PHARMACIA CORPORATION

(formerly Monsanto/DuPont)

(Lasagna™ In Situ Soil Remediation)

TECHNOLOGY DESCRIPTION:

The Lasagna™ process, so named because of its treatment layers, combines electroosmosis with treatment layers which are installed directly into the contaminated soil to form an integrated, in-situ remedial process. The layers may be configured vertically or horizontally (see figures below). The process is designed to treat soil and groundwater contaminants completely in situ, without the use of injection or extraction wells.

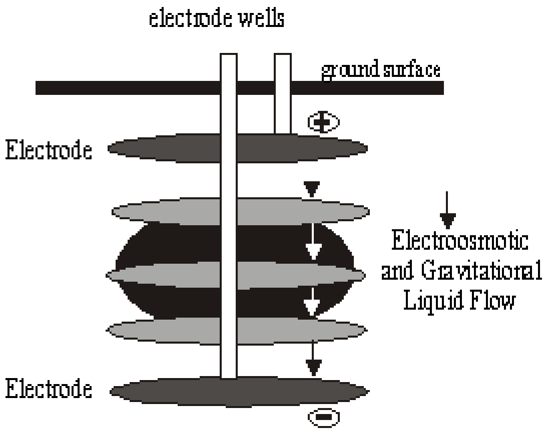
The outer layers consist of either positively or negatively charged electrodes which create an electrical potential field. The electrodes create an electric field which moves contaminants in soil pore fluids into or through treatment layers. In the vertical configuration, rods that are steel or granular graphite and iron filings can be used as electrodes. In the horizontal configuration, the electrodes and treatment zones are installed by hydraulic fracturing. Granular graphite is used for the electrodes and the treatment zones are granular iron (for zero-valent, metal-enhanced, reductive dechloronation) or granular activated carbon (for biodegradation by methanotropic microorganisms).

The orientation of the electrodes and treatment zones depends on the characteristics of the site and the contaminants. In general, the vertical configuration is probably more applicable to more shallow contamination, within 50 feet of the ground surface. The horizontal configuration, using hydraulic fracturing or related methods, is uniquely capable of treating much deeper contamination.

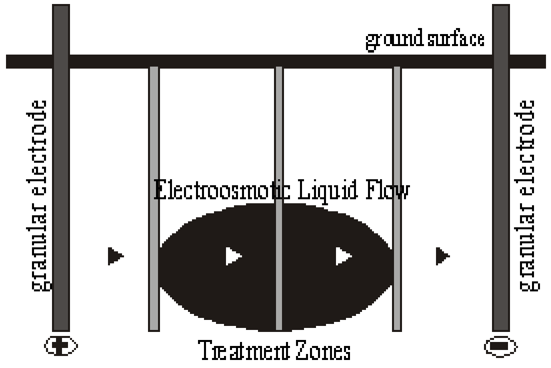
WASTE APPLICABILITY:

The process is designed for use in fine-grained soils (clays and silts) where water movement is slow and it is difficult to move contaminants to extraction wells. The process induces water movement to transport contaminants to the treatment zones so the contaminants must have a high solubility or miscibility in water. Solvents

A. Horizontal Configuration



B. Vertical Configuration



such as trichloroethylene and soluble metal salts can be treated successfully while low-solubility compounds such as polychlorinated biphenyls and polyaromatic hydrocarbons cannot.

STATUS:

The Lasagna™ process (vertical configuration) was accepted into the SITE Demonstration Program in 1995. Two patents covering the technology have been granted to Monsanto, and the term Lasagna™ has also been trademarked by Monsanto. Developing the technology so that it can be used with assurance for site remediation is the overall objective of the sponsoring consortium.

DEMONSTRATION RESULTS:

The vertical configuration demonstration by Pharmacia at the Gaseous Diffusion Plant in Paducah, Kentucky, has been completed. The analysis of trends in TCE contamination of soil before and after Lasagna™ treatment indicated that substantial decreases did occur and the technology can be used to meet action levels.

The horizontal configuration demonstration by the University of Cincinnati and EPA at Rickenbacker ANGB (Columbus, OH) has been completed and both cells decommissioned. The cells were installed in soil containing TCE. The work demonstrated that horizontal Lasagna™ installations are feasible and that the installation results in some treatment of contaminants. The extent of treatment of the TCE-contaminated soil was not clear because of the small size of the cells and transport of TCE into the cells from adjacent contaminated areas.

In cooperation with the U.S. Air Force, EPA installed two horizontal configuration Lasagna™ cells in TCE-contaminated soil at Offutt AFB (Omaha, NE) in November 1998. The cells have been in operation since September 2000. An interim sampling in December 2000 at the four locations with highest concentrations in each cell showed slight decreases in organic chloride in one cell, but these were not statistically different from initial (pretreatment) concentrations. A second interim sampling will be conducted in June 2001 and the final (posttreatment) sampling in September 2001.

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PHYTOKINETICS, INC.
(Phytoremediation Process)

TECHNOLOGY DESCRIPTION:

Phytoremediation is the treatment of contaminated soils, sediments, and groundwater with higher plants. Several biological mechanisms are involved in phytoremediation. The plant's ability to enhance bacterial and fungal degradative processes is important in the treatment of soils. Plant-root exudates, which contain nutrients, metabolites, and enzymes, contribute to the stimulation of microbial activity. In the zone of soil closely associated with the plant root (rhizosphere), expanded populations of metabolically active microbes can biodegrade organic soil contaminants.

The application of phytoremediation involves characterizing the site and determining the proper planting strategy to maximize the interception and degradation of organic contaminants. Site monitoring ensures that the planting strategy is proceeding as planned. The following text discusses (1) using grasses to remediate surface soils contaminated with organic chemical wastes (Figure 1), and (2) planting dense rows of poplar trees to treat organic contaminants in the saturated groundwater zone (Figure 2).

Phytoremediation of Surface Soil

Soil Remediation - Phytoremediation is best suited for surface soils contaminated with intermediate levels of organic contaminants. Preliminary soil phytotoxicity tests are conducted at a range of contaminant concentrations to select plants which are tolerant. The contaminants should be relatively nonleachable, and must be within the reach of plant roots. Greenhouse-scale treatability studies are often used to select appropriate plant species.

Grasses are frequently used because of their dense fibrous root systems. The selected species are planted, soil nutrients are added, and the plots are intensively cultivated. Plant shoots are cut during the growing season to maintain vegetative, as opposed to reproductive, growth. Based on the types and concentrations of contaminants, several growing seasons may be required to meet the site's

Phytoremediation of the Saturated Zone

remedial goals.

Groundwater Remediation - The use of poplar trees for the treatment of groundwater relies in part on the tree's high rate of water use to create a hydraulic barrier. This technology requires the establishment of deep roots that use water from the saturated zone. Phytokinetics uses deep-rooted, water-loving trees such as poplars to intercept groundwater plumes and reduce contaminant levels. Poplars are often used because they are phreatophytic; that is, they have the ability to use water directly from the saturated zone.

A dense double or triple row of rapidly growing poplars is planted downgradient from the plume, perpendicular to the direction of groundwater flow. Special cultivation practices are use to induce deep root systems. The trees can create a zone of depression in the groundwater during the summer months because of their high rate of water use. Groundwater contaminants may tend to be stopped by the zone of depression, becoming adsorbed to soil particles in the aerobic rhizosphere of the trees. Reduced contaminant levels in the downgradient groundwater plume would result from the degradative processes described above.

WASTE APPLICABILITY:

Phytoremediation is used for soils, sediments, and groundwater containing intermediate levels of organic contaminants.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1995. The demonstration occurred at the former Chevron Terminal #129-0350 site in Ogden, Utah. A total of 40 hybrid poplar trees were planted using a deep rooting techniques in 1996 and data were collected through 1999 growing season.

DEMONSTRATION RESULTS:

Water removal rates estimated using a water use multiplier and leaf area index to adjust a reference evapo-ranspiration rate was 5 gallons per day per tree in 1998 and 113 gallons per day per tree in 1999. Water removal rates determined using SAP velocity measurements done in September and October of 1998 agreed closely with the estimated values. Although the trees transpired a volume of water equivalent to a 10-ft thickness of the saturated zone, water table elevation data collected in 1999 did not indicate a depression in the water table.

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PINTAIL SYSTEMS, INC.

(Spent Ore Bioremediation Process)

TECHNOLOGY DESCRIPTION:

This technology uses microbial detoxification of cyanide in heap leach processes to reduce cyanide levels in spent ore and process solutions. The biotreatment populations of natural soil bacteria are grown to elevated concentrations, which are applied to spent ore by drip or spray irrigation. Process solutions are treated with bacteria concentrates in continuous or batch applications. This method may also enhance metal remineralization, reducing acid rock drainage and enhancing precious metal recovery to offset treatment costs.

Biotreatment of cyanide in spent ore and ore processing solutions begins by identifying bacteria that will grow in the waste source and that use the cyanide for normal cell building reactions. Native isolates are ideally adapted to the spent ore environment, the available nutrient pool, and potential toxic components of the heap environment. The cyanide-detoxifying bacteria are typically a small fraction of the overall population of cyanide-tolerant species.

For this reason, native bacteria isolates are extracted from the ore and tested for cyanide detoxification potential as individual species. Any natural detoxification potentials demonstrated in flask cyanide decomposition tests are preserved and submitted for bioaugmentation. Bioaugmentation of the cyanide detoxification population eliminates nonworking species of bacteria and enhances the natural detoxification potential by growth in waste infusions and chemically defined media. Pintail Systems, Inc. (PSI) maintains a bacterial library of some 2,500 strains of microorganisms and a database of their characteristics.

The working population of treatment bacteria is grown in spent ore infusion broths and process solutions to adapt to field operating conditions. The cyanide in the spent ore serves as the primary carbon or nitrogen source for bacteria nutrition. Other required trace nutrients are provided in the chemically defined broths. The bacterial consortium is then tested on spent ore in a 6-inch-by-10-foot column in the field or in the laboratory. The column simulates leach pile conditions, so that detoxification rates, process completion, and effluent quality can be verified. Following column tests, a field test may be conducted to verify column results.

The spent ore is remediated by first setting up a stage culturing system to establish working populations of cyanide-degrading bacteria at the mine site. Bacterial solutions are then applied directly to the heap using the same system originally designed to deliver cyanide solutions to the heap leach pads (see figure on previous page). Cyanide concentrations and leachable metals are then measured in heap leach solutions. This method of cyanide degradation in spent ore leach pads degrades cyanide more quickly than methods which treat only rinse solutions from the pad. In addition to cyanide degradation, biological treatment of heap leach pads has also shown significant biomineralization and reduction of leachable metals in heap leachate solutions.

WASTE APPLICABILITY:

The spent ore bioremediation process can be applied to treat cyanide contamination, spent ore heaps, waste rock dumps, mine tailings, and process water from gold and silver mining operations.

STATUS:

This technology was accepted into the SITE Demonstration Program in May 1994. The field treatability study was conducted, at the Echo Bay/McCoy Cover mine site near Battle Mountain, Nevada, between June 11, 1997 and August 26, 1997.

DEMONSTRATION RESULTS:

Results from the study are summarized below:

- The average % WAD CN reduction attributable to the Biocyanide process was 89.3 during the period from July 23 to August 26. The mean concentration of the feed over this period was 233 ppm, while the treated effluent from the bioreactors was 25 ppm. A control train, used to detect abiotic loss of cyanide, revealed no destruction of cyanide (average control affluent = 242 ppm).
- Metals that were monitored as part of this study were As, Cd, Co, Cu, Fe, Mn, Hg, Ni, Se, Ag, and Zn. Significant reductions were noted fro all metals except Fe and Mn. Average reduction in metals concentration after July 23 for all other metals were 92.7% for As 91.6% for Cd, 61.6% for Co, 81,4% for Cu, 95.6% for Hg, 65.0% for Ni, 76.3% for Se, 94.6% for Ag, and 94.6% for Zn. Reductions for As, Cd, Co, and Se are probably greater than calculated due to non-detect levels in some effluent samples. A biomineralization mechanism is proposed for the removal of metals for solution. Biomineralization is a process in which microbes mediate biochemical reactions forming novel mineral assemblages on solid matrices.
- The Aqueous Biocyanide Process was operated fro two and one-half months. During the first 42 days (June 11 to July 22) system performance was variable, and occasional downtimes were encountered. This was due to greatly higher cyanide and metals concentration in the feed than was encountered during benchscale and design phases of the project. Once optimized for the more concentrated feed, the system performed well with continuous operation for 35 days (July 23 to August 26). The ability to "re-engineer" the system in the field to accommodate the new waste stream is a positive attribute of the system.

