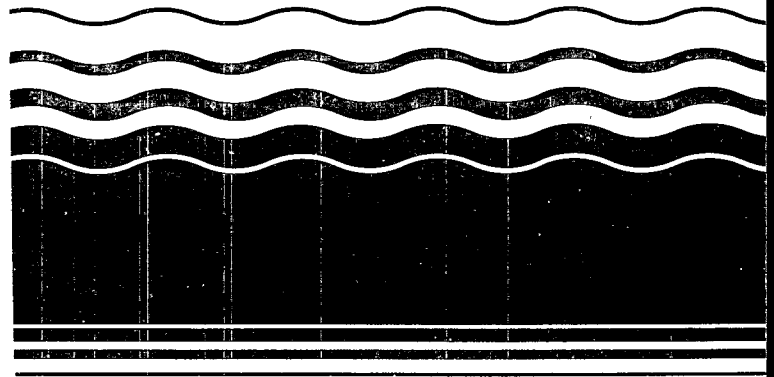


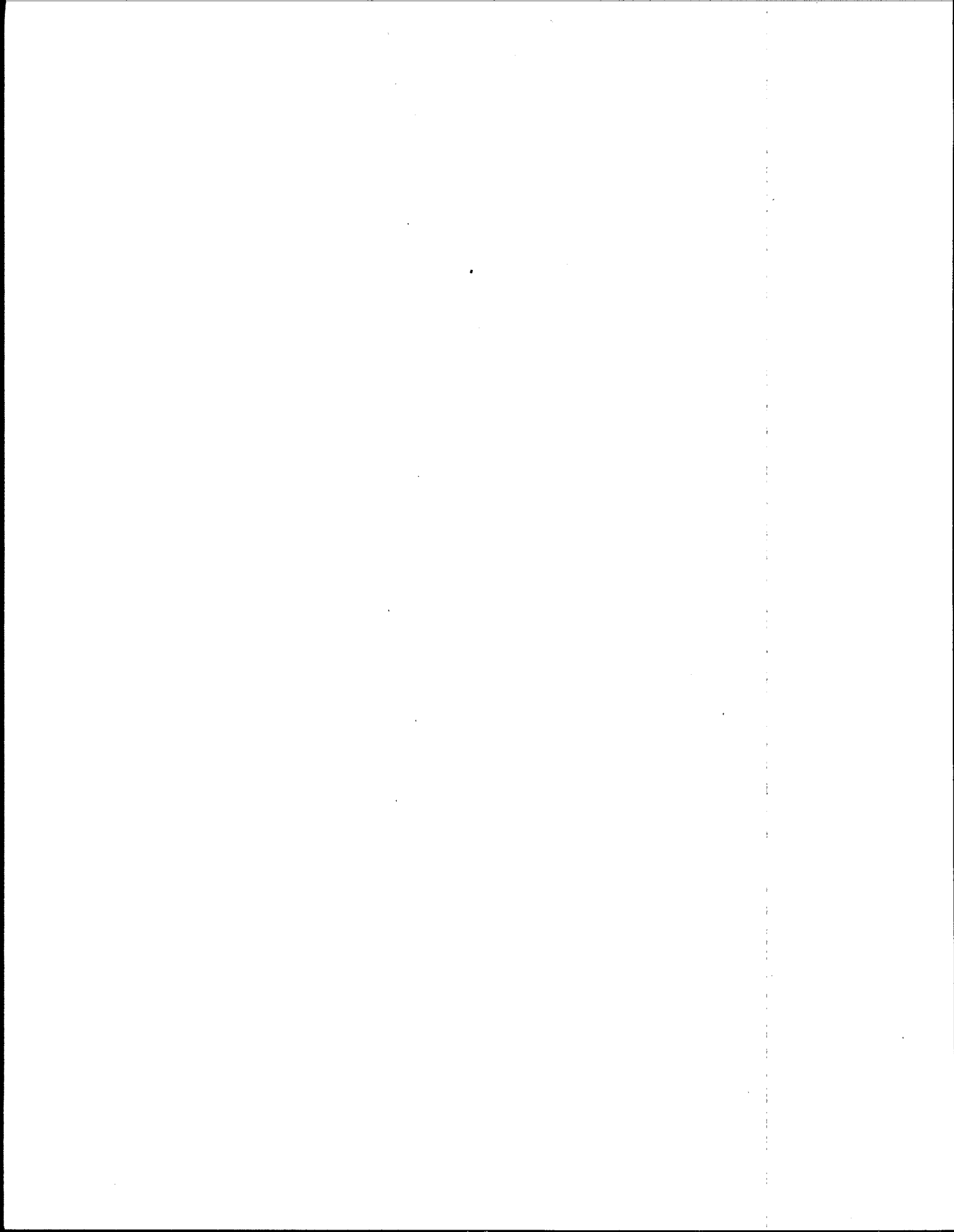


The Superfund Innovative Technology Evaluation Program:

Technology Profiles

SITE
*SUPERFUND INNOVATIVE
TECHNOLOGY EVALUATION*





SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

TECHNOLOGY PROFILES

U.S. ENVIRONMENTAL PROTECTION AGENCY
RISK REDUCTION ENGINEERING LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
26 WEST MARTIN LUTHER KING DRIVE
CINCINNATI, OHIO 45268

DISCLAIMER

The development of this document has been funded wholly or in part by the United States Environmental Protection Agency under Contract No. 68-03-3484, Work Assignment No. 28, to PRC Environmental Management, Inc. The document has been subjected to the Agency's administrative and peer review and has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

FOREWORD

The U.S. Environmental Protection Agency (EPA) is charged by Congress with protecting the Nation's land, air, and water resources. As the enforcer of national environmental laws, the EPA strives to balance human activities and the ability of natural systems to support and nurture life. A key part of the EPA's effort is its research into our environmental problems to find new and innovative solutions.

The Risk Reduction Engineering Laboratory (RREL) is responsible for planning, implementing, and managing research, development, and demonstration programs to provide an authoritative, defensible engineering basis in support of the policies, programs, and regulations of the EPA with respect to drinking water, wastewater, pesticides, toxic substances, solid and hazardous wastes, and Superfund-related activities. This publication is one of the products of that research and provides a vital communication link between the researcher and the user community.

Now in its fourth year, the Superfund Innovative Technology Evaluation (SITE) Program is part of EPA's research into cleanup methods for hazardous waste sites around the nation. Through cooperative agreements with developers, alternative or innovative technologies are refined at the bench- and pilot-scale level and then demonstrated at actual sites. EPA collects and evaluates extensive performance data on each technology to use in remediation decision-making for hazardous waste sites.

This document profiles fifty-two demonstration and emerging technologies being evaluated under the SITE Program. Each technology profile contains a description of the technology; a discussion of its applicability to various wastes; an update on its development or demonstration status; and any available demonstration results. This document is intended for EPA Regional decision-makers and other interested individuals involved in hazardous waste site cleanups.

E. Timothy Oppelt, Director
Risk Reduction Engineering Laboratory

ABSTRACT

This document is intended as a reference guide for EPA Regional decision makers and others interested in technologies in the SITE Demonstration and Emerging Technologies programs. The Technologies are described in technology profiles, presented in alphabetical order by developer name and separated into Demonstration and Emerging Technologies sections. Each profile describes a single technology, its applicability, its current status, and any demonstration results. The names of the EPA Project Manager and a Developer Contact are also provided for each technology.

This document was submitted in partial fulfillment of Contract No. 68-03-3484, Work Assignment No. 28, by PRC Environmental Management, Inc., under the sponsorship of the U.S. Environmental Protection Agency. The document was prepared between August 1989 and November 1989.

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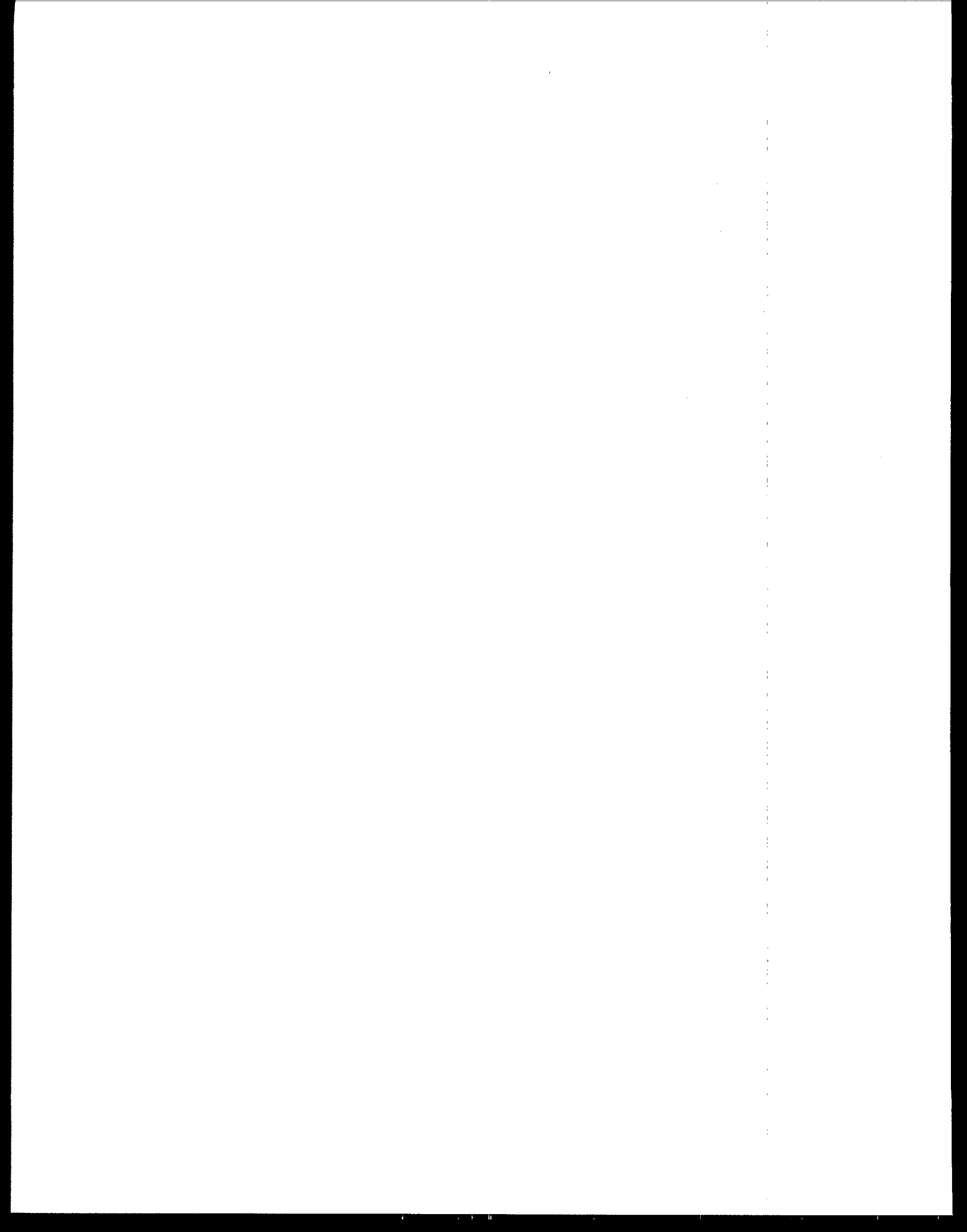
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Participating in the development of this document for PRC Environmental Management, Inc. were Lisa M. Scola, Robert I. Foster, Stanley Labunski, Thomas Raptis, and Aaron Lisec. Special recognition is given to Madeline Dec, Carole Van Hooser, Carolyn Blanko, Linda Graff, and Laurie Corey for their contribution to the layout and graphics. Also, appreciation is given to Joe Schwartzbaugh and Rebecca Keiter of PEER Consultants, P.C. for their cooperative efforts.



PROGRAM DESCRIPTION

INTRODUCTION

The Superfund Amendments and Reauthorization Act of 1986 (SARA) directed the Environmental Protection Agency (EPA) to establish an "Alternative or Innovative Treatment Technology Research and Demonstration Program." In response, the EPA's Office of Solid Waste and Emergency Response and the Office of Research and Development established a formal program called the Superfund Innovative Technology Evaluation (SITE) Program, to accelerate the development and use of innovative cleanup technologies at hazardous waste sites across the country.

The SITE Program is comprised of the following five component programs:

- Demonstration Program
- Emerging Technologies Program
- Measurement and Monitoring Technologies Development Program
- Innovative Technologies Program
- Technology Transfer Program

This document focuses on the Demonstration and Emerging Technologies Program, both of which are designed to assist private developers in commercializing alternative technologies for site remediation. Figure 1 depicts the process of technology development from initial concept to commercial use, and shows the interrelationship between these two programs.

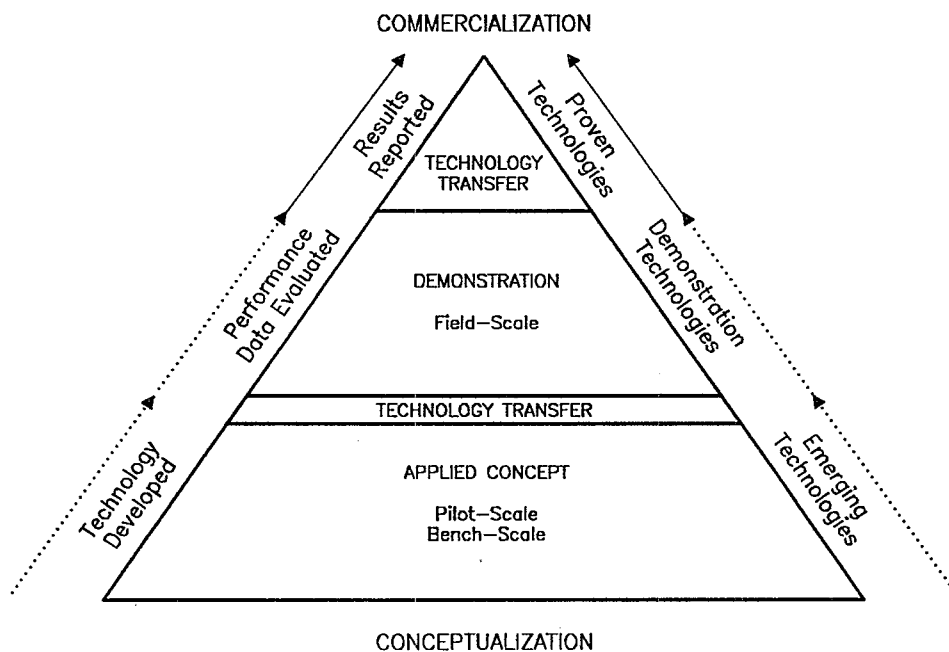


Figure 1. Development of Alternative and Innovative Technologies

Before a technology can be accepted into the Emerging Technology Program, sufficient data must be available to validate its basic concepts. The technology is then subjected to a combination of bench- and pilot-scale testing in an attempt to apply the concept under controlled conditions. After testing and development, the technology's performance is documented and a report is prepared, which may include recommendations for further developing the technology.

If bench and pilot test results are encouraging, a technology may proceed with approval to a field demonstration. In the Demonstration Program, technologies are field-tested on hazardous waste materials. Engineering and cost data are gathered to assess the technologies applicability for site clean-up. The Demonstration (Technology Evaluation) Report presents information such as: testing procedures, sampling and analytical data, quality assurance/quality control standards, and significant results.

To encourage general use of the technology, a second report, called the Applications Analysis Report, is prepared to evaluate all available information on the specific technology and analyze its applicability to other site characteristics, waste types, and waste matrices. As part of the formal SITE Technology Transfer Program, these informational documents are published and distributed to the user community to provide reliable technical data for Superfund decision making, and to promote the technology's commercial use.

Currently there are 14 technologies participating in the Emerging Technology Program. These projects vary from a constructed wetlands-based treatment technology to bench- and pilot-scale studies of a laser-stimulated photochemical oxidation process.

The Demonstration Program has 37 active participants, divided into the following five categories: thermal (6 projects), biological (4), chemical (3), physical (11), and solidification/stabilization (9). In addition, 4 technologies involve combinations of these treatment categories. To date, twelve technology demonstrations have been completed; several reports have been published and others are in various stages of production. Table 1 lists these demonstrations, in chronological order, along with information on the technology transfer opportunities for the project.

OTHER SITE PROGRAMS

Measurement and Monitoring Technologies Development Program

Under this program, EPA laboratories explore new and innovative technologies for assessing the nature and extent of contamination as well as evaluating remedial/removal activities performed at hazardous waste sites. Effective measurement and monitoring technologies at Superfund sites are needed to: (1) accurately assess the degree of contamination at a site; (2) provide data and information to determine impacts to health and the environment; (3) supply data for the selection of the most appropriate remedial action; and (4) monitor the success/failure of a selected remedy. To date, the program has focused on two major research areas -- immunoassays for toxic substances and fiber optic sensing for in-situ analysis.

**TABLE 1
COMPLETED SITE DEMONSTRATIONS
AS OF NOVEMBER 1989**

Developer:	Shirco Infrared Systems, Inc., Carrollton, TX (September 1987)
Technology:	Infrared Thermal Destruction
Site Location:	Peak Oil Superfund Site in Brandon, Florida
Visitor's Day:	Demonstration conducted July 31 - August 5, 1987
Technology Evaluation Report:	SITE Program Demonstration Test, Shirco Infrared Incineration System, Peak Oil, Brandon, Florida, September 1988, EPA 540/5-88/002a
Applications Analysis Report:	Shirco Infrared Incineration System, EPA/540/A5-89/010, June 1989
Regional Contact:	Fred Stroud, EPA Region IV, 404-347-3931

Profile Reference Page 69

Developer:	Hazcon, Inc., Katy, TX (October 1987)
Technology:	Solidification/Stabilization
Site Location:	Douglassville Superfund Site, Berks County, near Reading, Pennsylvania
Visitor's Day:	October 14, 1987
Technology Evaluation Report:	SITE Program Demonstration Test, HAZCON Solidification, Douglassville, PA, EPA 540/5-89/001a Vol. 1
Applications Analysis Report:	HAZCON Solidification Process, Douglassville, Pennsylvania, EPA/540/A5-89/001, May 1989
Regional Contact:	Victor Janosik, EPA Region III, 215-597-8996

Profile Reference Page 47

Developer:	Shirco Infrared Systems, Inc., Carrollton, TX (November 1987)
Technology:	Infrared Thermal Destruction
Site Location:	Rose Township Superfund Site, Oakland County, Michigan
Visitor's Day:	November 4, 1987
Technology Evaluation Report:	SITE Program Demonstration Test, Shirco Pilot-Scale Infrared Incineration System at the Rose Township Demode Road Superfund Site, EPA/540/5-89/007a, Vol. 1, April 1989
Applications Analysis Report:	Shirco Infrared Incineration System, EPA 540/A5-89/007, June 1989
Regional Contact:	Kevin Adler, EPA Region V, 312-886-7078

Profile Reference Page 69

Developer:	American Combustion Technologies, Inc., Norcross, GA (January 1988)
Technology:	Pyreton Thermal Destruction System
Site Location:	EPA's Combustion Research Facility in Jefferson, Arkansas
Visitor's Day:	Soil from Stringfellow Acid Pit Superfund Site in California
Technology Evaluation Report:	Demonstration conducted from November 16, 1987 to January 29, 1988
Applications Analysis Report:	SITE Program Demonstration Test - The American Combustion Pyretron Thermal Destruction System at the U.S. EPA's Combustion Research Facility, EPA/540/5-89/008, April 1989
EPA Contact:	In preparation. EPA/540/A5-89/005, 1989
	Laurel Staley, EPA ORD, Cincinnati, 513-569-7863

Profile Reference Page 15

TABLE 1 (Continued)
COMPLETED SITE DEMONSTRATIONS
AS OF NOVEMBER 1989

Developer:	International Waste Technologies, Wichita, KS/ GeoCon, Inc., Pittsburgh, PA (May 1988)
Technology:	In-Situ Stabilization/Solidification
Site Location:	General Electric Electric Service Shop in Hialeah, Florida
Visitor's Day:	April 14, 1988
Technology Evaluation Report:	Technology Evaluation Report, SITE Demonstration Program, International Waste Technologies in Situ Stabilization/Solidification, Hialeah, Florida, EPA/540/5-89/004a, August 1989
Applications Analysis Report:	In preparation
Regional Contact:	James Orban, Region IV, 404-347-2643

Profile Reference Page 51

Developer:	Terra Vac, Inc., San Juan, Puerto Rico (December 1987 through April 1988)
Technology:	In Situ Vacuum Extraction
Site Location:	Groveland Wells Superfund Site, Valley Manufactured Product Company, Inc. in Groveland, Massachusetts
Visitor's Day:	January 15, 1988
Technology Evaluation Report:	SITE Program Demonstration Test Terra Vac In Situ Vacuum Extraction System, Groveland, Massachusetts, EPA/540/5-89/003a, April 1989
Applications Analysis Report:	Terra Vac In Situ Vacuum Extraction System, EPA/540/A5-89/003, July 1989
Regional Contact:	Robert Leger, EPA Region I, 617-573-5734

Profile Reference Page 77

Developer:	C.F. Systems Corporation, Waltham, MA (September 1988)
Technology:	Solvent Extraction
Site Location:	New Bedford Harbor Superfund Site in Massachusetts
Visitor's Day:	August 26 - 27, 1988
Demonstration Report:	In publication
Applications Analysis Report:	In preparation
Regional Contact:	David Lederer, EPA Region I, 617-573-9665

Profile Reference Page 25

Developer:	Soliditech, Inc., Houston, TX (December 1988)
Technology:	Solidification/Stabilization
Site Location:	Imperial Oil Company/Champion Chemicals Superfund site in Morganville, Monmouth County, New Jersey
Visitor's Day:	December 7, 1988
Technology Evaluation Report:	SITE Program Demonstration Test - Soliditech, Inc. Solidification/Stabilization Process, no number, Draft September 1989 (Final was submitted to EPA on September 20, 1989)
Applications Analysis Report:	In preparation, expected January 1990
Regional Contact:	Trevor Anderson, EPA Region II, 212-264-5391

Profile Reference Page 73

TABLE 1 (Continued)
COMPLETED SITE DEMONSTRATIONS
AS OF NOVEMBER 1989

Developer:	Ultrox International, Inc., Santa Ana, CA (March 1989)
Technology:	Ultraviolet Radiation, Hydrogen Peroxide, and Ozone
Site Location:	Lorentz Barrel and Drum Company in San Jose, California
Visitor's Day:	March 8, 1989
Demonstration Report:	SITE Program Demonstration of the Ultrox International Ultraviolet Radiation/Oxidation Technology, no number, September 1989 (Final was submitted to EPA on October 13, 1989)
Applications Analysis Report:	In preparation, expected March 1990
Regional Contact:	Joseph Healy, EPA Region IX, 415-974-8011

Profile Reference Page 81

Developer:	Chemfix Technologies, Inc., Metairie, LA (March 1989)
Technology:	Chemical Fixation/Stabilization
Site Location:	Portland Equipment Salvage Company in Clackamas, Oregon
Visitor's Day:	March 15, 1989
Demonstration Report:	In preparation. Technology evaluation and application analysis reports are to be combined
Applications Analysis Report:	In preparation
Regional Contact:	John Sainsbury, EPA Region X, 206-442-1196

Profile Reference Page 27

Developer:	BioTrol, Inc., Chaska, MN (September 1989)
Technology:	Soil Washing
Site Location:	MacGillis & Gibbs Superfund Site in New Brighton, MN
Visitor's Day:	September 27, 1989
Demonstration Report:	In preparation
Applications Analysis Report:	In preparation
Regional Contact:	Rhonda McBride, EPA Region V, 312-886-7242

Profile Reference Page 23

Developer:	BioTrol, Inc., Chaska, MN (July 1989)
Technology:	Aqueous Treatment System
Site Location:	MacGillis & Gibbs Superfund Site in New Brighton, MN
Visitor's Day:	September 27, 1989
Demonstration Report:	In preparation
Applications Analysis Report:	In preparation
Regional Contact:	Rhonda McBride, EPA Region V, 312-886-7242

Profile Reference Page 21

The technical reports listed above may be obtained by calling the Center for Environmental Research Information (CERI) in Cincinnati, Ohio at 513-569-7562. If you would like to be placed on the SITE mailing list, write to:

ORD Publications
 26 West Martin Luther King Drive (G72)
 Cincinnati, Ohio 45268

Innovative Technologies Program

The aim of this program is to encourage private sector development by firms that are willing to commercialize EPA-developed technologies for use at Superfund sites. Formerly called the Innovative Development and Evaluation Program, the Innovative Technologies Program is an outgrowth of early research and development efforts for on-site destruction and cleanup of hazardous wastes. The Federal Technology Transfer Act of 1986 authorized the EPA-industry partnership that is necessary to bring these technologies to commercialization, by reducing the marketing risk in commercializing these technologies and accelerating their development.

There are currently seven technologies in the Innovative Technologies Program. To promote the commercialization of three of these innovative technologies, EPA sponsored an exhibition in January 1989, at which participants were invited to view videos of the technologies in operation, inspect the equipment, and obtain information on the assistance available in commercializing these technologies.

Technology Transfer Program

In this program, technical information on technologies is exchanged through various activities that support the SITE Program. Data from the Demonstration Program and existing hazardous waste remediation data are disseminated in an effort to increase awareness of alternative technologies available for use at Superfund sites. The goal of technology transfer activities is to develop interactive communication among individuals requiring up-to-date technical information.

The Technology Transfer Program includes the following activities and resources:

- Alternative Hazardous Waste Treatment Technologies Clearinghouse
- SITE Brochures, Publications, Reports, and Videos
- Pre-Proposal Conferences on SITE Solicitations
- Public Meetings and Demonstration Site Visits
- Seminar Series
- SITE Exhibit at Major Conferences
- Innovative Technologies Program Exhibition
- Networking with Forums, Associations, Centers of Excellence, Regions, and States
- Technical Assistance to Regions, States, and Cleanup Contractors

SITE PROGRAM CONTACTS

The SITE Program is administered jointly by EPA's Office of Research and Development (ORD) and Office of Solid Waste and Emergency Response (OSWER). For further information on the SITE Program in general, or its component programs, contact:

SITE Program

Robert A. Olexsey, Division Director
Superfund Technology Demonstration Division
513-569-7696 (FTS: 684-7696)

Stephen C. James, Acting Chief
SITE Demonstration and Evaluation Branch
513-569-7696 (FTS: 684-7696)

Demonstration Program

John Martin, Acting Chief
Demonstration Section
513-569-7510 (FTS: 684-7510)

Emerging Technologies Program/ Innovative Technologies Program

Donald E. Sanning, Chief
Emerging Technology Section
513-569-7879 (FTS: 684-7879)

U.S. Environmental Protection Agency
26 West Martin Luther King Drive
Cincinnati, OH 45268

Measurement and Monitoring Program

Eric Koglin
Environmental Monitoring Systems Laboratory
U.S. EPA
P.O. Box 93478
Las Vegas, NV 89193-3478
702-798-2432 (FTS: 545-2432)

Office of Solid Waste and Emergency Response Contact

John Kingscott
Office of Solid Waste and Emergency Response
U.S. EPA
401 M Street, SW
Washington, D.C. 20460
202-382-4362 (FTS: 684-4362)

TECHNOLOGY PROFILE PURPOSE AND FORMAT

This document contains profiles of technologies being evaluated under the SITE Demonstration and Emerging Technologies Programs. It is intended to provide EPA Regional decision makers and other interested individuals with a ready reference document on alternative technologies. Technologies are presented in alphabetical order by developer name, with separate sections for the Demonstration and Emerging Technologies Programs.

Each technology profile contains: (1) a technology description, (2) a discussion on waste applicability, (3) a project status report, and (4) EPA Project Manager and technology developer contacts. For completed demonstrations, the profiles also include demonstration results and a summary of the applications analysis.

Reference tables for the SITE program participants precede the Demonstration and Emerging sections, and contain EPA and Developer contacts. Inquiries about a specific SITE technology should be directed to the EPA Project Manager and inquiries on the technology itself should be directed to the Technology Developer Contact. Both contacts are also listed in the "For Further Information" section of each technology profile.

DEMONSTRATION PROGRAM

The objective of the SITE Demonstration Program is to develop reliable engineering performance and cost data on innovative alternative technologies, so that potential users can evaluate each technology's applicability for a specific site compared to other alternatives. Demonstrations are conducted at hazardous waste sites (usually Superfund sites) or under conditions that closely simulate actual wastes and conditions, to assure the accuracy and reliability of information collected.

Data collected during a demonstration are used to assess the performance of the technology, the potential need for pre- and post-processing of the waste, applicable types of wastes and media, the potential operating problems, and the approximate capital and operating costs. Demonstration data can also provide insight into long-term operating and maintenance costs and long-term risks.

Technologies are selected for the SITE Demonstration Program through annual requests for proposals (RFPs). Proposals are reviewed by ORD and OSWER staff to determine the technologies with the most promise for use at hazardous waste sites. Technologies are selected following interviews with the developers. Cooperative agreements between EPA and the developer set forth responsibilities for conducting the demonstration and evaluating the technology. Developers are responsible for demonstrating their innovative systems at a selected site, and are expected to pay the costs to transport equipment to the site, operate the equipment on-site during the demonstration, and remove the equipment from the site. EPA is responsible for project planning, sampling and analysis, quality assurance and quality control, preparing reports, and disseminating information. If the developer is unable to obtain financing elsewhere, EPA may consider bearing a greater portion of the total project cost.

To date, four solicitations have been completed -- SITE 001 in 1986 through SITE 004 in 1989. The RFP for SITE 005 will be issued in January 1990. The program has 37 active participants, presented in alphabetical order in Table 2 and in the technology profiles that follow.

