



A Citizen's Guide to Solvent Extraction

Technology Innovation Office

Technology Fact Sheet

What Is solvent extraction?

Solvent extraction is a treatment technology that uses a *solvent* (a fluid that can dissolve another substance) to separate or remove hazardous organic contaminants from sludges, sediments, or soil. (*Sludge* is a mud-like material produced from industrial or sewage waste, and *sediment* is fine-grained rock and mineral fragments which have settled to the bottom of a water body such as a river or lake.) Solvent extraction does not destroy contaminants. It concentrates them so they can be more easily recycled or destroyed by another technology.

When the soil enters an extractor (a tank where the contaminated soil is mixed with the solvent), the soil is separated into three components, or "fractions." The three fractions are: solvent with dissolved contaminants, solids, and water. Different contaminants concentrate into different fractions. For example, polychlorinated biphenyls (PCBs) concentrate in the contaminated solvent, while metals are left behind in the solids and water. Each fraction can be individually treated or disposed of more cost effectively. A simplified drawing of the solvent extraction process is illustrated in Figure 1 on page 2.

The solvent extraction process involves five steps:

- Preparation (sorting the contaminated material)
- Extraction
- Separation of concentrated contaminants from solvent
- Removal of residual solvent
- Contaminant recovery, recycling, or further treatment.

How does it work?

Treatment of contaminated *soil* is discussed in this guide, but the method would be basically the same for treatment of sludges or sediments.

The entire process is conducted on-site and begins by excavating the contaminated soil and moving it to a staging area where it is prepared for treatment. The soil is then sifted to remove debris and rocks. The soil may be processed in either a batch, a semi-batch, or a continuous mode. In the semi-batch mode, the material is cycled through the extraction unit in increments. If the soil is processed continuously, it may need to be made more fluid so it can move easily through the process by pumping. This is accomplished by adding water or, in the case of oily sludges, adding solvents to the material.

A Quick Look at Solvent Extraction

- Separates contaminants so they may be treated individually.
- Is a transportable technology that can be brought to the site.
- Reduces the volume of contaminated material.
- Processes up to 125 tons of waste per day.
- Is designed to operate without air emissions.

The soil is placed in the extractor. Extractors can vary in size. Some process 25 tons per day, while others may treat over 125 tons daily and require setup areas of 1,500 to 10,000 square feet or more. (For comparison, a tennis court covers about 4,000 square feet.) The solvent is added to the extractor, and the soil and solvent are mixed together. Consequently, the organic contaminants dissolve into the solvent.

A number of factors control the speed with which contaminants are dissolved from the soil. Some of these controlling factors include temperature, moisture content, and the level of contamination. Each is critical to the design of the treatment. Treatability studies performed in a laboratory are required to determine how much solvent is needed and how long the material must remain in the extractor in order to assure maximum effectiveness. Since some solids may contain contaminants that require more than one cycle in the extractor, this step of the process may need to be repeated.

The extraction process produces three fractions which require separation:

