once the extraction wells pull the air and vapors out of the ground, special air pollution control equipment collects them. The equipment separates the harmful vapors from the clean air. Then, the vapors *sorb* or stick to solid materials. Or they are condensed to liquids. These polluted solids and liquids are disposed of safely.

Air sparging works very much like SVE. However, the wells that pump air into the ground are drilled into water-soaked soil below the water table. Air pumped into the wells disturbs the groundwater. This helps the pollution change into vapors. The vapors rise into the drier soil above the groundwater and are pulled out of the ground by extraction wells. The harmful vapors are removed in the same way as SVE.



The air used in SVE and air sparging also helps clean up pollution by encouraging the growth of *microbes*. These tiny bugs are found naturally in soil and can use pollution for food. When microbes completely digest pollution, they can change it into water and harmless vapors. (*A Citizen's Guide to Bioremediation* [EPA 542-F-01-001] describes how microbes work.)

Are soil vapor extraction and air sparging safe?

When properly designed and operated, SVE and air sparging are safe cleanup methods. No one has to dig up the pollution, and no chemicals—just air—are added to the ground. EPA makes sure that harmful vapors are collected and disposed of properly.

How long will it take ?

Cleaning up a site using SVE and air sparging can take years. The time depends on several factors:

- size and depth of the polluted area
- type of soil and conditions present (wet or dense soil can slow the process.)
- type and amounts of harmful chemicals present

The air injected into the ground can be heated to speed up the process. The heated soil helps evaporate the chemicals faster. Also, other sources of heat, like steam or hot water can be pumped into the injection wells to heat up the soil. (See *A Citizen's Guide to In Situ Thermal Treatment* [EPA 542-F-01-012].)

Why use soil vapor extraction and air sparging?

SVE and air sparging are quicker than cleanup methods that rely on natural processes to do the work. In general, the wells and equipment are simple to install and maintain. And they can reach greater depths than methods that involve digging up soil. SVE and air sparging are effective at removing many types of pollution that can evaporate. Both methods can be used with other methods to clean up other types of pollution as well. Both methods work best in loose soils—like sand and gravel. But they both work well under many types of conditions.

SVE and air sparging are often chosen to clean up Superfund sites. EPA has selected SVE for use at approximately196 sites and air sparging for use at roughly 48 sites.

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For more information

write the Technology Innovation Office at:

U.S. EPA (5102G)
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Further information also can be obtained at **www.cluin.org** or **www.epa.gov/superfund/sites**.

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EPA 542-F-01-003
April 2001
www.epa.gov/superfund/sites
www.cluin.org

EPA

A Citizen's Guide to Thermal Desorption

The Citizen's Guide Series

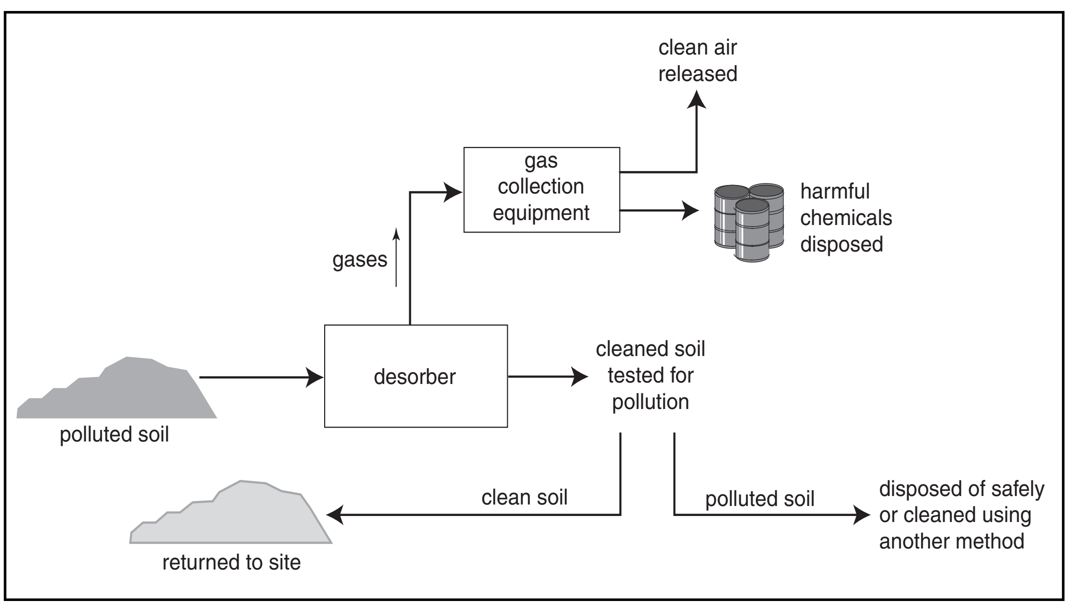
EPA uses many methods to clean up pollution at Superfund and other sites. If you live, work, or go to school near a Superfund site, you may want to know more about cleanup methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

What is thermal desorption?

Thermal desorption removes harmful chemicals from soil and other materials (like sludge and sediment) by using heat to change the chemicals into gases. These gases are collected with special equipment. The dust and harmful chemicals are separated from the gases and disposed of safely. The clean soil is returned to the site. Thermal desorption is not the same as incineration, which uses heat to *destroy* the chemicals.

How does it work?

Thermal desorption uses equipment called a *desorber* to clean polluted soil. Soil is excavated and placed in the desorber. The desorber works like a large oven. When the soil gets hot enough, the harmful chemicals evaporate. To get the soil ready for the desorber, workers may need to crush it, dry it, blend it with sand, or remove debris. This allows the desorber to clean the soil more evenly and easily.



During each step of the process, workers use special equipment to control dust from the soil and collect harmful gases that are released to the air. The polluted gases are separated from the clean air using gas collection equipment. The gases are then changed back into liquids and/or solid materials. These polluted liquids or solids are disposed of safely.

Before returning the cleaned soil to the site, workers may spray it with water to cool it and control dust. If the soil still contains harmful chemicals, workers clean it further by placing it back in the desorber. Or they may try other cleanup methods instead. If the soil is clean, it is returned to the site. If the soil is not clean, it is sent to a landfill.

Is thermal desorption safe?

Thermal desorption has been used at many sites over the years. EPA makes sure that materials are handled safely at each stage of the process. EPA tests the air to make sure that dust and gases are not released to the air in harmful amounts. EPA also tests the soil to be sure it is clean before it is returned to the site. All equipment must meet federal, state, and local standards.

How long will it take ?

Thermal desorption systems can clean over 20 tons of polluted soil per hour. The time it takes to clean up a site using thermal desorption depends on:

- the amount of polluted soil
- the condition of the soil (Is it wet or dry? Does it contain a lot of debris?)
- type and amounts of harmful chemicals present

Cleanup can take only a few weeks at small sites with small amounts of chemicals. If the site is large and the chemical levels are high, cleanup can take years.

Why use thermal desorption?

Thermal desorption works well at sites with dry soil and certain types of pollution, such as fuel oil, coal tar, chemicals that preserve wood, and solvents. Sometimes thermal desorption works where some other cleanup methods cannot—such as at sites that have a lot of pollution in the soil.

Thermal desorption can be a faster cleanup method than most. This is important if a polluted site needs to be cleaned up quickly so it can be used for other purposes. The equipment for thermal desorption often costs less to build and operate than equipment for other cleanup methods using heat. EPA has selected thermal desorption to clean up 59 Superfund sites.

For more information
write the Technology Innovation Office at:

U.S. EPA (5102G)
1200 Pennsylvania Ave., NW
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(703) 603-9910.

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(5102G)

EPA 542-F-01-023
December 2001
www.epa.gov/superfund/sites
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A Citizen's Guide to Soil Excavation

The Citizen's Guide Series

EPA uses many methods to clean up pollution at Superfund and other sites. If you live, work, or go to school near a Superfund site, you may want to learn more about cleanup methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

What is excavation?

Excavation is digging up polluted soil so it can be cleaned or disposed of properly in a landfill. The soil is excavated using construction equipment, like backhoes or bulldozers.

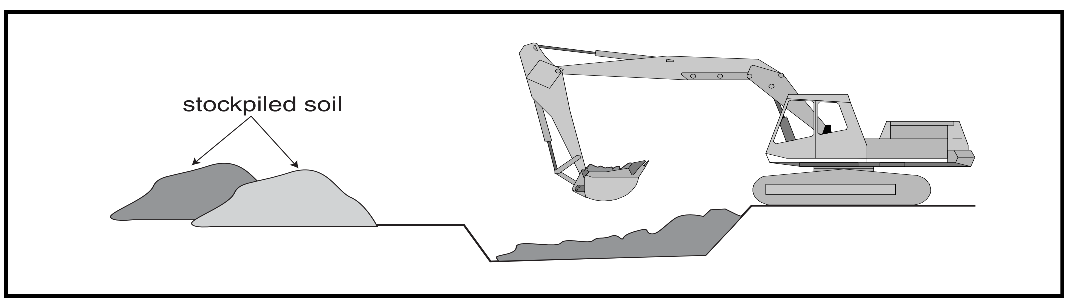
How does it work?