TABLE 2

SITE Demonstration Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
American Combustion Technologies, Inc. Norcross, GA (001)	Pyretron Oxygen Burner	James Untz 404-662-8156	Laurel Staley 513-569-7863 FTS 684-7863	Soil, Sludge	NA	Non-specific
American Toxic Disposal, Inc. Waukegan, IL (004)	Vapor Extraction System	W.C. Meenan 312-662-8455	Laurel Staley 513-569-7863 FTS 684-7863	Soil, Sludge, Sediment	Volatile	Volatile and Semivolatile Organics including PCBs, PAHs, PCPs, some Pesticides
AWD Technologies, Inc. Burbank, CA (004)	Integrated Vapor Extraction and Steam Vacuum Stripping	David Bluestein 415-876-1504	Norma Lewis/Gordon Evans 513-569-7696 FTS 684-7696	Ground Water, Soil	NA	Volatile Organic Compounds
Biotrol, Inc. Chaska, MN (003)	Biological Aqueous Treatment System	Thomas Chresand 612-448-2515	Mary Stinson 201-321-6683 FTS 340-6683	Liquid	Can be applied to Nitrates	Chlorinated and Nonchlorinated Hydrocarbons
Biotrol, Inc. Chaska, MN (003)	Soil Washing System	Steve Valine 612-448-2515	Mary Stinson 201-321-6683 FTS 340-6683	Soil	Metals	High Molecular Weight Organics
CF Systems Corporation Waltham, MA (002)	Solvent Extraction	Chris Shallice 617-890-1200	Richard Valentinetti 202-382-2611 FTS 382-2611	Soil, Sludge, Wastewater	NA	PCBs, Volatile, and Semivolatile Organic Compounds, Petroleum Byproducts
Chemfix Technologies, Inc. Metairie, LA (002)	Solidification/Stabilization	Philip Baldwin 504-831-3600	Edwin Barth 513-569-7669 FTS 684-7669	Soil, Sludge, Other Solids	Heavy Metals	High Molecular Weight Organics

NA = Non Applicable

TABLE 2 (Continued)

SITE Demonstration Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
Chemical Waste Management, Inc. Oakbrook, IL (003)	X*TRAX™ Low-Temperature Thermal Desorption	Robert LaBoube 708-218-1500	Paul dePercin 513-569-7797 FTS 684-7797	Soil, Sludge, Other Solids	NA	Volatile and Semivolatile Organics, PCBs
Dehydro-Tech Corporation East Hanover, NJ (004)	Carver-Greenfield Process for Extraction of Oily Waste	Thomas Halcombe 201-887-2182	Laurel Staley 513-569-7863 FTS 684-7863	Soil, Sludge	NA	PCBs, Dioxin, Oil-Soluble Organics
DETOX, Inc. Dayton, OH (003)	Submerged Aerobic Fixed-Film Reactor	Edward Galaska 513-433-7394	Ronald Lewis 513-569-7856 FTS 684-7856	Ground Water, Wastewater	Metals inhibit process	Readily Biodegradable Organic Compounds
E.I. Du Pont de Nemours and Co./Oberlin Filter Co. Newark, DE (003)	Membrane Microfiltration	Ernest Mayer 302-366-3652	John Martin 513-569-7758 FTS 684-7758	Ground Water, Leachate, Wastewater	Heavy Metals, Cyanide, Uranium	Non-specific
Ecova Corporation Redmond, WA (003)	In Situ Biological Treatment	Michael Nelson 206-883-1900	Naomi Barkley 513-569-7854 FTS 684-7854	Water, Soil, Sludge, Sediment	NA	Chlorinated Solvents, Nonchlorinated Organic Compounds
EPOC Water, Inc. Fresno, CA (004)	Leaching and Microfiltration	Ray Groves 209-291-8144	Jack Hubbard 513-569-7507 FTS 684-7507	Soil, Sludge	Specific for Heavy Metals	NA
Exxon Chemicals, Inc./Rio Linda Chemical Co. Long Beach, CA (004)	Chemical Oxidation/Organics Destruction	Mark McGlathery 213-597-1937	Teri Shearer 513-569-7949 FTS 684-7949	Ground Water, Wastewater	NA	Non-specific

NA = Non Applicable

TABLE 2 (Continued)

SITE Demonstration Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
Exxon Chemicals, Inc./ Rio Linda Chemical Co. Long Beach, CA (004)	Chemical Oxidation/Cyanide Destruction	Mark McGlathery 213-597-1937	Teri Shearer 513-569-7949 FTS 684-7949	Sludge, Soil	Cyanide	NA
Freeze Technologies Corp. Raleigh, NC (003)	Freezing Separation	James A. Heist 919-850-0600	Jack Hubbard 513-569-7507 FTS 684-7507	Liquid	Non-specific	Non-specific
GeoSafe Corporation Kirkland, WA (002)	In Situ Vitrification	James Hansen 206-822-4000	Teri Shearer 513-569-7949 FTS 684-7949	Soil, Sludge	Non-specific	Non-specific
HAZCON, Inc. Brookshire, TX (001)	Solidification/Stabilization	Ray Funderburk 713-934-4500 800-227-6543	Paul dePercin 513-569-7797 FTS 684-7797	Soil, Sludge	Heavy Metals	Not an Inhibitor
Horsehead Resources Development Co., Inc. Monaca, PA (004)	Flame (Slagging) Reactor	John Pusater 412-773-2279	Don Oberacker 513-569-7510 FTS 684-7510	Soil, Sludge, Other Solids	Heavy Metals	NA
International Waste Technologies/Geo-Con, Inc. Wichita, KS (001)	In Situ Solidification/ Stabilization	Jeff Newton 316-269-2660 Brian Jasperse 412-856-7700	Mary Stinson 201-321-6683 FTS 340-6683	Soil, Sediment	Non-specific	PCBs, Other Non- specific Organic Compounds
MoTec, Inc. Austin, TX (002)	Liquid/Solid Contact Digestion	Randy Kabrick 512-477-8661	Ronald Lewis 513-569-7856 FTS 684-7856	Soil, Sludge	NA	Halogenated and Nonhalogenated Organic Compounds, Pesticides

NA = Non Applicable

TABLE 2 (Continued)

SITE Demonstration Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
Ogden Environmental Services San Diego, CA (001)	Circulating Fluidized Bed Combustor	Brian Baxter 619-455-2613	Joseph McSorley 919-541-2920 FTS 629-2920	Soils, Sludge, Slurry	NA	Halogenated and Nonhalogenated Organic Compounds
Ozonics Recycling Corp. Boca Raton, FL (004)	Soil Washing, Catalytic/ Ozone Oxidation	Allen Legel 407-395-9505	Norma Lewis 513-569-7665 FTS 684-7665	Soil, Sludge, Leachate, Ground Water	Cyanide	Semivolatiles, Pesticides, PCBs, PCP, Dioxin
QUAD Environmental Technologies Corp. Northbrook, IL (004)	Chemtact Gaseous Waste Treatment	Harold Rafson 312-564-5070	Ronald Lewis 513-569-7856 FTS 684-7856	Gaseous Waste Streams	Varied Based on Absorbent Liquid	Varied Based on Absorbent Liquid
Resources Conservation Co. Bellevue, WA (001)	Solvent Extraction (BEST)	Lisa Robbins 206-828-2400	Edward Bates 513-569-7774 FTS 684-7774	Sludge, Soil	NA	Specific for High Molecular Weight Organics
Retech, Inc. Ukiah, CA (002)	Plasma Reactor	R.C. Eschenbach 707-462-6522	Laurel Staley 513-569-7863 FTS 684-7863	Liquids, Soil, Sludge	Metals	Non-specific
S.M.W. Seiko, Inc. Redwood City, CA (004)	In Situ Solidification/ Stabilization	David Yang 415-591-9646	Jack Hubbard 513-569-7507 FTS 684-7507	Soil	Metals	Semivolatile Organic Compounds
Separation and Recovery Systems, Inc. (SRS) Irvine, CA (002)	Solidification/Stabilization	Joseph de Franco 714-261-8860	Edward Bates 513-569-7774 FTS 684-7774	Liquid/Solid	Low Level Metals	Specific for Acidic Sludges with at Least 5% Hydrocarbons
Shirco Infrared Systems, Inc. (001)	Infrared Thermal Destruction	Several Vendors (see Technology Profile)	Howard Wall 513-569-7691 FTS 684-7691	Soil, Sediment	NA	Non-specific

NA = Non Applicable

TABLE 2 (Continued)

SITE Demonstration Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
Silicate Technology Corp. Scottsdale, AZ (003)	Solidification/Stabilization with Silicate Compounds	Steve Pegler 602-941-1400	Edward Bates 513-569-7774 FTS 684-7774	Ground Water, Sludge, Soil	Metals, Cyanide, Ammonia	High Molecular Weight Organics
Soliditech, Inc. Houston, TX (002)	Solidification/Stabilization	Carl Brassow 713-778-1800	Walter Grube 513-569-7798 FTS 684-7798	Soil, Sludge	Metals	Non-specific
Solvent Services, Inc. San Jose, CA (004)	Steam Injection and Vacuum Extraction (SIVE)	Doug Dieter 408-453-6046	Paul dePercin 513-569-7797 FTS 684-7797	Soil	NA	Volatile and Semivolatile Organic Compounds
Terra Vac, Inc. San Juan, PR (001)	In Situ Vacuum Extraction	James Malot 809-723-9171	Mary Stinson 201-321-6683 FTS 340-6683	Soil	NA	Volatile and Semivolatile Organic Compounds
Toxic Treatments (USA) Inc. San Francisco, CA (003)	In Situ Steam/Air Stripping	Philip La Mori 415-391-2113	Paul dePercin 513-569-7797 FTS 684-7797	Soil	NA	Volatile Organic Compounds and Hydrocarbons
Ultrox International, Inc. Santa Ana, CA (003)	Ultraviolet Radiation and Ozone Treatment	David Fletcher 714-545-5557	Norma Lewis 513-569-7665 FTS 684-7665	Ground Water, Leachate, Wastewater	NA	Halogenated Hydrocarbons, Volatile Organic Compounds, Pesticides, PCBs
Wastech, Inc. Oak Ridge, TN (004)	Solidification/Stabilization	E. Benjamin Peacock 615-483-6515	Edward Bates 513-569-7774 FTS 684-7774	Soil, Sludge, Liquid Waste	Non-specific, Radioactive	Non-specific
Zimpro/Passavant, Inc. Rothschild, WI (002)	PACT®/Wet Air Oxidation	William Copa 715-359-7211	John Martin 513-569-7758 FTS 684-7758	Ground Water, Wastewater, Leachate	NA	Volatile and Semivolatile Organic Compounds

NA = Non Applicable



Technology Profile

Demonstration Program



November 1989

AMERICAN COMBUSTION TECHNOLOGIES, INC. (Pyretron® Oxygen Burner)

TECHNOLOGY DESCRIPTION:

The Pyretron® technology involves an oxygen-air-fuel burner, and uses advanced fuel injection and mixing concepts to burn wastes. Pure oxygen, in combination with air and natural gas, is burned in the Pyretron burner to destroy solid hazardous waste (Figure 1). The burner operation is computer-controlled to automatically adjust the amount of oxygen to sudden changes in the heating value of the waste.

The burner can be fitted onto any conventional combustion unit for burning liquids, solids and sludges. Solids and sludges can be co-incinerated when the burner is used in conjunction with a rotary kiln or similar equipment.

WASTE APPLICABILITY:

Solid wastes contaminated with hazardous organics are suitable for the Pyretron

technology. In general, the technology is applicable to any waste that can be incinerated. The technology is not suitable for processing aqueous wastes, RCRA heavy metal wastes, or inorganic wastes.

STATUS:

A demonstration project was conducted at EPA's Combustion Research Facility in Jefferson, Arkansas, using a mixture of 40 percent contaminated soil from the Stringfellow Acid Pit Superfund site in California and 60 percent decanter tank tar sludge from coking operations (RCRA listed waste K087). The demonstration began in November 1987, and was completed at the end of January 1988.

Both the Technology Evaluation Report and Project Summary have been published.

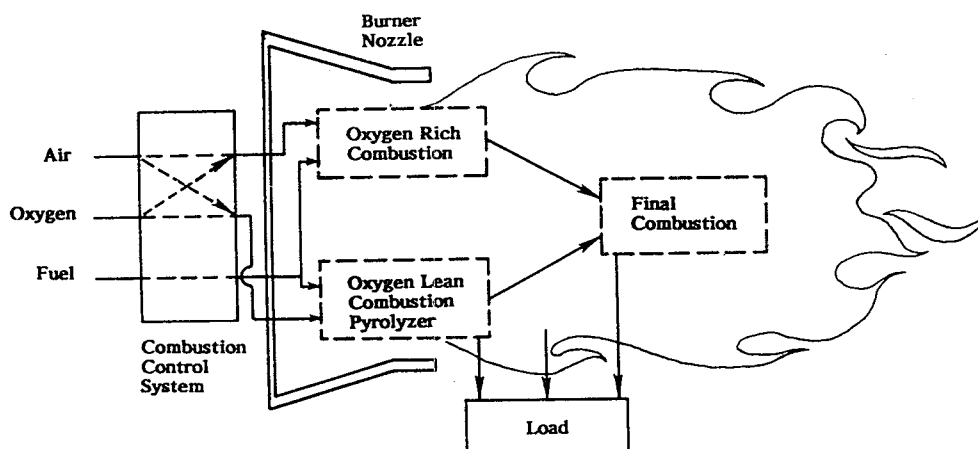


Figure 1. Pyretron combustion and heating process flow diagram.

DEMONSTRATION RESULTS:

Six polynuclear aromatic hydrocarbon compounds were selected as the principal organic hazardous constituents (POHC) for the test program -- naphthalene, acenaphthylene, fluorene, phenanthrene, anthracene, and fluoranthene.

The Pyretron technology achieved greater than 99.99 percent destruction and removal efficiencies (DRE) of all POHCs measured in all test runs performed.

- The Pyretron technology with oxygen enhancement achieved double the waste throughput possible with conventional incineration.
- All particulate emission levels in the scrubber system discharge were significantly below the hazardous waste incinerator performance standard of 180 mg/dscm at 7 percent oxygen.
- Solid residues were contaminant free.
- There were no significant differences in transient carbon monoxide level emissions between air-only incineration and Pyretron oxygen enhanced operation.
- Costs savings can be achieved in many situations.

APPLICATIONS ANALYSIS SUMMARY:

The field evaluations conducted under the SITE Demonstration Program yielded the following conclusions:

- The Pyretron burner system is a viable technology for treating Superfund wastes.
- The system is capable of doubling the capacity of a conventional rotary kiln incinerator. This increase is more significant for wastes with low heating values.
- In situations where particulate carryover causes operational problems, the Pyretron system may increase reliability.
- The technology can be an economical addition to an incinerator when operating and fuel costs are high and oxygen costs are relatively low.

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AMERICAN TOXIC DISPOSAL, INC. (Vapor Extraction System)

TECHNOLOGY DESCRIPTION:

The Vapor Extraction System (VES) uses a low-temperature, fluidized bed to remove organic and volatile inorganic compounds from soils, sediments, and sludges. Contaminated materials are fed into a co-current, fluidized bed, where they are well mixed with hot gas (about 320° F) from a gas-fired heater (Figure 1). Direct contact between the waste material and the hot gas forces water and contaminants from the waste into the gas stream, which flows out of the dryer to a gas treatment system.

The gas treatment system removes dust and organic vapors from the gas stream. A cyclone separator and baghouse remove most of the particulates in the gas stream from the dryer. Vapors from the cyclone separator are cooled in a venturi scrubber, counter-current washer, and chiller section before they are treated in a vapor-phase carbon adsorption system. The

liquid residues from the system are clarified and passed through two activated carbon beds arranged in series. Clarified sludge is centrifuged, and the liquid residue is also passed through the carbon beds.

By-products from the VES treatment include: (1) 96 to 98 percent of solid waste feed as clean, dry dust; (2) a small quantity of pasty sludge containing organics; (3) a small quantity of spent adsorbent carbon; (4) wastewater that may need further treatment; and (5) small quantities of baghouse and cyclone dust.

WASTE APPLICABILITY:

This technology can remove volatile and semivolatile organics, including polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), and pentachlorophenol (PCP), volatile inorganics, and some pesticides

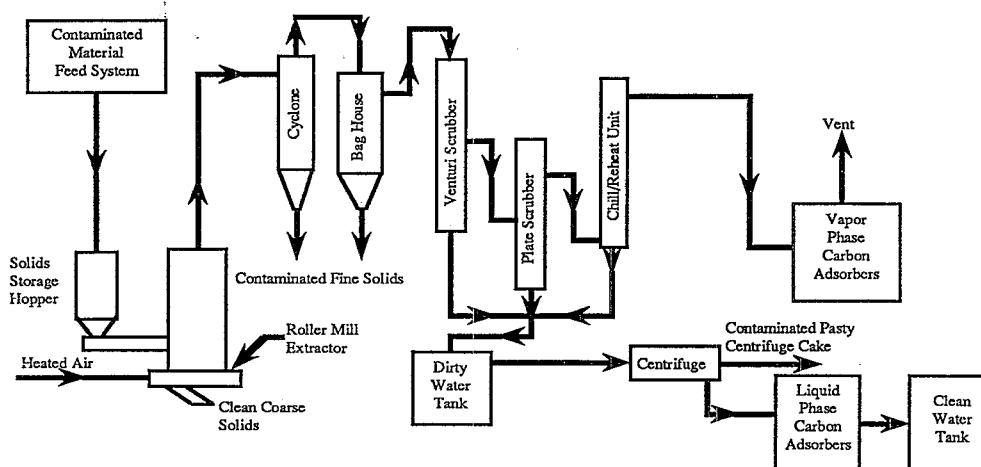


Figure 1. Process flow diagram.

from soil, sludge, and sediment. In general, the process treats waste containing less than 5 percent total organic contaminants and 30 to 90 percent solids. Nonvolatile inorganic contaminants (such as metals) in the waste feed do not inhibit the process, but are not treated.

STATUS:

EPA is currently locating a demonstration site for this process. The wastes preferred for the demonstration are harbor or river sediments containing at least 50 percent solids and contaminated with PCBs and other volatile or semivolatile organics. Sandy soil with these characteristics may also be acceptable. About 320 tons of waste are needed for a one-week test. Major test objectives are to evaluate feed handling, decontamination of solids, and treatment of gases generated by the process.

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AWD TECHNOLOGIES, INC. (Integrated Vapor Extraction and Steam Vacuum Stripping)

TECHNOLOGY DESCRIPTION:

The integrated AquaDetox/SVE system simultaneously treats ground water and soil contaminated with volatile organic compounds (VOCs). The integrated system consists of two basic processes: an AquaDetox moderate vacuum stripping tower that uses low-pressure steam to treat contaminated ground water; and a soil gas vapor extraction/reinjection (SVE) process to treat contaminated soil. The two processes form a closed-loop system that provides simultaneous in-situ remediation of contaminated ground water and soil with no air emissions.

AquaDetox is a high efficiency, countercurrent stripping technology developed by Dow Chemical Company. A single-stage unit will typically reduce up to 99.99 percent of VOCs from water. The SVE system uses a vacuum to treat a VOC-contaminated soil mass, inducing a flow of air through the soil and

removing vapor phase VOCs with the extracted soil gas. The soil gas is then treated by carbon beds and reinjected into the ground to remove additional VOCs. The AquaDetox and SVE system (Figure 1) share a granulated activated carbon (GAC) unit. Noncondensable vapor from the AquaDetox system is combined with the vapor from the SVE compressor and decontaminated by the GAC unit. By-products of the system are a free-phase recyclable product and treated water. Mineral regenerable carbon will require disposal after approximately three years.

A key component of the closed-loop system is a vent header unit designed to collect the noncondensable gases extracted from the ground water or air that may leak into the portion of the process operating below atmospheric pressure. Further, the steam used to regenerate the carbon beds is condensed and treated in the AquaDetox system.

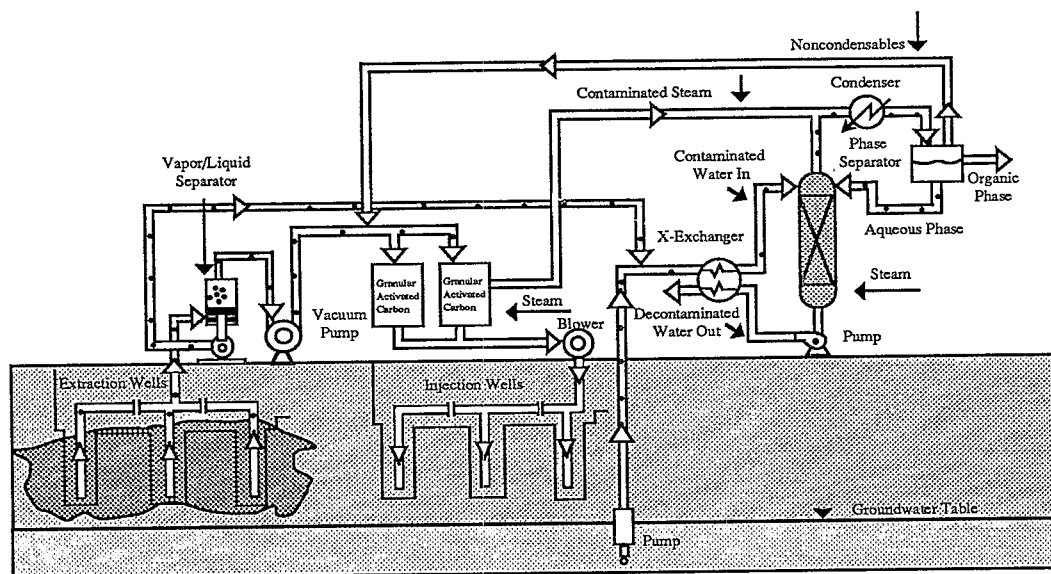


Figure 1. Zero air emissions integrated AquaDetox/SVE system.

WASTE APPLICABILITY:

This technology removes VOCs, including chlorinated hydrocarbons, in ground water and soil. Sites with contaminated ground water and soils containing trichloroethylene (TCE), perchloroethylene (PCE), and other VOCs are suitable for this on-site treatment process. AquaDetox is capable of effectively removing over 90 of the 110 volatile compounds listed in 40 CFR Part 261, Appendix VIII.

STATUS:

The AWD AquaDetox/SVE system is currently being used at the Lockheed Aeronautical Systems Company in Burbank, California. At this site, the system is treating ground water contaminated with as much as 2,200 ppb of TCE and 11,000 ppb PCE; and soil gas with a total VOC concentration of 6,000 ppm. Contaminated ground water is being treated at a rate of up to 1,200 gpm while soil gas is removed and treated at a rate of 300 cfm. The system occupies approximately 4,000 square feet.

A proposed SITE demonstration project will evaluate the ongoing remediation effort at the Lockheed site in Burbank, California. Demonstration testing is scheduled to begin in the first quarter of 1990.

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BIOTROL, INC. (Biological Aqueous Treatment System)

TECHNOLOGY DESCRIPTION:

The Biotrol Aqueous Treatment System, or BATS, is a biological treatment system which is effective for treatment of contaminated groundwater and process water. The system employs an amended microbial consortium, that is, a microbial population indigenous to the wastewater to which a specific microorganism has been added. This system accomplishes removal of both the target contaminants as well as the naturally occurring background organics.

Figure 1 is a schematic of the BATS. Contaminated water enters a mix tank where the pH is adjusted and inorganic nutrients are added. If necessary, the water is heated to

reach an optimum temperature; however, a heat exchanger is used to minimize energy costs. The water then flows to the reactor where the contaminants are biodegraded. The microorganisms which perform the degradation are immobilized in a three cell, submerged, fixed-film bioreactor. Each cell is filled with a highly porous packing material to which the microbes adhere. For aerobic conditions, air is supplied by fine bubble membrane diffusers mounted at the bottom of each cell. The system may also be run under anaerobic conditions. As the water flows through the bioreactor, the contaminants are degraded completely to carbon dioxide, water and chloride ion. The resulting effluent water may be discharged to a Publicly Owned Treatment Works (POTW) or may be reused on site.

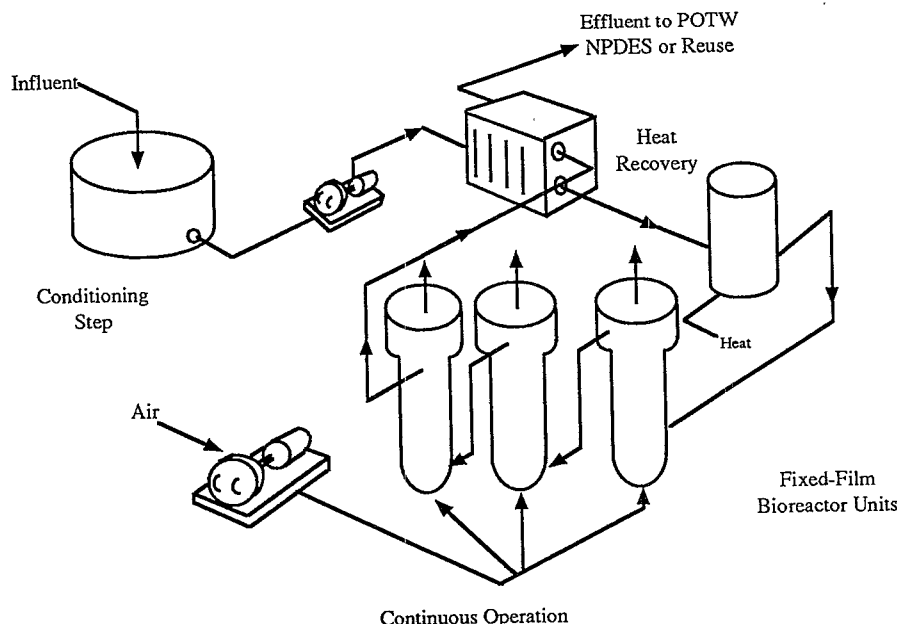


Figure 1. Biotrol aqueous treatment system process diagram.

WASTE APPLICABILITY:

This technology is mainly applicable to aqueous streams contaminated with organic compounds, such as pentachlorophenol and creosote (wood treatment compounds) and other hydrocarbons. The technology can be used to remove certain inorganic compounds (such as nitrates); however, it cannot remove metals.

Other potential target waste streams include chlorinated hydrocarbons, coal tar residues, and organic pesticides. Underground storage tank contaminants, such as fuels and solvents, are being evaluated for applicability.

STATUS:

In 1986, Biotrol, Inc., performed a successful 9-month pilot field test of BATS on ground water at a wood preserving facility. The SITE demonstration of the BATS technology took place from July 24 to September 1, 1989 at the MacGillis and Gibbs Superfund site in New Brighton, Minnesota. The system was operated continuously for 6 weeks on groundwater with different throughput rates.

The Technology Evaluation Report will be available in April 1990.

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BIOTROL, INC. (Soil Washing System)

TECHNOLOGY DESCRIPTION:

Soil washing is a volume reduction method for treating excavated soils and is applicable for soils which are predominantly sand and gravel. It is based on the principle that the contaminants are associated primarily with soil components finer than 200 mesh, including fine silts, clays, and soil organic matter.

The system uses attrition scrubbing to disintegrate or break up soil aggregates resulting in the liberation of the highly contaminated fine particles from the coarser sand and gravel (Figure 1). Furthermore, the surfaces of the coarser particles are scoured by abrasive action.

Volume reduction is achieved by separating the "washed" coarse material from the highly contaminated fine particles, oils, and wash water. The contaminated residual products can then be treated by other methods, including incineration, stabilization, and biodegradation.

Contaminated soil is first excavated and screened to remove oversize debris greater than one-half to one inch in diameter. Various segregation methods can be used to sort debris into categories for treatment and/or disposal. The debris-handling equipment is engineering on a case-by-case basis.

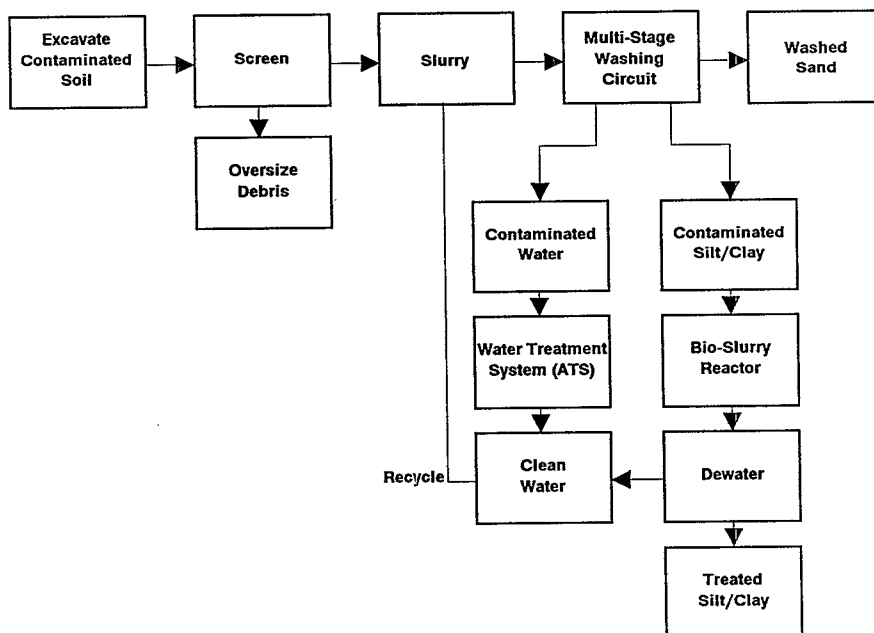


Figure 1. Biotrol soil treatment system process diagram.

Once the debris is removed, the contaminated soil is fed to the soil washing system, where it is slurried with water. It is screened again and fed to froth flotation where hydrophobic components (such as oil and certain clay minerals) are removed in the froth phase. The soil slurry then enters a multi-stage, countercurrent, attrition/classification circuit consisting of attrition scrubbing units, hydrocyclones, and spiral classifiers. The bulk of the soil is then discharged as the washed product.

The process water contains the highly contaminated fine particles as well as dissolved contaminants. The fine solids are dewatered prior to secondary treatment. Where biodegradation is feasible, the thickened fine particle slurry is treated in a low energy reactor consisting of three continuous stirred tanks in series. In the reactor, indigenous microorganisms can be amended with specific bacteria. For pentachlorophenol (PCP) contamination, a *Flavobacterium* species is used.

The clarified process water may also be treated biologically, if applicable, using a fixed-film bioreactor system. Again, indigenous and specific microorganisms are used to degrade dissolved organic contaminants.

WASTE APPLICABILITY:

This technology was initially developed to clean soils contaminated with oil, pentachlorophenol, and creosote (polyaromatic hydrocarbons) from wood-preserving sites. It is also expected to be applicable to soils contaminated with petroleum hydrocarbons and pesticides.

STATUS:

The soil washing system was operated successfully over a 2-year period at a wood treating site in Minnesota. During this time, biological treatment of the process water from soils washing was also successfully demonstrated. In 1989, Biotrol, Inc., added slurry biodegradation technology to treat the fine particle sludge generated by soil washing of soils contaminated by degradable, organic contaminants.

The SITE demonstration of the soil washing technology took place from September 25 to October 27, 1989 at the MacGillis & Gibbs Superfund site in New Brighton, Minnesota. The soil washing system used in the demonstration was a pilot-scale unit with a treatment capacity of 500 to 1,000 pounds per hour.

The soil washing process was operated continuously for two days on a soil contaminated with low levels of PCP (about 300 ppm PCP) and seven days on a high PCP level soil (about 1,000 ppm PCP). All process water from soil washing was treated in a fixed-film bioreactor and recycled back to soil washing. A portion of the fine particle slurry from the high PCP soil washing test was treated in a pilot scale EIMCO Biolift Reactor supplied by EIMCO Process Equipment Company.

The Technology Evaluation Report will be available in May 1990.

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Technology Profile

Demonstration Program



November 1989

CF SYSTEMS CORPORATION (Solvent Extraction)

TECHNOLOGY DESCRIPTION:

This technology uses liquefied gas solvent to extract organics (such as hydrocarbons), oil, and grease from wastewater or contaminated sludges and soils. Carbon dioxide is the gas used for aqueous solutions, while propane and/or butane is used for sediment, sludges and soils (semisolids).

Contaminated solids, slurries or wastewaters are fed into the extractor (Figure 1). Solvent (gas condensed by compression) is also fed to the extractor, making nonreactive contact with the waste. Typically, the solvent separates more than 99 percent of the organics from the feed waste. Following phase separation of the solvent and organics, treated water is removed from the extractor while the mixture of solvent and organics passes to the separator through a valve, where pressure is partially reduced. In the separator, the solvent is vaporized and recycled as fresh solvent. The organics are drawn off from the separator, and either reused or disposed of.

The extractor design is different for contaminated wastewaters and semisolids. For wastewaters, a trayed tower contactor is used. For semisolids, a series of extractor/decanter operating countercurrently is used.

WASTE APPLICABILITY:

This technology can be applied to waste containing carbon tetrachloride, chloroform, benzene, naphthalene, gasoline, vinyl acetate, furfural, butyric acid, higher organic acids, dichloroethane, oils and grease, xylene, toluene, methyl acetate, acetone, higher alcohols, butanol, propanol, phenol, heptane, PCBs and other complex organics.

STATUS:

The pilot-scale system was tested on PCB-laden sediments from the New Bedford (Mass.) Harbor Superfund site during September 1988.

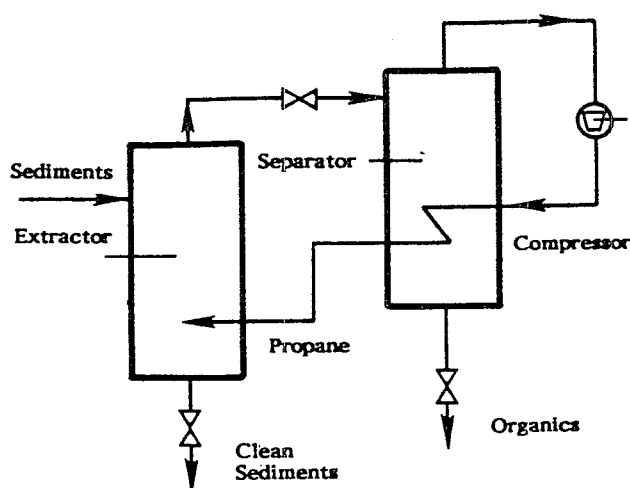


Figure 1. Solvent extraction unit process diagram.