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PRAXIS ENVIRONMENTAL TECHNOLOGIES, INC.
(In Situ Thermally Enhanced Extraction (TEE) Process)

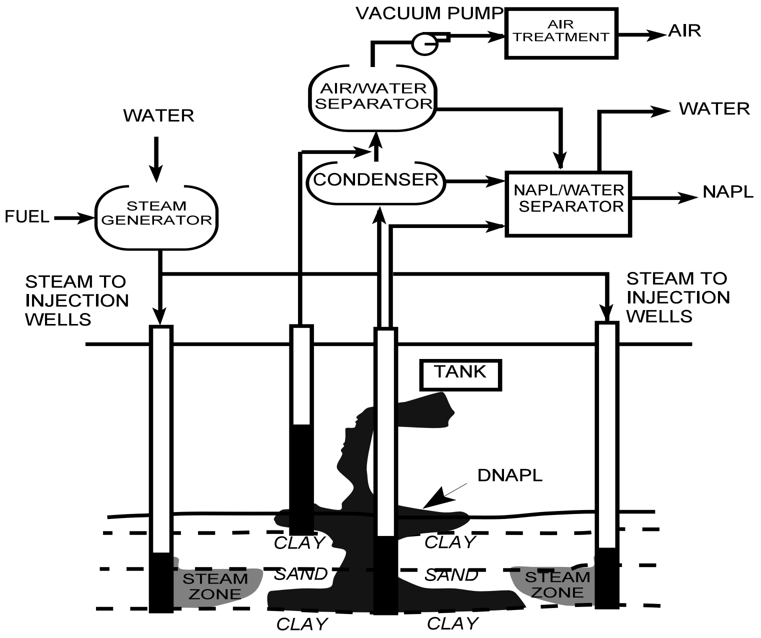
TECHNOLOGY DESCRIPTION:

The PRAXIS TEE in situ thermal extraction process heats soil with steam injection, enhancing pump-and-treat and soil vapor extraction processes used to treat volatile organic compounds (VOC) and semivolatile organic compounds (SVOC). This process is an effective and relatively inexpensive technique to raise a target soil volume to a nearly uniform temperature.

As illustrated in the figure below, steam is introduced to the soil through injection wells screened in contaminated intervals. The vacuum applied to the extraction wells, during and after steam/hot air injection, forms a pneumatic barrier at the treatment boundaries. This barrier limits lateral migration of steam and contaminants while air sweeping the steam zone boundaries carries contaminants to extraction wells.

Groundwater and liquid contaminants are pumped from the extraction wells; steam, air, and vaporized contaminants are extracted under vacuum. After the soil is heated by steam injection, the injection wells can introduce additional agents to facilitate the cleanup.

Recovered vapors pass through a condenser. The resulting condensate is combined with pumped liquids for processing in separation equipment. Separated nonaqueous phase liquids (NAPL) can be recycled or disposed of, and the water is treated prior to discharge. The noncondensible gases are directed to a vapor treatment system consisting of (1) catalytic oxidation equipment, (2) activated carbon filters, or (3) other applicable vapor technologies. The in situ thermal extraction process uses conventional injection, extraction and monitoring wells, off-the-shelf piping, steam generators, condensers, heat exchangers, separation equipment, vacuum pumps, and vapor emission control equipment.



In Situ Thermal Extraction Process

WASTE APPLICABILITY:

The in situ thermal extraction process removes VOCs and SVOCs from contaminated soils and groundwater. The process primarily treats chlorinated solvents such as trichloroethene (TCE), tetrachloroethene (PCE), and dichloro-benzene; hydrocarbons such as gasoline, diesel, and jet fuel; and mixtures of these compounds.

The process can be applied to rapid cleanup of source areas such as dense NAPL pools below the water table surface, light NAPL pools floating on the water table surface, and NAPL contamination remaining after using conventional pumping techniques. Subsurface conditions are amenable to biodegradation of residual contaminants, if necessary, after application of the thermal process. A cap is required for implementation of the process near the soil surface. For dense NAPL compounds in high concentrations, a barrier must be present or created to prevent downward percolation of the NAPLs. The process is applicable in less permeable soils with the use of novel delivery systems such as horizontal wells or fracturing.

STATUS:

This technology was accepted into the SITE Demonstration Program in August 1993. The demonstration occurred at a former waste management area located at Operable Unit 2 at Hill Air Force Base in Ogden, Utah, during June and July 1997. The demonstration site was the location of two former unlined trenches that received unknown quantities of various chlorinated solvent wastes from 1967 to 1975.

DEMONSTRATION RESULTS:

The demonstration focused primarily on assessing and recovering dense NAPL from the trough area and reducing TCE and PCE levels in the lower saturated zone so as to meet or exceed the Record of Decision (ROD) cleanup goals and the Preliminary Remedial Goals (PRG) established for the site's soils. Soil PRGs for TCE and PCE were 58 milligrams per kilogram (mg/Kg) and 12 mg/Kg respectively. A total of 41 post-characterization soil samples were collected to determine if these goals were met by the technology. Thirty-five of the 41 samples had PCE concentrations below the PRG. Thirty-five of the 41 samples also had TCE concentrations below the PRG. There were 33 samples that had both TCE and PCE concentrations below the specified PRGs. Detailed reports on the demonstration are in preparation and will be available from EPA in 2001. The developer is presently seeking patents on various aspects of the system, while continuing to seek opportunities at other U.S. Department of Defense facilities.

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REGENESIS
(Time Release Electron Acceptors and Donors for Accelerated Natural Attenuation)

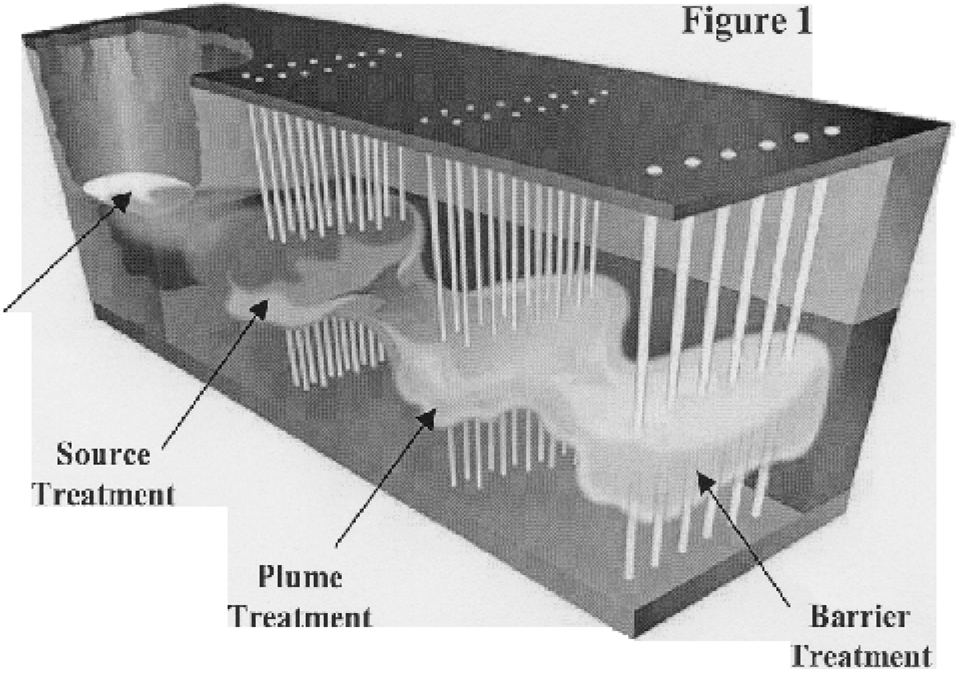
TECHNOLOGY DESCRIPTION:

The Regenesis technology is defined as the use of time-released electron acceptors and electron donors for the passive, long-term and cost effective acceleration of the bioremediation component of natural attenuation. The specific products are 1) Oxygen Release Compound (ORC®), which provides the electron acceptor oxygen to enhance the aerobic bioremediation of compounds such as petroleum hydrocarbons and 2) Hydrogen Release Compound (HRC®), which provides the electron donor hydrogen to enhance the anaerobic bioremediation of compounds such as chlorinated solvents. ORC® is a proprietary formulation of magnesium peroxide that only releases oxygen when hydrated and can provide a continuous source of oxygen (electron acceptor) for up to 12 months. HRC® is a polylactate ester and also requires hydration before it releases lactic acid, a fermentable substrate, which generates hydrogen (electron donor) for up to 18 months. Treatment is typically in situ and both products are applied to the subsurface via direct-push injection or borehole delivery methods. If needed, both products can be applied directly to open excavations via broadcast application techniques. These methods, as illustrated in Figure 1, can be used to emplace barriers to plume migration or be used directly in the plume to treat dissolved and residual contaminant mass.

The bioremediation component of natural attenuation describes a process by which contaminants are reduced in concentration over time by biological action. The process is facilitated by microbes that can be aerobic or anaerobic, requiring either oxygen or hydrogen respectively, to help carry out the degradation of target contaminants. At most sites the subsurface is lacking in these key substrates, which prevents the natural microbial population from facilitating bioremediation. The use of time-released substrates such as ORC® and HRC® typically accelerates natural attenuation 10 to 100 times faster than unassisted natural attenuation.

WASTE APPLICABILITY:

Figure 1



ORC® and HRC® can be applied to chlorinated solvents and hydrocarbon-contaminated groundwater plumes and soils.

STATUS:

Regenesis was invited to participate in the SITE Demonstration Program in 2000-2001 at two specific sites, Fisherville Mill and the Rocky Mountain Arsenal.

Fisherville Mill -Grafton, Massachusetts
Currently a pilot scale study is being conducted to demonstrate the effectiveness of using HRC® to reduce the concentration of trichloroethylene (TCE) in groundwater at the Fisherville Mill site in Grafton, MA. This site is considered a Brownfield site and has a sandy gravel aquifer impacted with the chlorinated solvent. The Pilot test consists of an array of 15 2-inch-diameter injection wells constructed to deliver the HRC® to the subsurface. The wells were constructed of PVC with a 10-foot screened interval. The HRC® injection well array was installed downgradient of an existing monitoring well. Ten new monitoring wells were constructed downgradient of the HRC injection array to track the progress of the accelerated reductive dechlorination. Hundred pounds of HRC® were injected into each injection well for a total of 1,500 lbs. of HRC®. This activity began in July 2000 and monitoring was scheduled to continue through October 2001. A report was scheduled to be released in December 2001.

Rocky Mountain Arsenal- Denver, Colorado.

Another HRC® field pilot scale study is being carried out at the Rocky Mountain Arsenal. The field demonstration is designed to treat a plume in the northern portion of Basin F that is contaminated by several organic compounds including PCE, TCE, chloroform, methylene chloride, dieldrin and di-isopropylmethyl phosphonate (DIMP). Based on a 60-day bench-scale study completed in March 2000, HRC® was shown to be very effective in dramatically reducing the entire range of contaminants, which prompted the Rocky Mountain Arsenal Water Team to arrange a field pilot test at the site. The recently installed pilot consists of a permeable reactive barrier utilizing 41 HRC® injection points at depths of 42 ft to 54 ft below the ground surface. Thirty-three pounds of HRC® were injected into each injection point for a total of 1,353 lbs of HRC® using direct-push technology and high-pressure injection techniques. This activity began in May 2001 and monitoring is scheduled to continue through October 2001. A report is scheduled to be released for December 2001.

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REGION 8 AND STATE OF COLORADO

(Multiple Innovative Passive Mine Drainage Technologies)

TECHNOLOGY DESCRIPTION:

These technologies include a successive alkalinity producing system (SAPS) and a lime addition approach known as the Aquafix system for removing high concentrations of metals (aluminum, copper, iron, manganese, and zinc) from acid mine drainage (AMD). A third treatment technology, an ion exchange system using a mixture of zeolites, was slated for evaluation as well, but construction delays precluded the collection of sufficient data from that system.

The SAPS technology has been developed in public domain over the past 10 years for the remediation of AMD. A SAPS is a pond that contains a combination of limestone and compost overlain by several feet of water (see figure). Mine drainage enters at the top of the pond; flows down through the compost, where the drainage gains alkalinity and the oxidation-reduction potential decreases; then flows into the limestone below. Dissolution of the limestone increases the alkalinity of the water, resulting in the precipitation of metals.

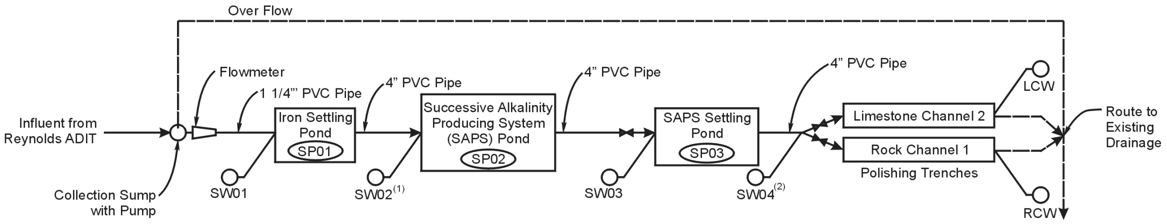
The Aquafix system, a proprietary technology of the Aquafix Corporation, uses lime to increase the pH of the AMD. In this system, a portion of the influent AMD is channeled to turn a water wheel on the Aquafix unit, driving an auger that drops lime from a hopper into the rest of the AMD that is flowing below (see figure). After the lime is added, the AMD is routed through a rock drain to promote mixing and dissolution of the lime and to aerate the AMD. The more alkaline and aerobic conditions cause metals to precipitate from solution.