Before soil can be excavated, EPA must figure out how much of it there is. EPA also determines the types of harmful chemicals in the soil. This requires research on past activities at the site as well as testing of the soil.

Once the polluted areas are found, digging can begin. Backhoes, bulldozers and front-end loaders remove the soil and put it on tarps or in containers. The soil is covered to prevent wind and rain from blowing or washing it away. The covers also keep workers and other people near the site from coming into contact with polluted soil. The digging is complete when test results show that the remaining soil does not pose a risk to people or the environment.

The polluted soil may be cleaned up onsite or taken elsewhere for this purpose (See *A Citizen's Guide to Thermal Desorption* [EPA 542-F-01-003], and *A Citizen's Guide to Soil Washing* [EPA 542-F-01-008]). The soil may also may be disposed of in a regulated landfill. If the soil is cleaned, it may be returned to the holes it came from. This is called *backfilling.* The area may also be backfilled with clean soil from another location.

After an excavation is backfilled, it may be landscaped to prevent erosion or it may be paved or prepared for some other use.



Is excavation safe?

Excavation can safely remove most types of polluted soil from a site. However, certain types of harmful chemicals require special safety precautions. For example, some chemicals may *evaporate*, or change into gases. To prevent the release of gases to the air, site workers may coat the ground with foam or draw the vapor into gas wells. Other chemicals, like acids and explosives, also require special handling and protective clothing to reduce the danger to site workers.

How long will it take?

Excavating polluted soil may take as little as one day or as long as several months. Cleaning the soil may take much longer. The total time it takes to excavate and clean up soil depends on several factors:

- types and amounts of harmful chemicals present
- size and depth of the polluted area
- type of soil
- amount of moisture in the polluted soil (wet soil slows the process)

Why use excavation?

EPA has had lots of experience using excavation to clean up sites. Excavation is used most often where other underground cleanup technologies will not work or will be too expensive. Excavation of soil for disposal or treatment above ground is often the fastest way to deal with chemicals that pose an immediate risk. Polluted soils deeper than 10 feet generally cannot be excavated. This method is most cost-effective for small amounts of soil.

For more information

write the Technology Innovation Office at:

U.S. EPA (5102G)
1200 Pennsylvania Ave., NW
Washington, DC 20460

or call them at
(703) 603-9910.

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United States Environmental Protection Agency
Office of Solid Waste and Emergency Response (5102G)
EPA 542-F-01-015
May 2001
www.epa.gov/superfund/sites
www.cluin.org

EPA

A Citizen's Guide to Fracturing

The Citizen's Guide Series

EPA uses many methods to clean up pollution at Superfund and other sites. If you live, work, or go to school near a Superfund site, you may want to learn more about cleanup methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

What is fracturing?

Fracturing is a way to crack rock or very dense soil, like clay, below ground. It is not necessarily a cleanup method in itself. Rather, fracturing is used to break up the ground to help other cleanup methods work better. The cracks, which are called *fractures*, create paths through which harmful chemicals can be removed or destroyed.

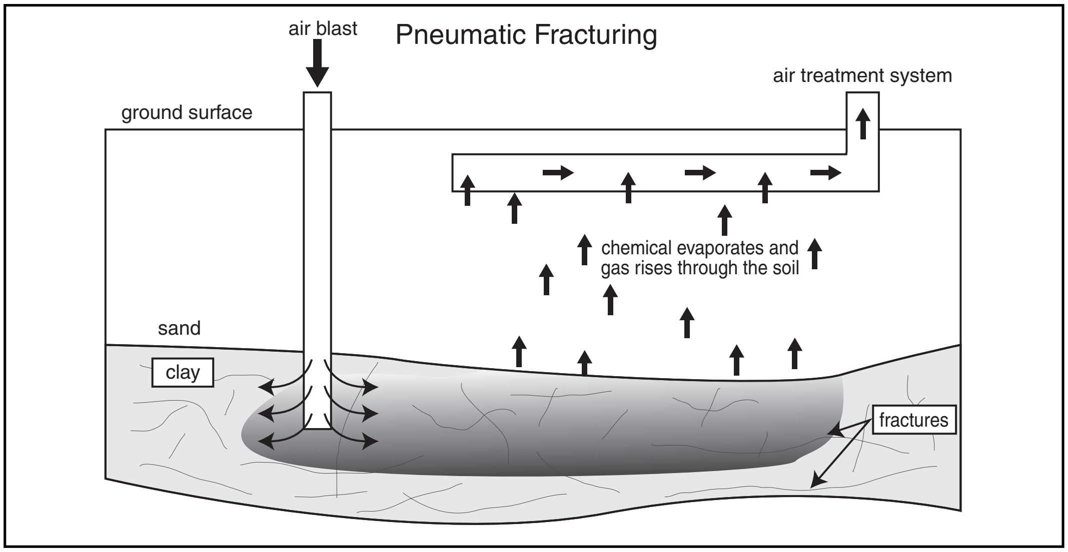
How does it work?

Harmful chemicals can travel deep below the ground surface. As a result, reaching the chemicals to clean them up can be difficult. Fracturing helps create paths through rock and dense soil to where the chemicals are located. Then the harmful chemicals can be pumped out of the ground through wells and treated (See *A Citizen's Guide to Pump and Treat* [EPA 542-F-01-025]). Or cleanup materials, like microbes and oxidants, can be pumped down into the polluted area to destroy the harmful chemicals (See *A Citizen's Guide to Bioremediation* [EPA 542-F-01-001] and *A Citizen's Guide to Chemical Oxidation* [EPA 542-F-01-013]). There are three ways to fracture soil and rock:

Hydraulic fracturing uses a liquid—usually water. The water is pumped under pressure into holes drilled in the ground. The force of the water causes the soil (or sometimes rock) to crack. It also causes existing fractures to grow larger. To fracture soil at greater depths, sand is pumped underground with the water. The sand helps prop the fractures open and keep them from closing under the weight of the soil.

Pneumatic fracturing uses air, to fracture soil. It also can help remove chemicals that *evaporate* or change to gases quickly when exposed to air. When air is forced into the soil, the chemicals evaporate and the gases are captured and treated above ground. (See the figure on page 2.)

Air can be forced into the ground at different depths within a hole. When air is forced near the ground surface, the surface around the holes may rise as much as an inch, but will settle back close to its original level. In both pneumatic and hydraulic fracturing, equipment placed underground directs the pressure to the particular zone of soil that needs to be fractured.



Blast-enhanced fracturing uses explosives, such as dynamite, to fracture rock. The explosives are placed in holes and detonated. The main purpose is to create more pathways for polluted groundwater to reach wells drilled for pump and treat cleanup.

Is fracturing safe?

When properly used, fracturing is a safe way to help cleanup methods work better. Before fracturing is used, EPA studies the site and tests the method to confirm it can work. EPA does not conduct fracturing near underground pipelines or above-ground structures that can be damaged.

How long will it take ?

Fracturing rock and soil does not take very long. It may only take a few days. However, even with the help of fracturing, actual cleanup may take months or years. The time it takes to clean up a site depends on several factors:

- size and depth of the polluted area
- types and amounts of harmful chemicals present
- type of soil or rock
- cleanup method used

Why use fracturing?

Fracturing is used to help reach chemicals in rock and dense soil so they can be cleaned up faster. It offers a way of reaching pollution deep in the ground where it would be difficult or costly to dig down so far. Fracturing can reduce the number of wells needed for certain cleanup methods, which can save time and reduce cleanup costs. Often fracturing is used to help clean up *non-aqueous phase liquids* or *NAPLs*—chemicals that don't dissolve readily in the groundwater. NAPLs are difficult to clean up where there are few fractures in the ground. Fracturing has been used in cleanups at many sites throughout the country.