PCB concentrations in the harbor ranged from 300 ppm to 2,500 ppm. The Technology Evaluation report is being published and will be available in November 1989. The Applications Analysis report is scheduled to be released in December 1989.

Commercial systems have been sold to Clean Harbors, Braintree, Massachusetts, for wastewater clean-up; and Ensco of Little Rock, Arkansas, for incinerator pretreatment. A unit is in operation at Star Enterprise, Port Arthur, Texas, treating API separator sludge to meet Best Demonstrated and Available Technology (BDAT) standards for organics.

DEMONSTRATION RESULTS:

This technology was demonstrated concurrently with dredging studies managed by the U.S. Army Corps of Engineers. Contaminated sediments were treated by the CF Systems Pit Cleanup Unit, using a liquified propane and butane mixture as the extraction solvent.

The following test results include the number of passes made during each test and the concentration of PCBs before and after each test:

	<u>Passes</u>	<u>PCB concentration</u>	
		<u>Before</u>	<u>After</u>
Test 2	9	360 ppm	8 ppm
Test 3	3	288 ppm	82 ppm
Test 4	6	2575 ppm	200 ppm

Extraction efficiencies were high, despite some operating difficulties during the tests. The use of treated sediment as feed to the next pass caused cross-contamination in the system. Full scale commercial systems are designed to eliminate problems associated with the pilot plant design.

APPLICATIONS ANALYSIS SUMMARY:

The following conclusions were drawn from this series of tests and other data:

- Extraction efficiencies of 90-98% were achieved on sediments containing between 350 and 2,575 ppm PCBs. PCB concentrations were as low as 8 ppm in the treated sediment.
- In the laboratory, extraction efficiencies of 99.9% have been obtained for volatile and semivolatile organics in aqueous and semi-solid wastes.
- Operating problems included solids being retained in the system hardware and foaming in receiving tanks. The vendor identified corrective measures that will be implemented in the full-scale commercial unit.
- Projected costs for PCB cleanups are estimated at approximately \$150 to \$450 per ton, including material handling and pre- and post-treatment costs. These costs are highly sensitive to the utilization factor and job size, which may result in lower costs for large cleanups.

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Technology Profile

Demonstration Program



November 1989

CHEMFIX TECHNOLOGIES, INC. (Solidification/Stabilization)

TECHNOLOGY DESCRIPTION:

This solidification/stabilization process is an inorganic system in which soluble silicates and silicate setting agents react with polyvalent metal ions, and certain other waste components, to produce a chemically and physically stable solid material. The treated waste matrix displays good stability, a high melting point, and a friable texture. The matrix may be similar to soil or rigid depending upon the water content of the feed waste.

The feed waste is first blended in the reaction vessel (Figure 1) with certain reagents, which are dispersed and dissolved throughout the aqueous phase. The reagents react with polyvalent ions in the waste. Inorganic polymer chains (insoluble metal silicates) form throughout the aqueous phase and physically entrap the organic colloids within the microstructure of the product matrix.

The water-soluble silicates then react with complex ions in the presence of a siliceous setting agent, producing amorphous, colloidal silicates (gels) and silicon dioxide, which acts as a precipitating agent. Most of the heavy metals in the waste become part of the silicate. Some of the heavy metals precipitate with the structure of the complex molecules. A very small percentage (estimated to be less than one percent) of the heavy metals precipitates between the silicates and is not chemically immobilized.

Since some organics may be contained in particles larger than the colloids, all of the waste is pumped through processing equipment, creating sufficient shear to emulsify the organic constituents. Emulsified organics are then solidified and discharged to a prepared area, where the gel continues to set. The resulting solids, though friable, encase any organic substances that may have escaped emulsification.

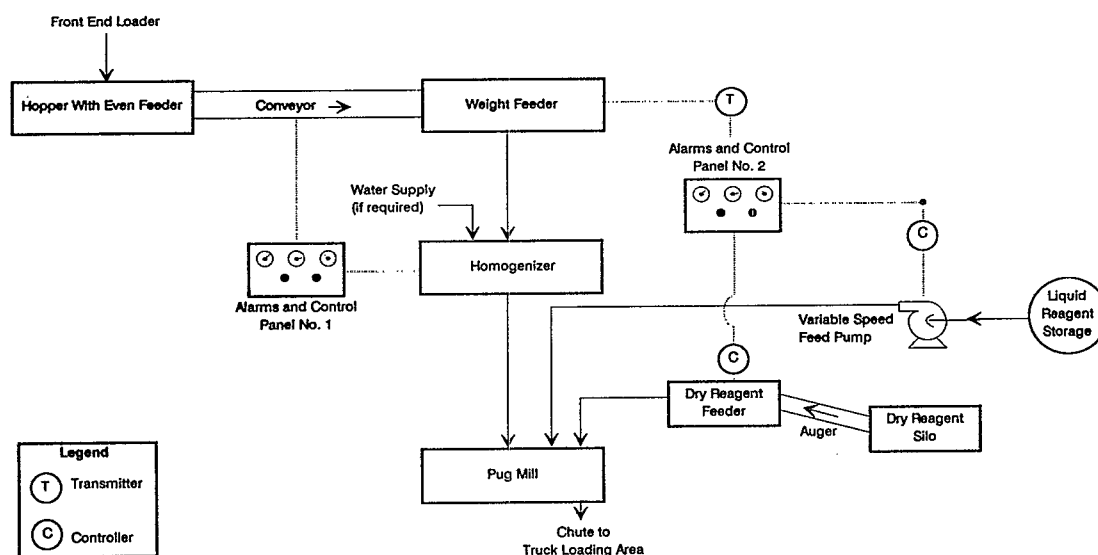


Figure 1. High solids handling system block process flow diagram.

The system can be operated at 5 to 80 percent solids in the waste feed; water is added for drier wastes. Portions of the water contained in the wastes are involved in three reactions after treatment: (1) hydration, similar to that of cement reactions; (2) hydrolysis reactions; and (3) equilibration through evaporation. There are no side streams or discharges from this process. The process is applicable to electroplating wastes, electric arc furnace dust, and municipal sewage sludge containing heavy metals such as aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc.

WASTE APPLICABILITY:

This technology is suitable for contaminated soils, sludges, and other solid wastes. It can also be used for base, neutral, or acid extractable organics of high molecular weight, such as refinery wastes, creosote, and wood-treating wastes.

STATUS:

The technology was demonstrated in March 1989 at the Portable Equipment Salvage Co. site in Clackamas, Oregon. Preliminary results are available in a Demonstration Bulletin (October 1989). A single draft report describing the demonstration and future application of this technology has been completed and is under review. This final demonstration report will be completed in early 1990.

DEMONSTRATION RESULTS:

- The Chemfix Technology was effective in reducing the concentrations of lead and copper in the extracts from the Toxicity Characteristic Leaching Procedure (TCLP). The concentrations in the extracts from the treated wastes were 94 percent to 99 percent less than those from the untreated wastes. Total lead concentrations in the raw waste approached 14 percent.
- The volume increase in the excavated waste material as a result of treatment varied from 20 to 50 percent.

- The results of the tests for durability were very good. The treated wastes showed little or no weight loss after 12 cycles of wetting and drying or freezing and thawing.
- The unconfined compressive strength (UCS) of the wastes varied between 27 and 307 psi after 28 days. Permeability decreased more than one order of magnitude.
- The air monitoring data suggest that there was no significant volatilization of PCBs during the treatment process.

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CHEMICAL WASTE MANAGEMENT (X*TRAX™ LOW-TEMPERATURE THERMAL DESORPTION)

TECHNOLOGY DESCRIPTION:

The X*TRAX™ technology is a low-temperature (500 to 800 ° F) thermal separation process designed to remove organic contaminants from soils, sludges, and other solid media. The pilot-scale system (Figure 1) is mounted on two trailers and has a capacity of 5 tons per day. The first trailer contains a rotary dryer used to heat contaminated materials and drive off water and organic contaminants. The second trailer contains a gas treatment system that condenses and collects the contaminants driven from the soil.

Contaminated material is fed into one end of the rotary dryer (Figure 2). As the dryer rotates, the feed material gradually moves to the other end of the dryer where it is discharged as a powdered or granular dry material. Propane burners supply heat to the outside of the dryer to vaporize water and organic contaminants from the feed material.

The degree of contaminant removal can be controlled by adjusting the feed rate, the dryer temperature, or the residence time of materials in the dryer.

Organic contaminant and water vapors driven from the soil are transported out of the dryer by an inert nitrogen carrier gas. The carrier gas flows through a duct to the gas treatment trailer where organic vapors, water vapors, and dust particles are removed and recovered from the gas. The gas first passes through a high-energy scrubber where it is cooled. Dust particles and approximately 30 percent of the organic contaminants are removed by the scrubber. The gas then passes through two heat exchangers in series where it is cooled further. Most of the remaining organic and water vapors are condensed out as liquids in the heat exchangers.

Most of the carrier gas that passes through the gas treatment trailer is reheated and recycled

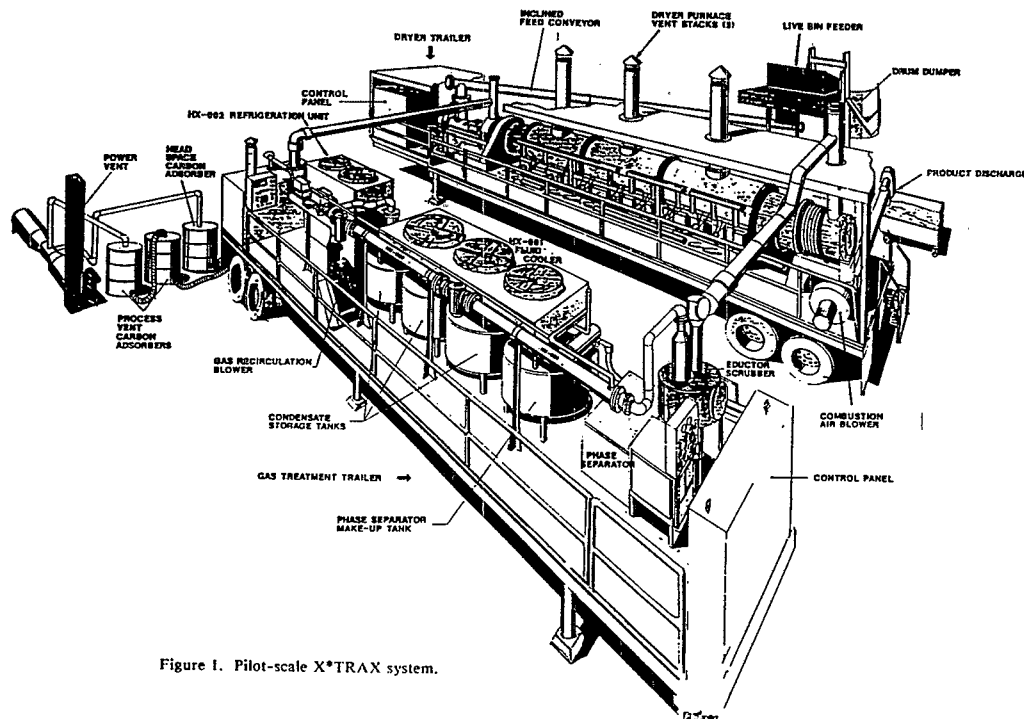


Figure 1. Pilot-scale X*TRAX system.

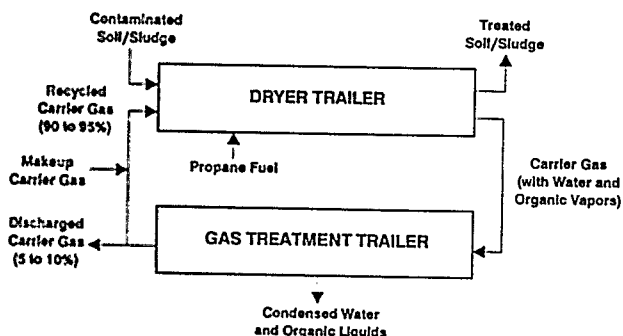


Figure 2. Simplified material flow diagram for X*TRAX process.

to the dryer trailer. Approximately 5 to 10 percent of the gas is cleaned by passing through a filter and two carbon adsorption drums and then discharged to the atmosphere.

This discharge helps maintain a small negative pressure within the system and prevents potentially contaminated gases from leaking out. The discharge also allows makeup nitrogen to be added to the system, preventing oxygen concentrations from exceeding combustibility limits.

WASTE APPLICABILITY:

This technology was developed to treat soils contaminated with polychlorinated biphenyls (PCBs), but can be applied to pond or process sludges and filter cakes contaminated with up to 10 percent PCBs or other organic contaminants. The system is designed to handle either soils or pumpable sludges containing at least 40 percent solids. The process should have little effect on most inorganic contaminants.

Treatment residuals include treated soils, liquids and sludges collected on the gas treatment trailer, and spent carbon. Some residuals can be recycled within the system. Treated soils can be returned to their original location if residual contaminant levels are sufficiently low. Aqueous phase liquids collected in the heat exchangers (after treatment by activated carbon) can be used to add moisture back to the soil prior to disposal. Other residuals, such as organic phase liquids, sludges, and spent carbon, will require further treatment and disposal outside the system.

STATUS:

CWM has conducted tests on both laboratory-scale and pilot-scale systems. The laboratory-scale system is capable of reducing PCB concentrations in soil from approximately 6,000 ppm to less than 2 ppm, removing more than 99 percent of chlorinated organic contaminants in soils. The pilot-scale system was tested on two wastewater treatment sludges in October 1988. Phenol concentrations of 54,000 ppm were reduced by greater than 99 percent under optimum operating conditions.

The pilot-scale system has been operating at CWM's Kettleman Hills, California, hazardous waste facility since July 1989, testing PCB-contaminated soils under a Toxic Substances Control Act (TSCA) Research and Development Permit. Results of some of these tests should be available in late 1989.

EPA plans to conduct the SITE demonstration at the Kettleman Hills facility in 1990. Current plans are to test three soils -- two contaminated with PCBs and one contaminated with other organic chemicals. EPA's primary objective for the demonstration is to evaluate the performance of the system in removing these contaminants from soils. A secondary objective is to determine how contaminants removed from soil are collected in the gas treatment trailer.

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DEHYDRO-TECH CORPORATION (Carver-Greenfield Process for Extraction of Oily Waste)

TECHNOLOGY DESCRIPTION:

The Carver-Greenfield Process® for continuous evaporation is designed to separate materials into their constituent solid, oil (including oil-soluble substances), and water phases. It is intended particularly for oil-soluble hazardous organics that are concentrated in the oil phase. The technology uses a food-grade "carrier oil" to extract the oil-soluble contaminants (Figure 1). Stones and metal present in the feed are separated from the slurry in a fluidization tank. Pretreatment is necessary to achieve particle sizes of less than 1/4-inch.

The carrier oil is mixed with waste sludge or soil and the mixture is placed in the evaporation system to remove any water. A carrier oil with a boiling point of 400° F is typically used. The oil serves to fluidize the mix and maintain a low slurry viscosity to ensure efficient heat transfer, thus allowing virtually 100 percent of the water to evaporate.

Mixing with the carrier oil causes the oil-soluble contaminants to be extracted from the waste. Volatile compounds present in the waste are also stripped out in this step and condensed with the carrier oil or water. After the water is evaporated from the mixture, the resulting dried slurry (no water) is sent to a centrifuging section to remove most of the carrier oil from the solids.

After centrifuging, any residual carrier oil is removed by a process known as "hydroextraction." The carrier oil is recovered by evaporation and steam stripping. The hazardous constituents are removed from the carrier oil by distillation. This stream can be incinerated or reclaimed, as appropriate. In some cases, heavy metals in the solids will be complexed with hydrocarbons and will also be extracted by the carrier oil.

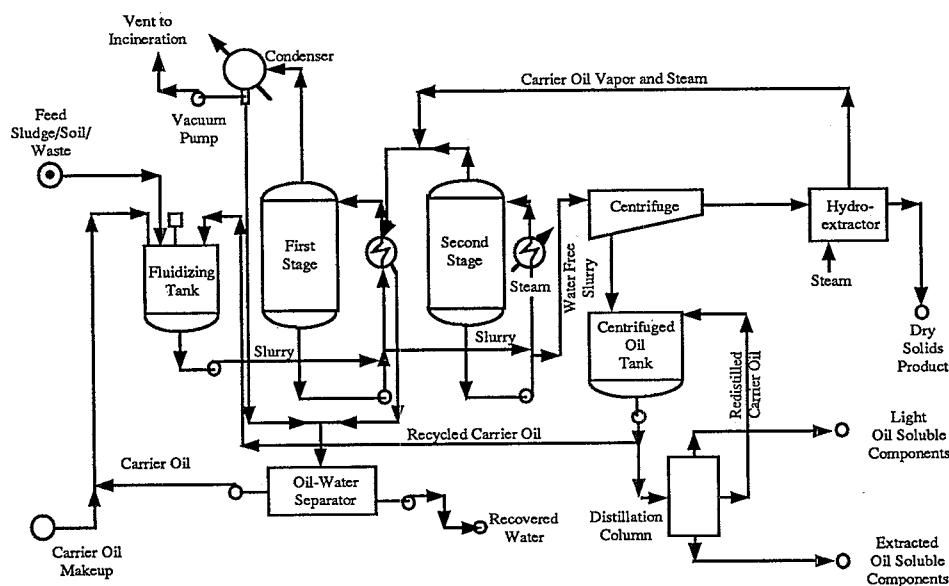


Figure 1. Simplified Carver Greenfield process flow diagram.

WASTE APPLICABILITY:

The Carver-Greenfield process can treat sludges, soils, and other water-bearing wastes containing oil-soluble hazardous compounds, including PCBs and dioxins. The process has been commercially applied to municipal wastewater sludge, paper mill sludge, rendering waste, and pharmaceutical plant sludge.

STATUS:

The process has been successfully tested in a pilot plant on refinery "slop oil," consisting of 72 percent water, as well as on a mixed refinery waste consisting of dissolved air flotation sludge, API separator bottoms, tank bottoms, and biological sludge. EPA is now identifying potential sites for demonstrating this technology.

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Technology Profile

Demonstration Program



November 1989

DETOX, INC. (Submerged Aerobic Fixed-Film Reactor)

TECHNOLOGY DESCRIPTION:

This biological treatment system relies on aerobic microbial processes to metabolize contaminants present in a liquid waste stream. The system can treat liquids containing low concentrations (<20 parts per million, ppm) of readily biodegradable materials and yield concentrations in the low parts per billion (ppb) range.

The biological treatment system consists of an aboveground fixed-film reactor, supplemental nutrient storage tank and pump, sump tank with pump, cartridge filter, and final activated-carbon filter. High surface area plastic media is used to fill the reactor, and the water level within the reactor is set to cover the plastic media. Bacterial growth is attached as film to the surface of the plastic media.

The bioreactor is operated on a one-pass, continuous-flow basis, at hydraulic retention times as low as one hour. The process begins (Figure 1) when contaminated water from a well or equalization tank is pumped into the bioreactor. The influent waste stream is evenly dispersed over the reactor packing by a header-distribution system. As the waste stream passes through the reactor, the biofilm removes the biodegradable organics. An air distribution system below the plastic media supplies oxygen to the bacteria in the form of fine bubbles. An effluent water header system collects water from the bottom of the reactor after it has been treated. Water exiting the reactor is first passed through a cartridge filter, to remove any excess biological solids, followed by activated carbon treatment, to further remove any remaining organic compounds. Depending upon the effluent water discharge criteria, the cartridge and carbon filters may not be needed.

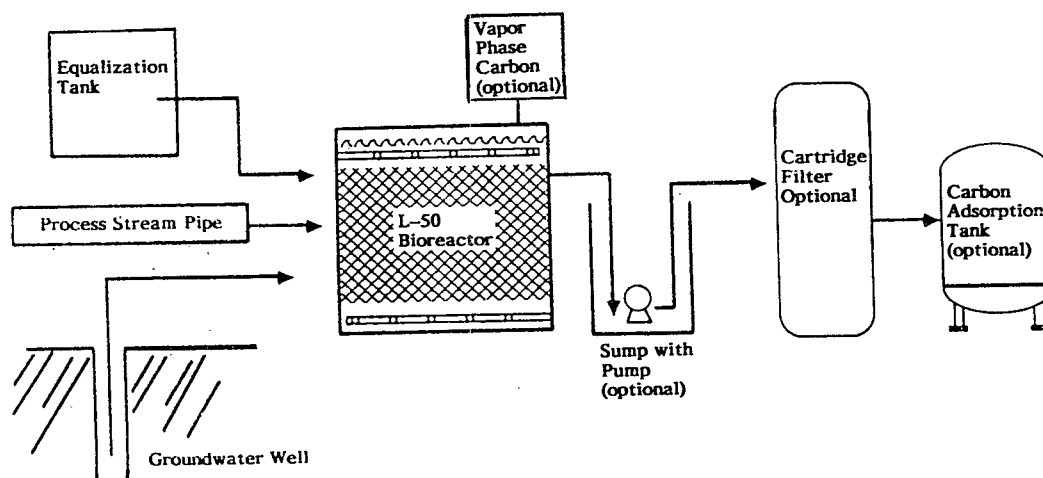


Figure 1. Proposed Detox biological treatment system.

WASTE APPLICABILITY:

This technology is typically used to treat groundwater and industrial process waters, but is also applicable to contaminated lagoon and/or pond waters. The water to be treated must fall within a pH of 6.5 to 8.5, a temperature of 60-95°F, and be free of toxic and/or inhibitory compounds, including certain metals. Readily biodegradable compounds such as methyl ethyl ketone (MEK) and benzene can be treated, along with some organic chemicals that are initially more resistant to biodegradation, such as chlorobenzene. Halogenated compounds (such as tetrachloroethylene, trichloroethylene, and chloroform) are not readily biodegraded and cannot be treated by this system.

STATUS:

Treatability tests are being conducted to determine whether the G&H Landfill NPL site in Utica, Michigan will be suitable for the demonstration of this process. If this site is selected, the demonstration is expected to start in late Spring or Summer 1990.

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E.I. DUPONT DE NEMOURS AND COMPANY OBERLIN FILTER COMPANY (Membrane Microfiltration)

TECHNOLOGY DESCRIPTION:

This microfiltration system is designed to remove solid particles from liquid wastes, forming filter cakes typically ranging from 40 to 60 percent solids. The system can be manufactured as an enclosed unit, requires little or no attention during operation, is mobile, and can be trailer-mounted.

The DuPont/Oberlin microfiltration system (Figure 1) uses Oberlin's automatic pressure filter combined with DuPont's special Tyvek filter material (Tyvek T-980) made of spun-bonded olefin. The filter material is a thin, durable plastic fabric with tiny openings (about one ten-millionth of a meter in diameter) that allow water or other liquids, along with solid particles smaller than the openings, to flow through. Solids in the liquid stream that are too large to pass through the openings accumulate on the filter, and can be easily collected for disposal.

The automatic pressure filter has two chambers -- an upper chamber for feeding waste through the filter, and a lower chamber for collecting the filtered liquid (filtrate). At the start of a filter cycle, the upper chamber is lowered to form a liquid-tight seal against the filter. The waste feed is then pumped into the upper chamber and through the filter. Filtered solids accumulate on the Tyvek surface, forming a filter cake, while filtrate is collected in the lower chamber. Air is fed into the upper chamber at about 45 pounds per square inch, and used to further dry the cake and remove any liquid remaining in the upper chamber. When the cake is considered to be dry, the upper chamber is lifted and the filter cake is automatically discharged. Clean filter material is then drawn from a roll into the system for the next cycle. Both the filter cake and the filtrate can be collected and treated further prior to disposal if necessary.

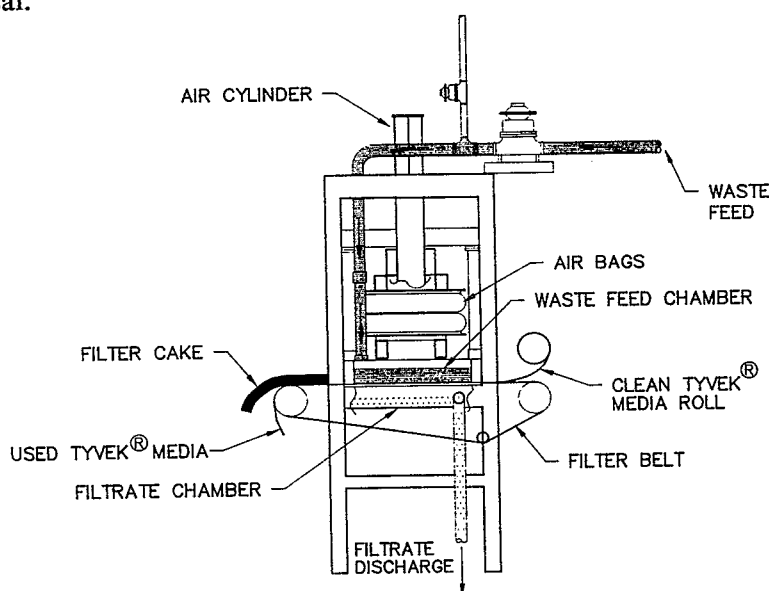


Figure 1. DuPont/Oberlin microfiltration system.

WASTE APPLICABILITY:

This treatment technology is applicable to hazardous waste suspensions, particularly liquid heavy metal- and cyanide-bearing wastes (such as electroplating rinsewaters); groundwater contaminated with heavy metals; landfill leachate; and process wastewaters containing uranium. The technology is best suited for treating wastes with solid concentrations less than 5,000 parts per million; otherwise, the cake capacity and handling become limiting factors. The developers claim the system can treat any type of solids, including inorganics, organics, and oily wastes with a wide variety of particle sizes. Moreover, because the unit is enclosed, the system is said to be capable of treating liquid wastes containing volatile organics.

STATUS:

This technology is proposed to be demonstrated at the Palmerton Zinc Superfund site in Palmerton, Pennsylvania. The shallow aquifer at the site, contaminated with dissolved heavy metals (such as cadmium, lead, and zinc), has been selected as the feed waste for the demonstration. Pilot studies on the ground water have shown that the microfiltration system can produce a 35 to 45 percent-solids filter cake, and a filtrate with non-detectable levels of heavy metals.

A fact sheet on the technology demonstration was prepared and offered for public comment in September 1989. The demonstration is scheduled for January 1990 and is expected to last 3 weeks. Following the demonstration, a technology evaluation report and an applications analysis report will be prepared and made available to the public.

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Technology Profile

Demonstration Program



November 1989

ECOVA CORPORATION (In Situ Biological Treatment)

TECHNOLOGY DESCRIPTION:

This bioremediation technology is designed to biodegrade chlorinated and non-chlorinated organic contaminants by employing aerobic bacteria that use the contaminants as their carbon source. The technology is proposed to be applied in two configurations: in situ biotreatment of soil and water, and on-site bioreactor treatment of contaminated ground water.

A chief advantage of in situ bioremediation is that contaminants in subsurface soils and ground water can be treated without excavating overlying soil. The technology uses special strains of cultured bacteria and microorganisms naturally occurring in on-site soils and ground water. Since the treatment process is aerobic, oxygen and soluble forms of mineral nutrients must be introduced throughout the saturated zone. The end result of the aerobic biodegradation is carbon dioxide, water, and bacterial biomass. Contaminated ground water

can also be recovered and treated in an above ground bioreactor. Nutrients and oxygen can then be added to some or all of the treated water and the water recycled through the soils as part of the in-situ soil treatment.

Because site-specific environments significantly influence biological treatment, all chemical, physical, and microbiological factors are anticipated and designed into the treatment system. Subsurface soil and ground water samples collected from a site are analyzed for baseline parameters, such as volatile organics, metals, pH, and total organic carbon types and quantities of microorganisms and nutrients. A treatability study, which includes flask and column studies, determines the effects of process parameters on system performance. The flask studies test biodegradation under optimum conditions, and the column studies test the three field applications: soil flushing, in situ biotreatment, and in situ biotreatment using ground water treated in a bioreactor.

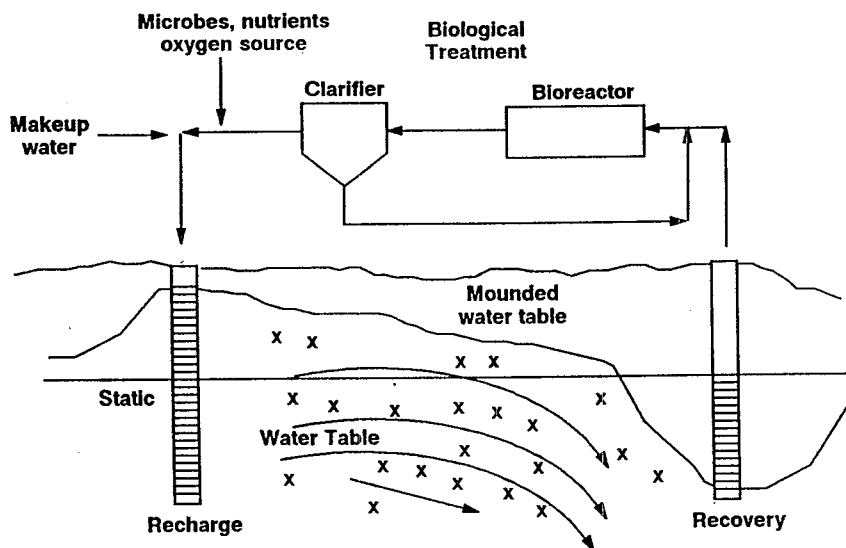


Figure 1. In situ bioreclamation processes.

WASTE APPLICABILITY:

Biological processes can be applied to water, soil, sludge, sediment, and other types of materials contaminated with organic constituents. The system must be engineered to maintain parameters such as pH, temperature, and dissolved oxygen (if the process is aerobic) within ranges conducive to the desired microbial activity. The technology is applicable to chlorinated solvents and non-chlorinated organic compounds.

STATUS:

Ecova will demonstrate this technology on a wide range of toxic organic compounds at the Goose Farm Superfund site in Plumstead Township, New Jersey. Four wells will be installed for the demonstration: an extraction well, a recharge well, and two monitoring wells. The demonstration will consist of pumping water, nutrients, and microorganisms into the saturated zone through the recharge well, and will be collected at the extraction well downgradient of the contaminant plume. The two monitoring wells will be placed between the recharge and the extraction well. The demonstration will continue until at least three pore volumes of water move between the recharge well and the recovery well. Water samples collected from the recovery well, the two monitoring wells, and the bioreactor, will be analyzed to determine changes in compound concentrations.

Quality Assurance, Test, Sampling and Analysis, and Health and Safety Plans have been prepared for the treatability study and the field study is scheduled for Spring 1990. Flask studies are scheduled for November 1989. The treatability study report is scheduled for completion in March 1990.

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Technology Profile

Demonstration Program



November 1989

EPOC WATER, INC. (Leaching and Microfiltration)

TECHNOLOGY DESCRIPTION:

In this process, soils and sludges are decontaminated by leaching and microfiltration. The technology consists of three main steps (Figure 1):

- Chemical leaching to solubilize the metals in the waste;
- Separating the solids in the waste using a specially designed automatic tubular filter press, and washing the waste in situ; and
- Precipitating the metals using a proprietary microfiltration method, and dewatering to a low volume concentrate.

In most situations, leaching can be accomplished using low-cost mineral acids or alkalis. In

special circumstances, chelating agents can also be used to remove a particular metal. The leached slurry containing the solubilized metals is separated by an automatic cake discharge tubular filter press. The resulting filtrate is chemically treated to precipitate the heavy metals in hydroxide form.

Residual organic contamination in this precipitate can be removed with activated carbon. Heavy metals in the precipitate are separated and concentrated by microfiltration, using an innovative and flexible woven textile material that can separate particles as small as 0.1 microns. The process is capable of handling widely varying incoming solids concentrations.

