United States Environmental Protection Agency | Solid Waste and Emergency Response (5102G) | EPA 542-F-96-004 April 1996

A Citizen's Guide to Chemical Dehalogenation

Technology Innovation Office | Technology Fact Sheet

What is chemical dehalogenation?

Chemical dehalogenation is a chemical process to remove *halogens* (usually chlorine) from a chemical contaminant, rendering it less hazardous. *Halogens* are a class of chemical elements that include chlorine, bromine, iodine, and fluorine. Polychlorinated biphenyls are halogenated compounds that once were used in high voltage electrical transformers because they conducted heat well while being fire resistant and good electrical insulators. In addition, halogenated compounds are used to produce pesticides because their addition causes the toxicity needed to control pests. Halogenated compounds also are commonly used in water treatment, swimming pool chemicals, and plastic piping and textile production. The chemical dehalogenation process can be used on common halogenated contaminants such as PCBs and dioxins which are usually found in soil and oils.

How does it work?

There are two common versions of the chemical dehalogenation process in use: **glycolate dehalogenation** and the **base-catalyzed decomposition process.**

Glycolate Dehalogenation

Glycolate dehalogenation makes use of a chemical reagent called APEG. APEG consists of two parts: an alkali metal hydroxide (the "A" in APEG) and polyethylene glycol (PEG), a substance similar to antifreeze. Sodium hydroxide and potassium hydroxide are two common alkali metal hydroxides. Potassium polyethylene glycolate is the most common APEG reagent. The process consists of mixing and heating the contaminated soils with the APEG reagent. During heating, the alkali metal hydroxide reacts with the halogen from the contaminant to form a non-toxic salt; and the PEG takes the location in the PCB molecule formerly occupied by the halogen making it less hazardous.

The glycolate dehalogenation process consists of five steps: preparation, reaction, separation, washing, and dewatering (Figure 1). During the preparation step, the contaminated waste (soil, for example) is excavated and sifted to remove debris and large objects such as boulders and logs. Next, in the reaction step, the contaminated soils and the APEG reagent are blended in a large container called a *reactor*, mixed, and heated for four hours.

Vapors resulting from the heating process are collected. The vapor is separated into water and the gaseous contaminants by means of a condenser. The water can be used during a later step in the process and the gaseous contaminants are passed through activated carbon filters to capture the contaminant.

A Quick Look at Chemical Dehalogenation

- Used to treat halogenated aromatic organic contaminants, particularly PCBs and dioxins.
- Chemically converts toxic materials to less toxic or non-toxic materials.
- Involves heating and physically mixing contaminated soils with chemical reagents.
- Is a transportable technology that can be brought to the site.

The soil-APEG mixture, after treatment in the reactor, goes to the separator, where the APEG reagent is separated from the soil and recycled for future use in the system. The treated soil contains products of the treatment which are less toxic chemicals resulting from the dehalogenation reaction. These new chemical products are a non-toxic salt and a less toxic, partially dehalogenated organic compound.

The soil passes from the separation step to a washer, where the water collected in the earlier reaction step is added. The last traces of residual APEG reagent are extracted from the soil and recycled. The soil proceeds to a dewatering phase where the water and soil are separated. The water is treated to remove contaminants before discharge to a municipal water treatment system, a receiving stream, or other appropriate discharge areas. The soil is retested for contaminant concentrations. If it still contains contaminants above targeted treatment concentrations, it is recycled through the process or put into an environmentally safe landfill; if the soil is clean, it can be returned to its original location on the site.