WASTE APPLICABILITY:

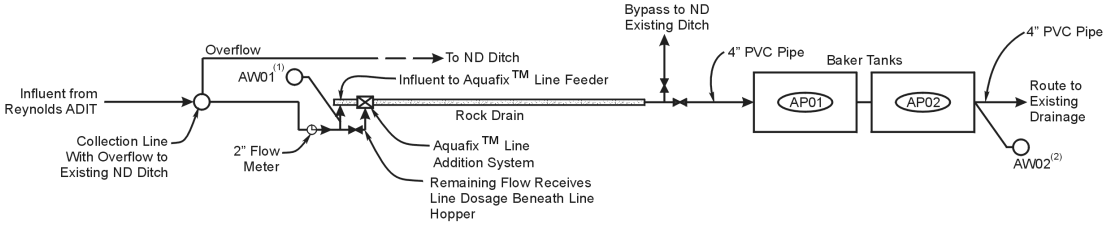
These technologies are suitable for any acidic water containing high concentrations of metals. Treatment at very low concentrations is likely not achievable.

STATUS:

The SAPS technology is in the public domain and has been used in several locations in the midwestern and eastern United States. The Aquafix system is commercially available and has been used at several mine sites in the United States and Canada.



SAPS Treatment System Proccess Flow Schematic



Aquafix™ Treatment System Proccess Flow Schematic

Explanation

⋈ Gate Valve
○ Approximate Sampling Location
⬭ Sludge Sampling Location
(1) Influent Sampling Location for Primary Objective PI
(2) Effluent Samplint Locaiton for Primary Objective PI

DEMONSTRATION RESULTS:

The demonstration site was the Summitville Mine Superfund Site in the San Juan Mountains in southwestern Colorado. The drainage water at the site is highly acidic and contains high concentrations of metals. The results of the demonstration program indicate that both the SAPS and Aquafix systems removed significant percentages of aluminum, copper, iron, manganese, and zinc from the AMD. Removal efficiencies for the SAPS ranged from 11 percent (manganese) to 97 percent (aluminum) for metals while the removal rate for the Aquafix system was 97 (aluminum and manganese) to 99 percent (copper, iron, and zinc).

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REMEDIATION TECHNOLOGIES, INC.
(formerly MoTech, Inc.)
(Liquid and Solids Biological Treatment)

TECHNOLOGY DESCRIPTION:

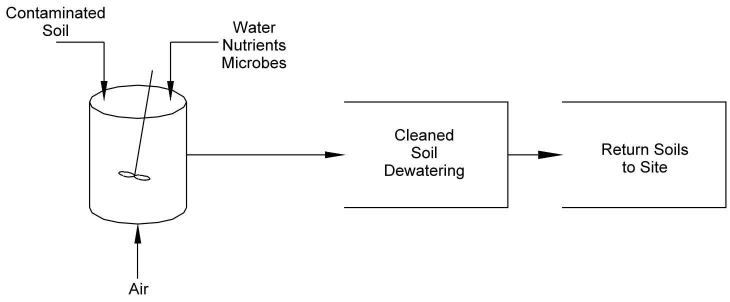
Liquid and solids biological treatment (LST) is a process that remediates soils and sludges contaminated with biodegradable organics (see figure below). The process is similar to activated sludge treatment of municipal and industrial wastewaters, but it treats suspended solids concentrations greater than 20 percent. First, an aqueous slurry of the waste material is prepared, and environmental conditions such as nutrient concentrations, temperature, and pH are optimized for biodegradation. The slurry is then mixed and aerated for a sufficient time to degrade the target waste constituents.

Several physical process configurations are possible, depending on site- and waste-specific conditions. Waste can be treated continuously or in batches in impoundment-based reactors. This configuration is sometimes the only practical option for projects greater than 10,000 cubic yards. Alternatively, tank-based systems may be constructed. Constituent losses due to volatilization must be controlled during LST operations. The potential for emissions is greatest in batch treatment systems and lowest in continuously stirred tank reactor systems, particularly those with long residence times. Technologies such as carbon adsorption and biofiltration can control emissions.

LST may require pre- and posttreatment operations. However, in situ applications that store treated sludge residues do not require multiple unit operations.

Overall bioremediation in a hybrid system consisting of LST and land treatment systems can provide an alternative to landfilling treated solids. This combination rapidly degrades volatile constituents in a contained system, rendering the waste suitable for landfilling.

Remediation Technologies, Inc. (ReTeC), has constructed a mobile LST pilot system for field demonstrations. The system consists of two reactors, two 2,000-gallon holding tanks, and aassociated process equipment. The reactors are aerated using coarse bubble diffusers and mixed using axial flow turbine mixers. The reactors can operate separately, or as batch or continuous systems. Oxygen and pH are continuously monitored and recorded. Additional features include antifoaming and temperature control systems.



Liquid and Solids Biological Treatment

WASTE APPLICABILITY:

The technology treats sludges, sediments, and soils containing biodegradable organic materials. To date, the process has mainly treated sludges containing petroleum and wood preservative organics such as creosote and pentachlorophenol (PCP). LST has treated polynuclear aromatic hydrocarbons (PAH), PCP, and a broad range of petroleum hydrocarbons in the laboratory and the field.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1987. The technology was demonstrated under SITE at the Niagara Mohawk Power Corporation facility at Harbor Point in Utica, New York from June through August 1995. The following equipment was used for the demonstration: (1) a 10,000-gallon cylindrical tank (12-foot diameter) with bottom-mounted air diffusers that provided aeration and assisted in suspending solids; (2) a tank cover outfitted with exhaust piping that contained and channeled air discharge; and (3) a spray system that recircultated liquid from within the tank to disperse foam buildup.

ReTeC has applied the technology in the field over a dozen times to treat wood preservative sludges with impoundment-type LST systems. In addition, LST has treated petroleum refinery impoundment sludges in two field-based pilot demonstrations and several laboratory treatability studies.

DEMONSTRATION RESULTS:

Analytical results from the SITE demonstration showed a reduction in oil and grease concentrations from 14,500 to 3,100 milligrams per kilogram (mg/kg), or 79 percent; total PAH concentrations were reduced from 137 to 51 mg/kg, or 63 percent; and total benzene, toluene, ethylbenzene, and xylene concentrations were reduced from 0.083 to 0.030 mg/kg, or 64 percent. PAH leachability in the solids was reduced to nondetect levels after treatment. Toxicity of the solids to earthworms was also decreased by the treatment. Only 24 percent of the earthworms survived when added to untreated contaminated soil, while earthworms placed in treated soil showed no toxic effects.

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RESOURCES CONSERVATION COMPANY

(B.E.S.T. Solvent Extraction Technology)

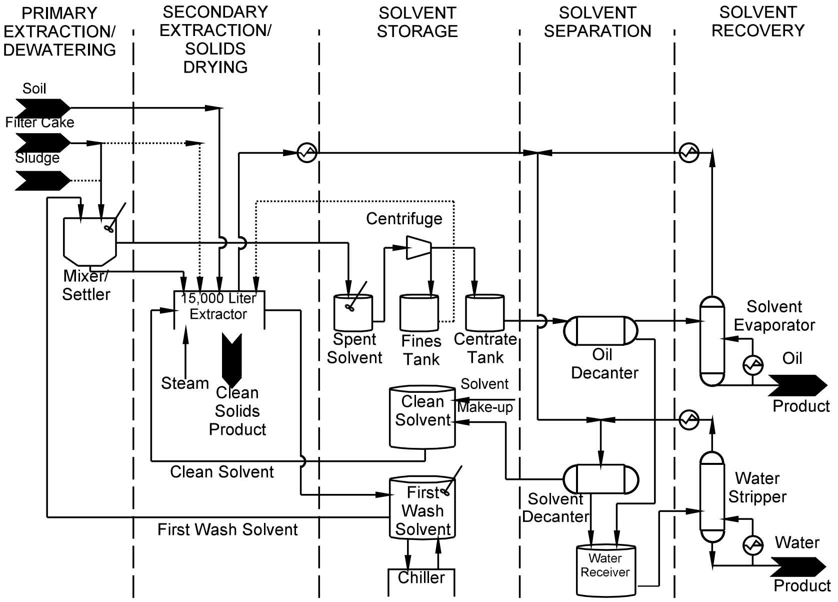
TECHNOLOGY DESCRIPTION:

Solvent extraction treats sludges, sediments, and soils contaminated with a wide range of hazardous contaminants including polychlorinated biphenyls (PCB), polynuclear aromatic hydrocarbons (PAH), pesticides, and herbicides. The waste matrix is separated into three fractions: oil, water, and solids. Organic contaminants, such as PCBs, are concentrated in the oil fraction, while metals are separated into the solids fraction. The volume and toxicity of the original waste is thereby reduced, and the concentrated waste streams can be efficiently treated for disposal.

The B.E.S.T. technology is a mobile solvent extraction system that uses secondary or tertiary amine solvents to separate organics from soils, sediments, and sludges. The B.E.S.T. solvents are hydrophobic above 20°C and hydrophilic below 20 °C. This property allows the process to extract both aqueous and nonaqueous compounds by changing the solvent temperature.

Pretreatment includes screening the waste to remove particles larger than 1 inch in diameter, which are treated separately.

The B.E.S.T. process begins by mixing and agitating the solvent and waste in a mixer/settler. Solids from the mixer/settler are then transferred to the extractor/dryer vessel. (In most cases, waste materials may be added directly to the extractor/dryer and the mixer/settler is not required.) Hydrocarbons and water in the waste simultaneously solubilize with the solvent, creating a homogeneous mixture. As the solvent breaks the oil-water-solid emulsions in the waste, the solids are released and settle by gravity. The solvent mixture is decanted from the solids and centrifuged to remove fine particles.



B.E.S.T. Solvent Extraction Technology

The solvent-oil-water mixture is then heated. As the mixture's temperature increases, the water separates from the organics and solvent. The organics-solvent fraction is decanted and sent to a solvent evaporator, where the solvent is recycled. The organics are discharged for recycling, disposal, or treatment. The water passes to a steam stripping column where residual solvent is recovered for recycling. The water is typically discharged to a local wastewater treatment plant.

The B.E.S.T. technology is modular, allowing for on-site treatment. The process significantly reduces the organic contamination concentration in the solids. B.E.S.T. also concentrates the contaminants into a smaller volume, allowing for efficient final treatment and disposal.

WASTE APPLICABILITY:

The B.E.S.T. technology can remove hydrocarbon contaminants such as PCBs, PAHs, pesticides, and herbicides from sediments, sludges, or soils. System performance can be influenced by the presence of detergents and emulsifiers.

STATUS:

The B.E.S.T. technology was accepted into the SITE Demonstration Program in 1987. The SITE demonstration was completed in July 1992 at the Grand Calumet River site in Gary, Indiana. The following reports are available from EPA:

- Applications Analysis Report (EPA/540/AR-92/079)
- Technology Evaluation Report - Volume I (EPA/540/R-92/079a)
- Technology Evaluation Report - Volume II, Part 1 (EPA/540/R-92/079b)
- Technology Evaluation Report - Volume II, Part 2 (EPA/540/R-92/079c)
- Technology Evaluation Report - Volume II, Part 3 (EPA/540/R-92/079d)
- Technology Demonstration Summary (EPA/540/SR-92/079)

The first full-scale B.E.S.T. unit was used at the General Refining Superfund site in Garden City, Georgia. A 75-ton-per-day B.E.S.T. unit is being installed at Idaho National Engineering Laboratory to extract organic contaminants from mixed wastes.

DEMONSTRATION RESULTS:

The SITE demonstration showed that the B.E.S.T. process removed greater than 99 percent of the PCBs found in river sediments without using mechanical dewatering equipment. Treated solids contained less than 2 milligrams per kilogram PCBs. Comparable removal efficiencies were noted for PAHs.

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RETECH M4 ENVIRONMENTAL MANAGEMENT INC.

(Plasma Arc Vitrification)

TECHNOLOGY DESCRIPTION:

Plasma arc vitrification occurs in a plasma arc centrifugal treatment (PACT) system, where heat from a transferred plasma arc torch creates a molten bath that detoxifies the feed material (see figure below). Solids are melted into the molten bath while organics are evaporated and destroyed. Metallic feed material can either form a separate liquid phase underneath the metal oxide slag layer or can be oxidized and become part of the slag layer.