For more information

write the Technology Innovation Office at:

U.S. EPA (5102G)
1200 Pennsylvania Ave., NW
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EPA 542-F-01-018
February 2002
www.epa.gov/superfund/sites
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EPA

A Citizen's Guide to Incineration

The Citizen's Guide Series

EPA uses many methods to clean up pollution at Superfund and other sites. If you live, work, or go to school near a Superfund site, you may want to learn more about these methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

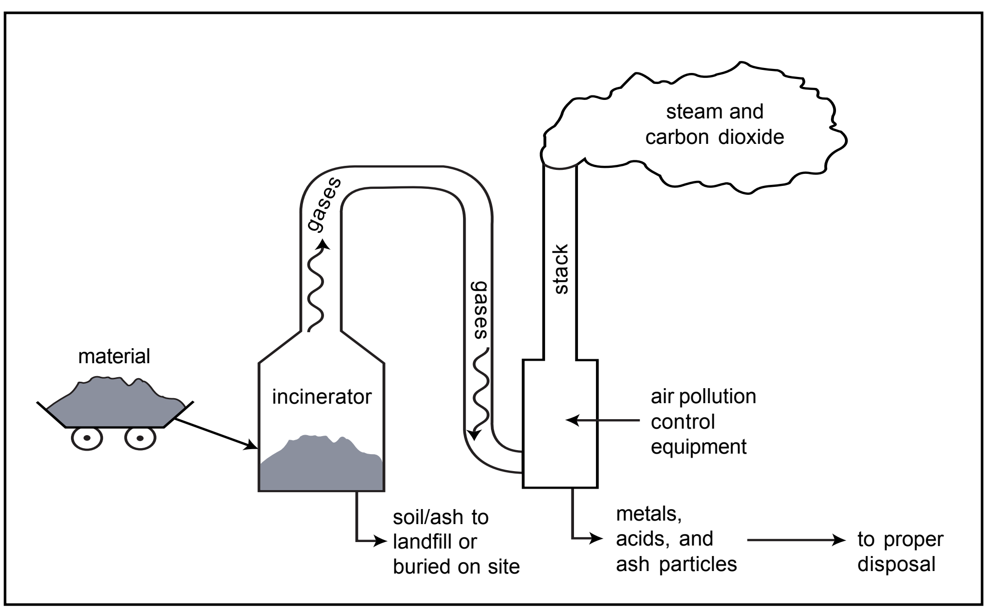
What is incineration?

Incineration is the process of burning hazardous materials to destroy harmful chemicals. Incineration also reduces the amount of material that must be disposed of in a landfill. Although it destroys a range of chemicals, such as PCBs, solvents, and pesticides, incineration does not destroy metals.

How does it work?

An *incinerator* is a type of furnace. It burns material, such as polluted soil, at a controlled temperature, which is high enough to destroy the harmful chemicals. An incinerator can be brought to the site for cleanup or the material can be trucked from the site to an incinerator.

The material is placed in the incinerator where it is heated. To increase the amount of harmful chemicals destroyed, workers control the amount of heat and air in the incinerator. As the chemicals heat up, they change into gases, which pass through a flame to be heated



further. The gases become so hot they break down into smaller components that combine with oxygen to form less harmful gases and steam.

The gases produced in the incinerator pass through air pollution control equipment to remove any remaining metals, acids, and particles of ash. These wastes are harmful and must be properly disposed of in a licensed landfill. The other cleaner gases, like steam and carbon dioxide, are released outside through a stack.

The soil or ash remaining in the incinerator after the burning may be disposed of in a landfill or buried on site. The amount of material that requires disposal is much less than the initial amount of waste that was burned.

Is incineration safe?

An incinerator that is properly designed and operated can safely destroy harmful chemicals. It can also run without producing odors or smoke. EPA tests the incinerator before and during operation to make sure that gases are not released in harmful amounts.

How long will it take?

The time it takes for incineration to clean up a site depends on several factors:

- size and depth of the polluted area
- types and amounts of chemicals present
- whether or not the waste must be trucked to the incinerator

Larger incinerators can clean up several hundred tons of waste each day.

Why use incineration?

Incineration can destroy some types of chemicals that other methods can't. It is also quicker than many other methods. This is important when a site must be cleaned up quickly to prevent harm to people or the environment. On-site incineration can reduce the amount of material that must be moved to a landfill. Incinerators have been used to clean up 136 Superfund sites across the country.

For more information
write the Technology Innovation Office at:

U.S. EPA (5102G)
1200 Pennsylvania Ave., NW
Washington, DC 20460

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(703) 603-9910.

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United States Environmental Protection Agency
Office of Solid Waste and Emergency Response (5102G)
EPA 542-F-01-011
May 2001
www.epa.gov/superfund/sites
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A Citizen's Guide to In Situ Flushing

The Citizen's Guide Series

EPA uses many methods to clean up pollution at Superfund and other sites. Some, like in situ flushing, are considered new or *innovative*. Such methods can be quicker and cheaper than more common methods. If you live, work, or go to school near a Superfund site, you may want to learn more about cleanup methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

What is in situ flushing?

In situ flushing is a way to clean up harmful chemicals in polluted soil and groundwater by pumping water or chemicals into the ground. This helps flush the harmful chemicals from the ground by moving them toward wells that pump the chemicals out of the ground. The process works *in situ*, which means the polluted soil is cleaned up in place and does not need to be dug up.

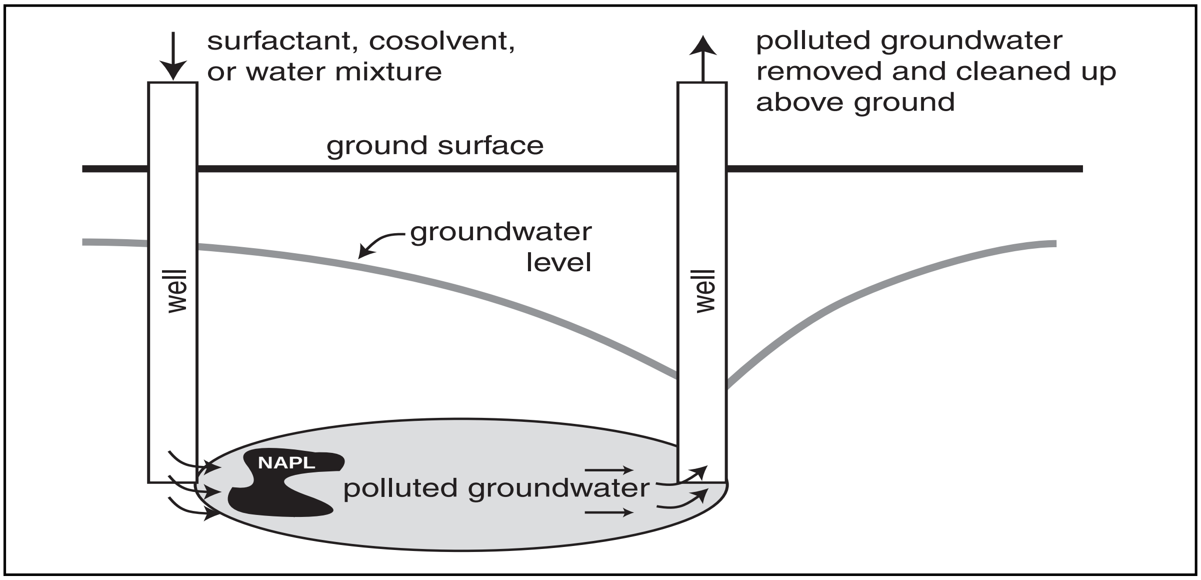
How does it work?

The goal of in situ flushing is to improve the effectiveness of *pump and treat* cleanup methods. Pump and treat methods pump polluted groundwater up through wells to the ground surface where it is cleaned up. (See *A Citizen's Guide to Pump and Treat* [EPA 542-F-01-025].) When harmful chemicals don't dissolve in the groundwater, they can't easily be pumped out of the ground. Some chemicals like solvents and heating oil exist as liquids but do not dissolve easily in water. They are called *non-aqueous phase liquids* or NAPLs. NAPLs can remain in the soil for many years and slowly dissolve into the groundwater. As a result, they can be a source of groundwater pollution for a long time.

In situ flushing using chemicals like surfactants and cosolvents can help dissolve NAPLs. Surfactants are commonly found in detergents and some food products. Cosolvents are alcohols, like ethanol or methanol. When used for in situ flushing, a surfactant or cosolvent is mixed with water. The mixture is pumped down a well, or several wells, drilled in the polluted area where it helps dissolve the NAPLs. The mixture also can help move the NAPLs toward the wells.

At some sites, the surfactant mixture may stick or *sorb* to the soil. This may increase the amount of surfactant required to remove the NAPL. If this happens, a cosolvent can be added to the surfactants mixture to prevent the surfactant from sorbing to the soil.

In situ flushing works best in soil that is very *permeable*. In other words, groundwater can flow through it easily. In situ flushing also works best if the soil underneath the polluted area is not very permeable, like clay. The clay prevents the surfactant or cosolvent from moving below the polluted area. When a clay layer does not exist, a *surfactant foam* method can be used. In this method, air is pumped underground with the surfactant and water. The air forms a foam that prevents the surfactant from moving beyond the polluted area.



Is in situ flushing safe?

In situ flushing can be quite safe, but there are some potential hazards. Workers that handle the chemicals pumped down the wells must wear protective clothing. Also, surfactant or cosolvent left behind after cleanup may be harmful. But at some sites, scientists may want to leave small amounts of surfactant or cosolvent in the polluted area to help with bioremediation. (See *A Citizen's Guide to Bioremediation* [EPA 542-F-01-001].)

How long will it take ?

The time it takes for in situ flushing to clean up a site depends on several factors:

- size and depth of the polluted area
- type and amount of NAPL
- type of soil and conditions present
- how groundwater flows through the soil (How fast? Along what path?)

Cleanup of a site can take months or years using in situ flushing.

Why use in situ flushing?