The demonstration unit is transportable and is skid-mounted. The unit is designed to process approximately 30 pounds of solids per hour.

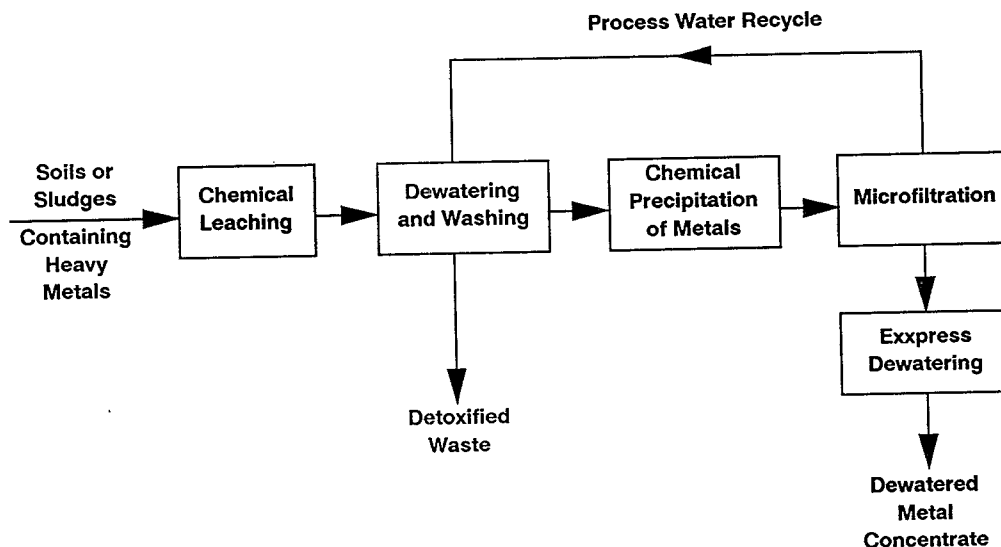


Figure 1. Schematic of detoxification process.

WASTE APPLICABILITY:

This process can be used to decontaminate sludges or soils containing heavy metals, including barium, cadmium, chromium, lead, molybdenum, mercury, nickel, selenium, silver, and zinc. The process is relatively insensitive to metal content, and can process solids with metal concentrations of up to 10,000 mg/kg.

STATUS:

This technology has been accepted into the Demonstration Program in October 1989. This project is currently being initiated.

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Technology Profile

Demonstration Program



November 1989

EXXON CHEMICALS, INC. & RIO LINDA CHEMICAL CO. (Chemical Oxidation/Cyanide Destruction)

TECHNOLOGY DESCRIPTION:

This technology uses chlorine dioxide, generated on-site by a patented process, to oxidize organically contaminated aqueous waste streams, and simple and complex cyanide in water or solid media. Chlorine dioxide is an ideal oxidizing agent because it chemically alters contaminants to salts and non-toxic organic acids.

Chlorine dioxide gas is generated by reacting sodium chlorite solution with chlorine gas, or by reacting sodium chlorite solution with sodium hypochlorite and hydrochloric acid. Both processes produce at least 95 percent pure chlorine dioxide.

In aqueous treatment systems (Figure 1) the chlorine dioxide gas is fed into the waste stream via a venturi, which is the driving force for the

generation system. The amount of chlorine dioxide required depends on the contaminant concentrations in the waste stream and the concentration of oxidizable compounds, such as sulfides.

In soil treatment applications, the chlorine dioxide may be applied in situ via conventional injection wells or surface flushing. The concentration of chlorine dioxide would depend on the level of contaminants in the soil.

Chlorine dioxide treatment systems have been applied to drinking water disinfection, food processing sanitation, and as a biocide in industrial process water. Since chlorine dioxide reacts via direct oxidation rather than substitution (as does chlorine), the process does not form undesirable trihalomethanes.

WASTE APPLICABILITY:

This technology is applicable to aqueous wastes, soils, or any leachable solid media contaminated with organic compounds. It can also be applied to groundwater contaminated with pesticides or cyanide; sludges containing cyanide, PCPs or other organics; and, industrial wastewater similar to refinery wastewater.

STATUS:

The SITE program has accepted two proposals from Exxon Chemicals, Inc. and Rio Linda Chemical Company to perform two separate demonstrations: one of cyanide destruction and the other of organics treatment. Site selection for these demonstrations is currently underway.

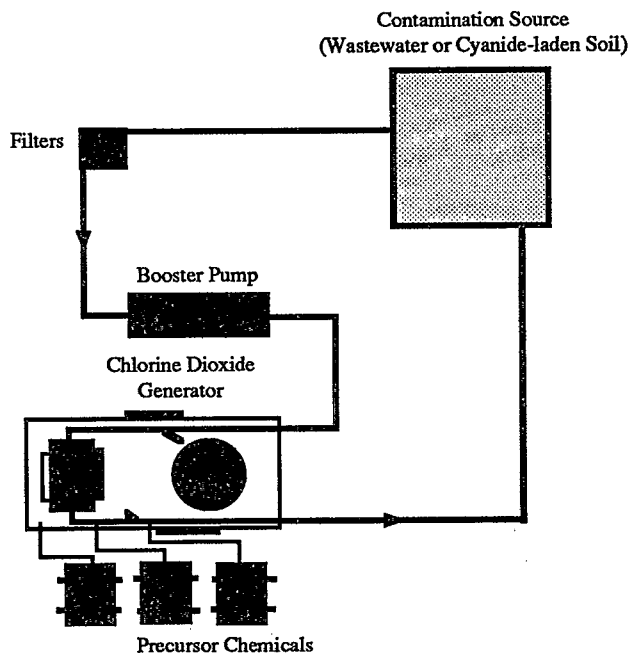


Figure 1. Typical treatment layout.

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FREEZE TECHNOLOGIES CORPORATION (Freezing Separation)

TECHNOLOGY DESCRIPTION:

Freeze crystallization operates on the principal that when water freezes, the crystal structure that forms naturally excludes contaminants from the water molecule matrix. In this freeze crystallization process, refrigerant is injected into the waste and the ice crystals are recovered and washed with pure water to remove any adhering contaminants.

Mixed liquid waste enters the system through the feed heat exchanger, where it is cooled to within a few degrees of its freezing temperature (Figure 1). The cooled waste then enters the freezer, where it is mixed with boiling refrigerant. Water is crystallized in the stirred solution, and is maintained at a uniform ice concentration by continuous removal of liquid and ice slurry. The slurry is pumped to an eutectic separator where ice and contaminant crystals are separated by gravity. In the separator is a zone where ice crystals grow in size to better accommodate subsequent washings.

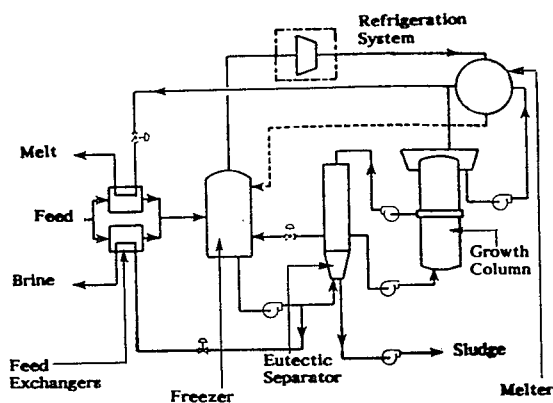


Figure 1. Process schematic.

Ice slurry from the eutectic separator is pumped to the wash column where it forms a porous pack. The slurry liquid is removed from the column via screened openings, and is then either returned to the eutectic separator or is removed from the system for recycling or disposal. Hydraulic forces generated by the flow of liquid to the screens in the middle of the ice pack propel the ice pack upward in the column. Ice is washed with melt water and scraped from the top of the pack into a reslurry chamber in the wash column. Melted product is used to transport the ice to a shell and tube heat exchanger, where the slurry is heated on the tube side and hot refrigerant gas is condensed on the shell side.

In most applications, more heat is generated by melting the ice in the refrigeration system than can be used. This leaves some uncondensed refrigeration vapor that must be further compressed and condensed by cooling water in a heat reinjection system.

All refrigerants are soluble in water to some degree. Strippers are used to remove this refrigerant from the purified water, the concentrated liquid, and any other liquid phases produced from the process. The strippers operate under vacuum and contain heaters that generate low-pressure steam to enhance refrigerant removal, if necessary. Excess generating capacity is built into the melt stripper for rapid melt-out of vessels and lines to allow maintenance or other access.

WASTE APPLICABILITY:

This technology will remove both organic and inorganic as well as ionic and non-ionic species from contaminated aqueous streams. It works on both surface waters and ground waters as well as directly on process wastes and mixed (radioactive and hazardous) wastes. Figure 2 graphically depicts the applicability of the technology as related to other technologies. As shown, freeze technologies can process all of the contaminant types in a single stage. It is also capable of concentrating residuals to higher concentrations than other liquid separation processes.

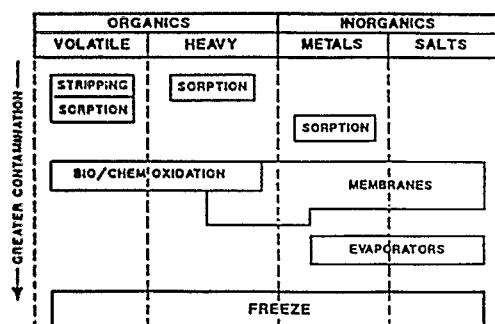


Figure 2. Water molecule matrix.

The process is applicable to free liquids, whether the liquid is water or an organic solvent. It can also be used in conjunction with other processes to treat other media. For example, contaminated soils can be washed to transfer the contaminant into a liquid medium. The low concentrations in the washing medium are concentrated by freezing to allow by-product recovery or more economical final destruction.

STATUS:

This project was accepted into the SITE Demonstration Program in July 1988. Treatability studies have been completed. A demonstration of the technology is scheduled for late November or early December 1989 at the Stringfellow Superfund Site in Glen Avon, California.

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GEOSAFE CORPORATION (In Situ Vitrification)

TECHNOLOGY DESCRIPTION:

In-situ vitrification (ISV) uses an electrical network to melt soil or sludge at temperatures, of 1600 to 2000° C, thus destroying organic pollutants by pyrolysis. Inorganic pollutants are immobilized within the vitrified mass, which has properties of glass. Both the organic and inorganic airborne pyrolysis byproducts are captured in a hood, which draws the contaminants into an off-gas treatment system that removes particulates and other pollutants of concern.

The vitrification process (Figure 1) begins by inserting large electrodes into contaminated zones containing sufficient soil to support the formation of a melt. An array (usually square) of four electrodes is placed to the desired treatment depth in the volume to be treated. Because soil typically has low conductivity, flaked graphite and glass frit are placed on the soil surface between the electrodes to provide a starter path for electric current. The electric current passes through the electrodes and begins to melt soil at the surface. As power is applied, the melt continues to grow downward.

The melt advances at a rate of 1 to 2 inches per hour. Individual settings (each single placement of electrodes) may grow to encompass a total melt mass of 1000 tons and a maximum width of 30 feet. Single setting depths as great as 30 feet are considered possible with the existing large-scale ISV equipment. Adjacent settings are positioned to fuse to each other and to completely process the desired volume at a site. Stacked settings for deep contamination are also possible.

The large-scale ISV system melts soil at a rate of 4 to 6 tons per hour. Since the void volume present in particulate materials (20-40% for typical soils) is removed during processing, a corresponding volume reduction occurs. Volume is further reduced as some of the materials present in the soil (such as humus, organic contaminants are removed as gases and vapors during processing. Upon cooling, a vitrified monolith results, with a silicate glass and microcrystalline structure. This monolith possesses excellent structural and environmental properties.

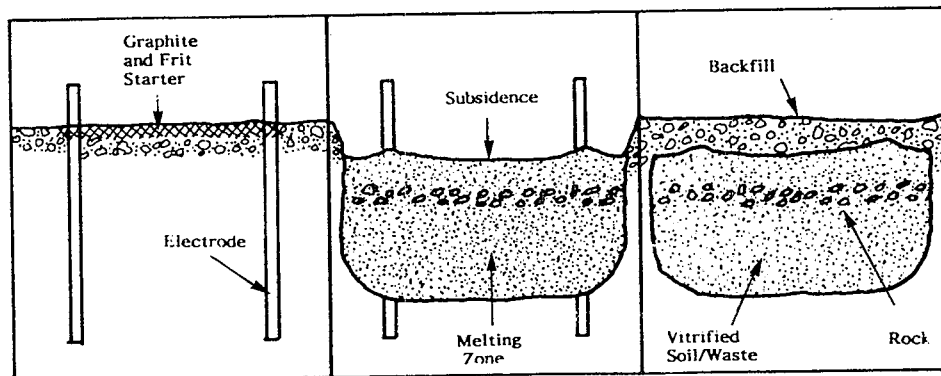


Figure 1. In-situ vitrification process.

The ISV system is mounted on three semi-trailers for transport to a site. Electric power is usually taken from a utility distribution system at transmission voltages of 12,500 or 13,800 volts; power may also be generated on-site by a diesel generator. The electrical supply system has an isolated ground circuit to provide appropriate operational safety.

Air flow through the hood is controlled to maintain a negative pressure (0.5 to 1.0 inches of water). An ample supply of air provides excess oxygen for combustion of any pyrolysis products and organic vapors from the treatment volume. The off-gases, combustion products, and air are drawn from the hood (by induced draft blower) into the off-gas treatment system, where they are treated by: (1) quenching, (2) pH controlled scrubbing, (3) dewatering (mist elimination), (4) heating (for dewpoint control), (5) particulate filtration, and (6) activated carbon adsorption.

WASTE APPLICABILITY:

The ISV process can be used to destroy or remove organics and/or immobilize inorganics in contaminated soils or sludges. On saturated soils or sludges, the initial application of the electric current must reduce the moisture content before the vitrification process can begin. This increases energy consumption and associated costs. Also, sludges must contain a sufficient amount of glass-forming material (non-volatile, nondestructible solids) to produce a molten mass that will destroy or remove organic and immobilize inorganic pollutants. The ISV process is limited by: (1) individual void volumes in excess of 150 cubic feet; (2) buried metals in excess of 5 percent of the melt weight or continuous metal occupying 90 percent of the distance between two electrodes; (3) rubble in excess of 10 percent by weight; and (4) the amount and concentration of combustible organics in the soil or sludge. These limitations must be addressed for each site.

STATUS:

The ISV process has been demonstrated at field-scale on radioactive wastes at the Department of Energy's Hanford Nuclear Reservation. Pilot-scale tests have been performed on PCB wastes, industrial lime sludge, dioxins, metal plating wastes and other solid combustibles and liquid chemicals. The process of choosing a site to demonstrate this technology is currently underway.

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Technology Profile

Demonstration Program



November 1989

HAZCON, INC. (Solidification/Stabilization)

TECHNOLOGY DESCRIPTION:

This treatment technology immobilizes contaminants in soils by binding them into a concrete-like, leach-resistant mass. The technology mixes hazardous wastes, cement, water, and an additive called Chloranan that encapsulates organic molecules.

Contaminated soil is excavated, screened for oversized material, and fed to a mobile field blending unit (Figure 1). The unit consists of soil and cement holding bins, a Chloranan feed tank, and a blending auger to mix the waste and pozzolanic materials (Portland cement, fly ash, or kiln dust). Water is added as necessary, and the resultant slurry is allowed to harden before disposal. The treated output is a hardened, concrete-like mass that immobilizes the contaminants. For large volumes of waste, larger blending systems are available.

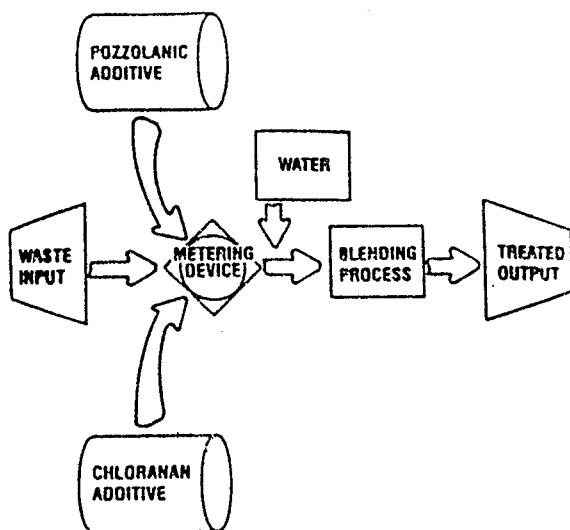


Figure 1. Solidification/stabilization process diagram.

WASTE APPLICABILITY:

This technology is suitable for soils and sludges contaminated with organic compounds, heavy metals, oil and grease.

STATUS:

The technology was demonstrated in October 1987 at a former oil reprocessing plant in Douglassville, Pennsylvania. The site contained high levels of oil and grease, volatile and semivolatile organics, PCBs, and heavy metals. A Technology Evaluation Report (September 1988) and Application Analysis Report (May 1990) describing the completed demonstration are available. A report on long-term monitoring will be completed by early 1990.

DEMONSTRATION RESULTS:

The comparison of the soil 7-day, 28-day, 9 month, and 22-month sample test results are generally favorable. The physical test results were very good, with unconfined compressive strength between 220 to 1570 psi. Very low permeabilities were recorded, and the porosity of the treated wastes was moderate. Durability test results showed no change in physical strength after the wet/dry and freeze/thaw cycles. The waste volume increased by about 120%. By using less stabilizer, it is possible to reduce volume increases, but lower strengths will result. There is an inverse relationship between physical strength and the waste organic concentration.

The results of the leaching tests were mixed. The TCLP results of the stabilized wastes were very low; essentially all values of metals, volatile organics and semivolatile organics were below 1 ppm. Lead leachate concentrations dropped by a factor of 200 to below 100 ppb.

Volatile and semivolatile organic concentrations, however, did not change from the untreated soil TCLP. Oil and grease concentrations were greater in the treated waste TCLPs than in the untreated waste, from less than 2 ppm up to 4 ppm.

APPLICATIONS ANALYSIS SUMMARY:

- The process can solidify contaminated material with high concentrations (up to 25%) of organics. However, organic contaminants, including volatiles and base/neutral extractables, were not immobilized to any significant extent.
- Heavy metals are immobilized. In many instances, leachate reductions were greater than 100 fold.
- The physical properties of the treated waste exhibit high unconfined compressive strengths, low permeabilities, and good weathering properties.
- Treated soils undergo volumetric increases.
- The process is economical, with costs expected to range between approximately \$90 and \$120 per ton.

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Technology Profile

Demonstration Program



November 1989

HORSEHEAD RESOURCE DEVELOPMENT CO., INC. (Flame Reactor)

TECHNOLOGY DESCRIPTION:

The Flame Reactor process (Figure 1) is a patented, hydrocarbon-fueled, flash smelting system that treats residues and wastes containing metals. The reactor processes wastes with a very hot (greater than 2000° C) reducing gas produced from the combustion of solid or gaseous hydrocarbon fuels in oxygen-enriched air. In a compact, low-capital cost reactor, the feed materials react rapidly, allowing a high waste throughput. The end products are a non-leachable slag (a glasslike solid when cooled) and a recyclable, heavy metal-enriched oxide. The volume reduction achieved (of waste to slag) depends on the chemical and physical properties of the waste.

The Flame Reactor technology can be applied to granular solids, soil, flue dusts, slags, and sludges containing heavy metals. The volatile metals are fumed and captured in a product dust collection system, the nonvolatile metals

are encapsulated in the slag. At the elevated temperature of the Flame Reactor technology, organic compounds should be destroyed. In general, the process requires that wet agglomerated wastes be dry enough (up to 15% total moisture) to be gravity-fed and fine enough (less than 200 mesh) to react rapidly. Larger particles (up to 20 mesh) can be processed, however, a decrease in the efficiency of metals recovery usually results.

WASTE APPLICABILITY:

Electric arc furnace dust, lead blast furnace slag, iron residues, zinc plant leach residues and purification residues, and brass mill dusts and fumes have been successfully tested. Metal bearing wastes previously treated contained zinc (up to 40%), lead (up to 10%), cadmium (up to 3%), chromium (up to 3%), as well as copper, cobalt, nickel and arsenic.

STATUS:

The Flame Reactor demonstration plant at Monaca, Pennsylvania, has a capacity of 1.5 to 3.0 tons/hour. The SITE demonstration will probably be conducted at the Monaca facility under a RCRA RD&D permit (pending) that will allow the treatment of Superfund wastes containing high concentrations of metals, but only negligible concentrations of organics. The major objectives of the SITE technology demonstration are to evaluate: (1) the levels of contaminants in the residual slag and their leaching potential; (2) the efficiency and economics of processing; and (3) the reuse potential for the recovered metal oxides. Approximately 120 tons of contaminated materials are needed for the test. The most likely candidate wastes include mine tailings or smelting waste such as slag, flue dust, and wastewater treatment sludges. Pretreatment may be required to produce a dryer feed and to reduce the particle size.

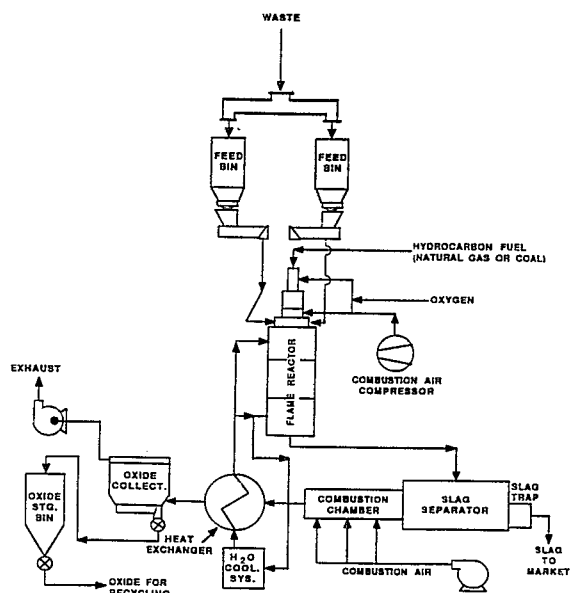


Figure 1. Horsehead Resource Development Company flame reactor process flow schematic.

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INTERNATIONAL WASTE TECHNOLOGIES/GEO-CON, INC.
(In Situ Solidification/Stabilization Process)

TECHNOLOGY DESCRIPTION:

This in situ solidification/stabilization technology immobilizes organic and inorganic compounds in wet or dry soils, using reagents (additives) to produce a cement-like mass. The basic components of this technology are: (1) Geo-Con's deep soil mixing system (DSM), a system to deliver and mix the chemicals with the soil in situ, and (2) a batch mixing plant to supply the International Waste Technologies' (IWT) proprietary treatment chemicals (Figure 1).

The proprietary additives generate a complex, crystalline, connective network of inorganic polymers. The structural bonding in the polymers is mainly covalent. The process involves a two-phased reaction in which the contaminants are first complexed in a fast-acting reaction, and then in a slow-acting reaction, where the building of macromolecules continues over a long period of time. For each type of waste, the amount of additives used varies and must be determined.

The DSM system involves mechanical mixing and injection. The system consists of one set

of cutting blades and two sets of mixing blades attached to a vertical drive auger, which rotates at approximately 15 rpm. Two conduits in the auger are used to inject the additive slurry and supplemental water. Additive injection occurs on the downstroke; further mixing takes place upon auger withdrawal. The treated soil columns are 36 inches in diameter, and are positioned in an overlapping pattern of alternating primary and secondary soil columns.

WASTE APPLICABILITY:

The IWT technology can be applied to soils, sediments, and sludge-pond bottoms contaminated with organic compounds and metals. The technology has been laboratory-tested on soils containing PCBs, pentachlorophenol, refinery wastes, and chlorinated and nitrated hydrocarbons.

The DSM system can be used in almost any soil type; however, mixing time increases with fines. It can be used below the water table and in soft rock formations. Large obstructions must be avoided.

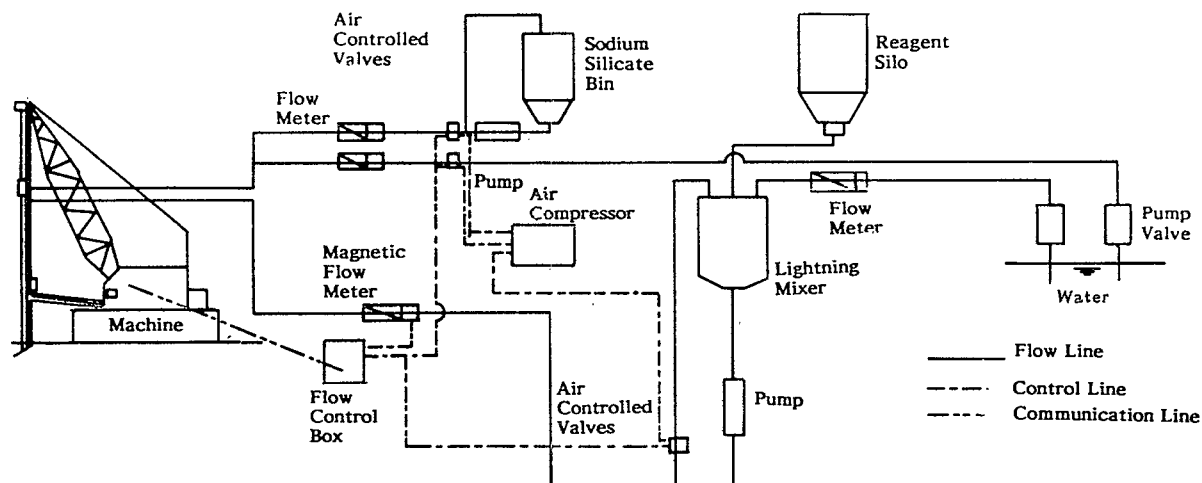


Figure 1. In-situ stabilization batch mixing plant process diagram.

STATUS:

The Site Program demonstration took place at a PCB-contaminated site in Hialeah, Florida, in April 1988. Two 10 x 20-foot test sectors of the site were treated -- one to a depth of 18 feet, and the other to a depth of 14 feet. Ten months after the demonstration, long-term monitoring tests were performed on the treated sectors. The Technology Evaluation Report is available. The Applications Analysis Report and long-term monitoring results are scheduled to be published in January 1990.

DEMONSTRATION RESULTS:

- Based on TCLP leachate analysis, the process appears to immobilize PCBs. However, because PCBs did not leach from most of the untreated soil samples, the immobilization of PCBs in the treated soil could not be confirmed.
- Sufficient data were not available to evaluate the performance of the system with regard to metals or other organic compounds.
- The bulk density of the soil increased 21% after treatment. This increased the volume of treated soil by 8.5% and caused a small ground rise of one inch per treated foot of soil.
- The unconfined compressive strength (UCS) of treated soil was satisfactory, with values from 300 to 500 psi.
- The permeability of the treated soil was satisfactory, decreasing four orders of magnitude compared to the untreated soil, or 10^{-6} and 10^{-7} compared to 10^{-2} cm/sec.
- The wet/dry weathering test on treated soil was satisfactory. The freeze/dry weathering test of treated soil was unsatisfactory.
- The microstructural analysis, scanning electron microscopy (SEM), optical microscopy, and x-ray diffraction (XRD), showed that the treated material was dense, non-porous, and homogeneously mixed.
- The Geo-Con DSM equipment operated reliably.

APPLICATIONS ANALYSIS SUMMARY:

This technology was demonstrated at a site composed primarily of unconsolidated sand and limestone. The following conclusions were reached:

- Microstructural analyses of the treated soils indicated a potential for long-term durability. High unconfined compressive strengths and low permeabilities were recorded.
- Data provided by IWT indicate some immobilization of volatile and semivolatile organics. However, this may be due to organophilic clays present in the IWT reagent. There are insufficient data to confirm this immobilization.
- Performance data are limited outside of SITE demonstrations. The developer modifies the binding agent for different wastes. Treatability studies should be performed for specific wastes.
- The process is economic: \$194 per ton for the 1-auger machine used in the demonstration; \$110 per ton for a commercial 4-auger operation.

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MOTEC, INC. (Liquid/Solid Contact Digestion)

TECHNOLOGY DESCRIPTION:

This process utilizes liquid-solid contact digestion (LSCD) technology to biologically degrade organic wastes. Organic materials and water are placed in a high energy environment. The organic constituents are then biodegraded by acclimated microorganisms.

The system consists of two or three portable tank digesters or lagoons (Figure 1): (1) a primary contact or mixing tank, (2) a primary digestion tank, and (3) a polishing tank. Treatment time may be one month or more, depending on the type of contaminants, their concentrations, and the temperature in the tanks.

In the primary contact tank, water is mixed with influent sludge or soil containing from 2,000 to 800,000 ppm total organic carbon. The mixing process is designed to achieve a 20 to 25 percent solids concentration. Water is obtained either from the contaminated source or a fresh water source. Emulsifying chemicals

are also added, and pH is adjusted to increase the solubility of the organic phase.

After water is added, the batch mixture is transferred to the primary digestion tanks, where pH is adjusted, acclimated seed bacteria are added, and aerobic biological oxidation is initiated. Most of the biological oxidation occurs during this phase. When the biodegradable organic concentration is reduced to a level between 50 and 100 ppm, the batch mixture is transferred to the polishing cell for final treatment.

Once the pH has been readjusted in the polishing cell, co-metabolites and nutrients are added to maintain and enhance the biomass. In this phase, organic constituents are degraded to target concentration levels. Because the system runs on a negative water balance, water is added throughout the process. Once target levels are reached, the supernatant from the polishing tank is recycled to the primary contact tank, and biological sludge is treated in land farms or reactors on-site.

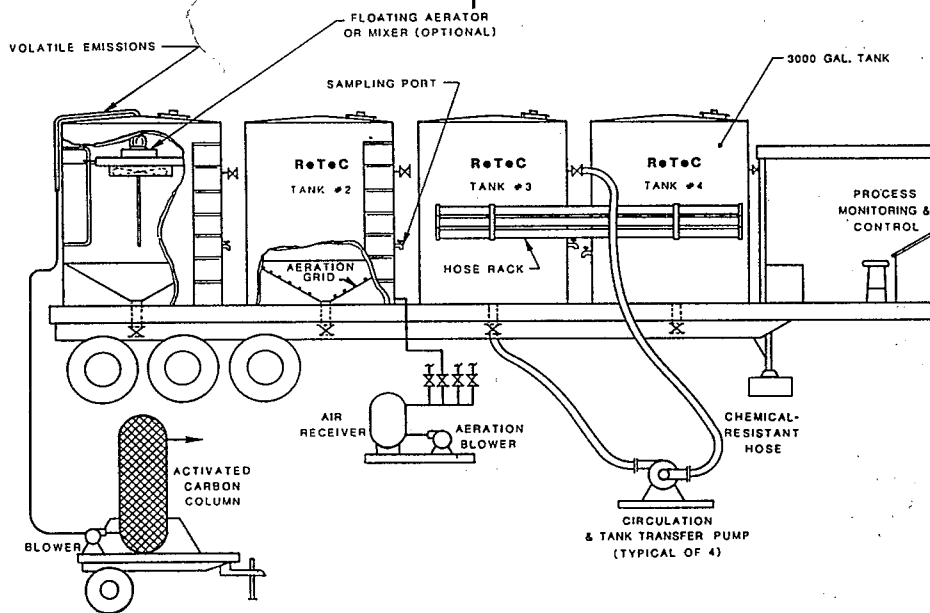


Figure 1. Mobile pilot-scale liquid solids contact treatment system.

WASTE APPLICABILITY:

The technology is suitable for treating halogenated and nonhalogenated organic compounds, and some pesticides and herbicides. LSCD has been demonstrated on liquids, sludges, and soils with high organic concentrations.

STATUS:

A demonstration project is proposed for testing this technology by processing 50 to 100 cubic yards of contaminated soil over a 3-month period. The soil will be from a wood-preserving facility. The demonstration is planned for April 1990.