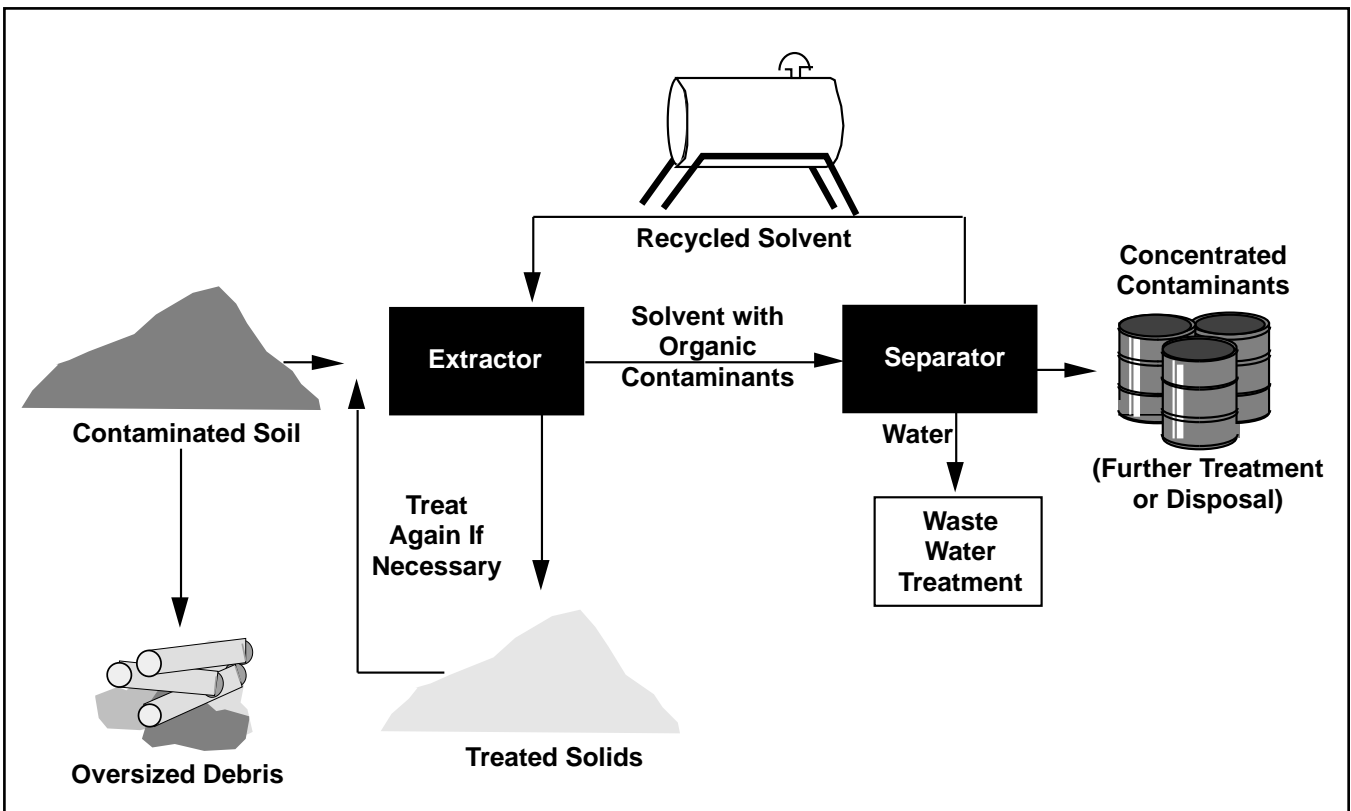
- The contaminated solvent mixture.
- The treated soil which, depending on the concentrations of contaminants present, may require a repeat cycle or further treatment by some other technique.

- The water, which must be analyzed to determine if further treatment is necessary before discharge to either a publicly-owned treatment plant or other approved discharge area.

The separation process occurs next. The contaminants are separated from the solvent either by changing the pressure and temperature, by using a second solvent to pull the first solvent out of the solvent/contaminant mixture, or by other physical separation processes. At the completion of this step, concentrated contaminants result. Concentrated contaminants are removed during the separation process, and the solvent is sent to a holding tank for reuse. The contaminants are then analyzed to determine their suitability for recycle/reuse, or need for further treatment before disposal.

Solvent extraction units are designed to operate without giving off contaminated vapors or *air emissions*. However, at some sites, air emissions could occur during excavation or preparation of contaminated soil. If air emissions exceed levels allowed by law, waste preparation and handling procedures at the site must be modified.

**Figure 1
The Solvent Extraction Process**



Why consider solvent extraction?

Solvent extraction can be both an effective and cost efficient process for separating hazardous contaminants from non-hazardous materials and concentrating the hazardous materials for further treatment. Because the contaminants are separated, the treatment selected can be targeted to the contaminant. As a result of solvent extraction, some contaminants may be recycled or re-used in manufacturing, thus minimizing disposal requirements. The process has been effective in removing organic contaminants from paint wastes, synthetic rubber process wastes, coal tar wastes, drilling muds, wood treating wastes, pesticide/insecticide wastes, and oily wastes.