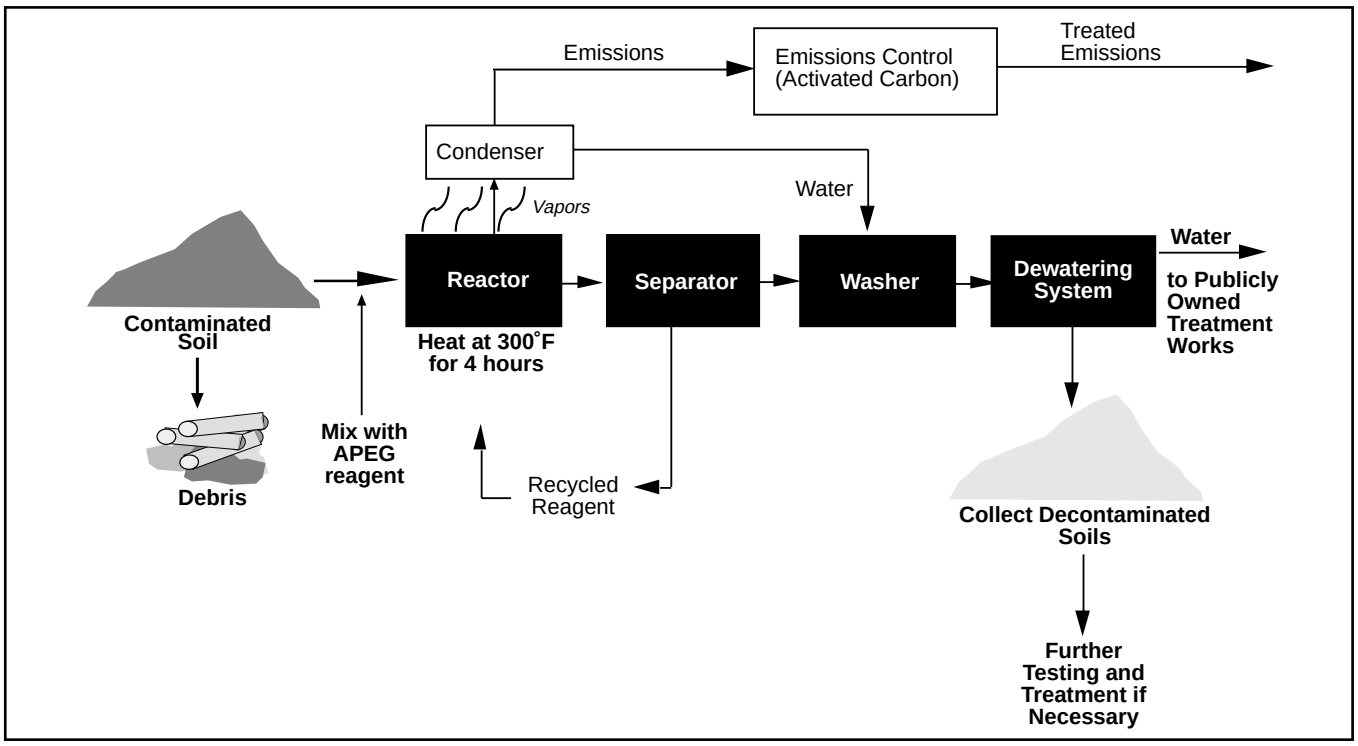
Base-Catalyzed Decomposition

A second type of chemical dehalogenation, the base-catalyzed decomposition (BCD) process, was developed by the U.S. Environmental Protection Agency as a clean, inexpensive way to remediate liquids, sludge, soil, and sediment contaminated with chlorinated organic compounds, especially PCBs, pesticides, some herbicides and dioxins.

In the BCD process (Figure 2 on page 3), contaminated soil is excavated and screened to remove debris and large particles, then crushed and mixed with sodium bicarbonate at roughly one part sodium bicarbonate to ten parts soil. This mixture is heated in a reactor. The heat separates the halogenated compounds from the soil by evaporation. The soil left behind is removed from the reactor and can be returned to the site. The contaminated gases, condensed into a liquid form, pass into a liquid-phase reactor. The dehalogenation reaction occurs when several chemicals including sodium hydroxide (a base) are mixed with the condensed contaminants and heated in the reactor. The resulting liquid mixture can be incinerated or treated by other technologies and recycled. The BCD process eliminates the need to remove the reactants from the treated soil as in the glycolate dehalogenation process.

The BCD process components are easily transported and safely operated. The process employs off-the-shelf equipment and requires less time and space to mobilize, set up, and take down than an incinerator—which is a common alternative treatment for PCB-contaminated wastes.

Figure 1
The Glycolate Dehalogenation Process



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 that 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 still lack well-documented cost and performance data under a variety of operating conditions.

Why consider chemical dehalogenation?

Dehalogenation can be an effective process for removing halogens from hazardous organic compounds, such as dioxins, furans, PCBs, and certain chlorinated pesticides. The treatment time is short, energy requirements are moderate, and operation and maintenance costs are relatively low. The technology can be brought to the site, so hazardous wastes do not have to be transported.

Will dehalogenation work at every site?

Characteristics of the contaminated material that interfere with the effectiveness of chemical dehalogenation are high clay or water content, acidity, or high natural organic content of the soil. Glycolate dehalogenation is not designed for large waste volumes or wastes with concentrations of chlorinated contaminants above 5%. Since contaminated soil must be excavated and screened before treatment, there must be sufficient space at the site to conduct this pretreatment process.