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OGDEN ENVIRONMENTAL SERVICES (Circulating Fluidized Bed Combustor)

TECHNOLOGY DESCRIPTION:

The Circulating Bed Combustor (CBC) uses high velocity air to entrain circulating solids and create a highly turbulent combustion zone for the efficient destruction of toxic hydrocarbons. The commercial-size combustion chamber (36 inches in diameter) can treat up to 100 tons of contaminated soil daily, depending on the heating value of the feed material.

The CBC technology operates at relatively low temperatures (approximately 1600° F), thus reducing operation costs. The high turbulence produces a uniform temperature around the combustion chamber, hot cyclone, and return leg. It also promotes the complete mixing of the waste material during combustion. The effective mixing and relatively low combustion temperature also reduces emissions of carbon monoxide and nitrogen oxides.

As shown on Figure 1, waste material and limestone are fed into the combustion chamber along with the recirculating bed material from the hot cyclone. The limestone neutralizes acid gases. The treated ash is transported out of the system by an ash conveyor for proper disposal.

Hot gases produced during combustion pass through a convective gas cooler and baghouse before being released to the atmosphere. Ogden states that the CBC technology can attain a destruction and removal efficiency (DRE) of 99.99% for hazardous waste and 99.9999% for PCB waste.

WASTE APPLICABILITY:

The CBC technology may be applicable to soils, slurries, and sludges contaminated with halogenated and nonhalogenated hydrocarbons. The CBC technology was recently applied at two site remediation projects for treating soils contaminated with PCBs and fuel oil.

STATUS:

The CBC technology, is one of seven nationwide incinerators permitted to burn PCBs. It will be demonstrated at the McColl Superfund site in early 1990. A preliminary test burn/treatability study of McColl waste was conducted in early 1989, and a demonstration plan is being developed.

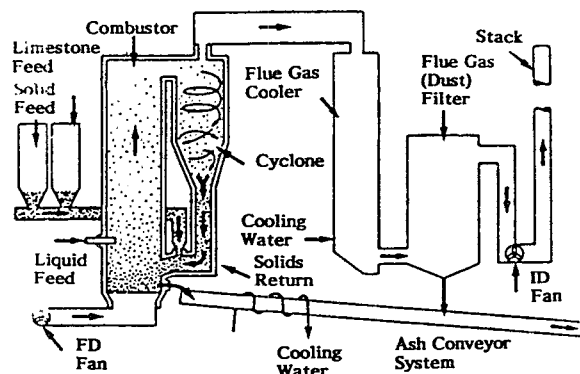


Figure 1. CBC process diagram.

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The treatment system is also equipped with a carbon filter to treat the off-gas from the reactor. The carbon filters are biologically activated to regenerate the spent carbon in-situ.

System capacities range from one cubic foot of solids per hour, with a water flow rate of one gallon per minute; to 27 cubic yards of solids per hour, with a water flow rate of 50 gallons per minute. The treatment units available for the demonstration can treat 1 to 5 cubic yards of solids per hour.

WASTE APPLICABILITY:

This technology can be applied to soils, solids, sludges, leachates and ground water containing organics such as PCB, PCP, pesticides and herbicides, dioxins, and inorganics such as cyanides. The total contaminant concentrations could range from 1 ppm to 20,000 ppm for the technology to be effective. Soils and solids greater than 1-inch in diameter need to be crushed prior to treatment.

STATUS:

Site selection to demonstrate this technology is underway.

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QUAD ENVIRONMENTAL TECHNOLOGIES CORPORATION (Chemtact™ Gaseous Waste Treatment)

TECHNOLOGY DESCRIPTION:

The Chemtact™ system uses gas scrubber technology to remove gaseous organic and inorganic contaminants through efficient gas-liquid contacting. Droplets of a controlled chemical solution are dispersed by atomizing nozzles within the scrubber chamber. Very small droplet sizes (less than 10 microns), along with a longer retention time than traditional scrubbers results in a once-through system that generates low volumes of liquid residuals. These residuals are then treated subsequently by conventional techniques.

Gas scrubbing is a volume reduction technology that transfers contaminants from the gas phase to a liquid phase. The selection of absorbent liquid is based on the chemical characteristics of the contaminants.

Two mobile pilot units are currently available: a two-stage, 800 cubic feet per minute (cfm) system; and a one-stage, 2,500 cfm system. This equipment is trailer-mounted, and can be transported to waste sites.

WASTE APPLICABILITY:

This technology can be used on gaseous waste streams containing a wide variety of organic or inorganic contaminants, but is best suited for volatile organic compounds. The system is applicable for use with source processes that generate a contaminated gaseous exhaust, such as air stripping of groundwater or leachate, soil aeration, or exhausts from driers or incinerators.

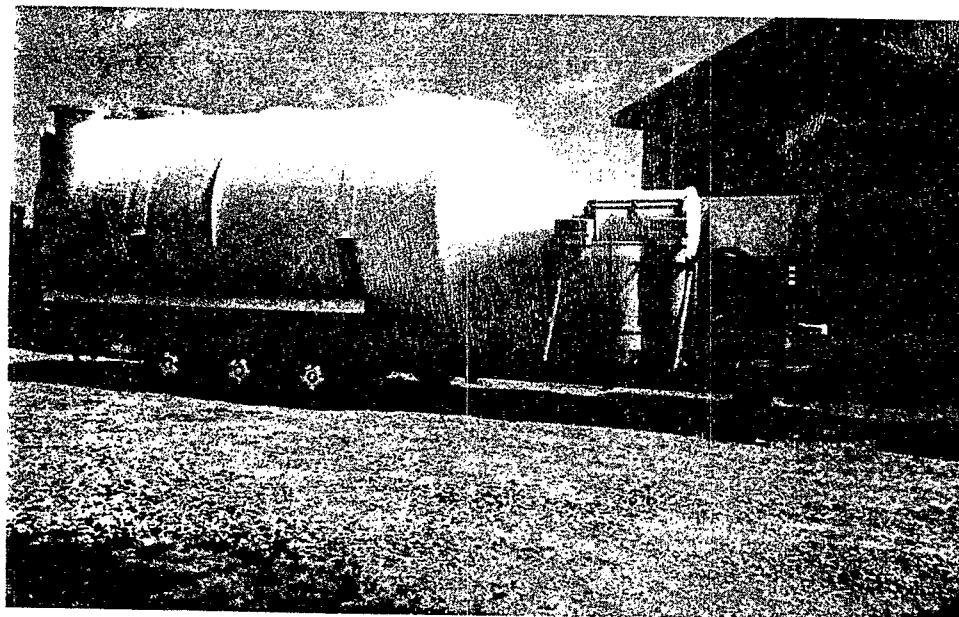


Figure 1. Mobile 2,500 CFM pilot scrubbing unit.

STATUS:

EPA is locating a suitable site to demonstrate this technology.

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RESOURCES CONSERVATION COMPANY (Solvent Extraction)

TECHNOLOGY DESCRIPTION:

Solvent extraction is potentially effective in treating oily sludges and soils contaminated with hydrocarbons by separating the sludges into three fractions: oil, water, and solids. As the fractions separate, contaminants are partitioned into specific phases. For example, PCBs are concentrated in the oil fraction, while metals are separated into the solids fraction. The overall volume and toxicity of the original waste solids are thereby reduced and the concentrated waste streams can be efficiently treated for disposal.

The BEST process is a mobile solvent extraction system which uses one or more secondary or tertiary amines (usually triethylamine (TEA)) to separate hydrocarbons from soils and sludges. The BEST technology is based on the fact that TEA is completely soluble in water at temperatures below 20° C.

Because TEA is flammable in the presence of oxygen, the treatment system must be sealed from the atmosphere and operated under a nitrogen blanket. Prior to treatment, it is necessary to raise the pH of the waste material to greater than 10, creating an environment where TEA will be conserved effectively for recycling to the process. This pH adjustment may be accomplished by adding sodium hydroxide. Pretreatment also includes screening the contaminated feed solids to remove cobbles and debris and size materials for smooth flow through the process.

The BEST process begins by mixing and agitating the cold solvent and waste in a washer/dryer (Figure 1). The washer/dryer is a horizontal steam-jacketed vessel with rotating paddles. Hydrocarbons and water in the waste simultaneously solvate with the cold TEA, creating a homogeneous mixture. As the solvent breaks the oil-water-solid bonds in the

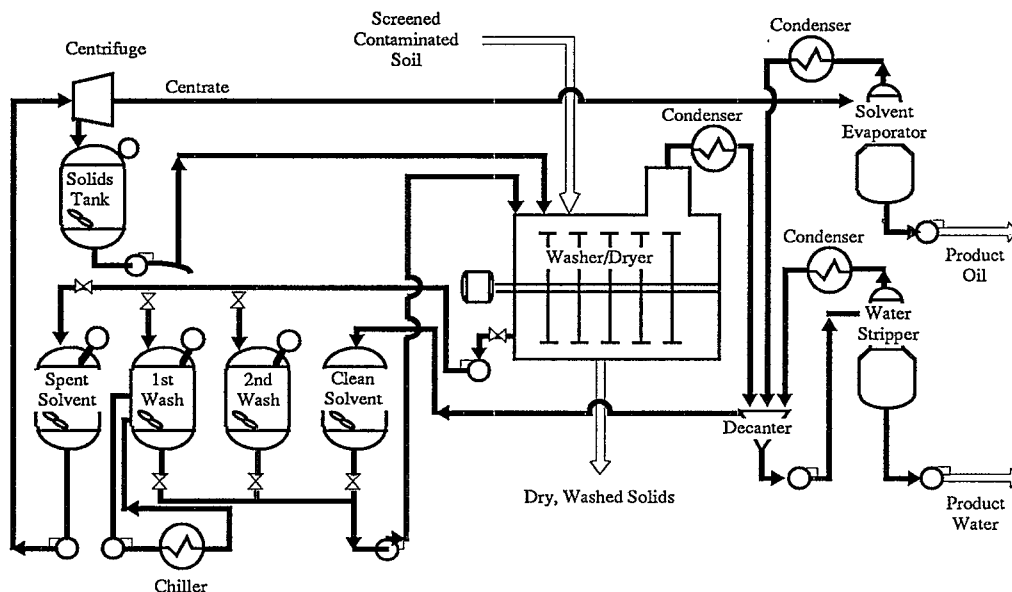


Figure 1. BEST soil cleanup unit schematic.

waste, the solids are released and allowed to settle by gravity. The solvent mixture is decanted and fine particles are subsequently removed by centrifuging. The resulting dry solids have been cleansed of hydrocarbons, but contain most of the original waste's heavy metals, and thus may require further treatment prior to disposal.

The liquids from the washer/dryer vessels containing the hydrocarbons and water extracted from the waste are heated. As the temperature of the liquids increases, the water separates from the organics and solvent. The organics-solvent fraction is decanted and sent to a stripping column, where the solvent is recycled and the organics are discharged for recycling or disposal. The water phase is passed to a second stripping column, where residual solvent is recovered for recycling. The water is typically discharged to a local wastewater treatment plant.

The BEST technology is modular, allowing for on-site treatment. Based on the results of many bench-scale treatability tests, the process significantly reduces the hydrocarbon concentration in the solids. Other advantages of the technology include the production of dry solids, the recovery and reuse of soil, and waste volume reduction. By removing organic contaminants, the process reduces the overall toxicity of the solids and water streams. It also concentrates the contaminants into a smaller volume, allowing for efficient final treatment and disposal.

WASTE APPLICABILITY:

The BEST process is applicable for most organics or oily contaminants in sludges or soils, including PCBs (see Table 1). Performance can be influenced by the presence of detergents and emulsifiers, low pH materials, and reactivity of the organics with the solvent.

Table 1
SPECIFIC WASTES CAPABLE OF TREATMENT
USING SOLVENT EXTRACTION

RCRA Listed Hazardous Wastes

- Creosote-Saturated Sludge
- Dissolved Air Flotation (DAF) Float
- Slop Oil Emulsion Solids
- Heat Exchanger Bundle Cleaning Sludge
- API Separator Sludge
- Tank Bottoms (Leaded)

Non-Listed Hazardous Wastes

- Primary Oil/Solids/Water Separation Sludges
- Secondary Oil/Solids/Water Separation Sludges
- Bio-Sludges
- Cooling Tower Sludges
- HF Alkylation Sludges
- Waste FCC Catalyst
- Spent Catalyst
- Stretford Unit Solution
- Tank Bottoms
- Treated Clays

STATUS:

The first full-scale BEST unit was used at the General Refining Superfund site in Garden City, Georgia. Solvent extraction is the selected remedial action at the Pinnete's Salvage site in Maine and is the preferred alternative at the F. O'Connor site in Maine.

The BEST process' demonstration under the SITE Program is pending selection of an appropriate site.

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RETECH, INC. (Plasma Reactor)

TECHNOLOGY DESCRIPTION:

The Centrifugal Reactor is a thermal treatment technology that uses the heat from a plasma torch to create a molten bath which is used to detoxify contaminated soils. Organic contaminants are vaporized and react at very high temperatures to form innocuous products. Solids melt and are incorporated into the molten bath. Metals are retained in this phase, and when cooled, this phase is a nonleachable matrix.

In the diagram of the reactor (Figure 1), contaminated soils enter through the bulk feeder. The interior of the reactor (the reactor well) rotates during waste processing. Centrifugal force created by this rotation prevents waste and molten material from flowing out of the reactor through the bottom. It also helps to transfer heat and electrical energy evenly throughout the molten phase. Periodically, the reactor is emptied.

Molten solids fall into the collection chamber where they solidify. Gases travel through the secondary combustion chamber where they remain at a high temperature for an extended period of time. This allows for further thermal destruction of any organics remaining in the gas phase. Downstream of the secondary combustion chamber, the gases pass through a series of air pollution control devices designed to remove particulates and acid gases. In the event of a process upset, a surge tank has been installed to allow for the reprocessing of any off-gases produced.

WASTE APPLICABILITY:

Liquid and solid organic compounds can be treated by this technology. It is most appropriate for soils and sludges contaminated with metals and hard-to-destroy organic compounds.

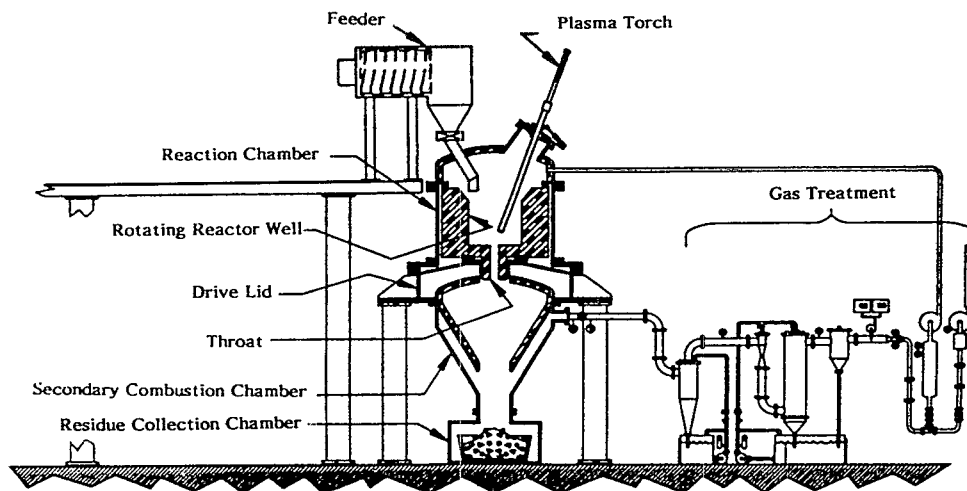


Figure 1. Centrifugal reactor.

STATUS:

A demonstration is planned for early 1990 at a Department of Energy research facility in Butte, Montana. During the demonstration, the reactor will process approximately 4,000 pounds of waste at a feed rate of 100 pounds per hour. All feed and effluent streams will be sampled to assess the performance of this technology. A report on the demonstration project will be available after its completion.

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Technology Profile

Demonstration Program



November 1989

S.M.W. SEIKO, INC. (In Situ Solidification/Stabilization)

TECHNOLOGY DESCRIPTION:

The Soil-Cement Mixing Wall (S.M.W.) technology involves the in-situ fixation stabilization and solidification of contaminated soils. Multi-axis overlapping hollow stem augers (Figure 1) are used to inject solidification/stabilization (S/S) agents and blend them with contaminated soils in-situ. The augers are mounted on a crawler-type base machine. A batch mixing plant and raw materials storage tanks are also involved. The machine can treat 90 to 140 cubic yards of soil per 8-hour shift at depths up to 100 feet.

The product of the in-situ S/S technology is a monolithic block down to the treatment depth. The volume increase ranges from 10 to 30 percent, depending on the nature of the soil matrix and the amount of fixation reagents and water required for treatment.

WASTE APPLICABILITY:

This technology is applicable to soils contaminated with metals and semi-volatile organic compounds (pesticides, PCBs, phenols, PANs, etc.).

The technique has been used in mixing soil cement or chemical grout for more than 18 years on various construction applications, including cutoff walls and soil stabilization.

STATUS:

This project was accepted into the SITE Demonstration Program in June 1989. Site selection is currently underway.

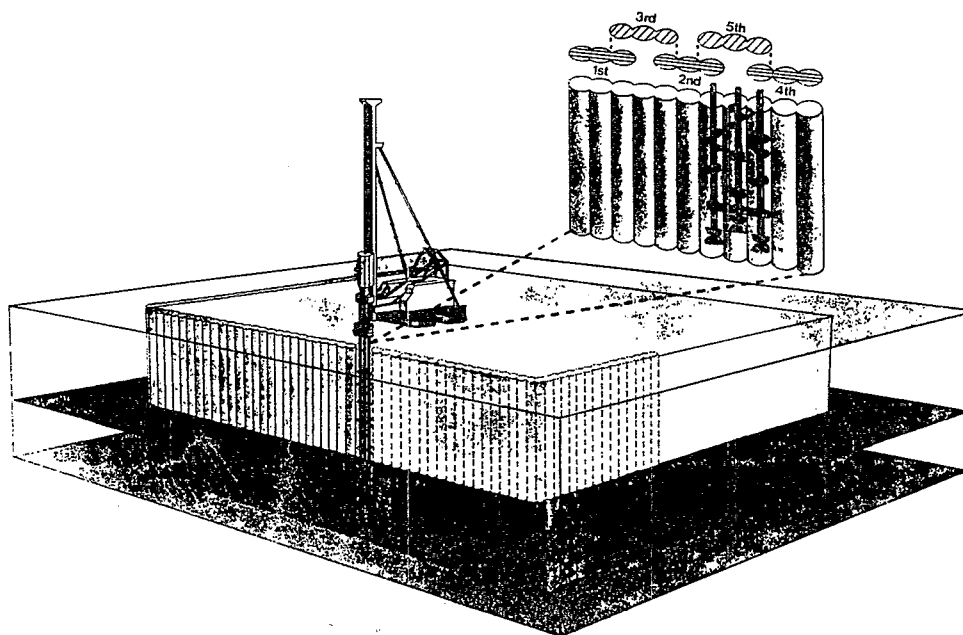


Figure 1. Soil cement mixing in-placed wall.

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Technology Profile

Demonstration Program

SITE
SUPERFUND INNOVATIVE
TECHNOLOGY EVALUATION

November 1989

SEPARATION AND RECOVERY SYSTEMS, INC. (Solidification/Stabilization)

TECHNOLOGY DESCRIPTION:

This technology uses lime to neutralize sludges with high levels of hydrocarbons. No hazardous materials are used in the process. The lime and other minor chemicals used are specially prepared to significantly improve their reactivity and other key characteristics.

Sludge is removed from the waste pit and mixed with lime in a separate blending pit. The temperature of the material in the blending pit rises for a brief time to around 100° C, and some steam is created. After 20 minutes, almost all of the material has been fixed. However, the chemicals mixed in the sludge continue to react with the waste over days. The fixed material is stored in a product pile until the waste pit has been cleaned. The waste is then returned to the pit and compacted to a permeability of 10^{-10} cm/sec. The volume of the waste is increased by 30 percent by adding lime. This process uses conventional earthmoving equipment.

WASTE APPLICABILITY:

The technology is applicable to acidic sludges containing at least 5 percent hydrocarbons (typical of sludges produced by re-manufacturing lubricating oils). The technology can also stabilize waste containing up to 80 percent organics. The process tolerates low levels of mercury and moderate levels of lead and other toxic metals.

STATUS:

EPA is in the process of locating a suitable site for demonstrating this technology.

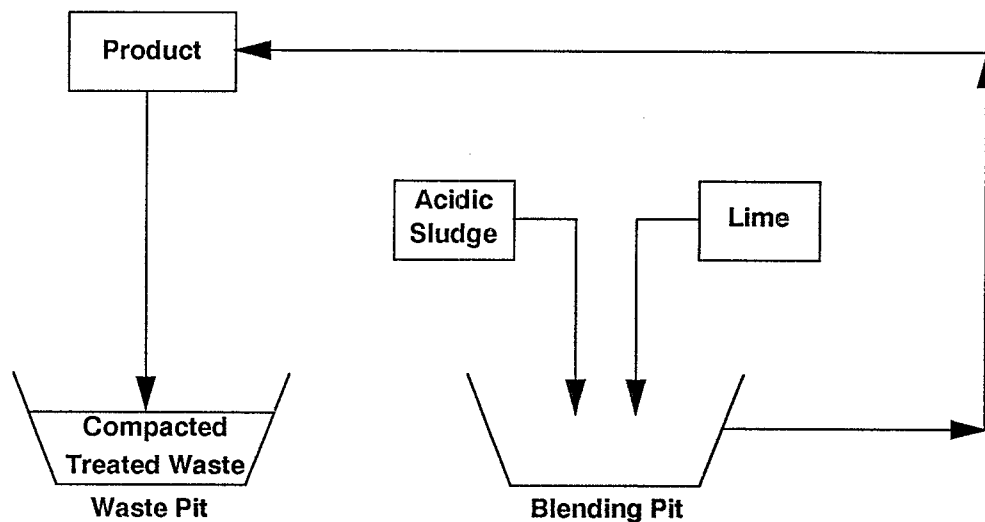


Figure 1. Process flow diagram.

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SHIRCO INFRARED SYSTEMS (Infrared Thermal Destruction)

TECHNOLOGY DESCRIPTION:

The electric infrared incineration technology (originally developed by Shirco Infrared Systems, Inc. of Dallas, Texas) is a mobile thermal processing system that uses electrically-powered silicon carbide rods to heat organic wastes to combustion temperatures. Any remaining combustibles are incinerated in an afterburner. One configuration for this mobile system (Figure 1) is comprised of four components: an electric-powered infrared primary chamber, a gas-fired secondary combustion chamber, an emissions control system, and a control center.

Waste is fed into the primary chamber on a wire-mesh conveyor belt and exposed to infrared radiant heat (up to 1850° F) provided by the horizontal rows of electrically-powered silicon carbide rods above the belt. A blower delivers air to selected locations along the belt and can be used to control the oxidation rate of the waste feed.

The ash material that drops off the belt in the primary chamber is quenched using scrubber water effluent. The ash is then conveyed to the ash hopper, where it is removed to a holding area and analyzed for PCB content.

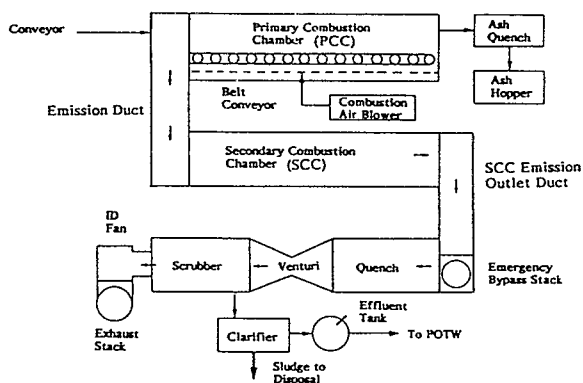


Figure 1. Peak Oil incineration unit process diagram.

Volatile gases from the primary chamber flow into the secondary chamber, which uses higher temperatures, greater residence time, turbulence, and supplemental energy (if required) to destroy these gases. Gases from the secondary chamber are ducted through the emissions control system. In the emissions control system, the particulates are removed in a venturi scrubber. Acid vapor is neutralized in a packed tower scrubber. An induced draft blower draws the cleaned gases from the scrubber into the free-standing exhaust stack. An emergency stack is installed prior to the venturi scrubber system so that if the temperature control system and its interlocks fail, the emissions control system will not be melted by the hot gases.

The scrubber liquid effluent flows into a clarifier, where scrubber sludge settles out for disposal, and through an activated carbon filter for reuse or to a POTW for disposal.

WASTE APPLICABILITY:

This technology is suitable for soils or sediments with organic contaminants. Liquid organic wastes can be treated after mixing with sand or soil. Data evaluated during the Application Analysis suggest that additional preprocessing may be needed to meet suitable ranges for various waste characteristics, as follows:

- Particle size, 5 microns to 2 inches
- Moisture content, up to 50% (wt.)
- Density, 30-130 lb/cf
- Heating value, up to 10,000 Btu/lb
- Chlorine content, up to 5% (wt.)
- Sulfur content, up to 5% (wt.)
- Phosphorus, 0-300 ppm
- pH, 5-9
- Alkali metals, up to 1% (wt.)

STATUS:

EPA conducted two evaluations of the infrared system. An evaluation of a full-scale unit was conducted from August 1 to 4, 1987, during a removal action by Region IV at the Peak Oil site, an abandoned oil refinery in Tampa, Florida. During the cleanup, a nominal 100-ton per day system treated nearly 7,000 cubic yards of waste oil sludge containing PCBs and lead. A second demonstration of the system, at pilot scale, took place at the Rose Township-Demodé Road site, an NPL site in Michigan, from November 2 to 11, 1987. Organics, PCBs, and metals in soil were the target waste compounds to be destroyed or immobilized. The pilot-scale operation allowed the evaluation of performance under varied operating conditions. In addition to Peak Oil, infrared incineration was used to remediate PCB-contaminated materials at the Florida Steel Corporation Superfund site, and is being used on PCB-contaminated soil at the LaSalle Electric NPL site in Illinois.

DEMONSTRATION RESULTS:

The results from the two SITE demonstrations are summarized below.

- In both tests, at standard operating conditions, PCBs were reduced to less than 1 ppm in the ash, with a DRE for air emissions greater than 99.99% (based on detection limits).
- In the pilot-scale demonstration the RCRA standard for particulate emission (180 mg/dscf) was achieved. In the full-scale demonstration, however, this standard was not met in all runs due to scrubber inefficiencies.
- Lead was not immobilized; however, it remained in the ash and significant amounts were not transferred to the scrubber water or emitted to the atmosphere.
- The pilot testing demonstrated satisfactory performance with high feed rate and reduced power consumption when fuel oil was added to the waste feed and the primary chamber temperature was reduced.

APPLICATIONS ANALYSIS RESULTS:

Additional results from the two demonstrations plus eight other case studies show that:

- The process is capable of meeting both RCRA and TSCA DRE requirements for air emissions. Operations on waste feed contaminated with PCBs have consistently met the TSCA guidance level of 2 ppm in ash.
- Improvements in the scrubber system resulted in compliance with RCRA and TSCA particulate emission standards. In some cases, restrictions in chloride levels in the waste and/or feed rate may be necessary to meet particulate emissions standards.
- Based on recent commercial operations, projected utilization factors range from 50% to 75%.
- Economic analysis and observation suggest a cost range from \$180/ton to \$240/ton of waste feed, excluding waste excavation, feed preparation, profit, and ash disposal costs. Overall costs may be as high as \$800/ton.

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Technology Profile

Demonstration Program



November 1989

SILICATE TECHNOLOGY CORPORATION (Solidification/Stabilization with Silicate Compounds)

TECHNOLOGY DESCRIPTION:

This solidification/stabilization technology uses silicate compounds and can be used as two separate technologies: (1) one that fixes and solidifies organics and inorganics contained in contaminated soils and sludges; and (2) another that removes organics from contaminated water. For soils and sludges, a proprietary reagent, FMS silicate, selectively adsorbs organic contaminants before the waste is mixed with a cement-like material to form a high-strength, non-leaching cement block (monolith). For water, the same reagent (FMS silicate) is used in conjunction with granular activated carbon to remove organics from the groundwater. The resulting waste material is then solidified by the first technology.

In this combined technology, the type and dose of reagents depend on the waste characteristics. Treatability studies and site investigations are conducted to determine reagent formulations for each site. The process begins with pretreating contaminated waste material. Coarse material is separated from fine material (Figure 1) and sent through a shredder, which cuts the material to the size required for the solidification technology. The waste is then loaded into a batch plant, where the FMS silicate is applied. The waste is weighed, and the proportional amount of FMS silicate is added. This mixture is conveyed to a concrete mixing truck, pug mill or other mixing equipment where water is added and the mixture is thoroughly blended. The treated material is then placed in a confining pit on-site for curing or cast into molds for transport and disposal off-site.

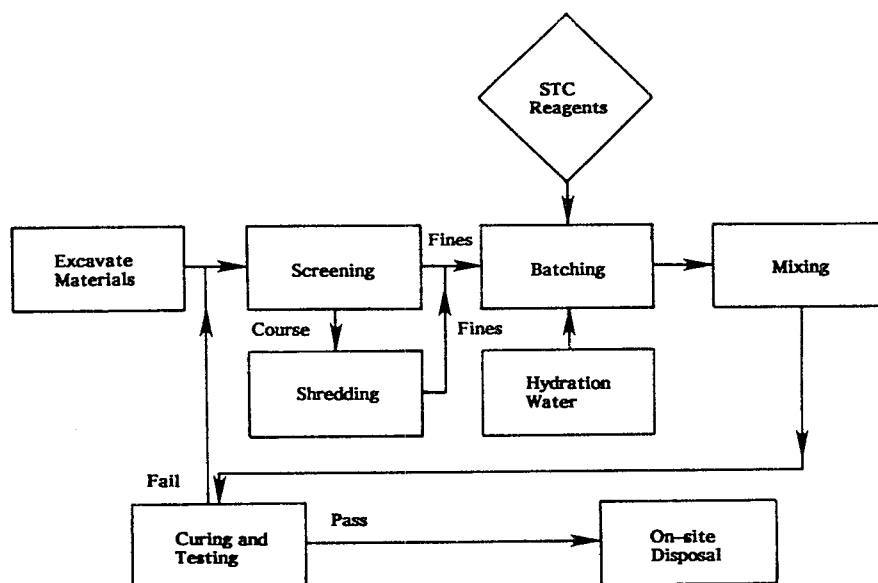


Figure 1. Contaminated soil process flow diagram.

A self-contained mobile filtration pilot facility is used to treat organic-contaminated ground water. Reagents aid in removing high molecular weight organics; granulated activated carbon is used to remove low molecular weight organics. The contaminated water is passed through a column filter containing the reagent. The high molecular weight organics are separated from the water in this step. The effluent from this column filter is then passed through a second column filter containing granulated activated carbon for removing low molecular weight organics.

WASTE APPLICABILITY:

This technology can be applied to soils and sludges to metals, cyanides, fluorides, arsenates, ammonia, chromates, and selenium in unlimited concentrations. Higher weight organics in groundwater, soils, and sludges -- including halogenated, aromatic, and aliphatic compounds -- can also be treated by this process. However, the process is not as successful on low molecular weight organics such as alcohols, ketones and glycols and volatile organics.

STATUS:

A demonstration of this combined technology should occur between December 1989 and August 1990 at the Kaiser Steel site in Fontana, California.

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Technology Profile

Demonstration Program

SITE
SUPERFUND INNOVATIVE
TECHNOLOGY EVALUATION

November 1989

SOLIDITECH, INC. (Solidification/Stabilization)

TECHNOLOGY DESCRIPTION:

This solidification/stabilization process immobilizes contaminants in soils and sludges by binding them in a concrete-like, leach-resistant matrix.

Contaminated waste materials are collected, screened to remove oversized material, and introduced to the batch mixer (Figure 1). The waste material is then mixed with: (1) water, (2) Urrichem -- a proprietary chemical reagent, (3) proprietary additives, and (4) pozzolanic material (flyash), kiln dust, or cement (cement was used for the demonstration). Once thoroughly mixed, the treated waste is discharged from the mixer.

