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EPA

Innovative Technology

BEST™ Solvent Extraction Process

TECHNOLOGY DESCRIPTION

Solvent extraction is potentially effective in treating oily sludges and soils by separating the media into three fractions: oil, water, and solids. As the fractions separate, certain contaminants are concentrated into specific phases. For example, PCBs concentrate in the oil fraction, while metals, unless organically bound, accumulate in the solids fraction. Individual phases can then be treated more efficiently. Solvent extraction is capable of processing the oily wastes shown in Table 1. Table 2 lists the effectiveness of solvent extraction on general contaminant groups.

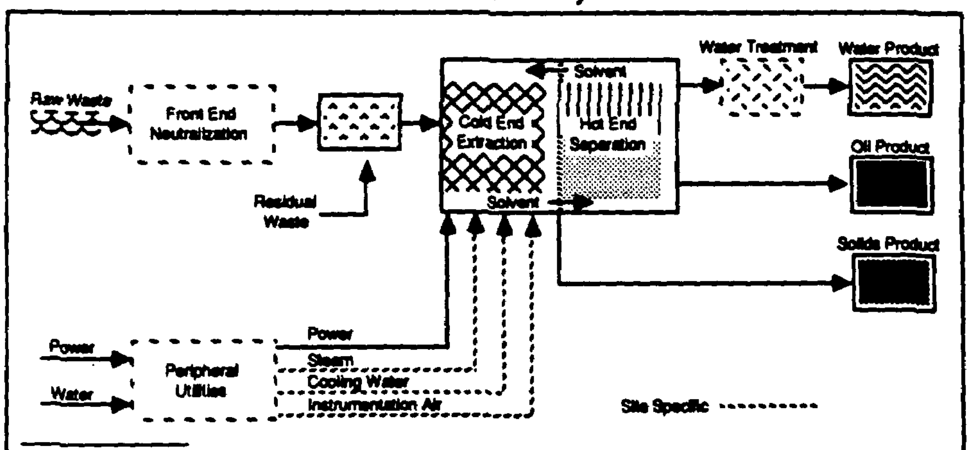
One type of solvent extraction, BEST™ treatment, is a mobile solvent extraction system developed by Resources Conservation Company (RCC). This system uses one or more secondary or tertiary amines [usually triethylamine (TEA)] to separate toxic wastes and oils from sludges or soils. The BEST™ technology is based on the fact that TEA is miscible in water at temperatures below 65°F.

A typical process diagram for the BEST™ process is shown in Figure 1. This process begins by mixing and agitating the cold solvent and sludge or soil in a mixing tank. Oil and water in the feed simultaneously solvate with the cold TEA creating a homogeneous mixture. As the solvent breaks the oil-water-solid bonds, the solids are released from the emulsion. These solids are subsequently removed by centrifuging, which ensures submicron particles are removed. The solids are passed to a second mixing tank where they are washed with additional solvent and centrifuged a second time. The wet solids (about 50% solids by weight) are sent to a dryer where the solvent is vaporized and collected for recycling. Dry solids containing heavy metals may require further treatment before disposal.

The liquids from the first centrifuge, containing the oil and water extracted from the feed, are heated in a series of heat exchangers. As the temperature of the liquids increase, the water separates from the oil-solvent. The oil-solvent fraction is decanted and sent to a stripping column where the solvent is recycled and the oil is discharged for recycling or disposal. The water phase is passed to a second stripping column where residual solvent is recovered for recycling; the water is typically discharged to a local wastewater treatment plant.

An advantage of RCC's facility is the modular capability, allowing on-site treat-

Figure 1: Schematic Diagram of a Typical BEST™ Treatment Facility



Note: adapted from Resources Conservation Company, for Booz, Allen & Hamilton Inc

Table 1
Specific Wastes Capable of Treatment Using Solvent Extraction

RCRA Listed Hazardous Wastes
- Creosote-Saturated Sludge
- Dissolved Air Flotation (DAF) Float
- Slop Oil Emulsion Solids
- Heat Exchanger Bundles Cleaning Sludge
- API Separator Sludge
- Tank Bottoms (Leaded)

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

Table 2
Effectiveness of Solvent Extraction on General Contaminant Groups for Soil and Sludge

	Treatability Groups	Effectiveness Soil	Effectiveness Sludge
Organics	Halogenated volatiles	◒	◒
	Halogenated semi-volatiles	◒	●
	Non-halogenated volatiles	◒	◒
	Non-halogenated semi-volatiles	◒	●
	PCBs	◒	●
	Pesticides	◒	◒
	Dioxins/Furans	◒	◒
	Organic cyanides	◒	◒
	Organic corrosives	◒	◒
Inorganics	Volatile metals	○	○
	Non-volatile metals	○	○
	Asbestos	○	○
	Radioactive materials	○	○
	Inorganic corrosives	○	○
	Inorganic cyanides	○	○
Reactive	Oxidizers	X	X
	Reducers	X	X

● Demonstrated Effectiveness ○ No Expected Effectiveness
◒ Potential Effectiveness X Potentially Detrimental

ment. Other advantages of the BEST™ technology include the production of dry solids, the recovery and reuse of oil, and waste volume reduction. BEST™ does not, however, reduce contaminant toxicity. Furthermore, implementation can require complex engineering considerations.