In situ flushing is used to help pump and treat groundwater. It is one of the few methods that can help clean up NAPL in place. This avoids the expense of digging up the soil for disposal or cleanup. Depending on the number of wells and the amount of surfactant or cosolvent needed, in situ flushing can be expensive and difficult to use. However, in situ flushing has successfully cleaned up many polluted sites and has been used, or is being used, at 16 Superfund sites across the country.

For more information

write the Technology Innovation Office at:

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1200 Pennsylvania Ave., NW
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EPA 542-F-01-012
May 2001
www.epa.gov/superfund/sites
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EPA

A Citizen's Guide to In Situ Thermal Treatment Methods

The Citizen's Guide Series

EPA uses many methods to clean up pollution at Superfund and other sites. Some, like in situ thermal treatment methods, are considered new or *innovative*. Such methods can be quicker and cheaper than more common methods. If you live, work, or go to school near a Superfund site, you may want to learn more about cleanup methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

What are in situ thermal treatment methods?

In situ thermal treatment methods, in general, are ways to move or *mobilize* harmful chemicals through soil and groundwater by heating them. The heated chemicals move through the soil and groundwater toward underground wells where they are collected and piped to the ground surface. There the chemicals can be treated above ground by one of the many cleanup methods available.

How do they work?

All thermal methods work by heating polluted soil and groundwater. The heat helps push chemicals through the soil toward collection wells. The heat also can destroy or evaporate certain types of chemicals. When they evaporate, the chemicals change into gases, which move more easily through the soil. Collection wells capture the harmful chemicals and gases and pipe them to the ground surface for cleanup. Thermal methods can be particularly useful for chemicals called *non-aqueous phase liquids* or *NAPLs*, which do not dissolve or move easily in groundwater. As a result, they can be a source of groundwater pollution for a long time without proper treatment. In situ thermal methods include:

Steam injection: Forces or *injects* steam underground through wells drilled in the polluted area. The steam heats the area and mobilizes, evaporates, and destroys the harmful chemicals.

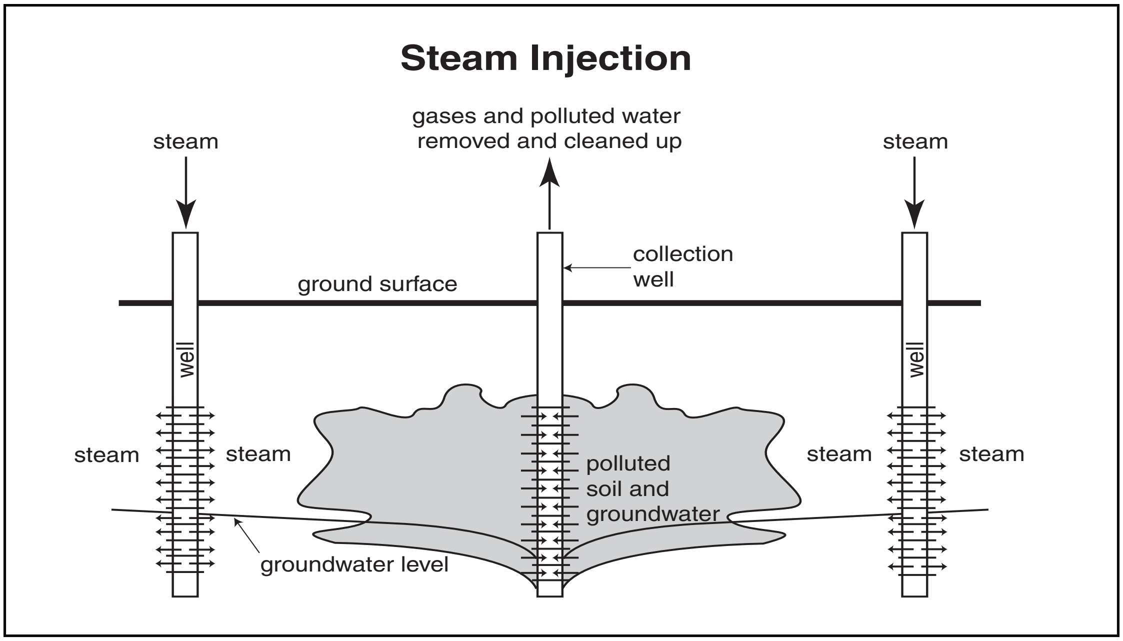
Hot air injection: Similar to steam injection except hot air is injected through the wells instead of steam. The hot air heats the soil causing the harmful chemicals to evaporate.

Hot water injection: Also similar to steam injection except that hot water is injected through the wells instead of steam. The hot water mobilizes chemicals like NAPLs.

Electrical resistance heating: Delivers an electric current underground through wells made of steel. The heat from the current converts groundwater and the water in the soil to steam, which evaporates the harmful chemicals.

Radio frequency heating: Typically involves placing an antenna that emits *radio waves* in a well. The radio waves heat the soil causing the harmful chemicals to evaporate.

Thermal conduction: Supplies heat to the soil through steel wells or with a blanket that covers the ground surface. As the polluted area heats up, the harmful chemicals are destroyed or evaporated. The blanket is used where the polluted soil is shallow. Steel wells are used when the polluted soil is deep.



Are in situ thermal treatment methods safe?

In situ thermal treatment methods are safe when properly operated. When there is a chance that gases may pollute the air, a cover is placed over the ground to prevent their escape. And EPA tests the air to make sure that the dust and gases are being captured. Scientists are also studying whether heat can kill microbes or help microbes *bioremediate* chemicals. (See *A Citizen's Guide to Bioremediation* [EPA 542-F-01-001].)

How long will it take ?

Cleaning soil and groundwater with thermal methods may take only a few months or several years. The time it takes depends on three major factors that vary from site to site:

- type and amounts of chemicals present
- size and depth of the polluted area
- type of soil and conditions present

Why use in situ thermal treatment methods?

Thermal methods speed the cleanup of many types of chemicals in the ground. Faster cleanups can mean lower cleanup costs. Depending on the number of wells needed, thermal methods can be expensive. However, they are some of the few methods that can help clean up NAPL in place. This avoids the expense of digging up the soil for disposal or cleanup. Thermal methods can work in some soils (such as clays) where other cleanup methods do not perform well. They also offer a way of reaching pollution deep in the ground where it would be difficult or costly to dig. Thermal methods are being used at several dozen sites across the country, including a few Superfund sites.

For more information

write the Technology Innovation Office at:

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1200 Pennsylvania Ave., NW
Washington, DC 20460

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EPA 542-F-01-004
April 2001
www.epa.gov/superfund/sites
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EPA

A Citizen's Guide to Monitored Natural Attenuation

The Citizen's Guide Series

EPA uses many methods to clean up pollution at Superfund and other sites. If you live, work, or go to school near a Superfund site, you may want to learn more about cleanup methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

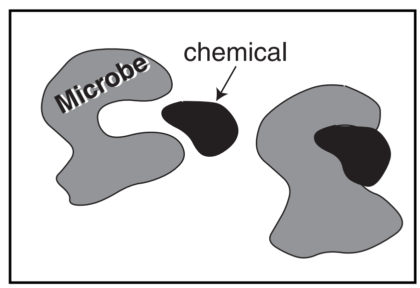
What is monitored natural attenuation?

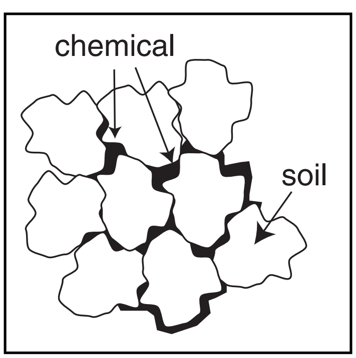
Natural attenuation relies on natural processes to clean up or *attenuate* pollution in soil and groundwater. Natural attenuation occurs at most polluted sites. However, the right conditions must exist underground to clean sites properly. If not, cleanup will not be quick enough or complete enough. Scientists *monitor* or test these conditions to make sure natural attenuation is working. This is called *monitored natural attenuation* or *MNA*.

How does it work?

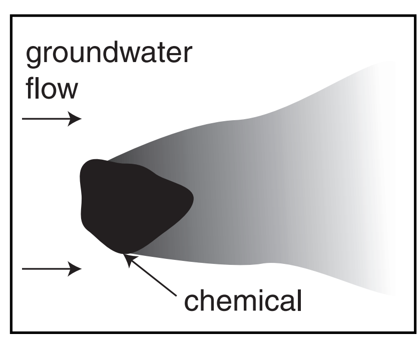
When the environment is polluted with chemicals, nature can work in four ways to clean it up:

1. Tiny bugs or *microbes* that live in soil and groundwater use some chemicals for food. When they completely digest the chemicals, they can change them into water and harmless gases. (*A Citizen's Guide to Bioremediation* [EPA 542-F-01-001] describes how microbes work.)