The treated waste is a solidified mass with significant unconfined compressive strength, high stability, and a rigid texture similar to that of concrete.

WASTE APPLICABILITY:

This technology is intended for treating soils and sludges contaminated with organic compounds, metals, inorganic compounds, and oil and grease. Batch mixers of various capacities are available to treat different volumes of waste.

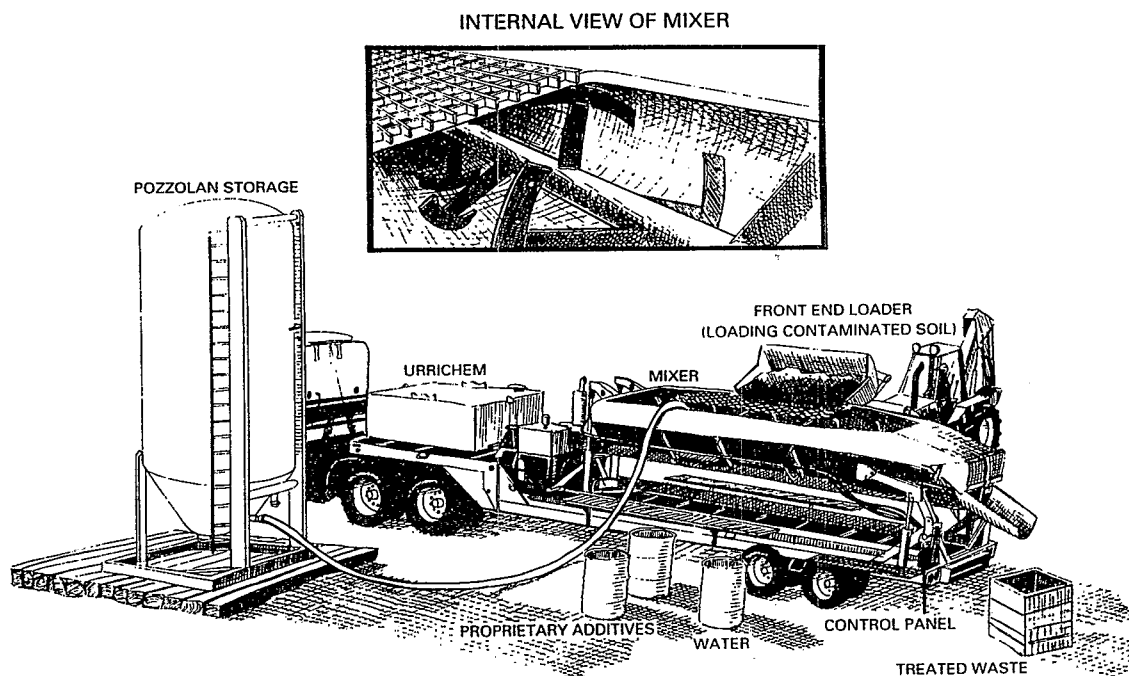


Figure 1. Soliditech processing equipment.

STATUS:

The Soliditech process was demonstrated in December 1988 at the Imperial Oil Company/Champion Chemical Company Superfund site in Morganville, New Jersey. This location formerly contained both chemical processing and oil reclamation facilities. Wastes treated during the demonstration were soils, a waste pile, and wastes from an old storage tank. These waste were contaminated with petroleum hydrocarbons, PCBs, other organic chemicals, and heavy metals.

DEMONSTRATION RESULTS:

Key findings from the Soliditech demonstration are summarized below:

- Chemical analyses of extracts and leachates showed that heavy metals present in the untreated waste were immobilized.
- The process solidified both solid and liquid wastes with high organic content (up to 17%) as well as oil and grease.
- Volatile organic compounds in the original waste were not detected in the treated waste.
- Physical test results of the solidified waste samples showed: (1) unconfined compressive strengths ranged from 390 to 860 psi; (2) very little weight loss after 12 cycles of wet/dry and freeze/thaw durability tests; (3) low permeability of the treated waste; and (4) increased density after treatment.
- The solidified waste increased in volume by an average of 22 percent. The bulk density of the waste material increased by approximately 35 percent due to solidification.
- Semivolatile organic compounds (phenols) were detected in the treated waste and the TCLP extracts from the treated waste, but not in the untreated waste or its TCLP extracts. The presence of these compounds is believed to result from chemical reactions in the waste treatment mixture.

- Oil and grease content of the untreated waste ranged from 2.8 to 17.3 percent (28,000 to 173,000 ppm). Oil and grease content of the TCLP extracts of the solidified waste ranged from 2.4 to 12 ppm.
- The pH of the solidified waste ranged from 11.7 to 12.0. The pH of the untreated waste ranged from 3.4 to 7.9.
- PCBs were not detected in any extracts or leachates of the treated waste.
- Visual observation of solidified waste showed dark inclusions approximately 1 mm in diameter. Ongoing microstructural studies are expected to confirm that these inclusions are encapsulated wastes.

A Technology Evaluation Report is scheduled for publication in November 1989. An Applications Analysis Report will be available in early 1990.

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Technology Profile

Demonstration Program



November 1989

SOLVENT SERVICES, INC. (Steam Injection and Vacuum Extraction)

TECHNOLOGY DESCRIPTION:

The Steam Injection and Vacuum Extraction (SIVE) process is used in situ to remove volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) from contaminated soil. Steam is forced through the soil, via injection wells, to thermally enhance the vacuum extraction process. Recovered gaseous contaminants are then either condensed and processed along with recovered liquids, or trapped by activated carbon filters. The contaminants are then recycled back into the condensing system.

The technology uses readily available components such as extraction and monitoring wells, manifold piping, vapor-liquid separator, vacuum pump, and emission control equipment, such as activated carbon canisters (Figure 1). Once a contaminated area is completely

defined, an extraction well is installed and connected by piping to a vapor-liquid separator. A vacuum pump draws the subsurface contaminants through the well, the separator, and an activated carbon canister before discharging to the atmosphere. Subsurface vacuum and soil vapor concentrations are monitored by vadose zone monitoring wells.

WASTE APPLICABILITY:

The technology is used to treat soil contaminated with VOCs and SVOCs in total concentrations ranging from 10 ppb to 100,000 ppm by weight. Soils contaminated by leaking underground storage tanks or surface spills are suitable. By-products include spent carbon and contaminated water. Further treatment of recovered liquids and condensate is necessary.

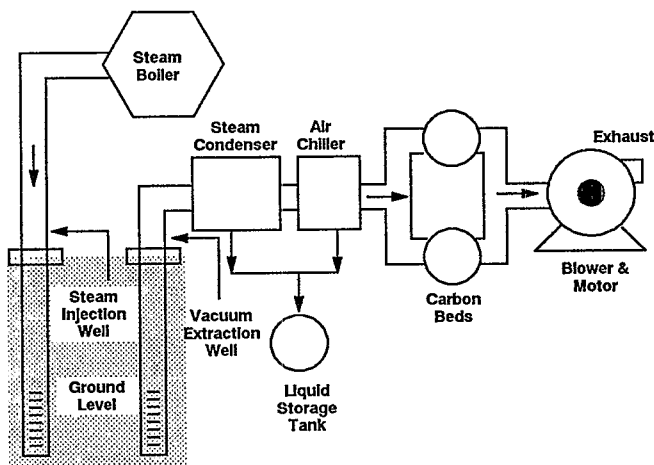


Figure 1. Solvent Services, Inc. process flow diagram.

STATUS:

The SIVE process system is currently under development and planned for demonstration in San Jose, California. Soil cleaning rates depend on soil type and physical properties, as well as contaminant types, distribution, and concentrations. The rates are expected to vary from 300 to 1,000 cubic yards of soil per day per well system.

The objective of the 6-month field demonstration of the SIVE process system is to fully remediate 1.2 acres of the site, containing approximately 30,000 cubic yards of soil. The demonstration began in September 1989; a visitors' day is planned for December 1989.

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TERRA VAC, INC. (In Situ Vacuum Extraction)

TECHNOLOGY DESCRIPTION:

In situ vacuum extraction technology is a process of removing and venting volatile organic compounds (VOCs) from the vadose or unsaturated zone of soils. Often, these compounds can be removed from the vadose zone before they contaminate ground water. In this technology, a well is used to extract subsurface organic contaminants. The extracted contaminant stream passes through a vapor/liquid separator, and the resulting off-gases undergo activated carbon treatment, before being released into the atmosphere.

The technology uses readily available equipment such as extraction and monitoring wells, manifold piping, a vapor/liquid separator, a vacuum pump, and an emission control device, such as an activated carbon canister. Once a contaminated area is completely defined, an extraction well is installed and connected by piping to a vapor/liquid separator device (Figure 1). A vacuum pump draws the subsurface contaminants through the well, to the separator device, and through an activated carbon canister before the air stream is discharged to the atmosphere. Subsurface

vacuum and soil vapor concentrations are monitored using vadose zone monitoring wells.

The technology does not require highly trained operators or soil excavation, and is not limited by depth. The technology works best at sites that are contaminated by liquids with high vapor pressures. The success of the system depends on site conditions, soil properties, and the chemical properties of the contaminants. The process works in soils of low permeability (clays) if the soil has sufficient air-filtered porosity. Depending on the soil type and the depth to ground water, the radius of influence of a single extraction well can range from tens to hundreds of feet. Typical contaminant recovery rates range between 20 and 2,500 pounds per day, and are a function of volatility of the organic compound recovered. Therefore, the more volatile the organic compound, the faster the process works. The process is more cost-effective at sites where contaminated soils are predominantly above the water table, although systems have been designed for both vapor and ground-water recovery.

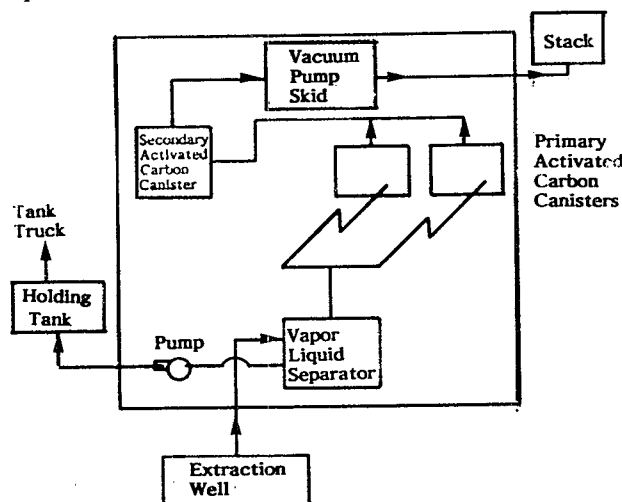


Figure 1. Process diagram for in-situ vacuum extraction.

WASTE APPLICABILITY:

This technology is applicable to organic compounds that are volatile or semivolatile at ambient temperatures in soils and ground water. Contaminants should have a Henry's constant of 0.001 or higher for effective removal.

STATUS:

The technology was first applied at a Superfund site in Puerto Rico, where carbon tetrachloride had leaked from an underground storage tank. In-situ vacuum extraction processes are now used at more than 60 waste sites across the United States, such as the Verona Wells Superfund Site in Battle Creek, Michigan, which contains trichloroethylene and contaminants from gasoline station spills. A field demonstration of the process was performed as part of the SITE Program at the Groveland Wells Superfund site in Groveland, Massachusetts, which is contaminated by trichloroethylene (TCE).

The Technology Evaluation Report and Applications Analysis Report have been published.

DEMONSTRATION RESULTS:

The in situ vacuum extraction demonstration at Groveland Wells Superfund site used four extraction wells to pump contaminants to the process system. Four monitoring wells were used to measure the impact of treatment on site contamination. During the SITE demonstration, 1,300 pounds of volatile organics, mainly TCE, were extracted during a 56-day operational period. The volatiles were removed from both highly permeable strata and low permeability clays. Table 1 presents the reductions in TCE concentrations achieved by the Terra Vac system.

TABLE 1
REDUCTION OF WEIGHTED AVERAGE TCE LEVELS IN SOIL

Extraction Well	TCE Concentrations (mg/kg)		% Reduction
	Pretreatment	Posttreatment	
1	33.98	29.31	13.74
2	3.38	2.36	30.18
3	6.89	6.30	8.56
4	96.10	4.19	95.64
Monitoring Well			
1	1.10	0.34	69.09
2	14.75	8.98	39.12
3	227.31	84.50	62.83
4	0.87	1.05	--

APPLICATIONS ANALYSIS SUMMARY:

The Terra Vac system was tested at several Superfund and non-Superfund sites. These field evaluations yielded the following conclusions:

- The process represents a viable technology to fully remediate a site contaminated with volatile organic compounds.
- The major considerations in applying this technology are: volatility of the contaminants (Henry's constant), site soil porosity, and the required cleanup level.
- The process performed well in removing VOCs from soil with measured permeabilities of 10^{-4} to 10^{-8} cm/sec.
- Pilot demonstrations are necessary when treating soils of low permeability and high moisture content.
- Based on available data, treatment costs are typically near \$50 per ton. Costs can be as low as \$10 per ton at large sites not requiring off-gas or wastewater treatment. Costs for small sites may range as high as \$150 per ton.

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Technology Profile

Demonstration Program

SITE
SUPERFUND INNOVATIVE
TECHNOLOGY EVALUATION

November 1989

TOXIC TREATMENTS (USA) INC. (In Situ Steam/Air Stripping)

TECHNOLOGY DESCRIPTION:

A transportable "detoxifier" treatment unit is used for in-situ steam and air stripping of volatile organics from contaminated soil.

Two main components of the on-site treatment equipment are the process tower and process train (Figure 1). The process tower contains two counter-rotating hollow-stem drills, each with a modified cutting bit 5 feet in diameter, capable of operating to a 27-foot depth. Each drill contains two concentric pipes. The inner pipe is used to convey steam supplied by an oil-fired boiler at 450°F and 450 psig to the rotating cutting blades. The outer pipe conveys air at approximately 300°F and 250 psig to the rotating blades.

Steam is piped to the top of the drills and injected through the cutting blades. The steam heats the ground being remediated, increasing the vapor pressure of the volatile contaminants and thereby increasing the rate at which they can be stripped. Both the air and steam serve as carriers to convey these contaminants to the

surface. A metal box, called a shroud, seals the process area above the rotating cutter blades from the outside environment, collects the volatile contaminants, and ducts them to the process train.

In the process train, the volatile contaminants and the water vapor are removed from the off-gas stream by condensation. The condensed water is separated from the contaminants by distillation, then filtered through activated carbon beds and subsequently used as make-up water for a wet cooling tower. Steam also is used to regenerate the activated carbon beds and as the heat source for distilling of the volatile contaminants from the condensed liquid stream.

WASTE APPLICABILITY:

This technology is applicable to organic contaminants such as hydrocarbons and solvents with sufficient partial pressure in the soil. The technology is not limited by soil particle size, initial porosity, chemical concentration, or viscosity.

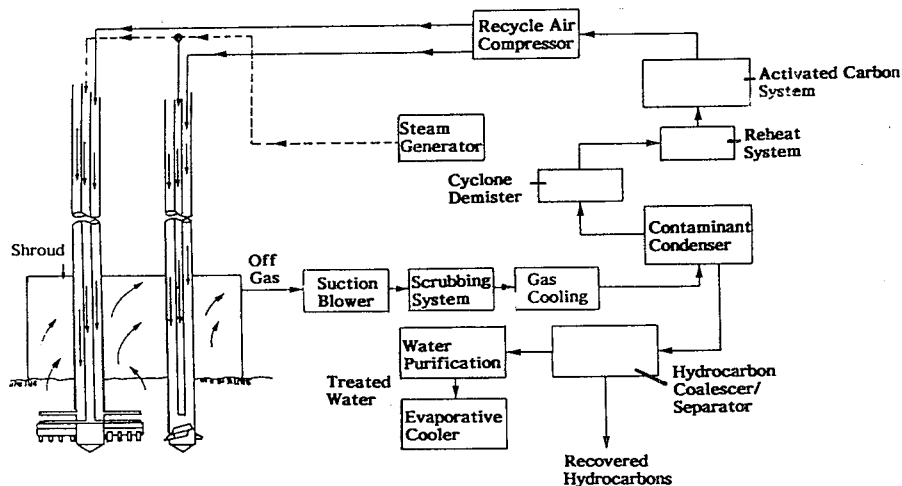


Figure 1. Typical detoxifier system process flow diagram.

STATUS:

A SITE demonstration was performed the week of September 18, 1989. Twelve soil blocks were treated for the demonstration. Various liquid samples were collected, and the process operating procedures were closely monitored and recorded.

DEMONSTRATION RESULTS:

Demonstration results are not available at this time, but are expected to be published early 1990.

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ULTROX INTERNATIONAL (Ultraviolet Radiation/Oxidation)

TECHNOLOGY DESCRIPTION:

This ultraviolet (UV) radiation/oxidation process uses UV radiation, ozone (O_3) and hydrogen peroxide (H_2O_2) to destroy toxic organic compounds, especially chlorinated hydrocarbons, in water. The process oxidizes compounds that are toxic or refractory (resistant to biological oxidation) in concentrations of parts per million or parts per billion.

The Ultrox system consists of a reactor module, an air compressor/ozone generator module, and a hydrogen peroxide feed system. It is skid-mounted and portable, and permits on-site treatment of a wide variety of liquid wastes, such as industrial wastewaters, groundwaters,

and leachate. The reactor size is determined from the expected wastewater flow rate and the necessary hydraulic retention time to treat the contaminated water. The approximate UV intensity, ozone and hydrogen peroxide dose are determined from pilot-scale studies.

Influent to the reactor (Figure 1) is simultaneously exposed to UV radiation, ozone, and hydrogen peroxide to oxidize the organic compounds. Off-gas from the reactor passes through an ozone destruction (Decompozon) unit, which reduces ozone levels before air venting. The Decompozon unit also destroys gaseous volatile organic compounds (VOC) stripped off in the reactor. Effluent from the reactor can be directly discharged to a

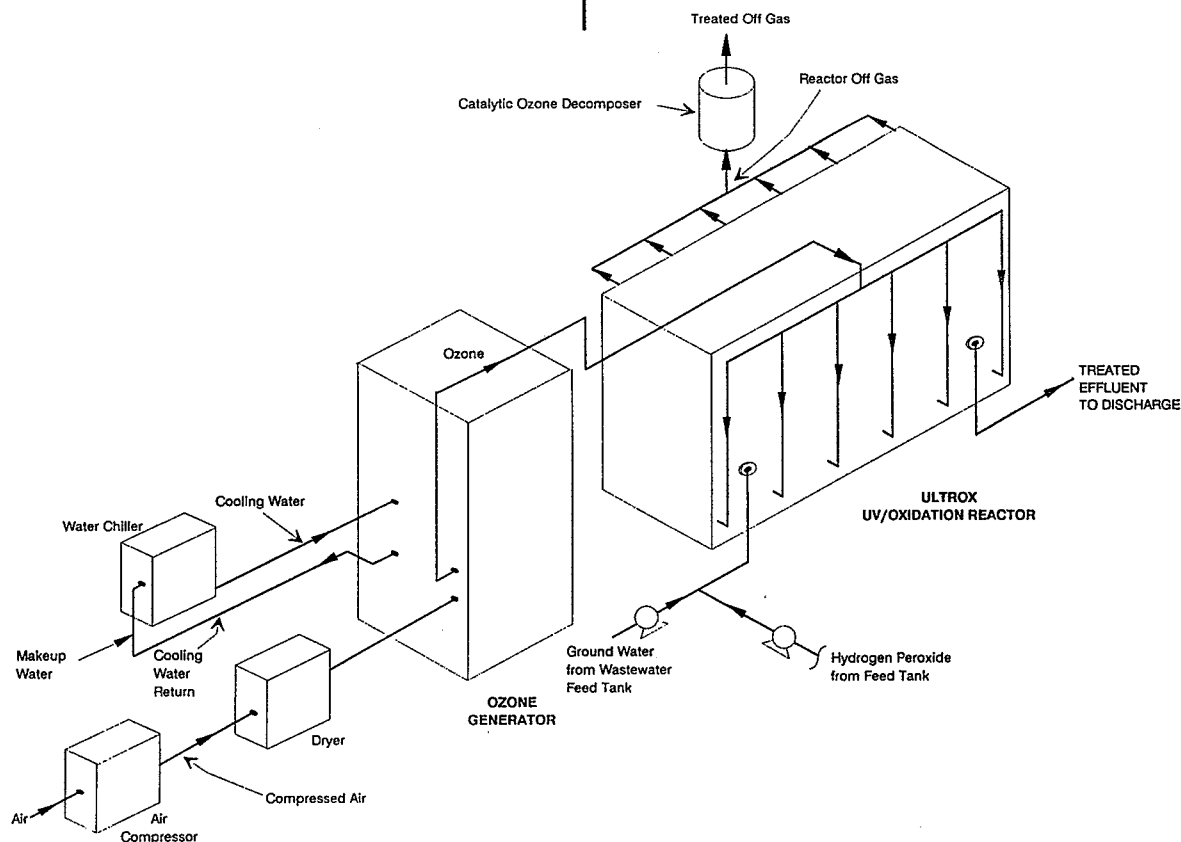


Figure 1. Isometric view of Ultrox system.

WASTE APPLICABILITY:

Contaminated groundwater, industrial wastewaters and leachates containing halogenated solvents, phenol, pentachlorophenol, pesticides, PCBs, and other organic compounds are suitable for this treatment process.

STATUS:

A field-scale demonstration was completed in March 1989 at a hazardous waste site in San Jose, California. The test program was designed to evaluate the performance of the Ultrox System at several combinations of five operating parameters: (1) influent pH, (2) retention time, (3) ozone dose, (4) hydrogen peroxide dose, and (5) UV radiation intensity. The Technology Evaluation Report and the Applications Analysis Report will be available in the Spring of 1990.

DEMONSTRATION RESULTS:

Contaminated groundwater treated by the Ultrox system met regulatory standards at the following operating conditions:

Retention time	-	40 minutes
Influent pH	-	7.2 (unadjusted)
O ₃ dose	-	110 mg/L
H ₂ O ₂ dose	-	13 mg/L
UV lamps	-	all 24 operating at 64 watts each

Out of 44 VOC samples, three were chosen to be used as indicator parameters. The VOC removal efficiencies at these conditions are presented in Table 1.

TABLE 1
PERFORMANCE DATA FOR REPRODUCIBLE RUNS

	Mean Influent (µg/L)	Mean Effluent (µg/L)	Percent Removal
<u>Run 9</u>			
TCE	65	1.2	98
1,1-DCA	11	5.3	52
1,1,1-TCA	4.3	0.75	83
Total VOCs	170	16	91
<u>Run 12</u>			
TCE	52	0.55	99
1,1-DCA	11	3.8	65
1,1,1-TCA	3.3	0.43	87
Total VOCs	150	12	92
<u>Run 13</u>			
TCE	49	0.63	99
1,1-DCA	10	4.2	58
1,1,1-TCA	3.2	0.49	85
Total VOCs	120	20	83

Removal efficiencies for TCE were about 99 percent. Removal efficiencies for 1,1-DCA and 1,1,1-TCA were about 58 percent and 85 percent, respectively. Removal efficiencies for total VOCs were about 90 percent.

For some compounds, removal from the water phase was due to both chemical oxidation and stripping. Stripping accounted for 12 to 75 percent of the total removal for 1,1,1-TCA and 5 to 44 percent for 1,1-DCA. Stripping was less than 10 percent for TCE and vinyl chloride, and was negligible for other VOCs present.

The Decompozon unit reduced ozone to less than 0.1 ppm (OSHA standards), with efficiencies greater than 99.99 percent. VOCs present in the air within the treatment system, at approximately 0.1 to 0.5 ppm, were not detected after passing through the Decompozon unit.

Very low TOC removal was found, implying that partial oxidation of organics occurred without complete conversion to CO₂ and H₂O.

The average electrical energy consumption was about 11 kWh/hour of operation.

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Technology Profile

Demonstration Program



November 1989

WASTECH, INC. (Solidification/Stabilization)

TECHNOLOGY DESCRIPTION:

This solidification/stabilization technology applies proprietary bonding agents to soils, sludge, and liquid wastes containing volatile or semivolatile organic and inorganic contaminants to fix the pollutants within the wastes. The treated waste is then mixed with cementitious materials and placed in a stabilizing matrix. The specific reagents used are custom-selected based on the particular waste to be treated. The resultant material is a high-strength, non-leaching monolith that can be placed into the ground without double liners or covering caps.

The process uses standard engineering and construction practices. Since the type and dose of reagents depend on the waste's characteristics, treatability studies and site investigations need to be conducted to determine the proper reagent mix. The process begins with a front end loader and/or a backhoe excavating the waste material. Material

containing large pieces of debris must be prescreened. The waste is then placed, in measured quantities, into a pug mill or other mixer (see Figure 1), where it is mixed with a controlled amount of water and reagent. From there, the waste-reagent mixture is transferred to the cement batcher, where it is mixed with dry blends of a pozzolanic mixture. The operation does not generate waste byproducts.

WASTE APPLICABILITY:

This technology has treated a wide variety of waste streams consisting of soils, sludges, and raw organic streams, such as lubricating oil, aromatic solvents, evaporator bottoms, chelating agents, and ion exchange resins, with contaminant concentrations ranging from ppm levels to 40% by volume. It can also be applied to mixed wastes containing radioactive materials along with organic and inorganic contaminants.

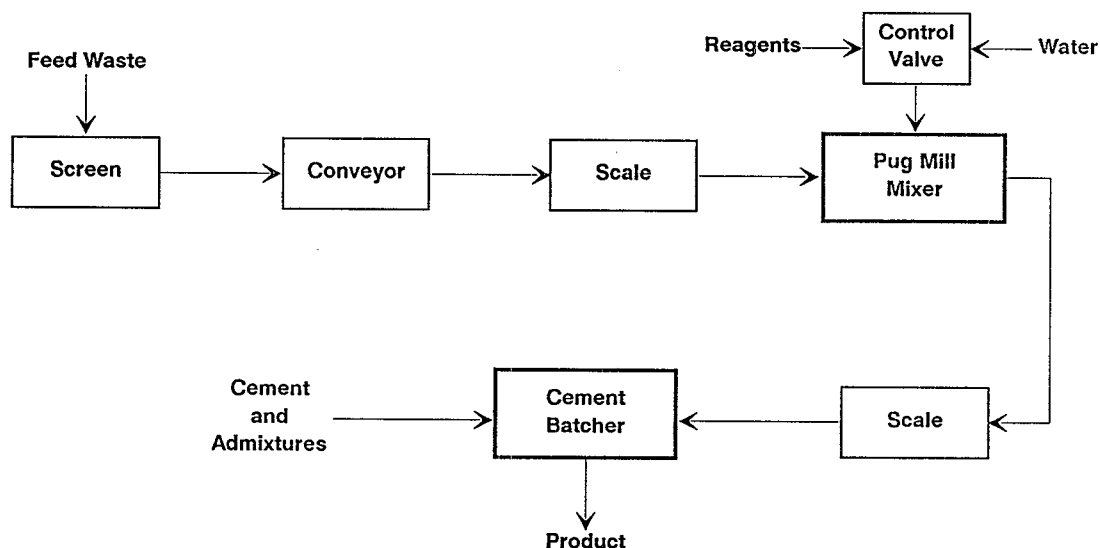


Figure 1. Wastech solids handling system flow diagram.

STATUS:

EPA is in the process of selecting a site for the technology demonstration. Treatability studies are currently underway on two wastes -- an oily waste and a wood preserving waste. A third study is proposed for a mixed waste.

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Technology Profile

Demonstration Program



November 1989

ZIMPRO/PASSAVANT INC. (PACT®/Wet Air Oxidation)

TECHNOLOGY DESCRIPTION:

Zimpro/Passavant Inc. has developed a treatment system that combines two technologies: the PACT® treatment system and wet air oxidation (WAO). The PACT® system uses powdered activated carbon (PAC) combined with conventional biological treatment (e.g., an activated sludge system) to treat liquid waste containing toxic organic contaminants. The WAO technology can regenerate the PAC for reuse in the PACT® system. The system is mobile, consisting of two skid-mounted units, and can treat from 2,500 to 10,000 gallons of wastewater per day. Larger stationary systems, treating up to 53 million gallons per day, are already in operation.

In the PACT® system, organic contaminants are removed through biodegradation and adsorption. Living microorganisms (biomass) in the activated sludge system are contained in liquid suspension in an aerated basin. This biomass removes biodegradable toxic organic compounds from the liquid waste. PAC is added to enhance this biological treatment by adsorbing toxic organic compounds. The degree of treatment achieved by the PACT® system depends on the influent waste characteristics and the system's operating parameters. Important waste characteristics include biodegradability, adsorbability, and concentrations of toxic organic compounds and inorganic compounds, such as heavy metals.

Major operating parameters include carbon dose, hydraulic retention time of the aeration basin, solids retention time of the biomass-carbon mixture, and biomass concentration in the system. Liquid wastes fed into the PACT® system should have sufficient nutrients (nitrogen and phosphorous) and biodegradable compounds to support the growth of active biomass in the aeration basin. The temperature of the waste should be in the range of 40° F to 100° F, and the influent pH in the range of 6 to 9. Solids retention times affect both the concentration and type of biomass in the system; these vary from 2 days to 50 days. Hydraulic retention times affect the degree of biodegradation achieved and typically range from 2 hours to 24 hours for relatively dilute wastes, such as contaminated groundwater, up to several days for concentrated wastes and leachate. Carbon doses vary widely, depending on the biodegradability and adsorptive characteristics of the contaminants in the waste. Higher PAC concentrations improve the settleability of the PAC-biomass mixture and reduce air stripping of volatile organic contaminants.

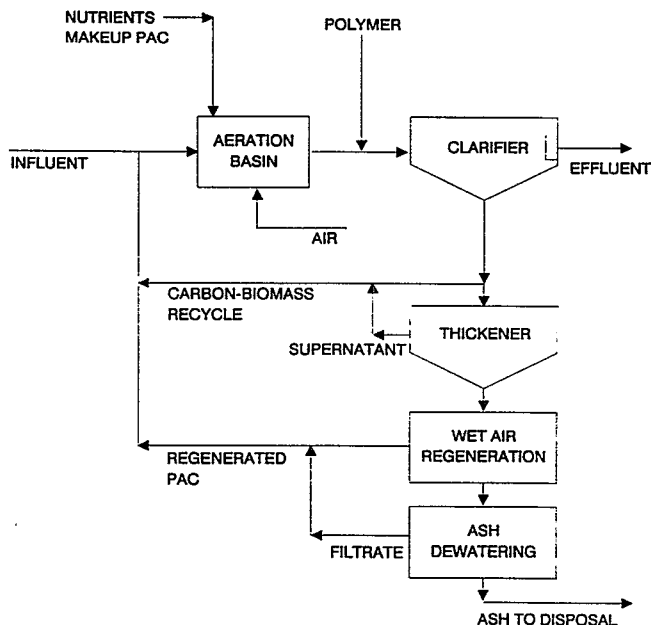


Figure 1. PACT® system with WAO.

Excess solids (PAC with adsorbed organics, biomass, and inert solids) are removed periodically from the system through the system's clarifier (settling tank) or thickener (see Figure 1). These excess solids are routed to the WAO system reactor to regenerate the spent PAC and destroy organics remaining in the biomass. Temperatures and pressures in the WAO system will be about 480° F and 800 to 850 pounds per square inch, respectively. After treatment in the WAO system, the regenerated PAC may be separated from the ash formed from destruction of the biomass, and returned to the aeration basin for reuse.

WASTE APPLICABILITY:

This technology is applicable to municipal and industrial wastewaters, as well as groundwater and leachates containing hazardous organic pollutants. According to the developer, the PACT® system has successfully treated a variety of industrial wastewaters, including chemical plant wastewaters, dye production wastewaters, pharmaceutical wastewaters, refinery wastewaters, and synthetic fuels wastewaters, in addition to contaminated groundwater and mixed industrial/municipal wastewater.