SITE CHARACTERISTICS AFFECTING TREATMENT FEASIBILITY

The BEST™ process is not limited by organics or oil concentrations. Performance, however, can be influenced by the presence of detergents and emulsifiers, low pH materials, and reactivity of the sludge with the solvent. Other factors that affect feasibility and actions to minimize these affects are listed in Table 3. Treatability tests should be conducted to determine the effectiveness of the treatment on specific site conditions.

Table 3
Site-Specific Characteristics and Impacts on BEST™

Characteristics Impacting Process Feasibility	Reasons for Potential Impact	Actions to Minimize Impacts
Presence of elevated levels of volatiles	Volatiles may combine with process solvent	Use an additional separation step
Particle diameter greater than 0.25 inches	Equipment used in process not capable of handling large particles	Screen waste to remove large particles or crush in a hammermill
pH less than 10	TEA (used in extraction process) is weak base and will not exist in solvent form at pH less than 10	Raise pH of waste with caustic soda
Presence of high amounts of emulsifiers	Adversely affect oil/water phase separation	Increase quantity of solvent
Compounds that undergo strong reactions under highly alkaline conditions	Strong reactions may occur during treatment because of caustic addition	Raise pH of waste with TEA instead of caustic soda
Types of waste	Some materials are not suitable for chemical extraction (e.g., highly volatile organics and wastes containing mostly toxic metals)	Conduct pre- and/or post-treatment

TECHNOLOGY CONSIDERATIONS

TEA is flammable in the presence of oxygen, therefore, the treatment system must be sealed from the atmosphere and operated under a nitrogen blanket. Also, TEA is known to be toxic to aquatic life and, depending on the disposal method, may need to be removed from the solids. Prior to treatment it is necessary to raise the pH to greater than 10, creating an environment where TEA is stable. This may be accomplished by adding either sodium hydroxide or TEA. (Sodium hydroxide is more cost-effective, however, TEA is less reactive.) It may also be necessary to add water or solvent to the feed to create a slurry capable of being pumped.

Additionally, pre-treatment may require screening of the feed to ensure that particles are all less than 0.25 inches. Because the equipment is incapable of handling large diameter particles, feed may be passed through a 2-inch screen and subsequently crushed in a 0.2-inch hammermill.

Further treatment of by-products may be necessary before disposal. Specifically, wastewater treatment may include carbon adsorption or biological treatment to remove residual organics. Chemical precipitation also may be required to remove soluble metal contaminants. Free water from sludge ponds may either be treated with the sludge or may be treated separately. In addition, waste oil may either be recycled or reused as fuel. If neither option is viable, the oil should be tested to determine appropriate treatment, storage, or disposal actions. Last, leachate tests should be conducted on residual solids to determine if stabilization is necessary before disposal. Other post-treatment alternatives for solids may include thermal stripping, wet air oxidation, in-situ vitrification, soil washing, and/or glycolate dehalogenation.

RCC quotes the cost of treatability studies to be $4,500 for 1 kg of non-PCB contaminated wastes and $5,500 for 1 kg of waste containing PCBs. These costs include three extractions and do not include organic analyses. Treatment costs range from $90/ton for a large facility treating 200 tons/day to $280/ton for a small facility treating 30 tons/day. More information about RCC can be found in Table 4.

Table 4
BEST™ Vendor Information

Company	Contact	Address
Resources Conservation Co.	Paul McGough	3006 Northup Way Bellevue, WA 98004 (206) 828-2400
Note: BEST™ was developed and patented by Resources Conservation Co.		

TECHNOLOGY STATUS

The first full-scale BEST™ unit was used at the CERCLA General Refining Site in Garden City, Georgia. Further information is summarized in Table 5. Solvent extraction is the selected remedial action for the Pinette's Salvage site and the F. O'Connor site, both located in Maine; the actual process has not yet been determined.

The BEST™ process has been selected for evaluation under the SITE Program. Formal demonstration and testing is being postponed until the developer has obtained funding for a demonstration at an appropriate site.

OFFICE OF RESEARCH AND DEVELOPMENT CONTACTS

For more information regarding the BEST™ technology, contact Edward Bates, U.S. EPA, Risk Reduction Engineering Laboratory, Cincinnati, Ohio 45268, (513) 569-7774 or FTS 684-7774.

Table 5
BEST™ Status at CERCLA Sites

SELECTED:		
Region 4 - General Refining, GA (Removal Action) FY86-FY87	PCBs, lead in Sludge	3,700 tons