United States Environmental Protection Agency
Solid Waste and Emergency Response (5102G)
EPA 542-F-96-006
April 1996

A Citizen's Guide to In Situ Soil Flushing

Technology Innovation Office
Technology Fact Sheet

What is in situ soil flushing?

In situ soil flushing is an innovative treatment technology that floods contaminated soils with a solution that moves the contaminants to an area where they are removed. "In situ"—meaning "in place"—refers to treating the contaminated soil without digging up or removing it.

The specific contaminants in the soil at any particular site determine the type of flushing solution needed in the treatment process. The flushing solution is typically one of two types of fluids: 1) *water only*; or 2) *water plus additives* such as acids (low pH), bases (high pH) or surfactants (like detergents).

Water is used to treat contaminants that dissolve easily in water. An *acidic solution* is a mixture of water and an acid, such as nitric acid or hydrochloric acid. Acidic solutions are used to remove metals and organic contaminants, such as those typically found in battery recycling or industrial chrome plating processes. For example, zinc contamination—which can result from plating operations—would be treated with an acidic solution. A *basic solution* is a mixture of water and a base, such as sodium hydroxide. (Ammonia is an example of a base commonly used in households.) Basic solutions are used to treat phenols and some metals. A *surfactant* can be a detergent or emulsifier. Emulsifiers help mix substances that normally do not mix such as oil and water. For this reason, surfactant solutions are effective at removing oily contaminants.

Researchers also are investigating the use of water plus *organic solvents* as a flushing solution. Organic solvents such as ethanol are used to dissolve certain contaminants that water alone cannot dissolve.

How does it work?

Figure 1 on page 2 provides an illustration of one type of in situ soil flushing process. The process begins with the drilling of injection wells and extraction wells into the ground where the contamination has been found. The number, location, and depth of the injection and extraction wells depend on many geological factors and engineering considerations. Wells may be installed either vertically or horizontally. In addition to placing the wells, other equipment—such as a wastewater treatment system—must be transported to or built on the site.

A Quick Look at In Situ Soil Flushing

- Injects a washing solution into unexcavated soils to flush out contaminants.
- Is most effective on soils with low silt or clay content.
- Requires the drilling of injection and extraction wells on-site.
- Is a transportable technology that can be brought to the site.
- Requires greater understanding of the site's geology than some other technologies.

The soil flushing equipment pumps the flushing solution into the injection wells. The solution passes through the soil, picking up contaminants along its way as it moves toward the extraction wells. The extraction wells collect the *elutriate*—the flushing solution mixed with the contaminants.

The elutriate is pumped out of the ground through the extraction wells. Here, the elutriate is typically treated by a wastewater treatment system to remove the contaminants. The contaminants are treated or disposed of, and the treated water can either be recycled for use in the flushing solution or disposed of in another acceptable manner. It is because of this circular process that in situ soil flushing systems are often referred to as injection/recirculation systems.

Any contaminated fumes or vapors that might be given off during the wastewater treatment step of the process are collected and treated.

How Is Soil Flushing Different From Soil Washing?

With soil flushing, the soil is treated in place using an injection/recirculation process. Soil washing involves excavating the contaminated soil and treating it at the surface in a soil washer.

Why consider in situ soil flushing?