In general, PACT® system can treat liquid wastes containing wide ranges of biochemical oxygen demand (BOD) -- 10 to 30,000 parts per million (ppm) -- and chemical oxygen demand (COD) -- 20 to 60,000 ppm. Toxic volatile organic compounds can be treated up to the level where they interfere with biomass growth, about 1,000 ppm. The developer's treatability studies have shown that the PACT system can reduce the organics in contaminated groundwater from several hundred ppm to below detection limits (parts per billion, ppb, range).

STATUS:

A tentative site has been selected for the technology demonstration -- the Syncon Resins Superfund site in Kearny, New Jersey. The shallow aquifer at the Syncon Resins site is contaminated with a variety of organic solvent compounds. Site preparation work for the technology demonstration is being coordinated with the State of New Jersey.

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EMERGING TECHNOLOGIES PROGRAM

The Emerging Technologies Program provides a framework to encourage the bench- and pilot-scale testing and evaluation of technologies that have already been proven at the conceptual stage. The goal is to promote the development of viable alternatives available for use in Superfund site remediations. The emerging technologies may then be considered for the SITE Demonstration Program, for field demonstration and evaluation.

Technologies are solicited for the Emerging Technologies Program through Requests for Pre-Proposals. Three solicitations have been issued to date -- in July 1987 (E01), July 1988 (E02), and July 1989 (E03). Cooperative agreements between EPA and the technology developer require cost sharing, and may be renewed for up to two years. The selection of E03 projects is expected in early 1990. The 14 program participants selected under E01 and E02 are presented in alphabetical order in Table 3 and in the technology profiles that follow.

TABLE 3

SITE Emerging Technology Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
Atomic Energy of Canada Ltd. Chalk River, Ontario (E01)	Chemical Treatment/ Ultrafiltration	Leo Buckley 613-584-3311	John Martin 513-569-7758 FTS 684-7758	Ground Water	Specific for Heavy Metals	NA
Babcock & Wilcox Co. Alliance, OH (E02)	Cyclone Combustor	Lawrence King 216-821-9110	Laurel Staley 513-569-7863 FTS 684-7863	Solids, Soil	Non-specific	Non-specific
Battelle Memorial Institute, Columbus Division Columbus, OH (E01)	In Situ Electroacoustic Decontamination	H.S. Muralidhara 614-424-5018	Diana Guzman 513-569-7819 FTS 684-7819	Soil	Specific for Heavy Metals	NA
Bio-Recovery Systems, Inc. Las Cruces, NM (E01)	Biological Sorption	Dennis W. Darnall 505-646-5888	Naomi Barkley 513-569-7854 FTS 684-7854	Ground Water, Leachate, Wastewater	Specific for Heavy Metals	NA
Colorado School of Mines Golden, CO (E01)	Wetlands-Based Treatment	Thomas Wildeman 303-273-3642	Edward Bates 513-569-7774 FTS 684-7774	Acid Mine Drainage	Specific for Metals	NA
Electro-Pure Systems, Inc. Amherst, NY (E02)	A/C Electrocoagulation Phase Separation and Removal	Patrick Ryan 716-691-2600	Naomi Barkley 513-569-7854 FTS 684-7854	Ground Water, Wastewater, Leachate	Heavy Metals	Petroleum Byproducts, Coal- Tar Derivatives
Energy and Environmental Engineering, Inc. East Cambridge, MA (E01)	Laser Stimulated Photochemical Oxidation	James H. Porter 617-666-5500	Ronald Lewis 513-569-7856 FTS 684-7856	Ground Water, Wastewater	NA	Non-specific

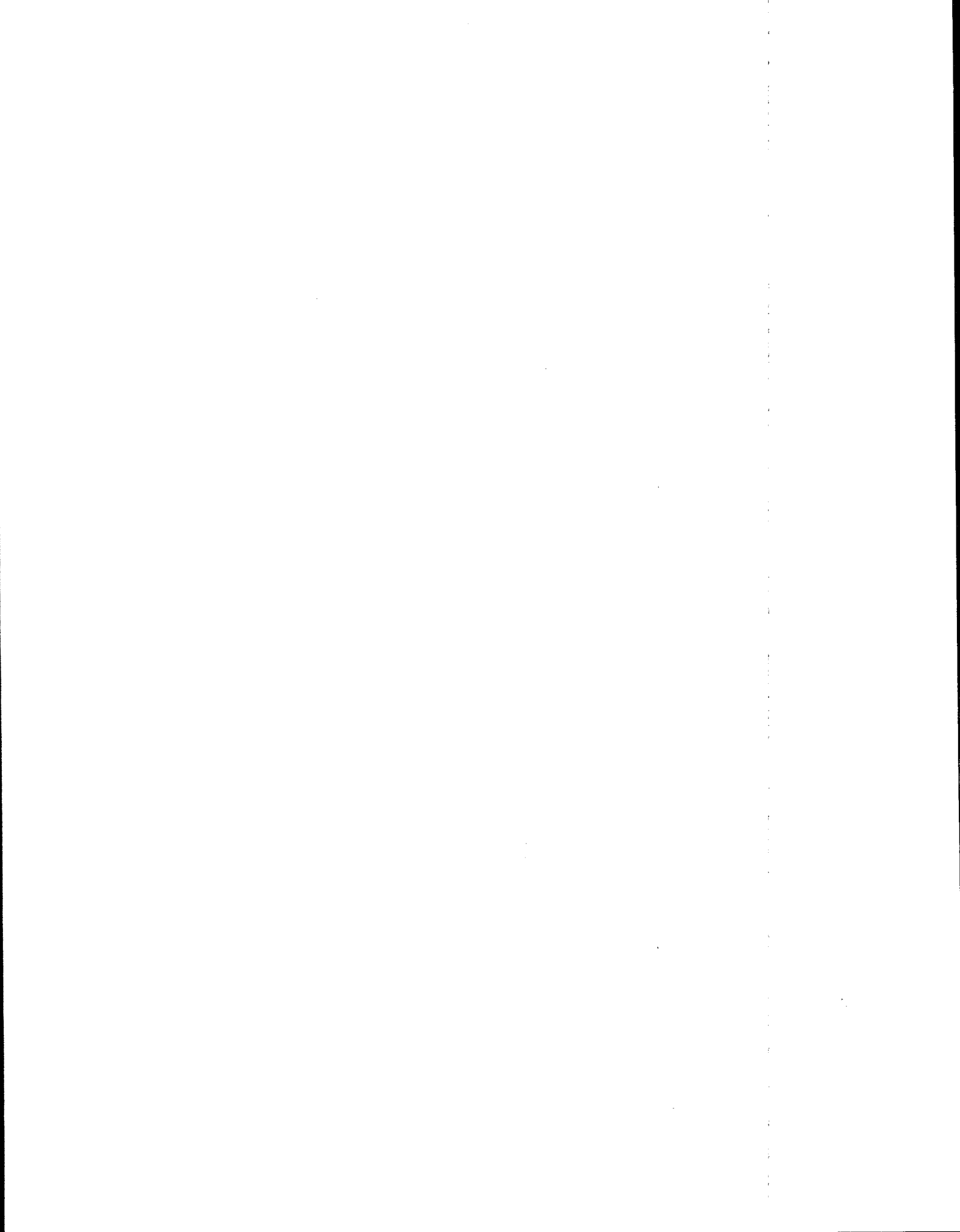
NA = Non Applicable

TABLE 3 (Continued)

SITE Emerging Technology Program Participants

Developer	Technology	Technology Contact	EPA Project Manager	Waste Media	Applicable Waste	
					Inorganic	Organic
Enviro-Sciences, Inc. Randolph, NJ (E02)	Low Energy Solvent Extraction	Zvi Blank 201-361-8840	Jack Hubbard 513-569-7507 FTS 684-7507	Soil, Sediments, Sludge	NA	PCBs, Other Non-specific Organic Compounds
Harmon Environmental Services, Inc. (formerly Enviro Field Services, Inc.) Auburn, AL (E01)	Soil Washing	William Webster 205-821-9253	Jack Hubbard 513-569-7507 FTS 684-7507	Soils	NA	Heavy Organic Compounds
IT Corporation Knoxville, TN (E02)	Batch Steam Distillation/Metal Extraction	Robert Fox 615-690-3211	Ronald Lewis 513-569-7856 FTS 684-7856	Soil, Sludge	Non-specific	Non-specific
Membrane Technology and Research, Inc. Menlo Park, CA (E02)	Membrane Process for Removal of Volatile Organics from Contaminated Air Streams	J.G. Wijmans 415-328-2228	Paul dePercin 513-569-7797 FTS 684-7797	Gaseous Waste Streams	NA	Halogenated and Nonhalogenated Compounds
University of Washington, Dept. of Civil Engineering Seattle, WA (E02)	Adsorptive Filtration	Mark Benjamin 206-543-7645	Norma Lewis 513-569-7665 FTS 684-7665	Ground Water, Leachate, Wastewater	Metals	NA
Wastewater Tech. Centre Burlington, Ontario (E02)	Cross-Flow Pervaporation System	Abbas Zaidi 416-336-4605	John Martin 513-569-7758 FTS 684-7758	Ground Water, Leachate, Wastewater	NA	Volatile Organic Compounds
Western Research Institute Laramie, WY (E01)	Contained Recovery of Oily Wastes (CROW)	Wesley Barnes 307-721-2011	Eugene Harris 513-569-7862 FTS 684-7862	Soil	NA	Coal Tar Derivatives, Petroleum Byproducts

NA = Non Applicable



ATOMIC ENERGY OF CANADA LTD. (Chemical Treatment/Ultrafiltration)

TECHNOLOGY DESCRIPTION:

Ultrafiltration can be applied in combination with chemical treatment to selectively remove dissolved metal ions from dilute aqueous solutions. A high molecular weight chelating agent is added to the incoming waste solution to form macromolecular complexes. The metal ions can then be easily removed.

Usually, each chelating polymer is marked particularly for one metal cation or for a group of similar cations. Once the polymer is added, the solution is processed through an ultrafiltration membrane system that collects the macromolecular complexes (retentate) on the membrane but allows uncomplexed ions such as sodium, potassium, calcium, chloride, sulfate, and nitrate, to pass through as filtered water (permeate). The filtered water can be recycled or discharged depending upon the metal removal requirements. A removal efficiency approaching 100 percent can be achieved for metal ions in groundwater.

The retentate, which constitutes about 5 to 20 percent of the feed volume, contains the separated heavy metal ions and must be treated further. The retentate is either solidified to prevent the release of toxic metals back to the environment or recycled through the treatment process for further volume reduction.

Since many simple and non-toxic ions are allowed to pass through the membrane as permeate, they are not concentrated together with the metal ions. The retentate will have a smaller volume and the solidified product will be more resistant to leaching, due to its smaller salt content and the presence of chemicals that retard the migration of toxic metals.

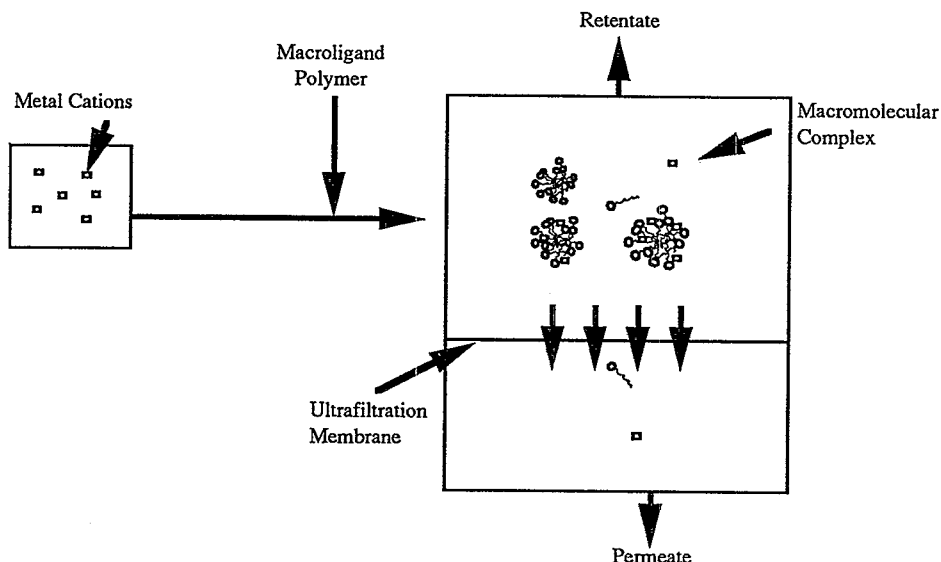


Figure 1. The concept of selective removal of heavy metals from leachate.

WASTE APPLICABILITY:

The combination chemical-ultrafiltration treatment process is intended for use on toxic metals in groundwater. Ultrafiltration has so far been applied exclusively to the removal of colloidal solids and fairly large molecules. The technology may potentially be used to separate toxic heavy metal ions such as cadmium, chromium, lead, mercury, selenium, silver and barium (as an in-situ formed precipitate) from groundwater generated at Superfund sites. Other inorganic and organic materials present as suspended and colloidal solids may also be removed.

STATUS:

Second-year funding for the project has been approved. Bench-scale tests were conducted on pure water to determine operating parameters and membrane-fouling behavior. Four ions were tested: cadmium, mercury, lead, and arsenic. The experimental design included five variables, each at two levels: pH, membrane type, polyelectrolyte type, polyelectrolyte concentration, and presence of organics.

The experiments were designed to identify dominant variables affecting membrane fouling as well as metal removal efficiencies. Results of these tests showed the following removal rates: cadmium and mercury, up to 99%; lead, 90%; and arsenic, 10 to 35%. Arsenic is an anionic species, and is not as effectively removed as the other metals. Separation of non-arsenic metals was found to be more efficient in alkaline conditions. Both water-soluble polymers that were studied were found to be good complexing agents for metal ions. This research also indicated that ultrafiltration, unlike conventional precipitation technologies, does not require the production of large particles, and thus may be more applicable to feed streams with high variability in metals concentration.

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Technology Profile

Emerging Program

November 1989

BABCOCK & WILCOX CO. (Cyclone Combustor)

TECHNOLOGY DESCRIPTION:

This cyclone furnace technology is designed to decontaminate wastes containing both organic and metal contaminants. The cyclone furnace expects to retain heavy metals in a non-leachable slag and vaporizes and incinerates the organic materials in the waste.

The cyclone combustor (Figure 1) is designed to achieve very high heat release rates and temperatures by inducing swirl in the incoming combustion air. High swirl efficiently mixes air and fuel, and increases combustion gas residence time. The burner is fired with coal. Fly ash and particulates from the waste are retained along the walls of the combustor by the swirling action of the combustion gas, and are incorporated into slag that forms along the furnace's walls.

WASTE APPLICABILITY:

This technology is applicable to solids/soil contaminated with organic compounds and metals.

STATUS:

This technology was accepted into the SITE Emerging Program in October 1989. This project is currently being initiated.

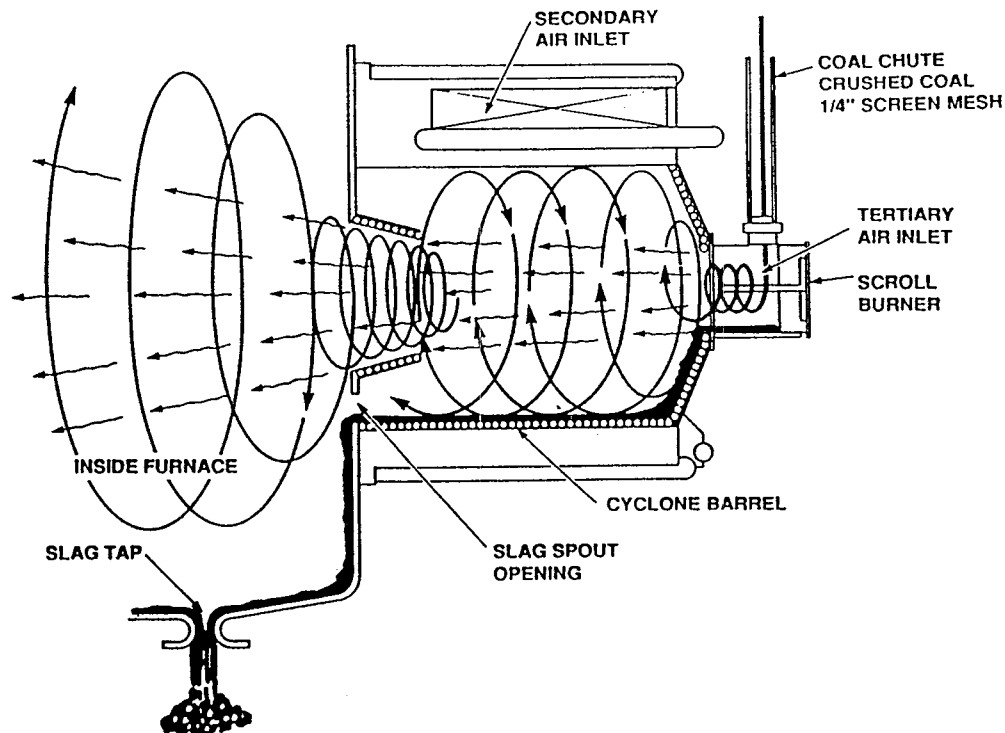


Figure 1. B&W pilot cyclone furnace.

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BATTELLE MEMORIAL INSTITUTE (In-Situ Electroacoustic Decontamination)

TECHNOLOGY DESCRIPTION:

This technology is used to decontaminate soils containing hazardous organics in-situ, by applying electrical (direct current) and acoustic fields. These direct currents facilitate the transport of liquids through soils. The process consists of electrodes (an anode and a cathode) and an acoustic source (Figure 1).

The double-layer boundary theory plays an important role when an electric potential is applied to soils. For soil particles, the double layer consists of a fixed layer of negative ions that are firmly held to the solid phase and a diffuse layer of cations and anions that are more loosely held. Applying an electric potential to the double layer displaces the loosely held ions to their respective electrodes. The ions drag water along with them as they move toward the electrodes.

Besides the transport of water through wet soils, the direct current produces other effects, such as ion transfer, development of pH gradients, electrolysis, oxidation and reduction,

and heat generation. The heavy metals present in contaminated soils can be leached out or precipitated out of solution by electrolysis, oxidation and reduction reactions, or ionic migration. The contaminants in the soil may be cations, such as cadmium, chromium, and lead; and anions, such as cyanide, chromate, and dichromate. The existence of these ions in their respective oxidation states depends on the pH and concentration gradients in the soil. The electric field is expected to increase the leaching rate and precipitate the heavy metals out of solution by establishing appropriate pH and osmotic gradients.

When properly applied in conjunction with an electric field and water flow, an acoustic field can enhance the dewatering or leaching of wastes such as sludges. This phenomenon is not fully understood. Another potential application involves recovery well clogging. Since contaminated particles are driven to the recovery well, the pores and interstitial spaces in the soil can become plugged. This technology could be used to clear these clogged spaces.

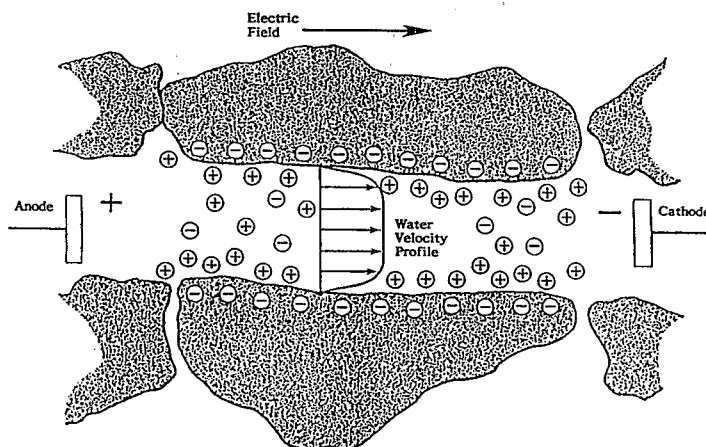


Figure 1. Electroosmosis principle.

WASTE APPLICABILITY:

Since the technology depends on surface charge, fine-grained clay soils are ideal. The technology's potential for improving non-aqueous phase liquid (NAPL) contaminant recovery and in-situ removal of heavy metals will be tested on a pilot-scale using clay soils.

STATUS:

Second-year funding for the project has not been approved. Phase I results indicate that electroacoustical decontamination is technically feasible for removal of inorganic species, such as zinc and cadmium, from clayey soils, and only marginally effective for hydrocarbon removal. To date, it has not been applied to in-situ site remediation.

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Technology Profile

Emerging Program

SITE
SUPERFUND INNOVATIVE
TECHNOLOGY EVALUATION

November 1989

BIO-RECOVERY SYSTEMS, INC. (Biological Sorption)

TECHNOLOGY DESCRIPTION:

The AlgaSORB™ sorption process is designed to remove heavy metal ions from aqueous solutions. The process is based upon the natural affinity in the cell walls of algae for heavy metal ions.

The sorption medium is comprised of algal cells immobilized in a silica gel polymer. This immobilization serves two purposes: (1) it protects the algal cells from decomposition by other microorganisms, and (2) it produces a hard material that can be packed into chromatographic columns which, when pressurized, still exhibit good flow characteristics.

The system functions as a biological ion-exchange resin to bind both metallic cations (positively charged ions) and metallic oxoanions (large, complex, oxygen-containing ions with a negative charge). Anions such as chlorides or sulfates are only weakly bound or not bound at all. Like ion-exchange resins, the algae-silica system can be recycled. However, in contrast to current ion-exchange technology, the components of hard water (Ca^{+2} , Mg^{+2}) or monovalent cations (Na^+ , K^+) do not significantly interfere with the binding of toxic, heavy metal ions to the algae-silica matrix.

Once the media is saturated, the metals are stripped from the algae using acids, bases, or other suitable reagents. This produces a small volume of very concentrated metal-containing solutions that must be further treated to detoxify them.

Figure 1 shows a prototype portable effluent treatment equipment (PETE) unit, consisting of two columns operated in series. Each column contains 0.25 cubic feet of AlgaSORB. The unit is capable of treating flows of approximately one gallon per minute (gpm).

Larger systems have been designed and manufactured to treat flow rates greater than 100 gpm.

WASTE APPLICABILITY:

This technology is useful for removing metal ions from groundwaters or surface leachates that are "hard" or contain high levels of dissolved solids. Rinse waters from electroplating, metal finishing, and printed circuit board manufacturing industries can also be treated.

The system can remove heavy metals such as aluminum, cadmium, chromium, cobalt, copper, gold, iron, lead, manganese, mercury, molybdenum, nickel, platinum, silver, uranium, vanadium, and zinc.

STATUS:

This is a one-year project and the final report is in preparation. The sorption process was tested on mercury-contaminated groundwater at a hazardous waste site in Oakland, CA, in the Fall of 1989.

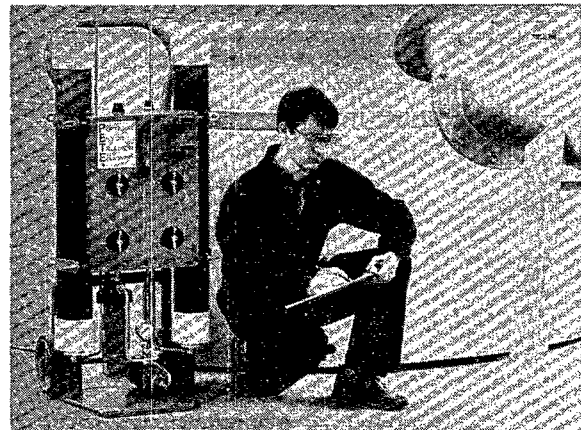


Figure 1. The PETE unit.

STATUS: (continued)

Testing was designed to determine optimum flow rates, binding capacities, and efficiency of stripping agents. The process is being commercialized for groundwater treatment and industrial point source treatment.

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COLORADO SCHOOL OF MINES (Wetlands-Based Treatment)

TECHNOLOGY DESCRIPTION:

The constructed wetlands-based treatment technology uses natural geochemical and biological processes inherent in a man-made wetland ecosystem (Figure 1) to accumulate and remove metals from influent waters. The treatment system incorporates principal ecosystem components found in wetlands, including organic soils, microbial fauna, algae, and vascular plants.

Influent waters, which contain high metal concentrations and have low pH, flow through the aerobic and anaerobic zones of the wetland ecosystem. Metals are removed by filtration, ion exchange, adsorption, absorption, and precipitation through geochemical and microbial oxidation and reduction. In filtration, metal flocculates and metals that are adsorbed onto fine sediment particles settle in quiescent ponds, or are filtered out as the water percolates through the soil or the plant canopy. Ion exchange occurs as metals in the water come into contact with humic or other organic substances in the soil medium. Oxidation/reduction reactions that occur in the aerobic/anaerobic zones, respectively, play a major role in removing metals as hydroxides and sulfides.

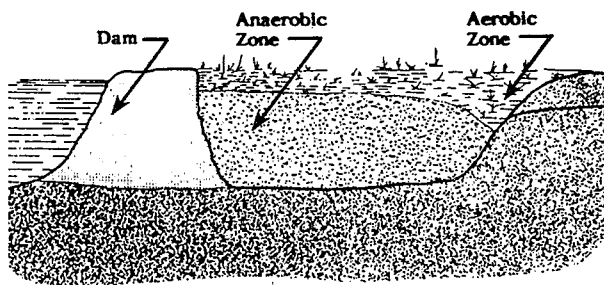


Figure 1. Typical wetland ecosystem.

WASTE APPLICABILITY:

The wetlands-based treatment process is suitable for acid mine drainage from metal or coal mining activities. These wastes typically contain high metals concentrations and are acidic in nature. Wetlands treatment has been applied with some success on wastewater in the eastern regions of the United States. The process may have to be adjusted to account for differences in geology, terrain, trace metal composition, and climate in the metal mining regions of the western United States.

STATUS:

Second-year funding for the project has been approved. A pilot-scale system has been built to assess the effectiveness of constructed wetlands in treating the effluent from the Big Five Tunnel near Idaho Springs, Colorado. Optimum results from the first year of operation are given below.

- pH raised from 2.9 to 6.5
- Cu reduced to below detection limit
- Zn reduced by 97%
- Fe reduced by 80%
- Al, Cd, and Pb decreased 90-100%
- Co and Ni decreased 50%
- Biototoxicity to fathead minnows and Ceriodaphnia reduced by factors of 4 to 20

Further candidate sites for this technology include California Gulch and Clear Creek/Central City in Colorado and the New Jersey zinc mine near Minturn, Colorado.

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ELECTRO-PURE SYSTEMS, INC. (Alternating Current Electrocoagulation Process)

TECHNOLOGY DESCRIPTION:

An alternating current electrocoagulator imposes an electric field on stable suspensions and emulsions and rearranges surface charges, which in turn facilitates particle flocculation and separation. Liquid/liquid and solid/liquid phase separations are achieved without the use of expensive polyelectrolytes. The process is also free of the excess waste solids attributed to chemical aids.

This technology is used to break stable aqueous suspensions containing submicron-sized particles up to 5 percent total solids. It also breaks stable aqueous emulsions containing up to 5 percent oil.

Figure 1 depicts the basic alternating current electrocoagulation (AC/EC) process. An electrocoagulator provides alternating current through aluminum electrodes spaced at nominal distances of 1/2 to 2 inches. The electrocoagulator is small, has no moving parts and can usually be integrated with existing processes as a pre-treatment or polishing step.

Coagulation and flocculation occur simultaneously within the electrocoagulator and continue in the product separation step. The redistribution of charges and onset of coagulation occur within the coagulator as a result of exposure to the electric field and dissociated catalytic precipitation of aluminum from the electrodes. This activity occurs rapidly (often within 30 seconds) for most aqueous suspensions. Aqueous emulsions take a little longer, approximately 2 minutes. Once the redistribution of charges and the onset of coagulation occur, treatment is complete and the suspension/emulsion may be transferred by gravity flow to the product separation step.

Product separation is accomplished in conventional gravity separation and/or decant vessels. Coagulation and flocculation continue until complete phase separation is achieved. Generally, the rate of separation is faster than with methods that employ chemical flocculants, and the solids are often more dense than those resulting from chemical treatment. Waste is removed using surface skimming, bottom scraping, and decanting.

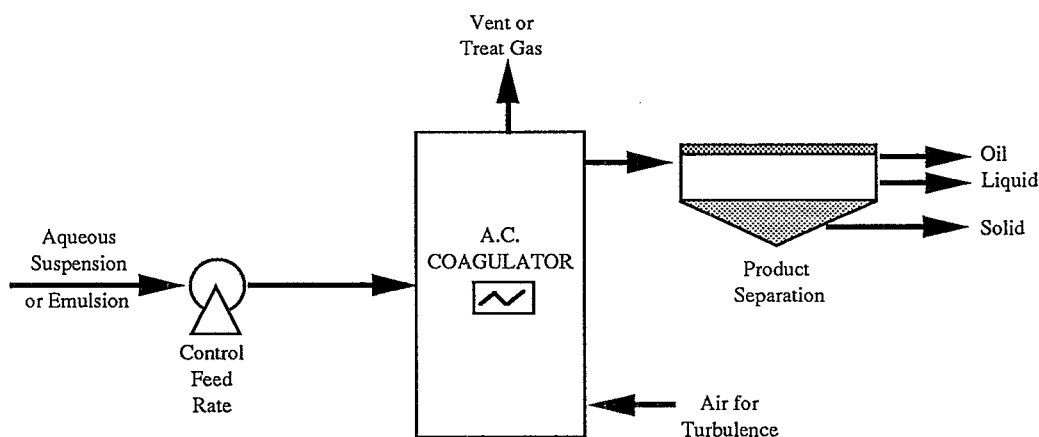


Figure 1. Alternating current electrocoagulation basic process flow.

In many applications, electrocoagulator performance may be improved by mixing the suspension/emulsion as it passes through the electric field. Turbulence can be induced by diffusing small air bubbles through the suspension in the space between the electrodes. System designs can include air emission controls using available conventional technologies as necessary.

After the product separation step, each phase (oil, water, solid) is removed for reuse, recycling, further treatment or disposal. The technology can be employed along or in conjunction with conventional water treatment systems, including those relying on metal precipitation, membrane separation technologies, mobile dewatering and incineration units, and soil extraction systems. A typical decontamination application, for example, would result in a water phase that could be discharged directly to a stream or to a local wastewater treatment plant for further treatment. The solid phase, after dewatering, would be shipped off-site for disposal, and the dewatering filtrate recycled. Any floatable material would be reclaimed, refined, or otherwise recycled or disposed.

WASTE APPLICABILITY:

The AC/EC technology can be applied to a variety of aqueous-based suspensions and emulsions typically generated as contaminated groundwater, surface run-off, landfill leachate, truck wash, scrubber solutions, treated effluents, and extract solutions. The suspensions include solids such as: inorganic and organic pigments, clays, metallic powders, metal ores, and natural colloidal matter. The emulsions include an array of organic solid and liquid contaminants including petroleum based byproducts.

AC/EC has been used to remove fines from coal washwaters and colloidal clays from mine ponds in capacities up to 750 gpm. It has also been used to remove suspended solids and heavy metals from pond water and creosote-based contaminants from groundwater.

STATUS:

This technology was accepted into the SITE Emerging Program in October 1989. AC/EC will be further developed for use at Superfund sites. Risk minimization and economic viability of the process will be assessed.

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Technology Profile

Emerging Program



November 1989

ENERGY AND ENVIRONMENTAL ENGINEERING, INC. (Laser Stimulated Photochemical Oxidation)

TECHNOLOGY DESCRIPTION:

This technology is designed to photochemically oxidize organic compounds in wastewater by applying ultraviolet radiation using an Excimer laser. The photochemical reactor is capable of destroying very low concentrations of organic molecules. The energy is sufficient to fragment the aromatic ring of organic compounds, but the radiation is not absorbed to any significant extent by the water molecules in the solution. The process is envisioned as a polishing step in treating organic contamination in ground water drawn from a hazardous waste site or industrial wastewater prior to discharge.