Waste material is fed into a sealed centrifuge, where a plasma torch heats solids to approximately 3,200°F and gas headspace to a minimum of 1,800°F. Organic material is evaporated and destroyed. Off-gases travel through a gas-slag separation chamber to a secondary chamber, where the temperature is maintained at over 2,000°F for at least 2 seconds. The off-gases then flow through an off-gas treatment system.

Inorganic material is reduced to a molten phase that is uniformly heated and mixed by the centrifuge and the plasma arc. Material can be added in-process to control slag quality. When the centrifuge slows, the molten material is discharged as a homogeneous, nonleachable, glassy slag into a mold or drum in the slag collection chamber. When cooled, the resulting product is a nonleachable, glassy residue which meets toxicity characteristic leaching procedure (TCLP) criteria.

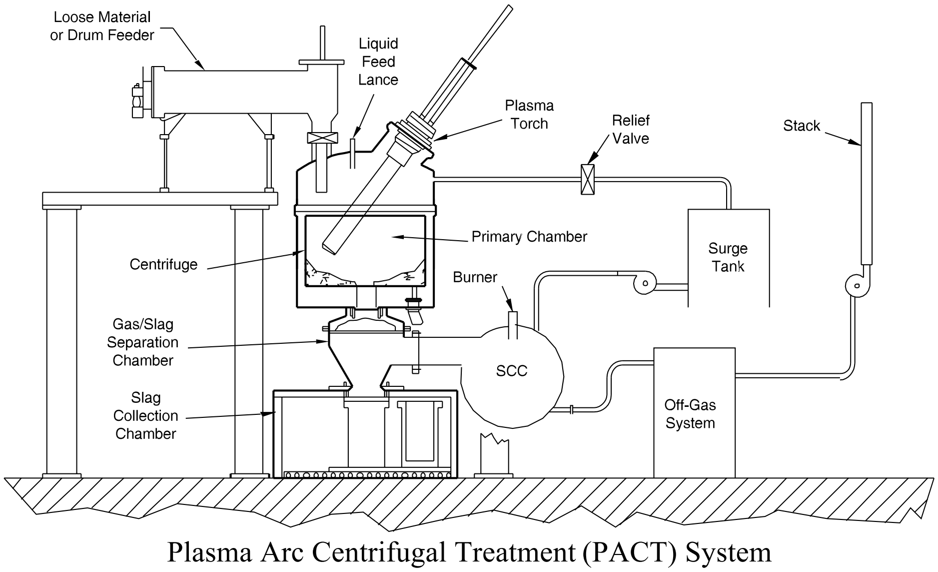
The off-gas treatment system removes particulates, acid gases, and volatilized metals. Off-gas monitoring verifies that all applicable environmental regulations are met. The design of the off-gas treatment system depends on the waste material.

The entire system is hermetically sealed and operated below atmospheric pressure to prevent leakage of process gases. Pressure relief valves connected to a closed surge tank provide relief if gas pressures in the system exceed safe levels. Vented gas is held in the tank, then recycled through the PACT system.

WASTE APPLICABILITY:

The technology can process organic and inorganic solid and liquid wastes. It is most appropriate for mixed, transuranic, and chemical plant wastes; soil containing both heavy metals and organics; incinerator ash; and munitions, sludge, and hospital waste.

Waste may be loose (shredded or flotation process) or contained in 55-gallon drums. It can be in almost



Plasma Arc Centrifugal Treatment (PACT) System any physical form: liquid, sludge, metal, rock, or sand. Volatile metals in the waste, such as mercury, are recovered by the off-gas treatment system.

STATUS:

The PACT-6 System, formerly PCF-6, was demonstrated under the SITE Program in July 1991 at the Component Development and Integration Facility of the U.S. Department of Energy in Butte, Montana. During the demonstration, about 4,000 pounds of waste was processed. The waste consisted of heavy metal-bearing soil from Silver Bow Creek Superfund site spiked with 28,000 parts per million (ppm) of zinc oxide, 1,000 ppm of hexachlorobenzene, and a 90-to-10 weight ratio of No. 2 diesel oil. All feed and effluent streams were sampled. The Demonstration Bulletin (EPA/540/M5-91/007), Applications Analysis Report (EPA/540/A5-91/007), and Technology Evaluation Report (EPA/540/ 5-91/007b) are available from EPA.

During subsequent testing at the Component Development and Integration Facility, the PACT-6 system achieved the following results:

- Hexachlorobenzene was at or below detection limits in all off-gas samples. The minimum destruction removal efficiency ranged from 99.9968 percent to greater than 99.9999 percent.
- The treated material met TCLP standards for organic and inorganic constituents.
- Particulates in the off-gas exceeded the regulatory standard. The off-gas treatment system is being modified accordingly. Particulate emissions from another PACT-8 system in Switzerland were measured at 1/200th of the U.S. regulatory limit.
- Nitrous oxide (NO_x) levels were very high during the demonstration, but can meet stricter standards. While NO_x concentrations during the demonstration exceeded 5,000 ppm, the NO_x concentrations in the off-gas from the PACT-8 furnace in Switzerland was reduced to 19 ppm. Subsequent PACT-6 applications include military pyrotechnics.

Two PACT-2 systems are in use in Europe, and another one is at Retech for research and development, while five Japanese PACT-8 systems are under construction for European and domestic nuclear and commercial applications. Two PACT-1 bench-scale systems are also in domestic use for nuclear and shipboard testing.

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ROCHEM SEPARATION SYSTEMS, INC.

(Reverse Osmosis: Disc Tube™ Module Technology)

TECHNOLOGY DESCRIPTION:

The Rochem Disc Tube™ Module System uses membrane separation to treat aqueous solutions ranging from seawater to leachate contaminated with organic solvents. The system uses osmosis through a semipermeable membrane to separate pure water from contaminated liquids.

Osmotic theory implies that a saline solution may be separated from pure water by a semipermeable membrane. The higher osmotic pressure of the salt solution causes the water (and other compounds having high diffusion rates through the selected membrane) to diffuse through the membrane into the salt water. Water will continue to permeate the salt solution until the osmotic pressure of the salt solution equals the osmotic pressure of the pure water. At this point, the salt concentrations of the two solutions are equal, eliminating any additional driving force for mass transfer across the membrane.

However, if external pressure is exerted on the salt solution, water will flow in the reverse direction from the salt solution into the pure water.

This phenomenon, known as reverse osmosis (RO), can separate pure water from contaminated matrices. RO can treat hazardous wastes by concentrating the hazardous chemical constituents in an aqueous brine, while recovering pure water on the other side of the membrane.

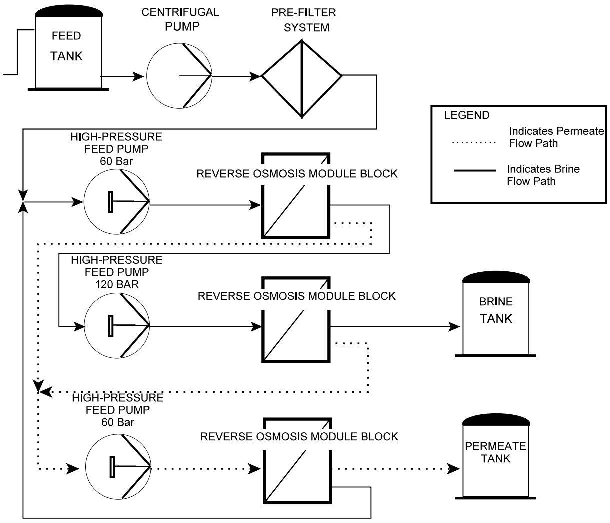
Fluid dynamics and system construction result in an open-channel, fully turbulent feed and water-flow system. This configuration prevents accumulation of suspended solids on the separation membranes, ensuring high efficiency filtration for water and contaminants. Also, the design of the disc tubes allows easy cleaning of the filtration medium, providing a long service life for the membranes.

A general flow path for the Rochem Disc Tube™ Module System as applied at the SITE demonstration is shown on the previous page. Waste feed, process permeate, and rinse water are potential feed materials to the RO modules. The modules are skid-mounted and consist of a tank and a high-pressure feed system. The high-pressure feed system consists of a centrifugal feed pump, a prefilter cartridge housing, and a triplex plunger pump to feed the RO modules. The processing units are self-contained and require electrical and interconnection process piping before operation.

WASTE APPLICABILITY:

Many types of waste material can be treated with this system, including sanitary and hazardous landfill leachate containing both organic and inorganic chemical species.

STATUS:



Three-Stage, Reverse Osmosis Flow Path

This technology was accepted into the SITE Demonstration Program in July 1991. The demonstration was conducted in August 1994 at the Central Landfill Superfund site in Johnston, Rhode Island. The system was used to treat landfill leachate from a hazardous waste landfill. During the demonstration, approximately 4 gallons per minute of contaminated waste was processed over a 3-week period. All feed and residual effluent streams were sampled to evaluate the performance of this technology. The Innovative Technology Evaluation Report (EPA/540/R-96/507), the Technology Capsule (EPA/540/R-96/507a), and the Demonstration Bulletin (EPA/540/MR-96/507) are available from EPA.

DEMONSTRATION RESULTS:

Preliminary results from the demonstration suggest the following:

- Over 99 percent of total dissolved solids, over 96 percent of total organic carbon, and 99 percent of all target metals were removed. In addition, the average percent rejection for volatile organic compounds was greater than the test criteria of 90 percent.
- The average water recovery rate for the Rochem Disc Tube™ Module System during the demonstration was approximately 75 percent. The test criterion was 75 percent treated water recovery rate.
- The Rochem Disc Tube™ Module System operated for 19 days at up to 8 hours per day. Daily operation hours were not as long as planned due to weather and field operational difficulties. However, the system operated long enough to evaluate the technology's performance.

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ROCKY MOUNTAIN REMEDIATION SERVICES, L.L.C.

(ENVIROBOND™ Solution)

TECHNOLOGY DESCRIPTION:

ENVIROBOND™ is a proprietary solution that binds with metals in contaminated soils and other wastes to form a virtually impenetrable chemical bond. Rocky Mountain Remediation Services, L.L.C., claims that the treatment process effectively prevents metals leaching and can be used with mechanical compaction to reduce the overall volume of contaminated media by 30 to 50 percent. The process generates no secondary wastes and requires minimal handling, transportation, and disposal costs. In addition, unlike some pozzolanic-based reagents, the ENVIROBOND™ liquid is safe to handle and does not generate any emissions.

ENVIROBOND™ consists of a mixture of additives containing oxygen, sulfur, nitrogen, and phosphorous; each additive has an affinity for a specific class of metals. ENVIROBOND™ converts metal contaminants from their leachable form to an insoluble, stable, nonhazardous metallic complex. ENVIROBOND™ is essentially a ligand that acts as a chelating agent. In the chelation reaction, coordinate bonds attach the metal ion to least two ligand nonmetal ions to form a heterocyclic ring. The resulting ring structure is inherently more stable than simpler structures formed in other binding processes. By effectively binding the metals, the process reduces the waste stream's RCRA toxicity characteristic leaching procedure (TCLP) test results to less than the RCRA-regulated levels, subsequently reducing the risks posed to human health and the environment.

The stabilized waste can then be placed in a pit or compacted into the earth using traditional field compaction equipment, or it can be mechanically compacted to produce a solid, compressed form called ENVIROBRIC™. The machine used to form the ENVIROBRIC™ is designed for mass production of sand-clay "rammed earth" bricks. Unlike conventional construction bricks, rammed earth bricks are produced under extremely high compaction forces and are not heated or fired. As a result, the bricks posses very high compressive strength and a correspondingly low porosity, making them ideal for on-site treatment by solidification/stabilization at industrial sites. The size of the individual bricks can be adjusted depending on specific site requirements, and the bricks have successfully passed various tests designed to measure their long-term durability.

WASTE APPLICABILITY:

The ENVIROBOND™ process doe not reduce the overall concentration of metal contaminants; instead it converts them to metal-ligand compounds, rendering them insoluble and stable in the media. The developer claims that the process can be applied to contaminated soils and other media in both industrial and residential use scenarios. At residential sites, contaminated soils and other media in both industrial and residential use scenarios. At residential sites, contaminated soil can be mixed with ENVIROBOND™ and stabilized before being disposed of off site. At industrial sites, ENVIROBOND™ can be mixed with contaminated waste streams or soils and then compacted in the ENVIROBRIC™ process and backfilled on site to reduce the overall volume of contaminated media.

Bench-scale and field tests indicate that ENVIROBOND™ can be added to waste streams containing more than four metal contaminants at concentrations ranging from 200 to more than 5,000 parts per million (ppm). TCLP tests have shown that metals concentrations in leachate frm treated media doe not exceed RCRA regulatory levels. Metals that can be stabilized with ENVIROBOND™ include arsenic, barium, cadmium, chromium, lead, mercury, nickel, selenium, silver, and zinc. However, the process is less effective in media containing more than 3 percent by weight of meals such as aluminum, magnesium, calcium, and manganese. These metals my reduce the number of chelating sites available by preferentially binding with the ENVIROBOND™ agent.