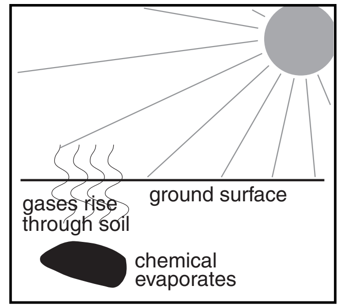


2. Chemicals can stick or *sorb* to soil, which holds them in place. This does not clean up the chemicals, but it can keep them from polluting groundwater and leaving the site.



3. As pollution moves through soil and groundwater, it can mix with clean water. This reduces or *dilutes* the pollution.

4. Some chemicals, like oil and solvents, can *evaporate*, which means they change from liquids to gases within the soil. If these gases escape to the air at the ground surface, sunlight may destroy them.



MNA works best where the source of pollution has been removed. For instance, buried waste must be dug up and disposed of properly. Or it can be removed using other available cleanup methods. After the source is removed, the natural processes get rid of the small amount of pollution that remains in the soil and groundwater. The soil and groundwater are monitored regularly to make sure they are cleaned up.

Is it safe?

MNA can be a safe process if used properly. No one has to dig up the pollution, and nothing has to be added to the land or water to clean it up. But MNA is not a "do nothing" way to clean up sites. Regular monitoring is needed to make sure pollution doesn't leave the site. This ensures that people and the environment are protected during cleanup.

How long will it take ?

The time it takes for MNA to clean up a site depends on several factors:

- type and amounts of chemicals present
- size and depth of the polluted area
- type of soil and conditions present

These factors vary from site to site, but cleanup usually takes years to decades. MNA is used when other methods will not work or are expected to take almost as long. Sometimes MNA is used as a final cleanup step after another method cleans up most of the pollution.

Why use monitored natural attenuation?

Depending on the site, MNA may work just as well and almost as fast as other methods. Because MNA takes place underground, digging and construction are not needed. As a result, there is no waste to dispose of in landfills. This is less disruptive to the neighborhood and the environment. Also, it allows cleanup workers to avoid contact with the pollution. MNA requires less equipment and labor than most methods. Therefore, it can be cheaper. Monitoring for many years can be costly, but it may cost less than other methods.

MNA is the only cleanup method being used at a few Superfund sites with groundwater pollution. At over 60 other sites with polluted groundwater, MNA is just one of the cleanup methods being used. MNA also is used for oil and gasoline spills from tanks.

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For more information

write the Technology Innovation Office at:

U.S. EPA (5102G)
1200 Pennsylvania Ave., NW
Washington, DC 20460

or call them at
(703) 603-9910.

Further information also can be obtained at **www.cluin.org** or **www.epa.gov/superfund/sites**.

United States
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Office of Solid Waste and
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(5102G)

EPA 542-F-01-013
April 2001
www.epa.gov/superfund/sites
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EPA

A Citizen's Guide to Chemical Oxidation

The Citizen's Guide Series

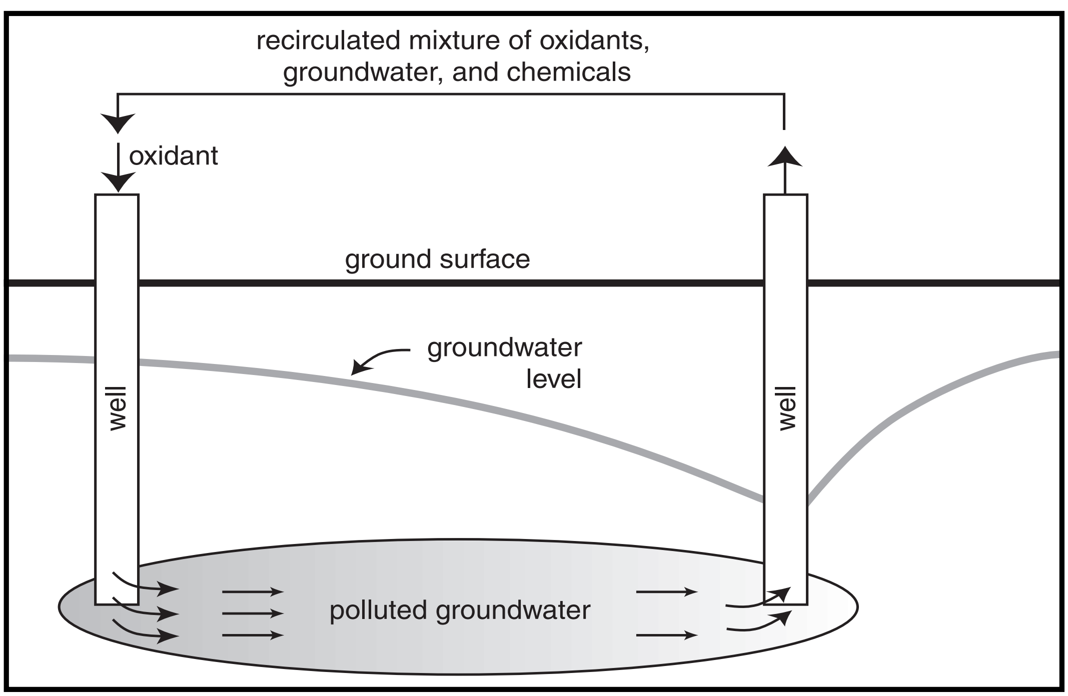
EPA uses many methods to clean up pollution at Superfund and other sites. Some, like chemical oxidation, are considered new or *innovative*. Such methods can be quicker and cheaper than more common methods. If you live, work, or go to school near a Superfund site, you may want to learn more about cleanup methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

What is chemical oxidation?

Chemical oxidation uses chemicals called *oxidants* to destroy pollution in soil and groundwater. Oxidants help change harmful chemicals into harmless ones, like water and carbon dioxide. Chemical oxidation can destroy many types of chemicals like fuels, solvents, and pesticides.

How does it work?

Chemical oxidation does not involve digging up polluted soil or groundwater. Instead, wells are drilled at different depths in the polluted area. The wells pump the oxidant into the ground. The oxidant mixes with the harmful chemicals and causes them to break down. When the process is complete, only water and other harmless chemicals are left behind.



To clean up a site faster, oxidants can be pumped in one well and out another well. This approach helps mix the oxidant with the harmful chemicals in the groundwater and soil. After the mixture is pumped out, it is pumped back (*recirculated*) down the first well. As pumping and mixing continues, more polluted soil and groundwater are cleaned up.

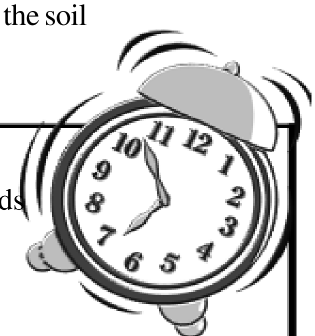
It can be hard to pump oxidants to the right spots in the ground. So before drilling starts, EPA must study the conditions underground by testing the soil and groundwater. Where is the pollution? How will the oxidant spread through the soil and groundwater to reach it?

The most common oxidant to clean up pollution is *hydrogen peroxide*. Another is *potassium permanganate*, which is cheaper. Both oxidants are pumped as liquids. And both have advantages depending on the site. Ozone is another strong oxidant, but because it is a gas, it can be difficult to use.

At some sites, a *catalyst* is used with the oxidant. A catalyst is a chemical that increases the strength or speed of a process. For instance, if hydrogen peroxide is mixed with an iron catalyst, it produces a strong chemical called a *free radical*. Free radicals can destroy more harmful chemicals than hydrogen peroxide alone.

Chemical oxidation can create enough heat to boil water. The heat can cause the chemicals underground to *evaporate*, or change into gases. The gases rise through the soil to the ground surface where they are captured and cleaned up.

How long will it take ?



The time it takes for chemical oxidation to clean up a site depends on several factors:

- size and depth of the polluted area
- type of soil and conditions present
- how groundwater flows through the soil (How fast? Along what path?)

In general, chemical oxidation offers rapid cleanup times compared to other methods. Cleanup times can be measured in months, rather than years.

Is chemical oxidation safe?

Chemical oxidation can be quite safe to use, but there are potential hazards. Oxidants are *corrosive*, which means they can wear away certain materials and can burn the skin. People who work with oxidants must wear protective clothing. Some oxidants can explode if used under the wrong conditions. Explosions can be prevented, however, through proper design of the chemical oxidation system. EPA makes sure that the system is properly designed. Workers also test the soil, groundwater, and air after chemical oxidation to make sure the site is cleaned up.

Why use chemical oxidation?

Chemical oxidation is being used at hundreds of sites across the country. It destroys pollution underground without having to dig it up or pump it out for transport to a treatment system. This saves time and money. Often chemical oxidation is used to clean up pollution that other methods can't reach, like pollution deep within the groundwater. Chemical oxidiation can be used to clean up the source of pollution. Most other methods that are used to remove the source are very slow and more expensive.

For more information

write the Technology Innovation Office at:

U.S. EPA (5102G)
1200 Pennsylvania Ave., NW
Washington, DC 20460

or call them at
(703) 603-9910.

