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Solid Waste And
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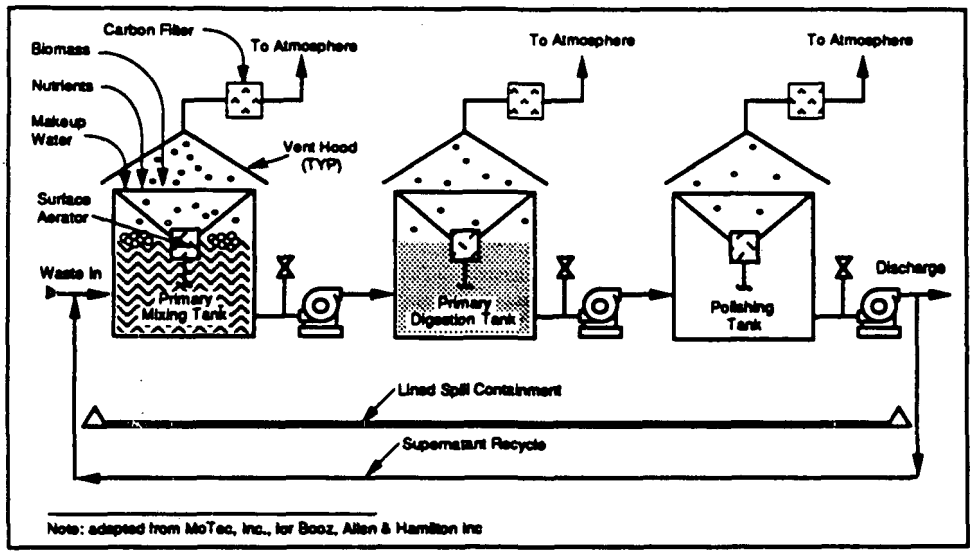
# Innovative Technology
# Slurry-Phase Biodegradation

## TECHNOLOGY DESCRIPTION

Slurry-Phase Biodegradation (SPB) is potentially effective in treating various organic contaminants. It involves the commingling of excavated contaminated soil and sludge with bioactive microorganisms in a mobile batch reactor or an in-ground reactor. A typical treatment facility is shown in Figure 1.

**Figure 1: Schematic Diagram of a Typical Slurry-Phase Biodegradation Treatment Facility**




Note: adapted from MoTec, Inc., for Booz, Allen & Hamilton Inc

Prior to treatment, large-grained constituents such as stones and rubble are physically removed from the waste. The remaining waste is mixed with water to create the desired slurry composition (50 weight percent solids maximum). The slurry water may be contaminated ground water, surface water, or another water source that is brought on-site. The slurry is then mechanically agitated in a reactor chamber which creates and maintains the appropriate ambient environmental conditions (e.g., nutrient supply, temperature range, oxygen content, and pH level) needed for maximum bio-oxidation of the target contaminants. Microorganisms may be added initially to seed the reactor and/or added continuously during treatment to maintain the appropriate biomass concentration. The residence time in the reactor varies with the soil or sludge matrix, the physical and chemical nature of the contaminants, contaminant concentrations, and the efficiency of the bio-oxidation reactions. Upon completion of the process, the slurry is dewatered and the treated soil is redeposited on-site.

Advantages of SPB include the following: biodegradable organic compounds may be transformed into non-toxic compounds or mineralized; elaborate or sophisticated equipment is not required; and batch operation may allow more accurate mass-balance determinations. The major disadvantages are that the treatment time can be relatively slow and SPB is ineffective against inorganic wastes. Applications and limitations of the SPB technology are discussed below.

## SITE CHARACTERISTICS AFFECTING TREATMENT FEASIBILITY

SPB has the potential to treat a wide range of contaminants such as pesticides, fuels, creosote, pentachlorophenol (PCP), polychlorinated biphenyls (PCBs), and some halogenated volatile organics. The projected effectiveness of this treatment on general contaminant groups is provided in Table 1.

Factors limiting treatment effectiveness include the inherent biodegradability of the target contaminant, dissolved oxygen content, operating temperature, soil/sludge characteristics, and the presence of reaction-inhibiting compounds such as heavy metals, chlorides, or even biodegradation by-products. Site-specific characteristics and their potential impact on the SPB process are listed in Table 2.

Variables governing the biodegradation process and resulting effectiveness can vary greatly between laboratory and actual field conditions. Therefore, in order to accurately model the effectiveness of SPB treatment, it is necessary to conduct bench- or pilot-scale tests at each site of interest.