The ENVIROBOND™ process is capable of achieving high processing rates of 20 to 40 tones per hour and can be used with contaminated media containing as much as 10 percent debris and other matter. For acidic wastes with a pH of 3 or less, buffering compounds can be added to the contaminated media before it is media with ENVIROBOND™. Volatile organic compounds such as benzene, toluene, ethylbenzene, and xylenes do not affect the process.

STATUS:

Under a cooperative agreement with the Ohio EPA, the ENVIROBOND™ process with demonstrated in September 1998 at two separate areas of the Crooksville/Roseville Pottery site in Ohio. Soil at the site, some of it adjacent to residential areas, is contaminated with lead from waste disposal practices associated with pottery production operations. Soil at the demonstration areas contains lead in concentrations ranging from 100 ppm to 80,000 ppm.

DEMONSTRATION RESULTS:

Soil treatment with ENVIROBOND™ reduced the bioavilablility of lead by at least 25%, as determined by the Physiological-Based Extracted Test (PBET), and reduced leachable lead concentrations form 247 to 563 mg/L to <0.50 to 2.1 µg/L, as determined by the Toxicity Characteristic Leaching Procedure (TCLP).

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SANDIA NATIONAL LABORATORIES

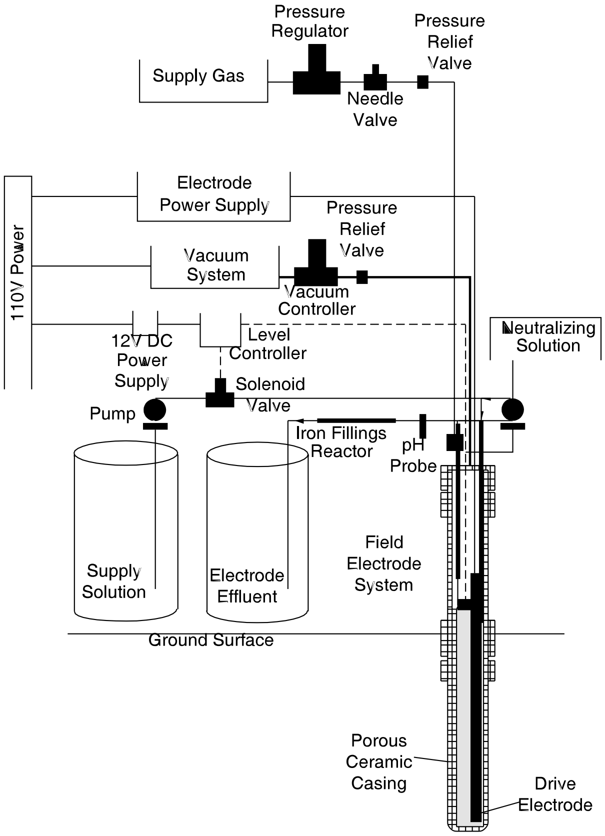
(In Situ Electrokinetic Extraction System)

TECHNOLOGY DESCRIPTION:

Electrokinetic remediation has been used successfully to treat saturated soils contaminated with heavy metals. At some sites, however, it may not be desirable to add the quantities of water needed to saturate a contamination plume in the vadose zone. Sandia National Laboratories (SNL) has developed an electrokinetic remediation technology that can be used in unsaturated soils without adding significant amounts of water.

The SNL electrokinetic extraction system, shown in the figure below, consists of three main units: the electrode assembly (electrode casing and internal assemblies), the vacuum system, and the power supply. The electrode casing consists of a porous ceramic end that is 5 to 7 feet long and has an outer diameter of 3.5 inches. During field installation, the casing is attached to the required length of 3-inch polyvinyl chloride pipe. The electrode internal assembly consists of the drive electrode, a water level control system, and a pump system. The vacuum system consists of a venturi vacuum pump and vacuum regulator that together supply a constant vacuum for the electrode. Up to four 10,000-watt power supplies can operate in either constant voltage or constant current mode.

When the drive electrode is energized, contaminants and other ions are attracted into the electrode casing. The water level control system adds water to, and extracts water from, the electrodes. Water is supplied to the electrode from a supply solution tank at the ground surface. This solution is either drawn into the electrode by the vacuum maintained in the electrode or by a supply pump. At the same time, water is continuously pumped out from the



Schematic Diagram of the In Situ Electrokinetic Extraction System electrode casing at a constant rate. Part of the contaminated water is sent to an effluent waste tank at the ground surface; the remainder is returned to the electrode to maintain circulation of the fluid surrounding the electrode. A metering pump controlled by in-line pH meters regulates the introduction of neutralization chemicals to each electrode. Process control and monitoring equipment is contained in a 10-foot- by-40-foot instrument trailer.

WASTE APPLICABILITY:

SNL has developed its electrokinetic extraction system to treat anionic heavy metals such as chromate in unsaturated soil. There is no lower limit to the contaminant concentration that can be treated; however, there may be a lower limit on the ratio of contaminant ions to other ions in the soil.

The technology can be expanded to treat saturated soils. Soil that is highly conductive because of a high salinity content is not suitable for this technology. In addition, sites with buried metal debris, such as pipelines, are not appropriate.

STATUS:

This technology was accepted into the SITE Demonstration Program in summer 1994. The SITE demonstration began May 1996, at an unlined chromic acid pit within a SNL RCRA regulated landfill. The operation was completed in November 1996 and site closure was completed in April 1997, with a closure report submitted to New Mexico state regulators in September 1997.

DEMONSTRATION RESULTS:

The demonstration verified the technology's capability of removing anionic contaminants from vadose zone soil through passive operation. Approximately 520 grams (g) of hexavalent chromium was remove d during the demonstration. Overall hexavalent chromium removal rates varied from 0.074 gram per hour (g/hour) during Test 1 to 0.338 g/hour during Test 5. Overall hexavalent chromium removal efficiencies varied from 0.0359 gram per kilowatt-hour (g/kW-h) during Test 7 to 0.136 g/kW-h during Test 13. More than 50 percent of the postdemonstration soil samples exceeded the toxicity characteristic leach procedure TCLP) limit of 5 milligrams per liter (mg/L) for total chromium. The soil TCLP leachate concentrations that were above the TCLP limit ranged from 6 to 67 mg/L.

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SBP TECHNOLOGIES, INC.

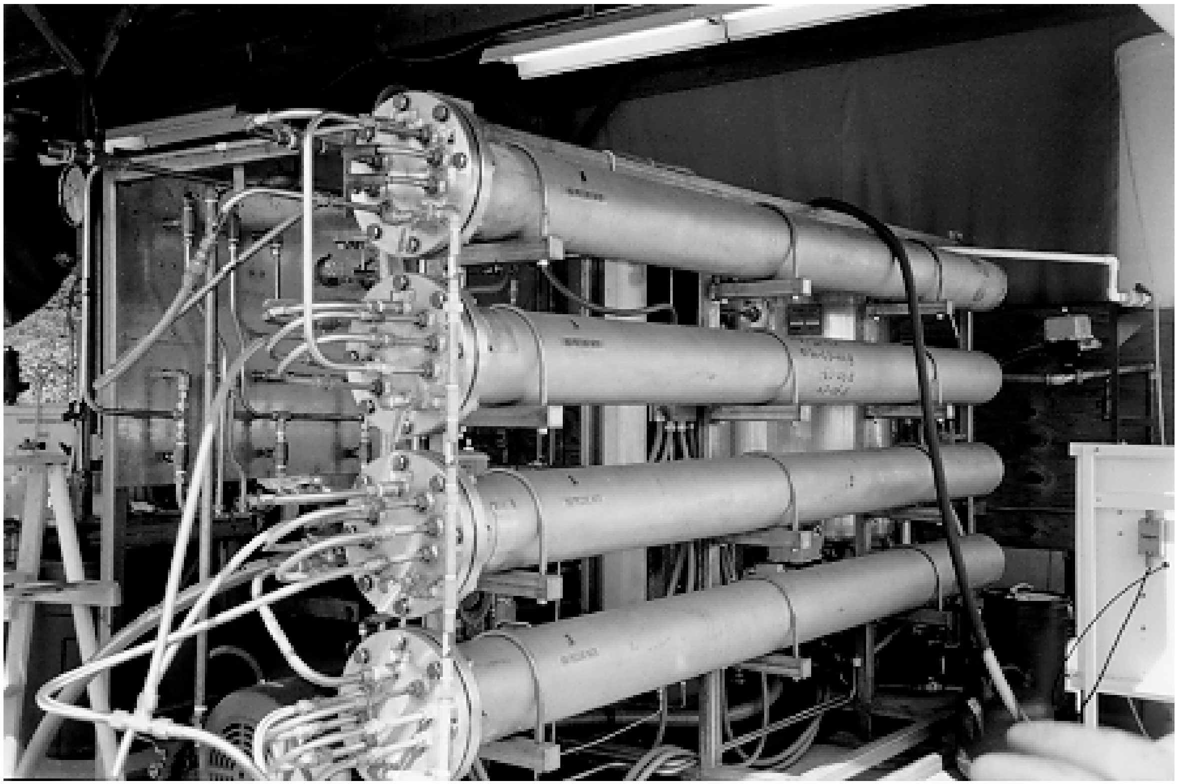
(Membrane Filtration and Bioremediation)

TECHNOLOGY DESCRIPTION:

SBP Technologies, Inc. (SBP), has developed a hazardous waste treatment system consisting of (1) a membrane filtration system that extracts and concentrates contaminants from groundwater, surface water, wash water, or slurries; and (2) a bioremediation system that treats concentrated groundwater, wash water, and soil slurries (see photograph below). These two systems treat a wide range of waste materials separately or as parts of an integrated waste handling system.

The membrane filtration system removes and concentrates contaminants by pumping contaminated liquids through porous stainless steel tubes coated with specifically formulated membranes. Contaminants are collected inside the tube membrane, while "clean" water permeates the membrane and tubes. Depending on local requirements and regulations, the clean permeate can be discharged to the sanitary sewer for further treatment at a publicly owned treatment works (POTW). The concentrated contaminants are collected in a holding tank and fed to the bioremediation system.

Contaminated water or slurry can also flow directly into the bioremediation system and be polished in the membrane filtration system. The bioremediation system consists of one or more bioreactors that are inoculated with specially selected, usually indigenous microorganisms to produce effluent with low to nondetectable contaminant levels. Integrating the two systems allows removal and destruction of many contaminants.



Membrane Filtration and Bioremediation

WASTE APPLICABILITY:

The membrane filtration system concentrates contaminants and reduces the volume of contaminated materials from a number of waste streams, including contaminated groundwater, surface water, storm water, landfill leachates, and industrial process wastewater.

The bioremediation system can treat a wide range of organic contamination, especially wood-preserving wastes and solvents. A modified version can also treat polynuclear aromatic hydrocarbons (PAH) such as creosote and coal tar; pentachlorophenol; petroleum hydrocarbons; and chlorinated aliphatics, such as trichloroethene.

The two technologies can be used separately or combined, depending on site characteristics and waste treatment needs. For example, for wastewaters or slurries contaminated with inorganics or materials not easily bioremediated, the membrane filtration system can separate the material for treatment by another process. Both the membrane filtration system and the bioremediation system can be used as part of a soil cleaning system to handle residuals and contaminated liquids.

STATUS:

The membrane filtration system, accepted into the SITE Program in 1990, was demonstrated in October 1991 at the American Creosote Works in Pensacola, Florida. The Demonstration Bulletin (EPA/540/MR- 92/014) and Applications Analysis Report (EPA/540/AR-92/014) are available from EPA. A full-scale SITE Program demonstration of the bioremediation system was canceled. However, a smaller-scale field study was conducted at the site; results are available through the developer. SBP is marketing its bioremediation and membrane filtration systems to industrial and governmental clients for on-site treatment of contaminated soil, sludge, and water.

DEMONSTRATION RESULTS:

Results from the SITE demonstration are summarized as follows:

- The system effectively concentrated the PAHs into a smaller volume.
- The process removed 95 percent of the PAHs found in creosote from the feed and produced a permeate stream that was acceptable for discharge to a POTW.
- The membrane removed 25 to 35 percent of smaller phenolic compounds.
- The system removed an average of about 80 percent of the total concentrations of creosote constituents (phenolics and PAHs) in the feedwater and permeate.

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SEVENSON ENVIRONMENTAL SERVICES, INC.

(formerly Mae Corp, Inc.)