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EPA 542-F-01-025
December 2001
www.epa.gov/superfund/sites
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A Citizen's Guide to Pump and Treat

The Citizen's Guide Series

EPA uses many methods to clean up pollution at Superfund and other sites. If you live, work, or go to school near a Superfund site, you may want to learn more about these methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

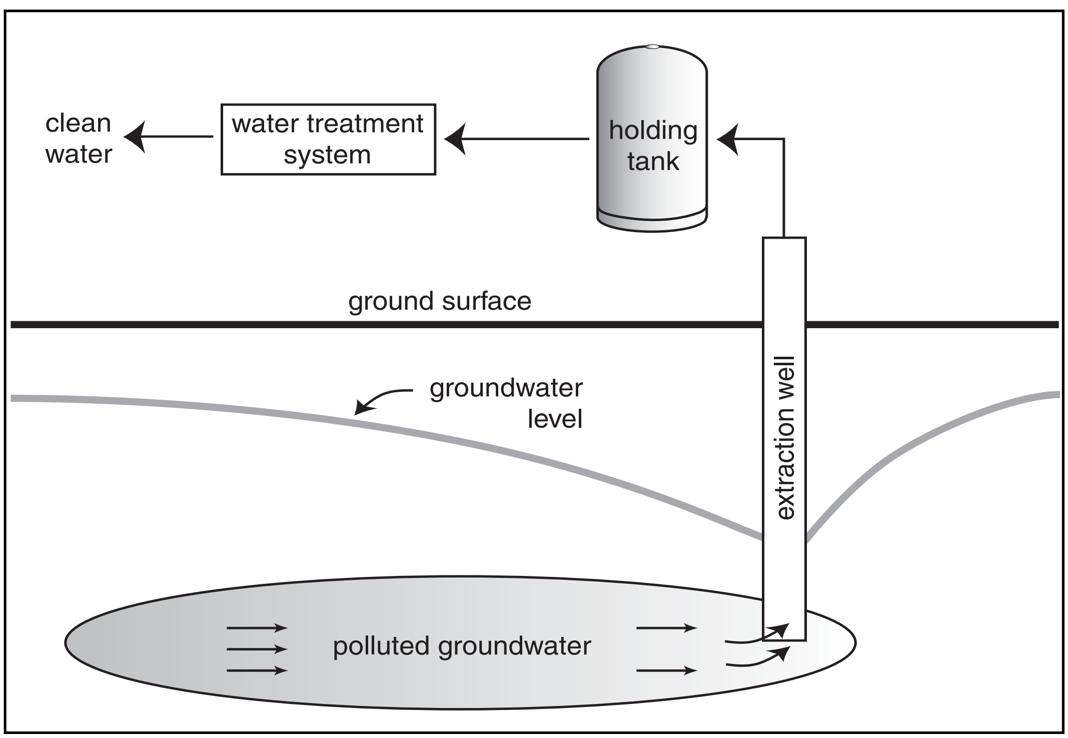
What is pump and treat?

Pump and treat is a common method for cleaning up groundwater. Pumps are used to bring polluted groundwater to the surface where it can be cleaned up (*treated*) more easily.

Groundwater is the water that has collected underground in the spaces between dirt particles and crack within rocks. Groundwater flows underground and may empty into rivers or lakes. Many people rely on groundwater as the source of their daily water needs.

How does it work?

To remove polluted water from underground, an *extraction system* is built. This system usually consists of one or more wells equipped with pumps. When the pumps are turned on,



they pull the polluted groundwater into the wells and up to the surface. At the surface, the water goes into a holding tank and then on to a treatment system, where it is cleaned. There are a number of treatment methods which can be used which either to destroy the polluting chemicals or to remove them for proper disposal (see *A Citizen's Guide to Air Stripping* [EPA 542-F-01-016], *A Citizen's Guide to Activated Carbon Treatment* [EPA 542-F-01-020], *A Citizen's Guide to Bioremediation* [EPA 542-F-01-001], and *A Citizen's Guide to Chemical Oxidation* [EPA 542-F-01-013]). The cleaned water can then be put back into the ground, into a public sewer, or into a pond.

In order for pump and treat to be effective, the source of the pollution must first be taken away so that it will not continue to seep into the groundwater. For example, leaking oil drums or tanks must be removed and the surrounding polluted soil must be cleaned up (see *A Citizen's Guide to Excavation* [EPA 542-F-01-023]).

Is pump and treat safe?

Pump and treat is quite safe when designed and operated properly. Since the polluted groundwater is pumped directly into holding tanks and from there into the treatment system, no one comes in contact with any harmful chemicals. The harmful chemicals are destroyed or removed and disposed of properly. The cleaned water is tested to make sure it is safe before it is put back into the ground or into a sewer system. EPA tests the groundwater regularly during the pump and treat process to make sure all of it is being collected and it is not spreading further.

How long will it take?

A pump and treat cleanup is a relatively slow process. It will usually last at least five to ten years, but can last for decades. The time it takes depends on:

• the type and amount of harmful chemicals present

• the size and depth of the polluted groundwater

• type of soil and rock rock in the area

Why use pump and treat?

Cleaning up polluted water while it is still underground is often very difficult and sometimes not possible. Pump and treat is the best remedy in such cases. Pump and treat can also be used to help keep polluted groundwater from spreading into nearby drinking water wells while other kinds of cleanup actions are being taken. EPA has used pump and treat at over 500 Superfund sites.

For more information

write the Technology Innovation Office at:

U.S. EPA (5102G)
1200 Pennsylvania Ave., NW
Washington, DC 20460

or call them at
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EPA 542-F-01-008
May 2001
www.epa.gov/superfund/sites
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EPA

A Citizen's Guide to Soil Washing

The Citizen's Guide Series

EPA uses many methods to clean up pollution at Superfund and other sites. Some, like soil washing, are considered new or *innovative*. Such methods can be quicker and cheaper than more common methods. If you live, work, or go to school near a Superfund site, you may want to know more about cleanup methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

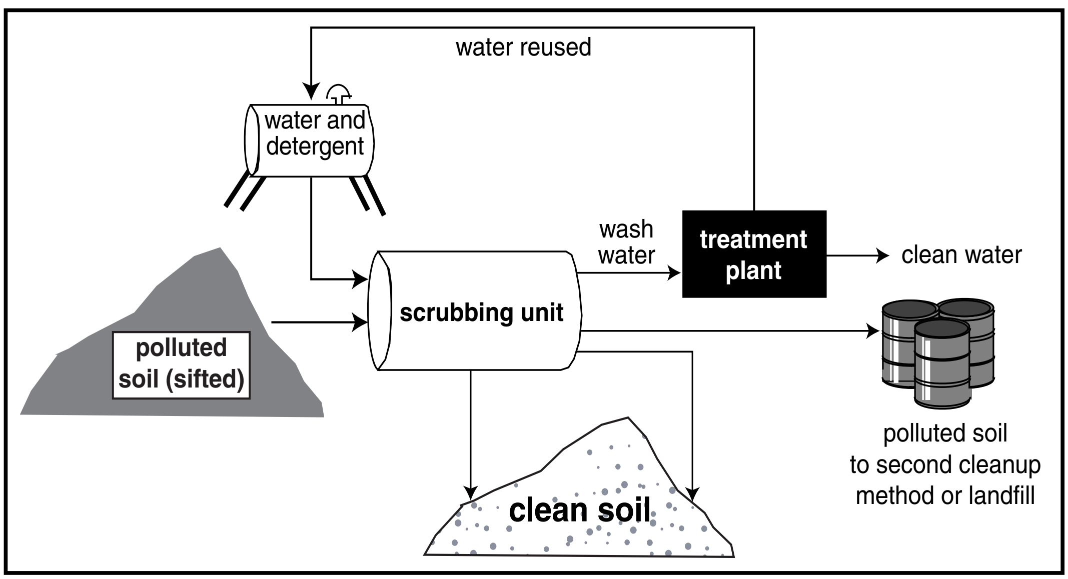
What is soil washing?

Soil washing "scrubs" soil to remove and separate the portion of the soil that is most polluted. This reduces the amount of soil needing further cleanup. Soil washing alone may not be enough to clean polluted soil. Therefore, most often it is used with other methods that finish the cleanup.

How does it work?

Chemicals tend to stick or *sorb* to some types of soil more than others. For instance, chemicals sorb more to fine-grained soils like silt and clay than to larger-grained soils like sand and gravel. The silt and clay, in turn, tend to stick to sand and gravel. Soil washing helps separate the silt and clay from the larger-grained, cleaner soils. It works best when the soil contains a much bigger portion of the larger-grained soils than the fine-grained ones. Soil washing can clean up a variety of chemicals, such as fuels, metals, and pesticides, that can sorb to soil.