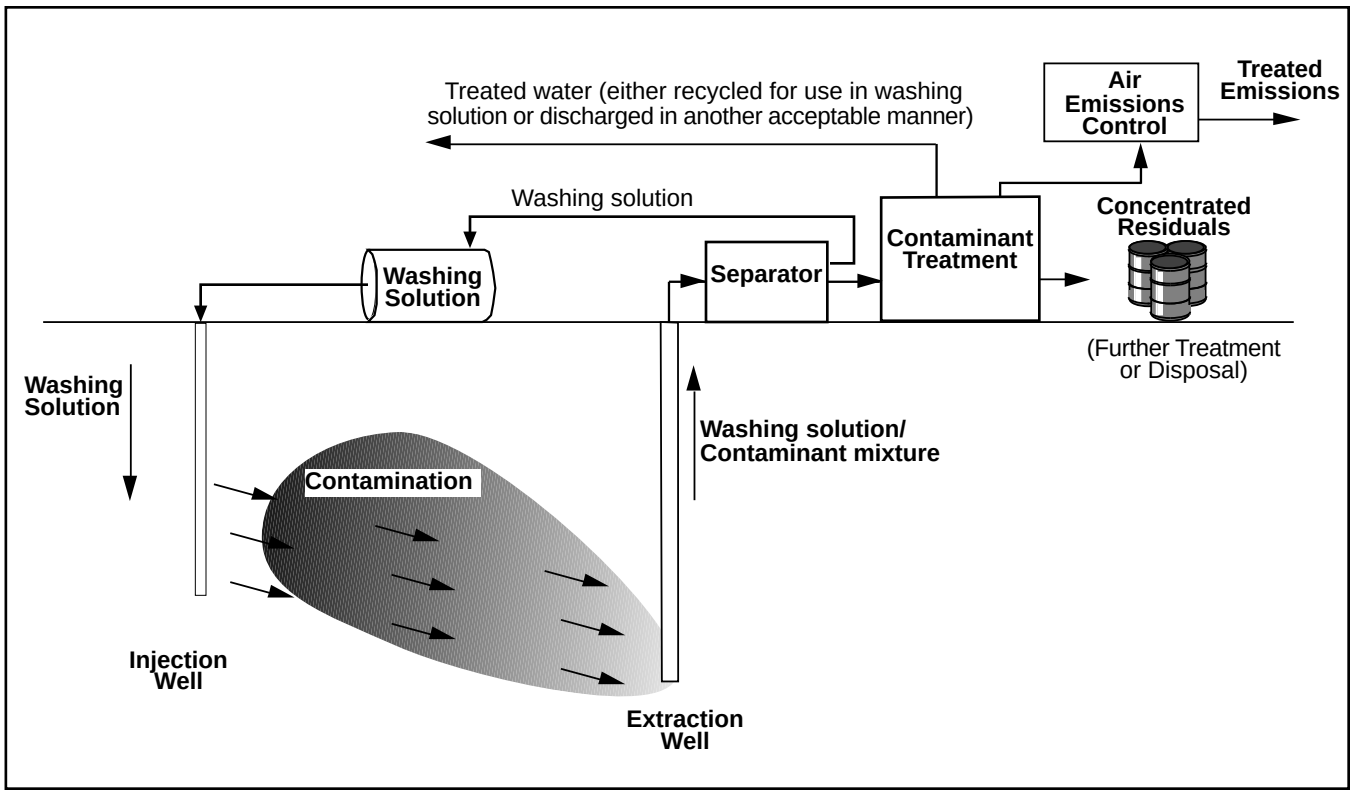
In situ soil flushing can be tailored to treat specific contaminants. For example, if a site is contaminated with oily waste, surfactants can be added to the flushing solution to remove them more easily from the soil.

In addition, since soil flushing is conducted in situ, it reduces the need for excavation, handling, or transportation of the hazardous substances. The process has been most effective in removing the contaminants such as those identified in Figure 2 on page 3.

Will it work at every site?

In situ soil flushing works best at sites with soil that has spaces that permit the wash solution to move

Figure 1
The In Situ Soil Flushing Process (Using Vertical Wells)



What Is an Innovative Treatment Technology?

Treatment technologies are processes applied to hazardous waste or contaminated materials to permanently alter their condition through chemical, biological, or physical means. Treatment technologies are able to alter, by destroying or changing, contaminated materials so they are less hazardous or are no longer hazardous. This may be done by reducing the amount of contaminated material, by recovering or removing a component that gives the material its hazardous properties or by immobilizing the waste.

Innovative treatment technologies are those that have been tested, selected or used for treatment of hazardous waste or contaminated materials but lack well-documented cost and performance data under a variety of operating conditions.

through it. If the soil has a high percentage of silt or clay, for example, the flushing solution can not easily move through the soil, so it can not easily make contact with the contaminants. This limits the overall effectiveness of the soil flushing process. In addition, some flushing fluids contain additives which may themselves create new groundwater contamination if they are not completely removed.

There are additional considerations for the use of this technology. For example:

- The flow of the groundwater must be well understood in order to design the well system for a given site. Extensive field investigations may be necessary to define the groundwater flow completely.