(MAECTITE® Chemical Treatment Process)

TECHNOLOGY DESCRIPTION:

The patented MAECTITE® chemical treatment process for lead and other heavy metals uses reagents and processing equipment to render soils, waste, and other materials nonhazardous when tested by the Resource Conservation and Recovery Act toxicity characteristic leaching procedure (TCLP). The MAECTITE® process reduces leachable lead, hexavalent chromium, and other heavy metals to below treatment standards required by land-ban regulations. Lead in treated material, as determined by approved EPA methods (such as the TCLP, extraction procedure toxicity test, and the multiple extraction procedure), complies with limits established by EPA. The photograph below shows a 500-ton-per-day ex situ unit.

500-Ton-Per-Day MAECTITE®
Processing System

Chemical treatment by the MAECTITE® process converts leachable lead into insoluble minerals and mixed mineral forms within the material or waste matrix. MAECTITE® reagents stimulate the nucleation of crystals by chemical bonding to yield mineral compounds in molecular forms. These forms are resistant to leaching and physical degradation from environmental forces. The durability of traditional monolithic solidification-stabilization process end-products is often measured by geotechnical tests such as wet-dry, freeze-thaw, permeability, and unconfined compressive strength. The MAECTITE® process does not use physical binders, is not pozzolanic or siliceous, and does not rely on the formation of metallic hydroxides using hydration mechanisms. Therefore, these tests are not relevant to MAECTITE® product chemical stability, although engineered properties are readily obtained, if required. MAECTITE® is not pH dependent and does not use adsorption, absorption, entrapment, lattice containment, encapsulation, or other physical binding principles. The technology is a true chemical reaction process that alters the structure and properties of the waste, yielding stable compounds.

The MAECTITE® process uses water to assist in dispersing reagents. However, the dehydration characteristic of the process liberates water present in waste prior to treatment (absorbed and hydrated forms) to a free state where it can be removed from the waste matrix by evaporation and capillary drying principles. The ability of treated material to readily lose water, the formation of dense mineral crystals, and the restructuring of the material as a result of MAECTITE® treatment (where interstitial space is minimized), all contribute to reduced waste volume and weight.

Ex situ MAECTITE® processing equipment generally consists of material screening and sizing components, liquid and solid reagent storage delivery subsystems, and a mixing unit such as a pug mill. Equipment is mobile but can be modified for fixed system operations. In situ MAECTITE® processing equipment is also available; system selection is largely dictated by contaminant plume configuration, soil characteristics, and site space limitations.

WASTE APPLICABILITY:

Materials that have been rendered nonhazardous include soils; sludges; sediments; battery contents, including casings; foundry sands; and firing range soil. Oversized material can be treated with the process as debris, but size reduction often makes processing more efficient. Even sludges with free liquids (as determined by the paint filter test) have been treated to TCLP compliance when excess fluids are present.

The range of lead levels effectively treated has not been fully determined; however, soils with total lead as high as 30 percent by weight and TCLP values over 15,000 milligrams per liter (mg/L) were not problematic. Common lead levels encountered have averaged from 200 milligrams per kilogram to 6,500 with TCLP concentrations averaging 20 to 400 mg/L. Material geochemistry most often dictates final MAECTITE® treatment designs. Furthermore, correlations between total lead and regulated leachable lead levels are inconsistent, with treatment efforts more strongly related to the geochemical characteristics of the waste material.

STATUS:

The chemical treatment technology was initially accepted into the SITE Demonstration Program in March 1992. EPA is seeking a suitable demonstration site.

Sevenson Environmental Services, Inc. (Sevenson), acquired the MAECTITE® technology in 1993 and was issued second, third and fourth patents in 1995, 1996, and 1997 respectively. Combining ex situ and in situ quantities, over 650,000 tons of material has been successfully processed. Treatability studies have been conducted on over 100 different materials in over 40 states, Canada, Italy, and Mexico. The technology has been applied at full-scale demonstration and remedial projects in over 25 states and in all 10 EPA regions.

The MAECTITE® process has been formally accepted into the EPA PQOPS program for the fixation-stabilization of inorganic species. Proprietary technology modifications have shown promise in rendering radionuclides nonleachable using gamma spectral counting methods on TCLP extract.

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SMITH ENVIRONMENTAL TECHNOLOGIES CORPORATION

(formerly Canonie Environmental Services Corporation)

(Low Temperature Thermal Aeration [LTTA®])

TECHNOLOGY DESCRIPTION:

The Low Temperature Thermal Aeration (LTTA®) technology is a low-temperature desorption process (see figure below). The technology removes organic contaminants from contaminated soils into a contained air stream, which is extensively treated to collect or thermally destroy the contaminants.

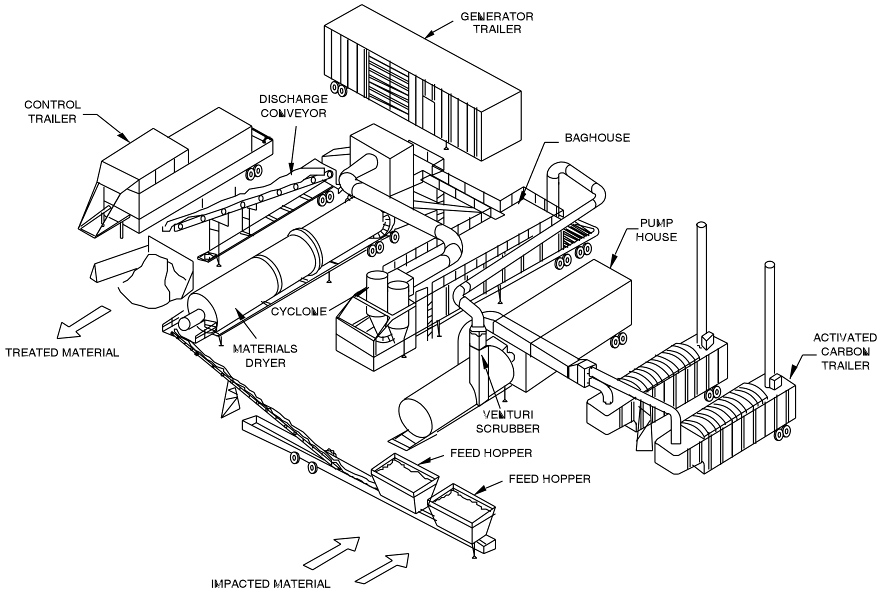
A direct-fired rotary dryer heats an air stream which, by direct contact, desorbs water and organic contaminants from the soil. Soil can be heated to up to 800°F. The processed soil is quenched to reduce temperatures and mitigate dust problems. The processed soil is then discharged into a stockpile. The hot air stream that contains vaporized water and organics is treated by one of two air pollution control systems. One system removes the organic contaminants from the air stream by adsorption on granular activated carbon (GAC) and includes the following units in series: (1) cyclones and baghouse for particulate removal; (2) wet scrubber for acid gas and some organic vapor removal; and (3) GAC adsorption beds for organic removal.

The second air pollution control system can treat soils containing high concentrations of petroleum hydrocarbons. The system includes the following units in series: (1) cyclones for particle removal; (2) thermal oxidizer-afterburner for destruction of organics; (3) quench tower for cooling of air stream; (4) baghouse for additional particle removal; and (5) wet scrubber for acid gas removal.

The LTTA® technology generates no wastewater or waste soils. Cyclone fines and baghouse dust are combined with treated soil and quenched with treated scrubber water. The treated soil, once verified to meet the treatment criteria, is backfilled on site without restrictions. GAC beds used for air pollution control are regenerated or incinerated when spent.

WASTE APPLICABILITY:

LTTA® can remove volatile organic compounds (VOC), semivolatile organic compounds (SVOC), organochlorine pesticides (OCP), organophosphorus pesticides (OPP), and total petroleum hydrocarbons (TPH) from soils, sediments, and some sludges.



Low Temperature Thermal Aeration (LTTA®) Technology

LTTA® has been used at full scale to remove VOCs such as benzene, toluene, tetrachloroethene, trichloroethene, and dichloroethene; SVOCs such as acenaphthene, chrysene, naphthalene, and pyrene; OCPs such as DDT, DDT metabolites, and toxaphene; OPPs such as ethyl parathion, methyl parathion, merphos, and mevinphos; and TPHs.

STATUS:

The LTTA® technology was accepted into the SITE Demonstration Program in summer 1992. LTTA® was demonstrated in September 1992 on soils contaminated with OCPs during a full-scale remediation at a pesticide site in Arizona. The Demonstration Bulletin (EPA/540/MR-93/504) and Applications Analysis Report (EPA/540/AR-93/504) are available from EPA.

The full-scale LTTA® system has remediated contaminated soils at six sites, including three Superfund sites. The system has treated more than 117,000 tons of soil.

DEMONSTRATION RESULTS:

Key findings from the demonstration are summarized below:

- The LTTA® system achieved the specified cleanup criteria for the site, a sliding scale correlating the concentrations of DDT family compounds (DDT, DDE, and DDD) with concentrations of toxaphene. The maximum allowable pesticide concentrations in the treated soil were 3.52 milligrams per kilogram (mg/kg) of DDT family compounds and 1.09 mg/kg of toxaphene.
- Residual levels of all the pesticides in the treated soil were generally below or close to the laboratory detection limit, with the exception of 4,4'-DDE, which was found at residual concentrations of 0.1 to 1.5 mg/kg. Removal efficiencies for pesticides found in the feed soil at quantifiable concentrations are summarized below:

Compound	Efficiency
4,4'-DDD	>99.97%
4,4'-DDE	90.26%
4,4'-DDT	99.97%
Endrin	>99.85%
Toxaphene	>99.83%
Endosulfan 1	>99.98%

- The LTTA® process did not generate dioxins or furans as products of incomplete combustion or thermal transformation.

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SOILTECH ATP SYSTEMS, INC.
(Anaerobic Thermal Processor)

TECHNOLOGY DESCRIPTION:

The SoilTech ATP Systems, Inc. (SoilTech), anaerobic thermal processor (ATP) uses a rotary kiln to desorb, collect, and recondense contaminants or recyclable hydrocarbons from a wide variety of feed material (see figure below).

The proprietary kiln contains four separate internal thermal zones: preheat, retort, combustion, and cooling. In the preheat zone, water and volatile organic compounds (VOC) are vaporized. The hot solids and heavy hydrocarbons then pass through a proprietary sand seal to the retort zone. The sand seal allows solids to pass and inhibits gas and contaminant movement from one zone to the other. Concurrently, hot treated soil from the combustion zone enters the retort zone through a second sand seal. This hot treated soil provides the thermal energy necessary to desorb the heavy organic contaminants. The vaporized contaminants are removed under slight vacuum to the gas handling system. After cyclones remove dust from the gases, the gases are cooled, and condensed oil and water are separated into their various fractions.

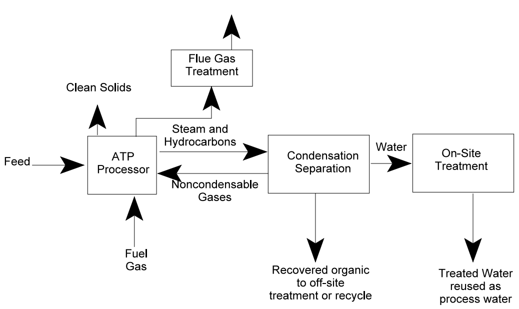
The coked soil passes through a third sand seal from the retort zone to the combustion zone. Some of the hot treated soil is recycled to the retort zone through the second sand seal as previously described. The remainder of the soil enters the cooling zone. As the hot combusted soil enters the cooling zone, it is cooled in the annular space between the outside of the preheat zone and the kiln shell. Here, the heat from the combusted soils is transferred indirectly to the soils in the preheat zone. The cooled, treated soil exiting the cooling zone is quenched with water and conveyed to a storage pile.

Flue gases from the combustion zone pass through the cooling zone to an emission control system. The system consists of a cyclone and baghouse to remove particulates, a wet scrubber to remove acid gases, and a carbon adsorption bed to remove trace organic compounds.

WASTE APPLICABILITY:

The system treats soils, sediments, and sludges contaminated with compounds that vaporize at temperatures up to 1,100 °F. Treated solids are free of organics and suited for backfill on site. Applicable contaminants include the following:

- Petroleum hydrocarbons: fuel, oil, lube oil, semivolatile organic compounds (SVOC), VOCs
- Halogenated hydrocarbons: polychlorinated biphenyls (PCB), dioxins, furans, pesticides, herbicides
- Aromatic hydrocarbons: coal tar residues polynuclear aromatic hydrocarbons (PAH)
- Volatile metals: mercury



Anaerobic Thermal Processor (ATP)

STATUS:

This technology was accepted into the SITE Demonstration Program in 1991. The ATP has been demonstrated at two sites. At the first demonstration, in May 1991, a full-scale unit dechlorinated PCB-contaminated soil at the Wide Beach Development Superfund site in Brant, New York. At the second demonstration, completed in June 1992, a full-scale unit remediated soils and sediments at the Waukegan Harbor Superfund site in Waukegan, Illinois. Two additional Superfund sites in Ohio and Kentucky have since been remediated by the ATP. Soils at these sites were contaminated with PCBs, PAHs, and pesticides.