Before using soil washing, soil dug from the polluted area is sifted to remove large objects, like rocks and debris. The sifted soil is placed in a machine called a *scrubbing unit*. Water,



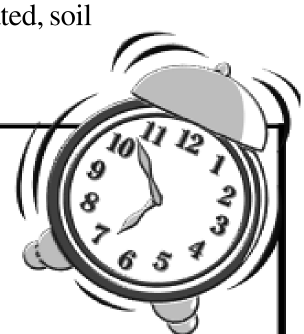
and sometimes detergents, are added to the polluted soil in the scrubbing unit. The mixture of soil and water is passed through sieves, mixing blades, and water sprays. This washes the silt and clay from the larger-grained soil and separates them. Some of the pollution may dissolve in the water or float to the top. The polluted wash water is removed and cleaned up at a treatment plant. The clean water then can be reused in the scrubbing unit or discharged.

The silt and clay, which contain most of the pollution, are tested for chemicals. Sometimes all of the pollution is removed in the wash water, but most often the silt and clay need further cleanup. The silt and clay may be washed again in the scrubbing unit or cleaned using another method like bioremediation or thermal desorption. (See *A Citizen's Guide to Bioremediation* [EPA 542-F-01-001] or *A Citizen's Guide to Thermal Desorption* [EPA 542-F-01-003].) Another option is to dispose of the polluted soils in a landfill.

The sand and gravel that settle to the bottom of the scrubbing unit also are tested for chemicals. If the sand and gravel are clean, they can be placed back on the site. If pollution is still present, they are washed again in the scrubbing unit. If necessary, another method is used to finish the cleanup.

Is soil washing safe?

Soil washing is usually performed at the site. This avoids the risks involved with trucking polluted soil from the site to a cleanup facility. During digging and cleanup, air pollution control equipment takes care of dust and other potential air pollution problems. Chemicals are seldom released from the scrubbing unit to the air. However, EPA tests the air at the site to ensure that chemicals are not released in harmful amounts. EPA also tests the soil to be sure it is clean before it is placed back on the site. When properly designed and operated, soil washing is quite safe.



How long will it take ?

The time it takes to clean up a site using soil washing depends on several factors:

- amount of silt, clay, and debris in the soil
- type and amount of pollution in the soil
- size of scrubbing unit (The largest units can clean up to 100 cubic yards of soil per day.)

Cleanup usually takes weeks to months, depending on the site.

Why use soil washing?

The greatest advantage of soil washing is that it reduces the amount of soil needing further cleanup. This reduction lowers the cost of cleanup and the cost for disposing of polluted material.

Soil washing can remove many types of pollution. It also works when the soil is very polluted, but may not be cost-effective for small amounts of pollution. It is also not as cost-effective on soils with a large amount of silt or clay. Soil washing is being used at six Superfund sites and other sites across the country.

For more information

write the Technology Innovation Office at:

U.S. EPA (5102G)
1200 Pennsylvania Ave., NW
Washington, DC 20460

or call them at
(703) 603-9910.

Further information also can be obtained at **www.cluin.org** or **www.epa.gov/superfund/sites**.

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(5102G)

EPA 542-F-01-009
October 2001
www.epa.gov/superfund/sites
www.cluin.org

A Citizen's Guide to Solvent Extraction

The Citizen's Guide Series

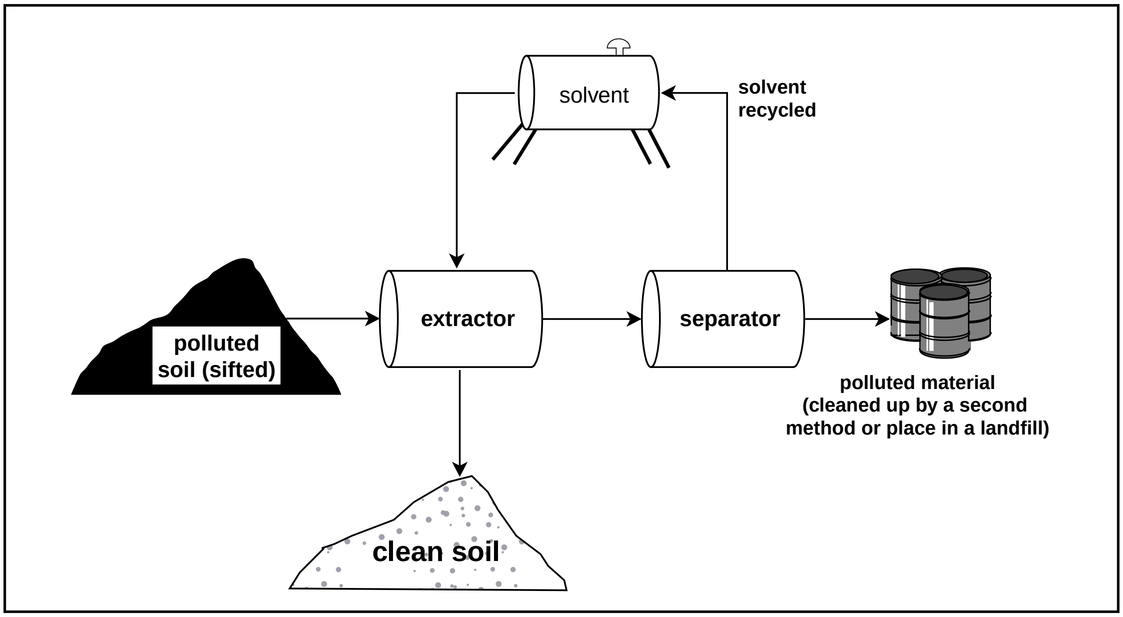
EPA uses many methods to clean up pollution at Superfund and other sites. Some, like solvent extraction, are considered new or *innovative*. Such methods can be quicker and cheaper than more common methods. If you live, work, or go to school near a Superfund site, you may want to learn more about cleanup methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

What is solvent extraction?

Solvent extraction (also known as chemical extraction) is a cleanup method that uses solvents to *extract* or remove harmful chemicals from polluted materials. Chemicals like PCBs, oil, and grease do not dissolve in water. Instead, they tend to stick or *sorb* to soil, sediment, and sludge, making it hard to clean them up. Solvents are chemicals that can dissolve sorbed chemicals and remove them from polluted materials.

How does it work?

Before using solvent extraction, the soil must be dug from the polluted area to be treated. The soil is sifted to remove large objects like rocks and debris. The sifted soil is then placed in a machine called an *extractor* where it is mixed with a solvent. The type of solvent will depend on the harmful chemicals present and the material being treated.



The cleaned soil is tested to make sure that the harmful chemicals have been removed. If harmful chemicals remain, the soil is placed back in the extractor to repeat the process. Clean soil (or sediment) can be placed back on the site.

Once the solvent dissolves the sorbed chemicals, the solvent is drained into a *separator*. This is where the chemicals are separated from the solvent. The used solvent often can be recycled and reused to clean up more soil. Otherwise, the solvents must be destroyed or disposed of in a landfill.

If any solvent remains in the soil following treatment, the soil is heated to remove it. The heat evaporates the solvent, changing it from a liquid to a gas. The gas is then removed from the clean soil. As the gas cools, it changes back to a liquid solvent, which can be recycled and reused.

Is solvent extraction safe?

When properly designed and operated, solvent extraction is a safe cleanup method for soil, sediment, and sludge. EPA tests the air while the materials are being dug. This ensures that chemicals are not released to the air in harmful amounts. The rest of the process is usually conducted in an enclosed area. Therefore, any harmful chemicals or solvents that evaporate can be captured and cleaned up. Following solvent extraction, EPA tests the soil to be sure it is clean before it is placed back on the site.

How long will it take ?

Solvent extraction can clean up to 125 tons of soil at a site per day. The time it takes to clean up a site depends on several factors:

- amount of polluted soil
- type of soil and conditions present (Is it wet or dry? Does it contain a lot of debris?)
- type and amounts of harmful chemicals present

Cleanup usually takes less than a year, depending on the site.

Why use solvent extraction?

Solvent extraction is used to clean up many chemicals that are difficult to remove from soil. Cleanup using solvent extraction is generally quicker than methods that treat the soil in place. It can be done at the site to avoid trucking polluted soil to cleanup facilities offsite. This saves money on transport and disposal of the soil. In addition, the solvents can often be recycled and reused. Solvent extraction is being used at four Superfund sites and at other sites across the country.

For more information

write the Technology Innovation Office at:

U.S. EPA (5102G)
1200 Pennsylvania Ave., NW
Washington, DC 20460

or call them at
(703) 603-9910.

Further information also can be obtained at **www.cluin.org** or **www.epa.gov/superfund/sites**.