What contaminants can it treat?

Solvent extraction has been shown to be effective in treating sediments, sludges, and soils containing primarily organic contaminants, such as polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), halogenated solvents (solvents containing halogens, which are bromine, chlorine, or iodine), and petroleum wastes. These contaminants typically come from metal degreasing, printed circuit board cleaning, gasoline, and wood preserving manufacturing processes. Table 1 lists the different solvents that are used. This technology is generally not used for removing inorganics (*i.e.*, acids, bases, salts, and heavy metals) as these materials do not readily dissolve in most solvents. Other treatment methods exist to treat these contaminants.

Will it work at every site?

Solvent extraction can be effective at separating hazardous organic contaminants from some contaminated soils, sludges, and sediments. It does not reduce the toxicity of the contaminants and, therefore, the final product of the process (the concentrated *residuals*) still require treatment or disposal. Some of the limitations of this technology include:

Table 1
Solvents Used in the Solvent Extraction Process

Liquid Carbon Dioxide
Propane
Butane
Triethylamine
Acetone
Methanol
Hexane
Dimethyl Ether

- If the waste contains detergents or strong acids or bases, solvent extraction may not be effective. Their presence can reduce the amount of contamination removed and slow the speed with which they are removed.
- The presence of lead and other inorganics may interfere with the removal of organic materials.
- Implementation can require complex engineering considerations. For example, some systems include compressed butane and propane, which require strict management to prevent them from vaporizing and igniting.
- Extensive pretreatment of the waste may be required to remove or break up large clumps.

Where is solvent extraction being used?

Table 2 on page 4 lists some Superfund sites at which solvent extraction has been selected as a treatment method. In addition to using this technology at Superfund sites, solvent extraction is commonly used by manufacturers in their day-to-day operations. Since solvents are expensive raw materials that can be reused, manufacturers, such as the dry cleaning and perfume industries, regularly recycle the solvents used in their manufacturing processes.

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 destroy or change contaminated materials so they are less hazardous or not hazardous at all. 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.

Table 2
Examples of Superfund Sites Using Solvent Extraction *

Name of Site	Status**	Type of Facility	Contaminants
Carolina Transformer, NC	In design	Transformer repair	Polychlorinated biphenyls (PCBs)
United Creosoting, TX	In design	Wood preserving	Polyaromatic hydrocarbons (PAHs)
Arrowhead Refinery Co., MN	Operational	Waste oil refining	Volatile organic contaminants (VOCs), PCBs, PAHs, metals, solvents
Idaho Nat'l Engineering Lab (Pit 9), ID	In design	Nuclear research	VOCs, PCBs

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

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Publications with "PB" document numbers are available by contacting the National Technical Information Service (NTIS) at 1-800-553-6847. There will be a charge for these documents. Mail orders can be sent to:

National Technical Information Service (NTIS)
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Springfield, VA 22161

- *Selected Alternative and Innovative Treatment Technologies for Corrective Action and Site Remediation: A Bibliography of EPA Resources*, EPA 542-B-95-001. **A bibliography of EPA publications about innovative treatment technologies.**
- *Physical/Chemical Treatment Technology Resource Guide*, 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, Solvent Extraction*, EPA 540-S-94-503, PB94-190477.
- *EPA Engineering Issue: Technology Alternatives for the Remediation of PCB-Contaminated Soil and Sediment*, EPA 540-S-93-506, PB94-144250/XAB.
- *WASTECH® Monograph on Solvent/Chemical Extraction*, ISBN #1-883767-05-9. Available for \$49.95 from the American Academy of Environmental Engineers, 130 Holiday Court, Annapolis, MD 21401. Telephone 410-266-3311.

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