The ATP has been used to treat more than 100,000 tons of waste on four separate sites. The system has operated in compliance with state and federal regulations in New York, Illinois, Ohio, and Kentucky. SoilTech is currently negotiating with a confidential client to remediate 25,000 cubic yards of trichloroethene- (TCE) and PCB-contaminated soil at a site located in Pennsylvania.

ZzSoilTech is continuing its research into more diverse organic remediation applications and bitumen recovery.

DEMONSTRATION RESULTS:

Test results from both SITE demonstrations indicate the following:

- The SoilTech ATP removed over 99 percent of the PCBs in the contaminated soil, resulting in PCB levels below 0.1 part per million (ppm) at the Wide Beach Development site and averaging 2 ppm at the Waukegan Harbor site.
- Dioxin and furan stack gas emissions were below the site-specific standards.
- PCB stack gas emissions were equivalent to 99.99 percent destruction and removal efficiency at the Waukegan Harbor site.
- No volatile or semivolatile organic degradation products were detected in the treated soil. Also, no leachable metals, VOCs, or SVOCs were detected in the treated soil.
- For the Wide Beach Development and Waukegan Harbor remediation projects, soil treatment costs were approximately $265 and $155 per ton, respectively. The regulatory support, mobilization, startup, and demobilization costs totaled about $1,400,000 for each site.

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SOLIDITECH, INC.

(Solidification and Stabilization)

TECHNOLOGY DESCRIPTION:

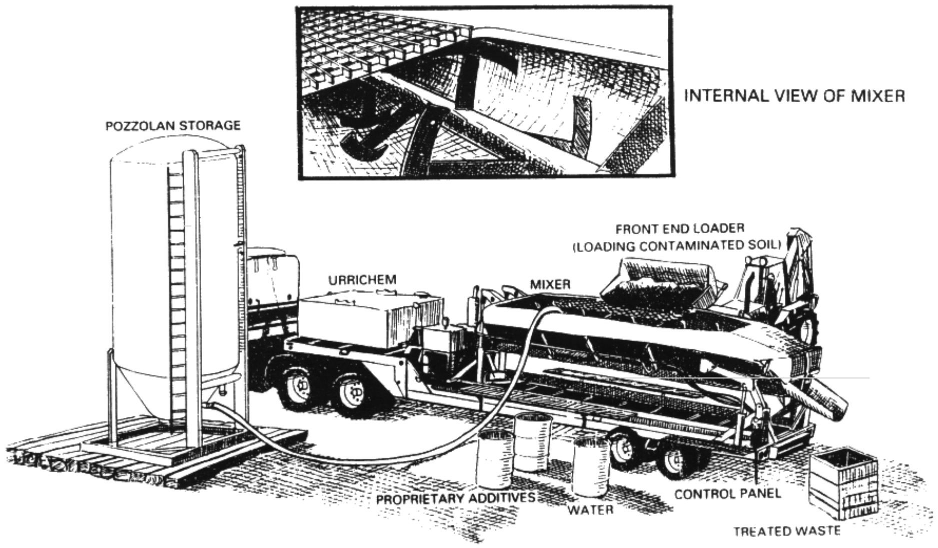
This solidification and stabilization process immobilizes contaminants in soils and sludges by binding them in a concrete-like, leach-resistant matrix. Contaminated waste materials are collected, screened to remove oversized material, and introduced to the batch mixer (see figure below). The waste material is then mixed with water; Urrichem, a proprietary chemical reagent; proprietary additives; and pozzolanic material (fly ash), kiln dust, or cement. After it is thoroughly mixed, the treated waste is discharged from the mixer. Treated waste is a solidified mass with significant unconfined compressive strength (UCS), high stability, and a rigid texture similar to that of concrete.

WASTE APPLICABILITY:

This process treats soils and sludges contaminated with organic compounds, metals, inorganic compounds, and oil and grease. Batch mixers of various capacities can treat different volumes of waste.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1988. The solidification and stabilization process was demonstrated in December 1988 at the Imperial Oil Company/Champion Chemical Company Superfund site in Morganville, New Jersey. This site formerly contained both chemical processing and oil reclamation facilities. Soils, filter cakes, and oily wastes from an old storage tank were treated during the demonstration. These wastes were contaminated with petroleum hydrocarbons, polychlorinated biphenyls (PCB), other organic chemicals, and heavy metals. The Technology Evaluation Report (EPA/540/ 5-89/005a), Applications Analysis Report (EPA/540/A5-89/005), and Demonstration Bulletin (EPA/540/M5- 89/005) are available from EPA. This technology is no longer available through a vendor. Contact the EPA Project Manager for further information.



Soliditech Processing Equipment

DEMONSTRATION RESULTS:

Key findings from the Soliditech demonstration are summarized below:

- Extract and leachate analyses showed that heavy metals in the untreated waste were immobilized.
- The process solidified both solid and liquid wastes with high organic content (up to 17 percent), 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 showed (1) UCS ranging from 390 to 860 pounds per square inch (psi); (2) very little weight loss after 12 cycles of wet and dry and freeze and 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. Because of solidification, the bulk density of the waste material increased by about 35 percent.
- Semivolatile organic compounds (phenols) were detected in the treated waste and the toxicity characteristic leaching procedure (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.
- The oil and grease content of the untreated waste ranged from 2.8 to 17.3 percent (28,000 to 173,000 parts per million [ppm]). The oil and grease content of the TCLP extracts from 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 from the treated waste.
- Visual observation of solidified waste revealed bulk oily material about 1 millimeter in diameter.

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SOLUCORP INDUSTRIES

(Molecular Bonding System®)

TECHNOLOGY DESCRIPTION:

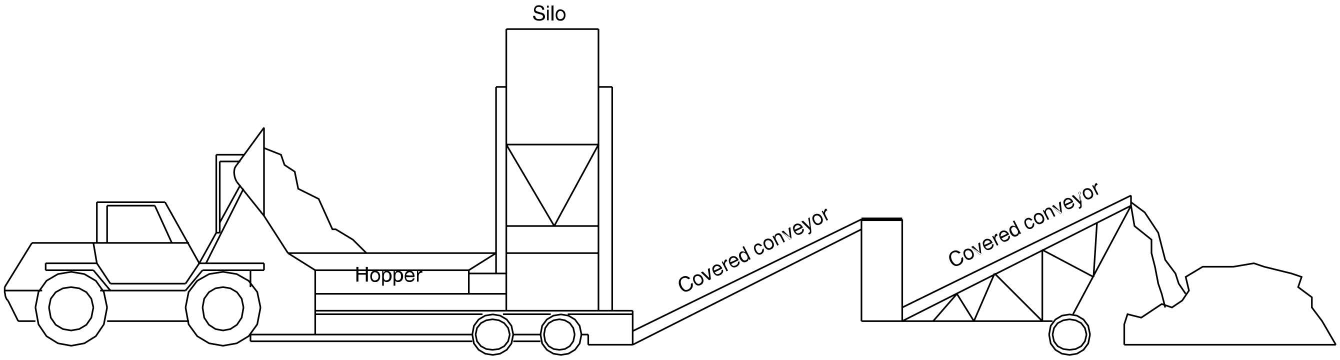
The Molecular Bonding System® (MBS) is a process developed for the stabilization of a variety of media, such as soil, sludge, slag, and ash, that is contaminated with heavy metals. The process employs a proprietary mixture of nonhazardous chemicals to convert the heavy metal contaminants from their existing reactive and leachable forms (usually oxides) into insoluble, stable, nonhazardous, metallic-sulfide compounds that will achieve toxicity characteristic leaching procedure (TCLP) levels far below regulatory limits. The MBS process maintains the pH levels in the media within the range where the insolubility of the heavy metal sulfides is assured. The system also provides buffer capacity to ensure that the pH is not significantly altered by the addition of acids or caustics to the media.

As depicted in the diagram below, the MBS treatment process is completely mobile and easily transportable (to allow for on-site treatment). Waste material is screened and crushed as required to reduce particle sizes to an average 1-inch diameter (particle size reduction increases surface area, which maximizes contact with the reagents). The waste media is then mixed with powdered reagents in a closed-hopper pug mill (the reagent mixture is established through treatability studies for the site-specific conditions). Water is then added to catalyze the reaction and to ensure homogeneous mixing. There is no curing time and the resulting increase in volume is between 2 to 3 percent. The treated media is then conveyed to a stockpile where it can then be either returned to the original site or disposed in a landfill as cover, fill, or contour material.

MBS can also be applied with traditional in situ mixing techniques such as tillers, eliminating the need for excavating and preparing the soil.

The MBS process can also be used to stabilize waste "in line" during the manufacturing process, preventing the waste from being classified as hazardous. Commercial applications on slag from a secondary smelter are underway.

The MBS process stabilizes heavy metals in soil, sludges, baghouse dust, ash, slag, and sediment. Heavy metals rendered inert by the process include arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. The process can simultaneously stabilize multiple heavy metal contaminants. The presence of organics does not affect treatment by MBS.



Process Flow Diagram of the Molecular Bonding System

STATUS:

The MBS technology was accepted into the SITE Demonstration Program in early 1995. A SITE demonstration was conducted at the Midvale Slag Superfund Site in Midvale, Utah in 1997. Three waste streams contaminated with As, Cd, and Pb were treated, including soil/fill material, slag, and miscellaneous smelter waste without brick. Approximately 500 tons of each waste stream was treated. The treated wastes and soils passed EPA's Multiple Extraction Procedure. The MBS process has undergone extensive bench-scale and pilot-scale testing prior to its successful full-scale commercialization. The same reductions in the TCLP levels of hazardous contaminants achieved in the laboratory were achieved at five manufacturing sites in five different states.

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SONOTECH, INC.

(Frequency-Tunable Pulse Combustion System)

TECHNOLOGY DESCRIPTION:

The Sonotech, Inc., frequency-tunable pulse combustion system (Sonotech system) is designed to significantly improve batch- and continuous-mode combustion or thermal processes (such as incineration) by creating large-amplitude, resonant pulsations inside the combustion chamber. This technology can be applied to new or existing combustion systems. The technology is used in fossil fuel combustion devices, residential natural gas furnaces, and industrial combustion systems. It should prove similarly beneficial to hazardous waste incineration and soil remediation applications.

The Sonotech system (see photograph below) consists of an air inlet, a combustor section, a tailpipe, a control panel, and safety features.

This system is designed to improve an incinerator's performance by (1) increasing mixing rates between the fuel and air, (2) increasing mixing rates between reactive gas pockets and ignition sources, and (3) increasing rates of heat and mass transfer between the gas and the burning waste. These improvements should (1) reduce the amount of excess air required to completely burn the waste, (2) increase destruction and removal efficiencies (DRE) of principal organic hazardous constituents, (3) minimize the formation of products of incomplete combustion, and (4) eliminate or minimize detrimental emissions or "puffs."

The Sonotech system has achieved sound amplitudes as high as 170 decibels and frequencies of 100 to 500 hertz within the combustion chamber. The high frequencies and velocities of these gas oscillations help mix the gases in the chamber and thus reduce or eliminate stratification effects.

Frequency-Tunable Pulse Combustion System Installed at EPA's Research Facility

The Sonotech system can function alone or as a supplemental retrofit to an existing combustion system. In the latter application, the frequency-tunable pulse combustion system can supply as little as 2 to 10 percent of the total energy requirements. The total fuel supplied to the main burner and the Sonotech system should be less than the amount of fuel supplied to the main burner before retrofitting.

WASTE APPLICABILITY:

This technology can be used with any material that can be treated in a conventional incinerator. Sonotech, Inc., believes that the technology is ready for incineration of hazardous, municipal, and medical wastes.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1992. The 6-week demonstration evaluated whether the technology improved the performance of a larger scale incineration system. To meet this goal, the pilot-scale rotary kiln incinerator at EPA's Incineration Research Facility in Jefferson, Arkansas was retrofit with a Sonotech system. The demonstration took place from September to October 1994. The retrofit incinerator was used to treat coal- and oil-gasification wastes, traditionally incinerated with conventional technology. The Technology Capsule (EPA/540/R-95/502a) is available from EPA.

DEMONSTRATION RESULTS:

The Sonotech system increased the incinerator waste feed rate capacity by 13 to 21 percent compared to conventional combustion. As the demonstration waste had significant heat content, the capacity increase was equivalent to a reduction in the auxiliary fuel needed to treat a unit mass of waste from 21,100 British thermal unit/pound (Btu/lb) for conventional combustion to 18,000 Btu/lb for the Sonotech system. Visual observations indicated improved mixing in the incinerator cavity with the Sonotech system operating.