- The makeup and arrangement of subsurface layers must be well understood to be able to predict the path of the flushing fluids and contaminants and ensure that the contamination is not spread beyond the area from which it can be collected.

- Since in situ soil flushing is tailored to treat specific contaminants, it is not highly effective with soils contaminated with a mixture of hazardous substances, for example, metals and oils. It would be difficult to prepare a flushing solution that would effectively remove several different types of contaminants at the same time.

Where is in situ soil flushing being used?

Table 1 on page 4 lists some Superfund sites where in situ soil flushing has been selected as a treatment method.

Figure 2
Contaminants Considered for Treatment by In Situ Soil Flushing

Contaminants	Industries Where Used
Heavy metals (lead, copper, zinc)	Battery Recycling, Metal Plating
Halogenated solvents (TCE, trichloroethane)	Drycleaning, Electronics Assembly
Aromatics (benzene, toluene, cresol, phenol)	Wood Treating
Gasoline and fuel oils	Petroleum, Automobile
PCBs and chlorinated phenol	Pesticide, Herbicide, Electric Power

Not all waste types and site conditions are comparable. Each site must be individually investigated and tested. Engineering and scientific judgment must be used to determine if a technology is appropriate for a site.

Table 1
Examples of Superfund Sites Using Soil Flushing *

Name of Site	Status**	Type of Facility	Contaminants
Lipari Landfill, NJ	Operational	Landfill	Volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), metals
Vineland Chemical, NJ	In design	Pesticide manufacturing	Metals
Ninth Avenue Dump, MI	Completed	Industrial landfill	VOCs, polyaromatic hydrocarbons (PAHs)
Lee Chemical, MO	Operational	Solvent recovery	VOCs
Idaho Pole Company, MT	In design	Wood preserving	SVOCs, PAHs
United Chrome Products, OR	Operational	Chrome plating	Metals
Umatilla Army Depot, OR	Design complete	Explosives storage	Explosives, propellants

For a listing of Superfund sites at which innovative treatment technologies have been used or selected for use, contact NCEPI at the address in the box below for a copy of the document entitled ***Innovative Treatment Technologies: Annual Status Report (7th Ed.)*, EPA 542-R-95-008.** Additional information about the sites listed in the Annual Status Report is available in database format. The database can be downloaded free of charge from EPA's Cleanup Information bulletin board (CLU-IN). Call CLU-IN at 301-589-8366 (modem). CLU-IN's help line is 301-589-8368. The database also is available for purchase on diskettes. Contact NCEPI for details.

** Not all waste types and site conditions are comparable. Each site must be individually investigated and tested. Engineering and scientific judgment must be used to determine if a technology is appropriate for a site.*
***As of August 1995*

For More Information

The publications listed below can be ordered free of charge by calling NCEPI at 513-489-8190 or faxing your request to 513-489-8695. If NCEPI is out of stock of a document, you may be directed to other sources. You may write to NCEPI at:

National Center for Environmental Publications and Information (NCEPI)
P.O. Box 42419
Cincinnati, OH 45242

- *Selected Alternative and Innovative Treatment Technologies for Corrective Action and Site Remediation: A Bibliography of EPA Resources,* January 1995, EPA 542-B-95-001. **A bibliography of EPA publications about innovative treatment technologies.**
- *Physical/Chemical Treatment Technology Resource Guide, September 1994, EPA 542-B-94-008.* **A bibliography of publications and other sources of information about soil flushing, soil washing, solvent extraction, and other innovative treatment technologies.**
- *Engineering Bulletin: In Situ Soil Flushing,* May 1991, EPA 540-2-91-021.
- *Engineering Issue: Considerations in Deciding to Treat Contaminated Soils In Situ,* EPA 540-S-94-500.
- *In Situ Remediation Technology Status Report: Surfactant Enhancement,* EPA 542-K-94-003.
- *In Situ Remediation Technology Status Report: Cosolvents,* EPA 542-K-94-006.
- WASTECH® Monograph on *Soil Washing/Soil Flushing,* ISBN #1-883767-03-2. Available for $49.95 from the American Academy of Environmental Engineers, 130 Holiday Court, Annapolis, MD 21401. Telephone 410-266-3311.