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Emergency Response
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EPA

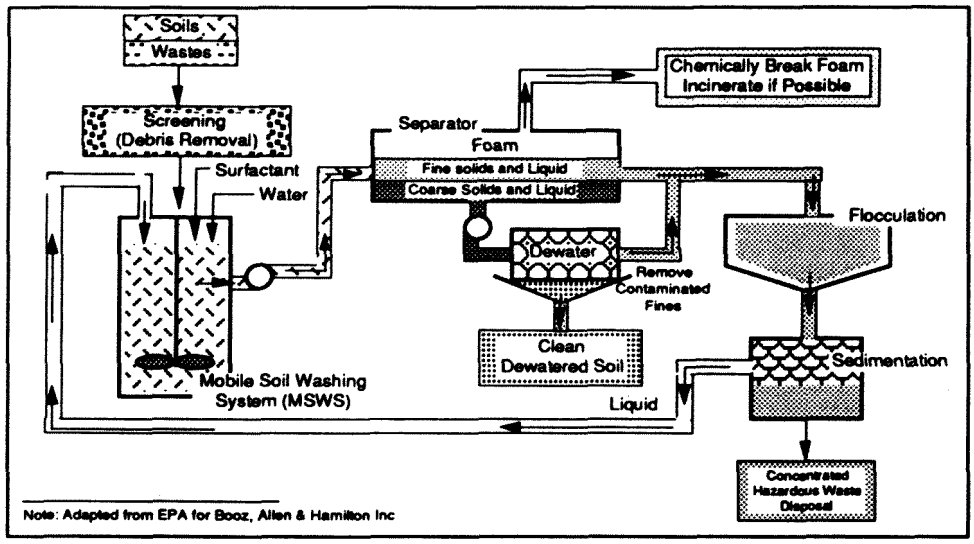
Innovative Technology

Soil Washing

TECHNOLOGY DESCRIPTION

Soil washing is potentially effective in treating various organic and inorganic waste groups. It was designed for the separation/segregation and volumetric reduction of hazardous materials in soils, sludges, and sediments. The process involves high energy contacting and mixing of excavated contaminated soils with an aqueous-based washing solution in a series of mobile washing units. A typical soil washing treatment flow diagram is shown in Figure 1.

Figure 1: Schematic Diagram of a Mobile Soil Washing Treatment Facility



Note: Adapted from EPA for Booz, Allen & Hamilton Inc

Before treatment, the contaminated soil is passed through a coarse-mesh sieve to remove material greater than two inches (e.g., rocks, debris). The remaining material then enters a soil scrubbing unit, where it is sprayed with a washing fluid and subsequently rinsed. Contaminants are primarily concentrated in the fine-grained soil fraction (i.e., silt and clay) and are less tenaciously sorbed on the coarser-grained particles (i.e., sand). Accordingly, the sand fraction of the soil usually requires only the initial rinsing treatment to meet designated performance criteria prior to redeposition. The remaining silt/clay soil fraction enters a four-staged countercurrent contactor to further separate the contaminants from the solids. The treated solid fractions (less than 74 microns) are then rinsed, dewatered, and redeposited. The contaminated washing fluid, containing highly contaminated fine fractions (greater than 74 microns) is recycled through a conventional wastewater treatment system and is reintroduced into the treatment process. The fines are separated, removed, and dewatered and are handled/disposed as a manifested hazardous waste material.

Advantages of soil washing include a closed treatment system that permits control of ambient environmental conditions, potential significant volume reduction of the contaminant mass (depending on soil characteristics), wide application to varied waste groups, mobility of technology (hazardous wastes remain on-site), and relatively low cost compared to other multi-contaminant treatment technologies. Disadvantages include little reduction of the contaminant toxicity, and potentially hazardous chemicals (e.g., chelating washing solutions) may be brought on-site to be used in the process, and also may be difficult to remove from the treated soil fraction. Applications and limitations of soil washing are discussed in the following sections.

SITE CHARACTERISTICS AFFECTING TREATMENT FEASIBILITY

Soil washing has the potential to treat a wide variety of contaminants such as heavy metals, halogenated solvents, aromatics, gasoline and fuel oils, polychlorinated biphenyls (PCBs), and chlorinated phenols. The projected effectiveness of this treatment on general contaminant groups is provided in Table 1; treatability tests are required to determine the feasibility of soil washing for specific target contaminants at a particular site.

Factors limiting the effectiveness of soil washing include complex waste mixtures, high humic content in the soil, inhibiting solvent-soil reactions, and a high fine-grained clay particle fraction. Site-specific characteristics and their potential impact on the soil washing process are listed in Table 2.