Where is dehalogenation being used?

Some Superfund sites where chemical dehalogenation has been selected as a treatment method are listed in Table 1 on page 4. The BCD process also has been used by the Navy at a Public Works Center in Guam to treat PCB-contaminated soil. The BCD process was successful at meeting EPA's cleanup goals for the soil.

Figure 2
The Base-Catalyzed Decomposition Process

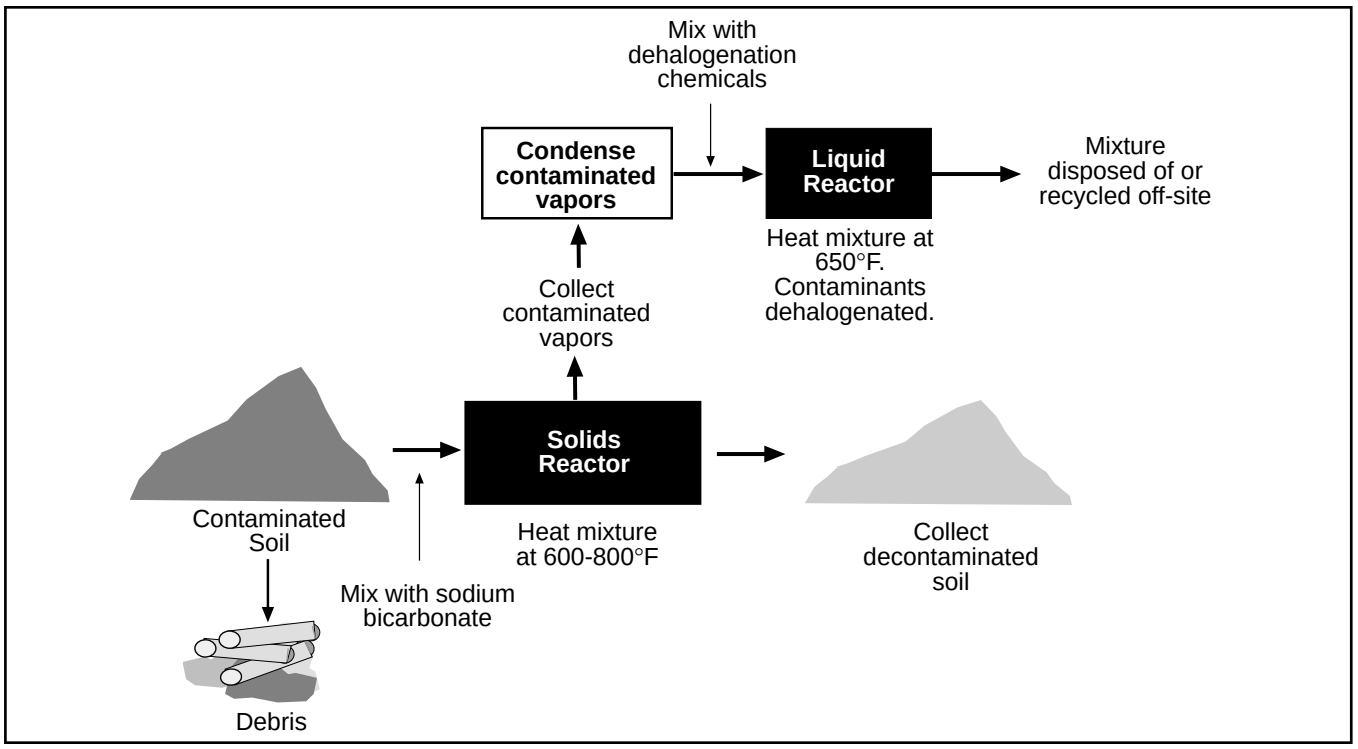


Table 1
Examples of Superfund Sites Using Chemical Dehalogenation*

Name of Site	Status**	Process	Contaminants
Wide Beach Development, NY	Completed	Glycolate dehalogenation	Polychlorinated biphenyls (PCBs)
Myers Property, NJ	In design	BCD	Semi-volatile organic compounds (SVOCs), pesticides
Saunders Supply Co., VA	In design	To be determined	SVOCs, dioxins

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. 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 Information Sources,* 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 about chemical dehalogenation and other innovative treatment technologies.**
- *Engineering Bulletin: Chemical Dehalogenation Treatment: APEG Treatment*, September 1990, EPA 540-2-90-015.
- *SITE Program Technology Profiles (7th Ed.)*, November 1994, EPA 540-R-94-526.