Benzene and naphthalene DREs were greater than 99.99%. The average concentration of carbon monoxide exiting the afterburner, corrected to 7 percent oxygen, decreased from 20 parts per million (ppm) with conventional combustion to 14 ppm with the Sonotech system. The average concentration of nitrogen oxides exiting the after burner, corrected to 7 percent oxygen, decreased from 82 ppm with conventional combustion to 77 ppm with the Sonotech system. Average soot emissions exiting the afterburner, corrected to 7 percent oxygen, were reduced from 1.9 milligrams per dry standard cubic meter (mg/dscm) for conventional combustion to less than 1.0 mg/dscm with the Sonotech system. Total air requirements for system combustion, determined from stoichiometric calculations, were lower with the Sonotech system in operation.

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STAR ORGANICS, L.L.C.

(Soil Rescue Remediation Fluid)

TECHNOLOGY DESCRIPTION:

Tart Organics, L.L.C., has developed a liquid remediation solution that binds heavy metal contaminants in soils, sludges, and aqueous solutions. The liquid, called Soil Rescue, consists of organic acids that occur naturally in trace concentrations in soil. The liquid is typically sprayed onto and then tilled into the contaminated media; the application process can be repeated until the metals concentration in the media are reduced to below the applicable cleanup standards. Laboratory and pilot-scale tests have shown that metals concentrations can be reduced to below Research Conservation and Recovery Act (RCRA) regulatory levels.

The Soil Rescue solution does not destroy or remove toxic concentrations of metals. Instead, organic acids in the solution bond with the metals to form more complex metallic compounds in a process known as chelation. Soil Rescue is essentially a ligand that acts as a chelating agent. In te chelation reaction, coordinate bonds attach the metal ion to least two ligand organic compounds to form a heterocyclic ring. The resulting ring structure is inherently more stable than simpler structures formed in other binding processes.

By effectively binding the metals, the process reduces the waste stream's toxicity characteristic leaching procedure (TCLP) test results to less than the RCRA-regulated levels, subsequently reducing the risks posed to human health and the environment. Once the toxic metals are bound to the ligand, the bond appears to be irreversible. The permanence of the bond has been tested using all recognized EPA test procedures for such determinations, including exposure to boiling acids.

The Soil Rescue process offers the following advantages over some treatment options: (1) it minimized the handling and transports costs associated with treatment and disposal, (2) it requires no air monitoring because it release no emissions, (3) its liquid application procedure minimized fugitive dust emissions, (4) it generates no effluent, (5) it requires no stockpiling of contaminated soil, and (6) it minimizes exposure risks for workers because it is sprayed directly onto the contaminated media.

The Soil Rescue solution has been shown to be effective in reducing concentrations of barium, cadmium chromium, cooper, lead, mercury, selenium, and zinc. In situ remediation of heavy metal contaminated soil may be possible in moderately permeable soils. In dense or heavily compacted soils, the remediation procedure may require soil excavation and application of the Soil Rescue solution to moisten the media, followed by mixing in a rotating cylinder. This procedure can be repeated until the metals concentrations in the soil are sufficiently reduced to allo the soil to be replaced as backfill in its original location. At a soil pH of 5.0, a single application can reduce lead concentrations of 1,000 parts per million (ppm) to below the EPA maximum permissible level; with a second application of the remediation fluid, lead concentrations can be reduced to below the RCRA regulatory limit of 5 ppm.

STATUS:

Under a cooperative agreement with the Ohio EPA, the Soil Rescue technology was demonstrated in September 1998 at two separate areas of the Crooksville/Roseville Pottery site in Ohio. Soil at the site, some of it adjacent to residential areas, is contaminated with lead from waste disposal practices associated with pottery production operations. Soil at the demonstration areas contain lead in concentrations ranging from 100 ppm to 80,000 ppm.

DEMONSTRATION RESULTS:

Soil treatment reduced leachable lead concentrations from 364 to 453 mg/L to 2.7 to 3.6 mg/L, as determined by the Toxicity Characteristic Leaching Procedure (TCLP).

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STC REMEDIATION, INC.

(formerly Silicate Technology Corporation)

(Organic Stabilization and Chemical Fixation/Solidification)

TECHNOLOGY DESCRIPTION:

STC Remediation, Inc. (STC Remediation), has developed both chemical organic stabilization and chemical fixation/ solidification technologies that treat inorganic and organic solid hazardous wastes (see photograph below). Leachable organic contaminant concentrations are reduced to well below regulatory limits. The chemical fixation/ solidification technology forms insoluble chemical compounds, reducing leachable inorganic contaminant concentrations in soils and sludges.

STC Remediation's technology has been successfully implemented on numerous full-scale hazardous waste remediation projects, successfully stabilizing more than 750,000 tons of hazardous soils, sediments, and sludges. These sites include Superfund sites and industrial sites across the United States and in Italy.

STC Remediation has evaluated various materials handling and mixing systems for use on full-scale remediation projects. Materials handling processes consist of pretreatment processes for screening and crushing contaminated soils, and placement and conveying systems for handling treated material. Mixing systems consist of various batching plants, pug mills, and high-shear batch mixing systems to properly meter and mix reagents with contaminated soils. STC Remediation provides complete treatability study services during project development and on site technical services and/or contracting services during full scale remediation to ensure effective application of the treatment technologies, documentation, and quality assurance/quality control procedures during the treatment process.

Treatment of Contaminated Soil

WASTE APPLICABILITY:

STC Remediation's technology can treat a wide variety of hazardous soils, sludges, and wastewaters, including the following:

- Soils and sludges contaminated with inorganics, including most metals, cyanides, fluorides, arsenates, chromates, and selenium
- Soils and sludges contaminated with organics, including halogenated aromatics, polynuclear aromatic hydrocarbons, and aliphatic compounds
- Wastewaters contaminated with heavy metals and emulsified and dissolved organic compounds, excluding low-molecular-weight organic contaminants such as alcohols, ketones, and glycols

STATUS:

This technology was accepted into the SITE Demonstration Program in 1988, and the demonstration was completed in November 1990 at the Selma Pressure Treating (SPT) Superfund site in Selma, California. STC Remediation was subsequently selected for the full-scale remediation of the SPT site, which is contaminated with organics, mainly pentachlorophenol (PCP), and inorganics, mainly arsenic, chromium, and copper. The Applications Analysis Report (EPA/540/AR-92/010) is available through the National Technology Information Service (Order No. PB93-172948). The Technology Evaluation Report (EPA/540/R-92/010) and Demonstration Bulletin (EPA/540/MR- 92/010) are available from EPA.

DEMONSTRATION RESULTS:

The SITE demonstration yielded the following results:

- The organic stabilization technology reduced total extractable PCP concentrations up to 97 percent.
- The chemical fixation/stabilization technology stabilized the residual PCP concentrations to very low leachable levels (from 5 to less than 0.3 milligrams per liter).
- STC Remediation's technology immobilized arsenic and copper, while chromium remained well within regulatory limits.
- Long-term monitoring at 18 and 32 months following the demonstration project provided comparable results for PCP, arsenic, and copper, while chromium remained well within regulatory limits.
- The treated wastes had moderately high unconfined compressive strength, averaging 300 pounds per square inch (psi) after 28 days, increasing to more than 700 psi after 18 months.
- Permeability of the treated waste was less than 1.7×10^{-7} centimeters per second). The relative cumulative weight loss after 12 wet/dry and 12 freeze/thaw cycles was negligible (less than 1 percent).
- Treatment costs depend on specific waste characteristics.

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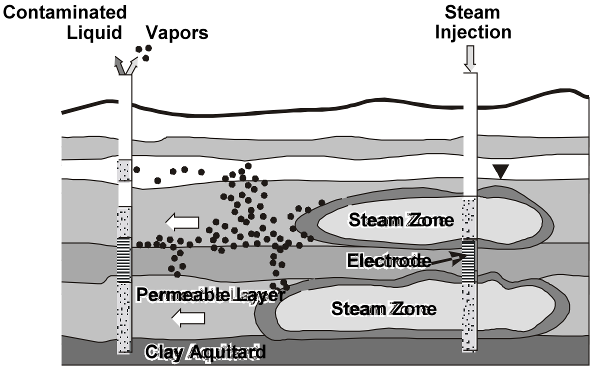
STEAMTECH ENVIRONMENTAL SERVICES

(Steam Enhanced Remediation [SER] at Loring AFB)

TECHNOLOGY DESCRIPTION:

Steam Enhanced Remediation – Dynamic Underground Stripping (SER – DUS) is a combination of technologies previously used separately, adapted to the hydrogeology of typical contaminated sites. Steam is injected at the periphery of the contaminated area to heat permeable subsurface areas, vaporize volatile compounds bound to the soil, and drive contaminants to centrally located vapor and liquid extraction wells. Electrical heating is used for less-permeable clays and fine-grained sediments to vaporize contaminants and drive them into the vapor. Since media at Edwards Air Force Base is fractured bedrock there will be no electrical heating. Progress is monitored by underground imaging, primarily Electrical Resistance Tomography (ERT) and temperature monitoring, which delineates the heated area and tracks the steam fronts daily to ensure total cleanup and precise process control.



SER – DUS is capable of extracting, separating and treating effluent vapors, nonaqueous phase liquids (NAPL), and water on-site for complete contaminant destruction or off-site disposal. The dominant removal mechanisms for volatile contaminants are the increased volatilization and steam stripping when the mixture of water and NAPL reaches the boiling point. Another major removal mechanism of contaminants is the fast removal of liquid, dissolved and vapor phase contaminants by physical transport to centrally located extraction wells. NAPL is removed from the extraction wells along with hot water. Contaminated vapors are extracted from the wells by aggressive vacuum extraction. In situ destruction of contaminants by thermally accelerated oxidation processes (hydrous pyrolysis, oxidation and biological mineralization) converts harmful chemicals into carbon dioxide and water.

WASTE APPLICABILITY:

Large and small sites contaminated with petroleum products, creosote and solvents can be remediated faster and at lower cost via SER. SER is highly effective for removal of both volatile and semivolatile compounds. SER works both above and below the groundwater table and both LNAPL and DNAPL contaminants can be removed.

STATUS:

Excellent cleanup results have been achieved in the laboratory, simulating cleanup using steam injection and Joule heating for gasoline, oils, creosote, and chlorinated solvent DNAPL. Field demonstrations include successful applications to sites containing chemical mixtures gasoline, jet fuel wood-treating chemicals, and chlorinated solvents such as TCE.

DEMONSTRATION RESULTS:

There has not yet been a demonstration at Loring Air Force Base, so there are no results up to this point. The demonstrations are planned for the summer of 2002.

FOR FURTHER INFORMATION:

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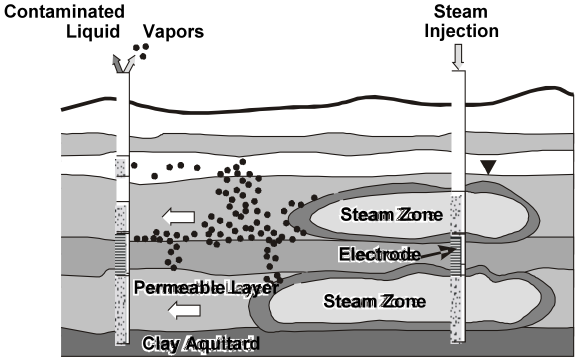
STEAMTECH ENVIRONMENTAL SERVICES

(Steam Enhanced Remediation [SER] at Ridgefield, WA)

TECHNOLOGY DESCRIPTION:

Steam Enhanced Remediation – Dynamic Underground Stripping (SER – DUS) is a combination of technologies previously used separately, adapted to the hydrogeology of typical contaminated sites. Steam is injected at the periphery of the contaminated area to heat permeable subsurface areas, vaporize volatile compounds bound to the soil, and drive contaminants to centrally located vapor and liquid extraction wells. Electrical heating is used for less-permeable clays and fine-grained sediments to vaporize contaminants and drive them into the vapor. Since media at Edwards Air Force Base is fractured bedrock there will be no electrical heating. Progress is monitored by underground imaging, primarily Electrical Resistance Tomography (ERT) and temperature monitoring, which delineates the heated area and tracks the steam fronts daily to ensure total cleanup and precise process control.



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WASTE APPLICABILITY:

Large and small sites contaminated with petroleum products, creosote and solvents can be remediated faster and at lower cost via SER. SER is highly effective for removal of both volatile and semivolatile compounds. SER works both above and below the groundwater table and both LNAPL and DNAPL contaminants can be removed.

STATUS:

Excellent cleanup results have been achieved in the laboratory, simulating cleanup using steam injection and Joule heating for gasoline, oils, creosote, and chlorinated solvent DNAPL. Field demonstrations include successful applications to sites containing chemical mixtures gasoline, jet fuel wood-treating chemicals, and chlorinated solvents such as TCE.

DEMONSTRATION RESULTS:

There has not yet been a demonstration in Ridgefield, WA, so there are no results up to this point. The demonstrations are planned for the spring of 2002.

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