**Table 1**
**Effectiveness of Biodegradation 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 | Insufficient Data |
| | Organic cyanides | X |
| | Organic corrosives | X |
| Inorganics | Volatile metals | X |
| | Non-volatile metals | X |
| | Asbestos | ○ |
| | Radioactive materials | X |
| | Inorganic corrosives | X |
| | Inorganic cyanides | X |
| Reactive | Oxidizers | X |
| | Reducers | X |

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

**Table 2**
**Site-Specific Characteristics and Impacts on Slurry-Phase Biodegradation Treatment**

| Characteristics Impacting Process Feasibility | Reasons for Potential Impact | Actions to Minimize Impacts |
|---|---|---|
| Variable waste composition | Inconsistent biodegradation caused by variation in biological activity | Dilution of waste stream |
| Water solubility | Contaminants with low solubility are harder to biodegrade | None; or longer exposure time to microorganisms |
| Biodegradability | Low biodegradability inhibits process | None; or longer exposure time to microorganisms; or co-metabolism with another compound; or dilution to nontoxic levels |
| Temperature outside 15° - 70°C range | Larger, more diverse microbial population present in this range | Temperature monitoring and adjustments |
| Nutrient deficiency | Lack of adequate nutrients for biological activity | Adjustment of the carbon/nitrogen/ phosphorus ratio |
| Oxygen deficiency | Lack of oxygen is rate limiting | Oxygen monitoring and adjustments |
| pH outside 4.8 - 8.5 range | Inhibition of biological activity | Sludge pH monitoring, addition of acidic or alkaline compounds |
| Microbial population | Insufficient population results in low biodegradation rates | Culture test, addition of culture strains |
| Water discharges and air emissions | Potential environmental and/or health impacts | Post treatment processes (e.g., air scrubbing, carbon filtration) |
| Nonuniform particle size | Waste mixtures must be of uniform particle size for proper slurry composition | Physical separation of large-grained particles |
| Presence of elevated levels of:<br>• Heavy metals<br>• Highly chlorinated organics<br>• Some pesticides, herbicides<br>• Inorganic salts | Can be highly toxic to microorganisms | Pretreatment processes (e.g., soil washing, precipitation) to remove constituents from or dilute them in the waste |
| Soil/sludge composition (i.e., clay, humus) | Clay and humus sorb contaminants more tightly | None; or pH adjustment or other chemical amendments |

**Table 3**
**Vendor Information**

| Company | Contact | Address |
|---|---|---|
| Ecova Corporation | Al Bourquin | 3820 159th Street NE<br>Redmond, WA 98052<br>(206) 883-1900 |
| Detox Industries, Inc. | Joe Dailey | 12919 Dairy Ashford<br>Sugarland, TX 77478<br>(713) 240-0892 |
| MoTec, Inc. | John R. Ryan | 22419 72th Ave. South<br>Kent, WA 98032<br>(206) 872-0247 |
| Biotrol, Inc. | Debra Lindstrom | 11 Peavey Road<br>Chaska, MN 55318<br>(612) 448-2515 |

## TECHNOLOGY CONSIDERATIONS

Some treatment limitations can be minimized by implementing pre- and post-treatment processes. For instance, wastes contaminated with heavy metals and high concentrations of volatile and semi-volatile organics can be initially treated prior to microbial degradation. Fugitive emissions of volatile organic compounds may also warrant further treatment (e.g., carbon adsorption). Acclimation of the microorganisms to the environment is waste/site specific and typically takes between 1 to 3 days. The standard reactor vessel requires an energy supply to run a 75 horsepower engine.

## TECHNOLOGY STATUS

The following vendors claim to have successfully applied SPB to various media and waste types and presently possess the technology to conduct full-scale waste remediation:

- Ecova Corporation applied full-scale SPB at a hazardous waste site to treat contaminated sludges containing a combination of pesticide and chlorinated organic wastes. Further treatment information is not available. Ecova quotes the cost of a treatability test to be between $5,000 and $50,000, depending on the chemistry of the treatability groups.

- Detox Industries, Inc. applied pilot-scale SPB treatment to PCBs at a hazardous waste site in Herne, Texas. Approximately 0.75 tons of sludge containing 2,000 ppm PCBs were treated to less than 4 ppm (99.8 percent removal) within four months. Detox quotes the cost of a treatability test to be between $20,000 and $25,000. The estimated range for treatment costs is between $200 and $600 per cubic yard, depending on site-specific characteristics.

- MoTec, Inc. has applied full-scale SPB treatment to contaminated sludges at State-level uncontrolled hazardous waste sites containing high concentrations of PAHs and PCPs associated with wood treatment operations. They estimate the average half-life of the biodegradation process to be 90 days. MoTec quotes the average cost of a treatability study to be approximately $20,000.

Vendor names, contacts, and addresses can be found in Table 3. These vendors state that pilot- and full-scale SPB treatments have been demonstrated, selected and implemented at private and State sites. This technology has not yet been thoroughly demonstrated to the SITE program, possibly due to quality control and/or project management. SPB has been tentatively selected as a component of the source control remedy at the General Motors Superfund site in Massena, NY, where SPB will be applied to small volumes of PCB-contaminated oils contained in an undetermined number of tanks.

## OFFICE OF RESEARCH AND DEVELOPMENT CONTACTS

**More information concerning SPB may be obtained from Ron Lewis or Naomi Barkley, U.S. EPA, Risk Reduction Engineering Laboratory, Cincinnati, Ohio 45268, (513) 569-7856 or FTS 684-7856, and (513)569-7854 or FTS 684-7854, respectively.**