Table 1
Effectiveness of Soil Washing Treatment on General Contaminant Groups for Soil and Debris

	Treatability Groups	Effectiveness
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	◒
	Reducers	◒

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

Table 2
Site-Specific Characteristics and Impacts on Soil Washing Treatment

Characteristics Impacting Process Feasibility	Reasons for Potential Impact	Actions to Minimize Impacts
Unfavorable separation coefficient for contamination	Excessive volumes of leaching medium required	Bench- and pilot-scale tests to determine a suitable washing solution
Complex mixtures of waste types (e.g., metals with organics)	Formulation of suitable washing fluids difficult	Employ secondary treatment technology
Unfavorable soil characteristics:		
• High humic content	Inhibition of desorption	Employ secondary treatment technology
• Soil, solvent reactions	May reduce contaminant mobility	Pilot testing to determine a suitable washing fluid
• Fine particle size (silt and clay)	Fine particles difficult to remove from washing fluid	None; or longer dewatering period
• Clay soil containing semi-volatiles	Low recovery rate because organics are held more tenaciously	None; or longer washing period
Unfavorable washing fluid characteristics:		
• Difficult recovery of solvent or surfactant	High cost if recovery low	Bench-scale testing to determine if technology is economically feasible
• Poor treatability of washing fluid	Requires replacement of washing fluid	Bench-scale testing to determine if technology is economically feasible
• High toxicity of washing fluid	Fluid processing requires caution, soil may require detoxification	Longer dewatering period; post-treatment of soils; bench- and pilot-scale tests to determine an alternate washing solution

TECHNOLOGY CONSIDERATIONS

Because soil washing is primarily a volume-reduction process that does not reduce the inherent toxicity of a contaminant, the major technology consideration is determining the initial composition and post-treatment of the washing fluid and contaminated fines. An ideal washing fluid should possess the following characteristics: a favorable separation coefficient for extraction, low volatility, low toxicity, safety and ease of handling, and efficient recoverability and treatability. Typical soil washing fluids may be composed of water only, or water in combination with organic solvents, chelating compounds, surfactants, acids, or bases; the exact washing fluid composition depends upon the chemistry of the target contaminant(s).

The treatment of the washing fluid is contingent upon the composition of the contaminants removed from the waste stream. For expensive washing fluids (e.g., lead chelating agents), the recyclability of the fluid is an important factor when determining the economic feasibility of the soil washing process. Full-scale soil washing units are projected to treat an average of 100 cubic yards of soil per day.

TECHNOLOGY STATUS

The following vendors claim to have successfully applied soil washing to various media and waste types and presently possess the technology to conduct pilot- and/or full-scale operation:

• MTA Remedial Resources, Inc., (MTARRI) uses technologies developed for mining and enhancing oil recovery to remove and concentrate organic contaminants from soils and sludges. In addition, MTA has treated various metallic compounds with acidic washing solutions. They state that 5 tons (5 percent) of contaminated treatment residue is generated per 100 tons of soil treated.

• BioTrol, Inc. employs soil washing as a pretreatment process in conjunction with biodegradation. EPA is presently evaluating the BioTrol Soil WashingTreatment System (BSTS) under the SITE program. BSTS will be demonstrated on wood-treating chemicals (i.e., PCP, PAHs, copper, chromium, and arsenic) at the MacGillis and Gibbs Site, New Brighton, Minnesota, by Fall 1989.

• EPA developed a mobile soil washing treatment system designed for water extraction of a broad range of hazardous materials from contaminated soils. The normal processing rate is 4 to 18 cubic yards of contaminated soil per hour depending on the average particle size. Treatability costs range from approximately $20,000 to over $100,000.

Vendor names, contacts, and addresses are listed in Table 3.

EPA has selected soil washing as a component of the source control remedy for five CERCLA sites. Site names, ROD sign dates, target contaminants, and waste volumes are provided in Table 4.

OFFICE OF RESEARCH AND DEVELOPMENT CONTACTS

Supplemental information concerning soil washing may be obtained from Richard P. Traver, P.E., U.S. EPA, Edison, New Jersey 08837, (201) 321-6677 or FTS 340-6677.

Table 3
Vendor Information

Company	Contact	Address
MTARRI	Paul Trost	1511 Washington Avenue Golden, CO 80401 (303) 279-4255
Ecova Corporation	Al Bourquin	3820 159th Avenue NE Redmond, WA 98052 (206) 883-1900
BioTrol, Inc.	Dale Pflug	11 Peavey Road Chaska, MN 55318 (612) 448-2515
U.S. EPA, Risk Reduction Engineering Laboratory	Richard P. Traver	Releases Control Branch Raritan Depot - Woodbridge Avenue Edison, NJ 08837-3679 (201) 321-6677
Soil Cleaning Company of America, Inc.	Verl Rothlisberger	753 Peralta Avenue San Leandro, CA 94577 (415) 568-1234

Table 4
Soil Washing Status at CERCLA Sites

SELECTED:		
Region 1 - Tinkham Garage, NH 9/86	TCE, PCE in Soil	10,800 cubic yards
Region 4 - Palmetto, SC 9/87	Arsenic, Chromium in Soil	19,850 cubic yards
Region 5 - United Scrap, OH 9/88	Arsenic, Lead in Soil	60,600 cubic yards
Region 6 - Koppers/Texarkana, TX 9/88	Arsenic in Soil	Not Provided
Region 6 - South Cavalcade, TX 9/88	PAHs in Soil	19,500 cubic yards