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EPA 542-F-01-024
December 2001
www.epa.gov/superfund/sites
www.cluin.org

EPA

A Citizen's Guide to Solidification/Stabilization

The Citizen's Guide Series

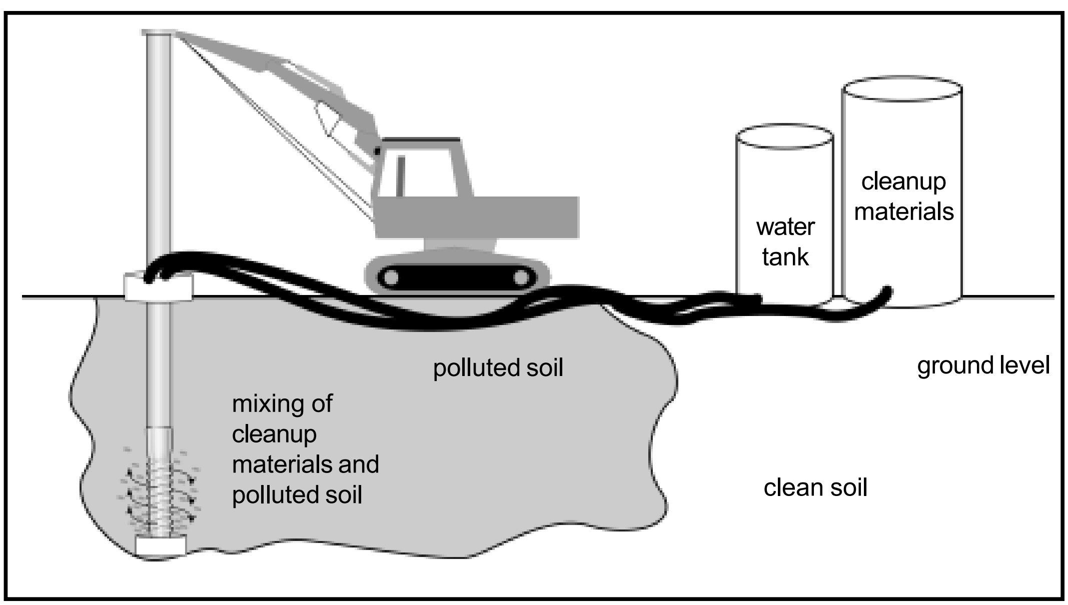
EPA uses many methods to clean up pollution at Superfund sites. If you live, work, or go to school near a Superfund site, you may want to learn more about these methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

What is solidification/stabilization?

Solidification/stabilization refers to a group of cleanup methods that prevent or slow the release of harmful chemicals from polluted soil or sludge. These methods usually do not destroy the chemicals—they just keep them from moving into the surrounding environment. Solidification refers to a process that binds the polluted soil or sludge and cements it into a solid block. Stabilization refers to changing the chemicals so they become less harmful or less mobile. These two methods are often used together to prevent exposure to harmful chemicals.

How do they work?

Solidification involves mixing polluted soil with a substance, like cement, that causes the soil to harden. The mixture dries to form a solid block that can be left in place or removed to another location. The solidification process prevents chemicals from spreading into the surrounding environment. Rain or other water cannot pickup or dissolve the chemicals as it



moves through the ground. Solidification does not get rid of the harmful chemicals, it simply traps them in place.

Stabilization changes harmful chemicals into substances that are less harmful or less mobile. For example, soil polluted with metals can be mixed with lime. The lime reacts with metals to form metal hydroxides. The metal hydroxides do not move through and out of the soil as easily.

Solidification/stabilization methods may or may not require the soil to be removed. Sometimes it is better to dig up the soil and place it in large mixers above ground to be sure that all of the polluted soil mixes with the cleanup materials, such as cement and lime. The mixture may then be returned to the ground at the site or placed in a landfill. At other sites, instead of digging up the soil, it is mixed in place with the cleanup materials. Then it is covered with clean soil or pavement. After solidification/stabilization is completed, EPA tests the surrounding soil to make sure no pollution was missed.

Is solidification/stabilization safe?

In order to make sure of the safety of the remedy, EPA tests the final mixture to confirm proper sealing of the harmful chemicals and for strength and durability of the solidified or stabilized materials. Sometimes EPA will place use restrictions on areas that have received solidification or stabilization. These land use restrictions can prevent future damage to the treated area.

How long will it take?

Solidification/stabilization may take weeks or months to complete, depending on several factors that vary from site to site:

- types and amounts of chemicals present
- size and depth of the polluted area
- types of soil and geologic conditions
- whether the mixing occurs in place or in mixing tanks

Why use solidification/stabilization?

Solidification/stabilization provides a relatively quick and low cost way to protect from the threat posed by harmful chemicals, especially metals. Solidification/stabilization has been chosen as part of the remedy at 183 Superfund sites across the country.

For more information
write the Technology Innovation Office at:

U.S. EPA (5102G)
1200 Pennsylvania Ave., NW
Washington, DC 20460

or call them at
(703) 603-9910.

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United States Environmental Protection Agency
Office of Solid Waste and Emergency Response (5102G)
EPA 542-F-01-017
December 2001
www.epa.gov/superfund/sites
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A Citizen's Guide to Vitrification

The Citizen's Guide Series

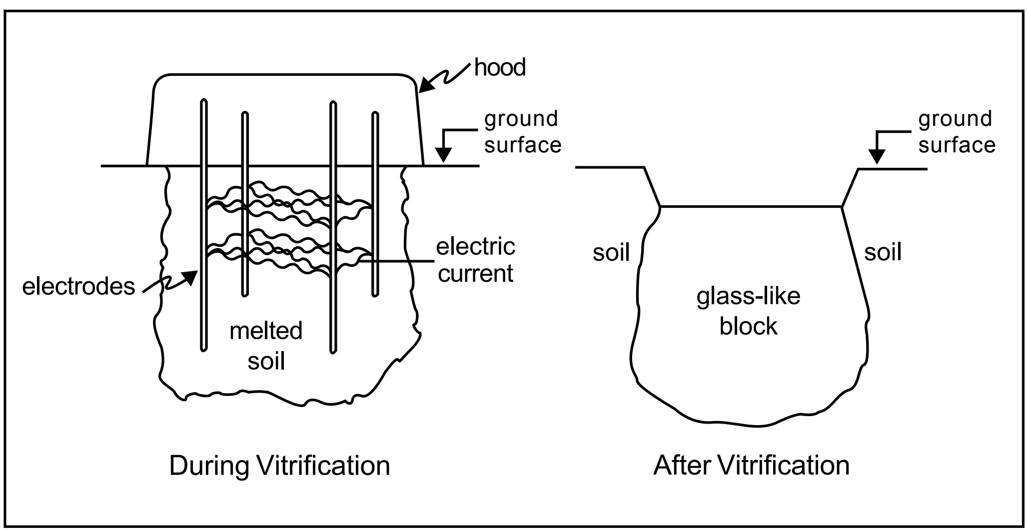
EPA uses many methods to clean up pollution at Superfund and other sites. Some, like vitrification, are considered new or *innovative*. Such methods can be quicker and cheaper than more common methods. If you live, work, or go to school near a Superfund site, you may want to learn more about cleanup methods. Perhaps they are being used or are proposed for use at your site. How do they work? Are they safe? This Citizen's Guide is one in a series to help answer your questions.

What is vitrification?

Vitrification is a process that permanently traps harmful chemicals in a solid block of glass-like material. This keeps them from leaving the site. Vitrification can be done either in place or above ground.

How does it work?

Vitrification uses electric power to create the heat needed to melt soil. Four rods, called electrodes, are drilled in the polluted area. An electric current is passed between the electrodes, melting the soil between them. Melting starts near the ground surface and moves down. As the soil melts, the electrodes sink further into the ground causing deeper soil to melt. When the power is turned off, the melted soil cools and *vitrifies*, which means it turns into a solid block of glass-like material. The electrodes become part of the block. When vitrified, the original volume of soil shrinks. This causes the ground surface in the area to sink slightly. To level it, the sunken area is filled with clean soil.



The heat used to melt the soil can also destroy some of the harmful chemicals and cause others to evaporate. The evaporated chemicals rise through the melted soil to the ground surface. Here, a hood, which covers the heated area, collects the chemicals. These chemicals are sent to a treatment system where they are cleaned up.

Any harmful chemicals that remain underground become trapped in the vitrified block, which is left in place. This prevents rainfall, groundwater flow, and wind from transporting the chemicals offsite.

Is vitrification safe?

When used properly, vitrification can be quite safe. The gas hood must be large enough to cover the polluted area so it can capture all the chemicals released from the soil. Any wet soil must be dried first to prevent steam from forming. The release of steam can splash hot, melted soil above ground. The hood further prevents site workers from being splashed.

The vitrified block that is left in place is permanent and not harmful to people. However, EPA may limit construction on the land to avoid damage to it. EPA also tests the soil and groundwater near the vitrified block to make sure that chemicals are not being released.

How long will it take?

The time it takes for in situ vitrification to clean up a site depends on several factors:

- size and depth of the polluted area
- types and amounts of chemicals present
- how wet the soil is (wet soil must be dried, which takes more time)

In general, in situ vitrification offers faster cleanup times than most methods. Cleanup can take from weeks to months, rather than years.

Why use vitrification?

Vitrification has been used at sites across the country, including one Superfund site. It can clean up several types of chemicals and soils. By cleaning up soil in place, it avoids the expense of digging up soil or trucking it to a landfill for disposal. Vitrification also tends to be faster than other methods.

For more information

write the Technology Innovation Office at:

U.S. EPA (5102G)
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