The existing process equipment has a capacity of 10 gallons per minute. It consists of a filtration unit and the photolysis reactor (Figure 1). The system can be used in the field, with the hardware components skid-mounted and stationed at a site. The exact makeup of the process will depend on the chemical composition of the ground water being treated. Chemical precipitation of heavy metals may be necessary. Carbon adsorption may also be required if the water contains high concentrations of organics.

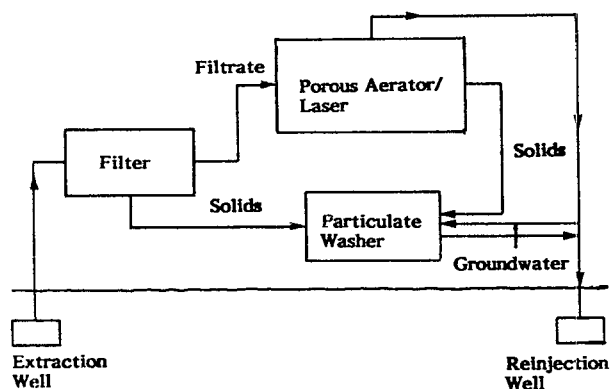


Figure 1. Diagram of the pilot scale laser-stimulated photolysis process.

Typically, contaminated ground water is pumped from a feed well through a filter unit to remove suspended particles. The filtrate is then fed to the photochemical reactor and irradiated. Air is introduced to the solution in the reactor to maintain the dissolved oxygen required for oxidation.

The detoxified water (containing carbon dioxide, hydrogen chloride, and some volatile organics) is sent to a degassing unit, where volatile materials are released to the atmosphere. Part of the detoxified ground water is reinjected into the ground, and the rest is recycled to wash the particulate matter separated in the filtration unit. Washing with detoxified ground water causes organics to desorb from the particulate matter. The washwater is then combined with the filtrate stream and returned to the photochemical reactor to further destroy the organics. The cleaned particulate matter may then be disposed of.

WASTE APPLICABILITY:

This technology can be applied to ground water and industrial wastewater containing organics. In the laboratory, this process has been used to destroy benzene, chlorinated benzenes, and phenol. Aeration just prior to treatment appears to aid in destroying the organic molecules. The most efficient destruction of chlorobenzene occurs with concentrations of 12.5 to 50 mg/L; efficiency is less when the concentrations are either too low (3 mg/L) or too high (100 mg/L).

STATUS:

Second-year funding for the project has been approved. Testing is continuing on the types of compounds that can be destroyed using this technology. A leachate containing phenols will be tested, and a revised pilot-scale unit built incorporating operational changes suggested by the results to date. One major change will be to shorten the length of the reaction chamber; almost all of the reaction occurs in the first few inches of the chamber.

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Technology Profile

Emerging Program



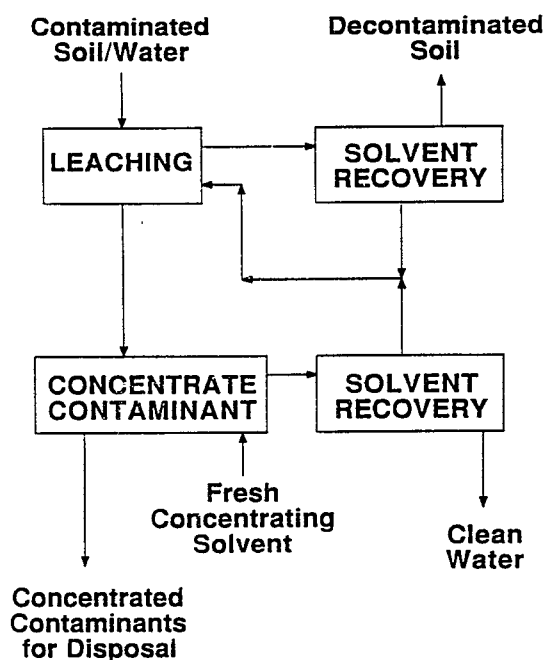
November 1989

ENVIRO-SCIENCES, INC. (Low Energy Solvent Extraction Process)

TECHNOLOGY DESCRIPTION:

The Low Energy Solvent Extraction Process (LEEP) uses common organic solvents to extract organic pollutants from soils and sediments. This process converts a high volume solid waste stream into a low volume liquid waste stream. The organic contaminants are removed from the solid matrix with a water leaching solvent and are then concentrated in a water-immiscible stripping solvent. The leaching solvent is recycled internally and the stripping solvent, containing virtually all the contaminants, leaves the process for final destruction.

The LEEP technology operates at ambient conditions, and the use of simple equipment results in a low energy process.



WASTE APPLICABILITY:

The LEEP technology is effective with PCBs and other organic contaminants from soils, sludges and sediments from harbors rivers and lagoons.

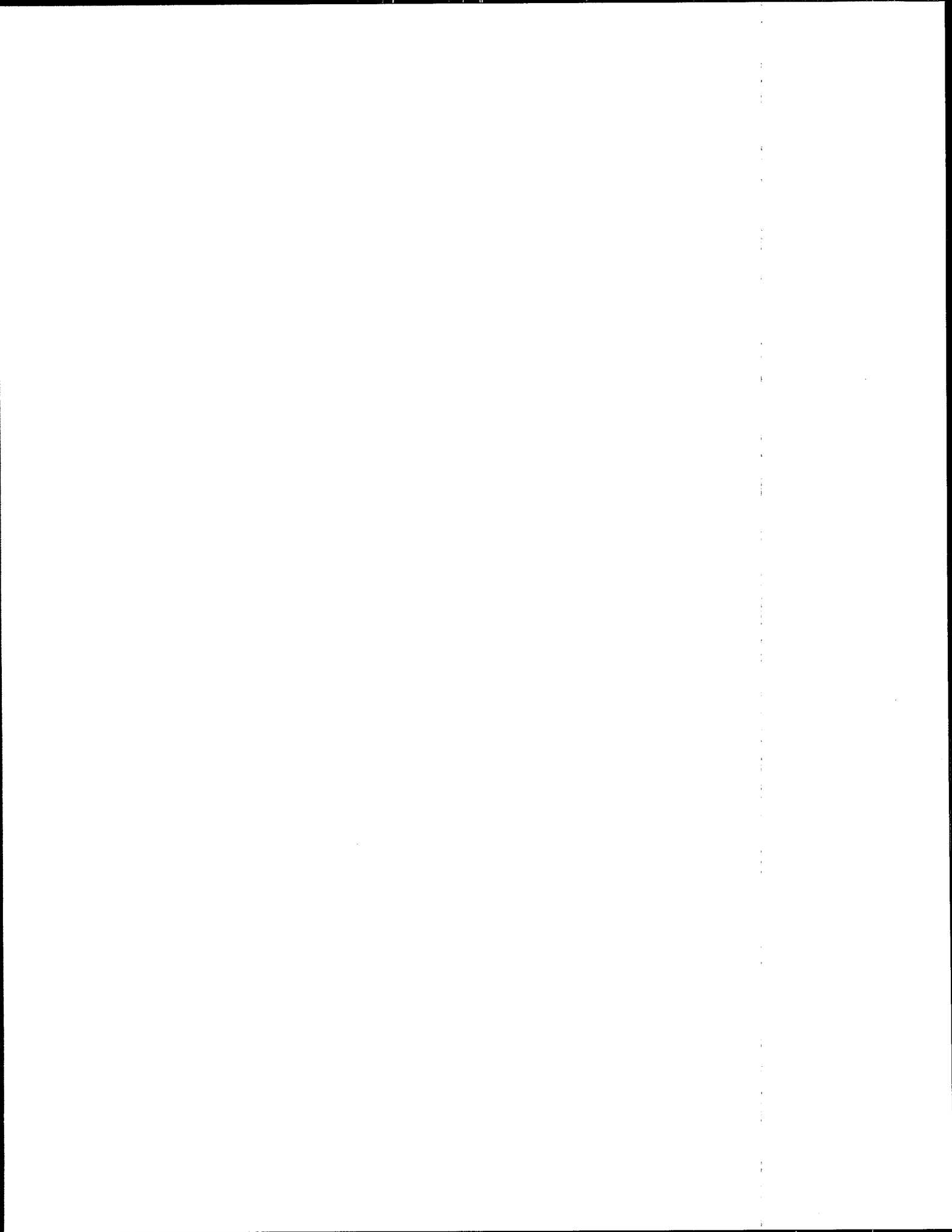
STATUS:

This technology was accepted into the SITE Emerging Program in October 1989. This project was accepted into the Emerging Technologies Program in June 1989. The developer has submitted a work plan and is preparing a quality assurance project plan. The technology is currently available for bench-scale treatability studies. Engineering, design, and construction of the pilot test bed are underway and the developer projects that the LEEP technology can be offered for pilot-scale treatability studies by the Spring of 1990.

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HARMON ENVIRONMENTAL SERVICES, INC. (Soil Washing)

TECHNOLOGY DESCRIPTION:

Solvent washing is a method of cleaning soils contaminated with heavy organic compounds, such as PCBs (polychlorinated biphenyls) and chlorodibenzodioxins (dioxins). This method is based on a patented solvent blend that has successfully reduced PCB concentrations in soil to less than 2 ppm, the level at which soil can be placed at the site without containment. The solvent used in soil washing is critical to the success of the system. It should be immiscible with water (so that the water naturally found on the soil will be displaced), and be able to break up soil clods without grinding or shredding. Depending on the solvent used, this technology can be tailored to remove most organic constituents from solid matrices.

The solvent washing process is analogous to dry-cleaning clothing (Figure 1). A soil/solvent contactor is used to mix contaminated solids with a solvent. The mixture is agitated for an appropriate length of time (usually one hour), and then the solvent with the dissolved organic contaminant is drawn off. A fraction of the

solvent remains mixed with the solids. The solvent is typically removed by subsequent washes until the solid is sufficiently decontaminated.

The solvent from each wash is delivered to a reclamation system, where it is distilled. The contaminant is concentrated as a still bottom. The still bottom, a small volume of the original soil, and a liquid residue can be further treated off- or on-site depending on economics and other considerations. Once the desired level of decontamination is achieved, the residual solvent is removed from the soil by steam stripping. To facilitate this removal, a solvent with a high vapor pressure should be used.

Aqueous discharges of this process are limited to non-contact cooling water and the water that is initially present in the soil. The latter discharge is a very clean, low-volume material that typically does not require additional treatment prior to discharge.

Unlike high-temperature processes such as incineration, this process leaves the base matrix unchanged. This technology produces clean soil suitable for sustaining vegetation. Process equipment is mobile, operates at low temperatures, is totally enclosed (thereby producing virtually no air emissions) and generates very few residual wastes.

WASTE APPLICABILITY:

This technology has been shown to successfully clean metal foil, paper and sand, clay soils, high-organic soils, and soils mixed with organic matter (such as leaves). It can be applied to soil contaminated with high molecular weight organic compounds, including PCBs and dioxins. Although the work to date has emphasized PCB decontamination, tests show that the technology can also remove chlorodibenzofurans and most types of petroleum products and oils.

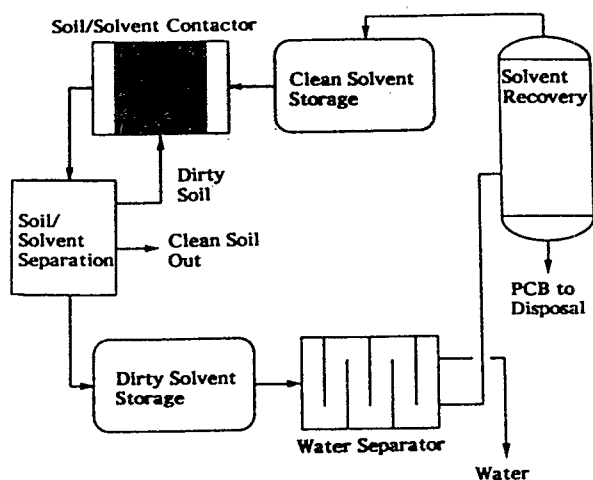


Figure 1. Simplified process schematic.

STATUS:

Second-year funding for the project has been approved. Laboratory and pilot-scale programs are complete, and an interim report has been prepared.

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IT CORPORATION (Batch Steam Distillation/Metal Extraction)

TECHNOLOGY DESCRIPTION:

The Batch Steam Distillation/Metal Extraction treatment process is a two-stage system to treat soils contaminated with both organics and inorganics. This technology uses conventional, readily available process equipment, and does not produce hazardous combustion products. Hazardous materials are separated from soils as concentrates, which can then be disposed of or recycled. After treatment, the soil is decontaminated and may be returned to the site.

Volatile organics are separated from the feed waste (soil) by direct steam injection (Figure 1). The resulting vapors are condensed and decanted to separate organic liquids from the aqueous phase. The soil is then transferred as a slurry to the metals extraction step (Figure 2). Condensed water from this step can be recycled through the system after further treatment to remove soluble organics.

After the volatiles are separated, heavy metals are removed from the soil slurry by hydrochloric acid. After contact with the acid, the solids are settled out, and the acid solution

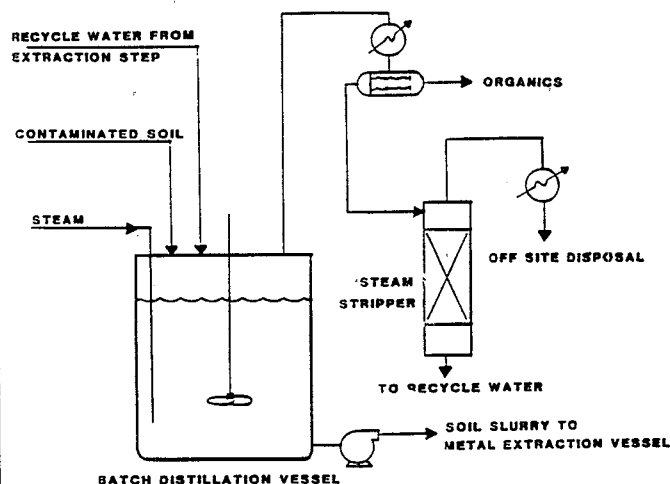


Figure 1. Batch steam distillation step.

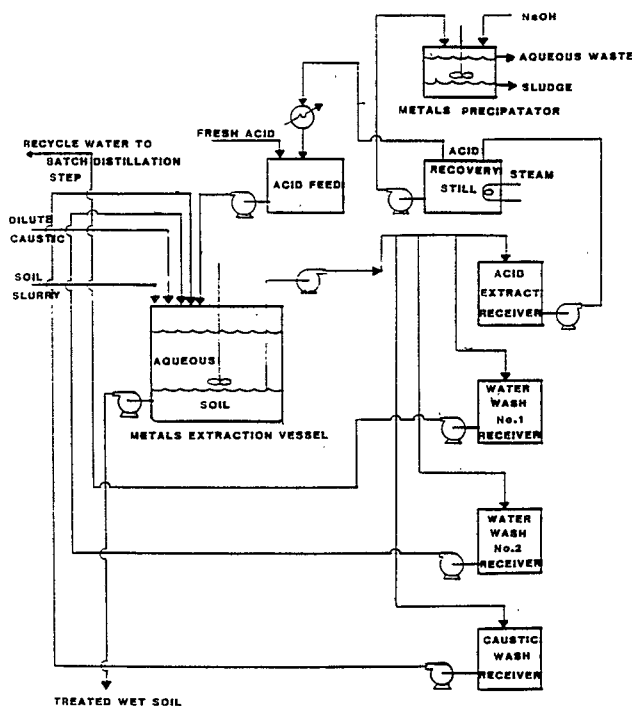


Figure 2. Metals extraction step.

containing the metals is pumped out. Most heavy metals are converted to chloride salts in this step. This stream is then charged to a batch distillation system, where hydrochloric acid is recovered. The bottoms from this still, containing the heavy metals, are precipitated as hydroxide salts, and drawn off as a sludge for off-site disposal or recovery.

WASTE APPLICABILITY:

This process is applicable to soils contaminated with both organics and heavy metals.

STATUS:

This technology was accepted into the SITE Emerging Program in October 1989. The technology has been tested in the laboratory on a limited basis, and has been effective in removing volatile and semi-volatile organics from sludges. In a separate study, bench-scale tests on representative soils showed that some heavy metals can be removed as chloride salts by hydrochloric acid extraction.

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Technology Profile

Emerging Program

SITE
SUPERFUND INNOVATIVE
TECHNOLOGY EVALUATION

November 1989

MEMBRANE TECHNOLOGY AND RESEARCH, INC. (Membrane Process for Removal of Volatile Organics from Contaminated Air Streams)

TECHNOLOGY DESCRIPTION:

This technology uses synthetic polymer membranes to remove organic contaminants from gaseous waste streams. The process has been tested on the bench scale and has achieved removal efficiencies of greater than 90% for selected organics. Organic contaminants are recovered in liquid form, and may be recycled or disposed off-site.

In this process, solvent-laden contaminated air at atmospheric pressure contacts one side of a membrane that is permeable to the organic material but impermeable to air (Figure 1). A partial vacuum on the other side of the membrane draws the organic vapor through the

membrane. The organic vapor is then cooled and condensed. The small volume of air that permeates the membrane is recycled through the system.

The treated stream may be vented, recycled for further use at the site, or passed to an additional treatment step. For more dilute waste streams, a two-stage process is required. Organic vapor is concentrated tenfold in the first stage, and an additional tenfold in the second stage.

The system is transportable, and is significantly smaller than a carbon adsorption system of similar capacity. The process generates a clean air stream and a pure liquid product stream

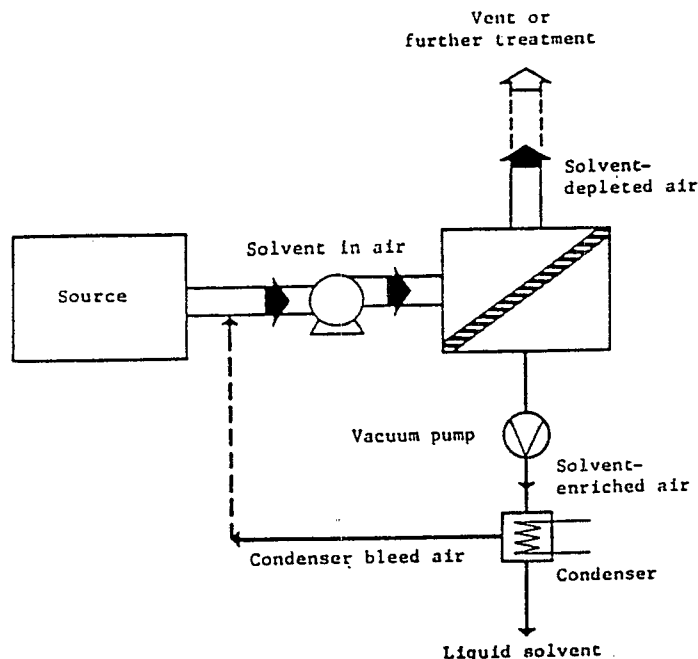


Figure 1. Schematic of a simple one-stage solvent vapor separation and recovery process.

that can be incinerated. Disposal problems associated with adsorption technologies are eliminated.

WASTE APPLICABILITY:

Membrane systems are applicable to small, relatively concentrated streams containing halogenated and nonhalogenated contaminants. A typical application would be the treatment of air stripper effluent before discharging it to the atmosphere.

STATUS:

This technology was accepted into the SITE Emerging Program in October 1989. This technology has been tested on air streams contaminated with organics in concentrations of 500 to 20,000 ppm. A series of tests on waste streams containing octane, toluene, acetone, and 1,1,1-trichloroethane has shown that membrane technology may be applicable to waste streams generated at Superfund sites.

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UNIVERSITY OF WASHINGTON (Adsorptive Filtration)

TECHNOLOGY DESCRIPTION:

This technology uses adsorptive filtration to remove inorganic contaminants (metals) from the liquid phase. An adsorbent, ferrihydrite, is applied to the surface of an inert substrate, such as sand, and placed in a vertical column (Figure 1). The column containing the coated sand acts as a filter and adsorbent. Once the adsorptive capacity of the column is reached, the metals are removed and concentrated for subsequent recovery using a pH-induced desorption process.

The sand is coated by heating an acidic ferric nitrate solution at 110° C. The resulting ferrihydrite-coated sand is insoluble at pHs approaching 0. As a result, very strong acids can be used in the regeneration step to ensure complete metal recovery. There has been no apparent loss of treatment efficiency after

several regeneration cycles. This should result in substantially reduced operating costs. The advantages of this technology over conventional treatment technologies for metals are that it: (1) removes metals present as complexes, including metals complexed with organics; (2) removes anions; and (3) acts as a filter to remove suspended matter from solution.

WASTE APPLICABILITY:

This represents a relatively inexpensive, highly efficient process for removing inorganic contaminants from aqueous waste streams. The control of pH during the adsorption or regeneration step can result in the selective removal of anionic or cationic contaminants. The technology is applicable to aqueous waste streams with a wide range of contaminant concentrations and pH values.

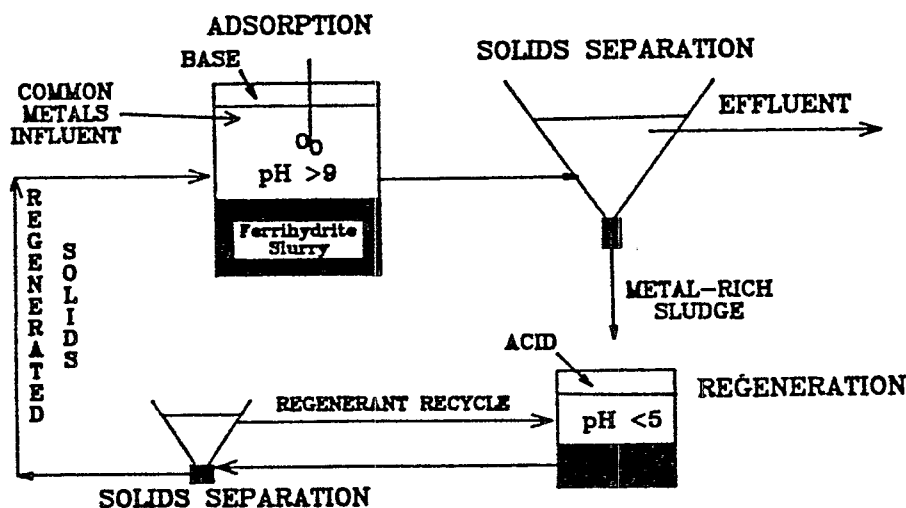


Figure 1. Schematic of treatment system using and recovering ferrihydrite for treating numerous batches of metal-bearing waste.

STATUS:

This technology was accepted into the SITE Emerging Program in October 1989. The technology has been investigated extensively at the bench-scale level. Further bench-scale tests will be performed to establish optimal operating conditions and to evaluate the effects of organic complexation and particulates on treatment efficiency. The first phase of the project was initiated July 20, 1989.

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Technology Profile

Emerging Program

SITE
SUPERFUND INNOVATIVE
TECHNOLOGY EVALUATION

November 1989

WASTEWATER TECHNOLOGY CENTER (Cross-Flow Pervaporation System)

TECHNOLOGY DESCRIPTION:

This membrane technology, called pervaporation, utilizes semi-permeable membranes to separate organic materials from contaminated water. The contaminated water flows on one side of the membrane while a vacuum is applied on the opposite side. The membrane is nearly impervious to water, but allows organic compounds to diffuse through. The vapors, after condensation, represent a small fraction of the feed (much less than 1%) and often separate into an organic phase and an aqueous phase. As opposed to systems that use activated carbon, this membrane process involves no competition between compounds for sites at the membrane surface, since the compounds are absorbed by and pass through the membrane.

Pervaporation also has an advantage when compared to air stripping, since the organic compounds removed from water are concentrated and contained.

The separation unit will be constructed so that contaminated material flows across the outside of hollow fiber membranes while the organic molecules diffuse into the interior of the fibers. This design will minimize chances for plugging or fouling the unit with solids. The hollow fiber membranes will be coated on the outside surface with active polymer. Project objectives include optimizing membrane thickness, developing the prototype module, testing a pilot-plant unit to provide scale-up data, and verifying the economics of the process.

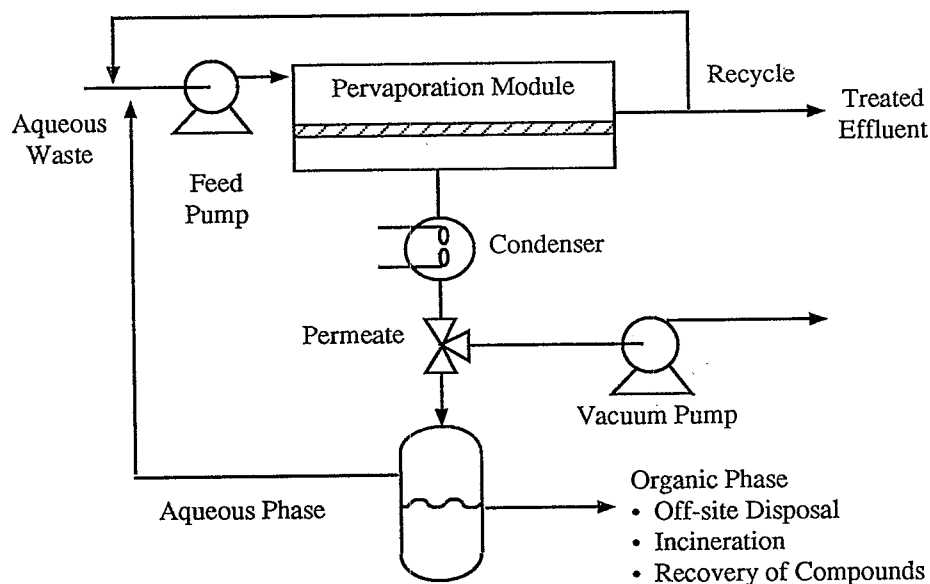


Figure 1. Pervaporation process diagram.

WASTE APPLICABILITY:

The unit is applicable to aqueous waste streams (groundwater, lagoons, leachate, and rinse water) contaminated with volatile organic compounds, such as solvents. The technology is applicable to the types of wastes currently treated by carbon adsorption, air stripping, and reverse osmosis separation.

STATUS:

This technology was accepted into the SITE Emerging Program in October 1989. Work is currently progressing on membrane selection. Design and construction of the pilot unit should begin during the spring of 1990.

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WESTERN RESEARCH INSTITUTE (Contained Recovery of Oily Wastes)

TECHNOLOGY DESCRIPTION:

The Contained Recovery of Oily Wastes (CROW) process involves adaptation of technology presently used for secondary petroleum recovery and for primary production of heavy oil and tar sand bitumen. Steam and hot water displacement moves the accumulated oily wastes and water above ground for treatment.

Injection and production wells are first drilled into soil contaminated with oily wastes (Figure 1). Low-quality steam is then injected below the deepest penetration or organic liquids. The steam condenses, causing rising hot water to dislodge and sweep buoyant organic liquids upward into the more permeable soil regions. Hot water is injected above the impermeable soil regions to heat and mobilize the oil waste accumulations, which are recovered by hot-water displacement.

When the oily wastes are displaced, the organic liquid saturations in the subsurface pore space increase, forming an oil bank. The hot water injection displaces the oil bank to the production well. Behind the oil bank, the oil saturation is reduced to an immobile residual saturation in the subsurface pore space. The oil and water produced is treated for reuse or discharge.

In-situ biological treatment follows the displacement and continues until ground water contaminants are no longer detected in any water samples from the site. During treatment, all mobilized organic liquids and water soluble contaminants are contained within the original boundaries of oily waste accumulations. Hazardous materials are contained laterally by groundwater isolation and vertically by organic liquid floatation. Excess water is treated in compliance with discharge regulations.

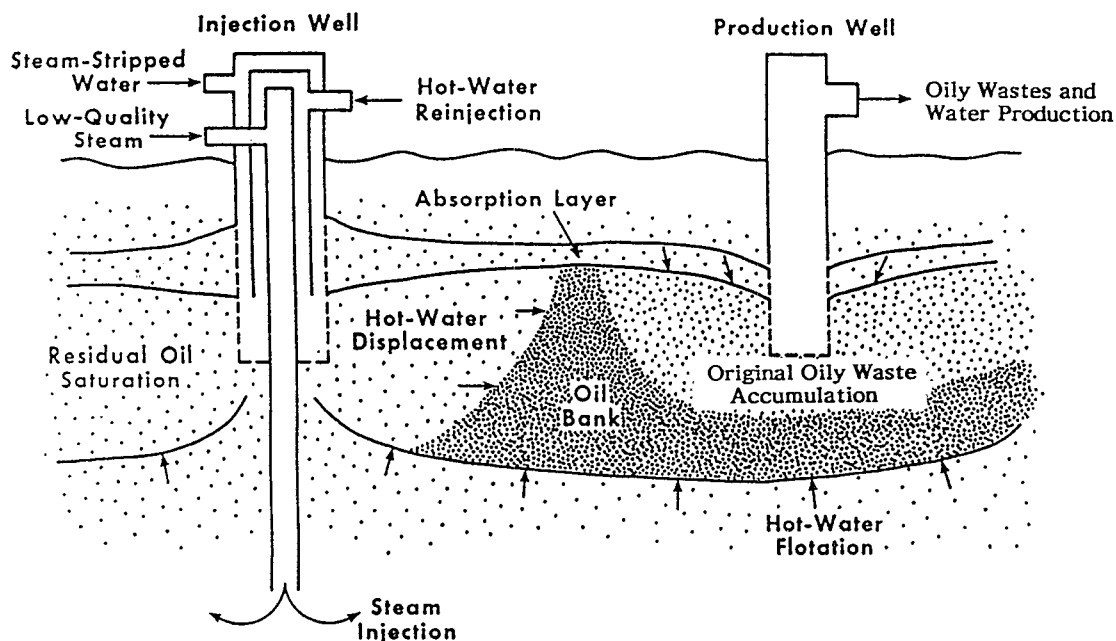


Figure 1. CROW process schematic.

The process removes large portions of oily waste accumulations; stops the downward migration of organic contaminants; immobilizes any residual saturation of oily wastes; and reduces the volume, mobility and toxicity of oily wastes. It can be used for shallow and deep contaminated areas, and uses the same mobile equipment as required by conventional petroleum production technology.

WASTE APPLICABILITY:

This technology could be applied to manufactured gas plant sites, woodtreating sites and other sites with soils containing organic liquids, such as coal tars, pentachlorophenol solutions, creosote, and petroleum byproducts.

STATUS:

Second-year funding for the project has been approved. This technology is being tested at laboratory and pilot-scale. The tests are expected to closely resemble previous laboratory tests in tar sand bitumen recovery using steamflood technology. A number of hot water leaching tests have been completed.

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INFORMATION REQUEST FORM

The EPA Risk Reduction Engineering Laboratory is responsible for testing and evaluating technologies used at Superfund site cleanups. To receive publications about these activities, indicate your area of interest by checking the appropriate box(es) below and mail the top half of this sheet to the following address:

Technical Information Manager
Risk Reduction Engineering Laboratory
U.S. Environmental Protection Agency
26 W. Martin Luther King Drive
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(Ma 15) ☐ Superfund
(Ma 16) ☐ Superfund Innovative Technology Evaluation
(SITE) Program

Name _____
Firm _____
Address _____
City, State, Zip Code _____

The U.S. Environmental Protection Agency plans to issue two Request for Proposals during the coming year; one in January 1990 for the Demonstration Program (SITE 005), and the other in July 1990 for the Emerging Technologies Program (E04). To receive these RFPs, indicate your area of interest by checking the appropriate box(es) below and mail the bottom half of this sheet to the following address:

U.S. Environmental Protection Agency
Risk Reduction Engineering Laboratory
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Cincinnati, Ohio 45268
Attention: William Frietsch, III

(005) ☐ Demonstration Program RFP
(E04) ☐ Emerging Technologies Program RFP

Name _____
Firm _____
Address _____
City, State, Zip Code _____

