REMEDIATIONS
BIOREMEDIATION
...The Natural Solution to Contamination

OBJECTIVES

Many microbes have been demonstrated to be effective in the degradation of petroleum and other hydrocarbons by breaking them down into harmless molecules such as carbon dioxide and water. Bioremediation seeks to use microbes such as bacteria and fungi naturally present in soil and groundwater systems and to enhance their contaminant degradation activity by supplying them with additional nutrients, adjusting their environment, and/or augmenting their colony population and/or diversity.

EVALUATING BIOREMEDIAL POTENTIAL

The potential for bioremediation to reduce contaminant concentrations at a specific site is evaluated using a combination of laboratory and field tests.

Laboratory biotreatability tests commonly include identification of contaminants and their concentrations, determination of the number of microbes present of types that potentially might be effective in degrading the specific contaminants present, confirmation that biological degradation will occur, evaluation of the physical conditions (pH, oxygen concentration, etc.) and supplemental nutrients that will most enhance degradation, assessment of toxins or conditions that could limit microbial activity, analytical of laboratory degradation rates, and recommendation of an engineering design that would maximize remedial potential.

Relatively small-scale field pilot test commonly are instituted to confirm actual biodegradation effectiveness and rates under field conditions and to identify any special engineering requirements associated with system design. Such tests often also are required by regulatory agencies prior to approval of technology implementation.

ALTERNATIVE ENGINEERING DESIGNS

Bioremedial activities may be conducted passivley, *in-situ*, or *ex-situ*. Bioremedial system design must address both the growth requirements of the contaminant-degrading microbes and the physical limitations of environmental conditions and site use. Depending on the nature of the contaminants to be degraded, site accessibility and size, and desired completion time frames, one or more alternative bioremedial system design may be to be more effective and cost-efficient (see back side of this summary sheet).

If sufficient degrading microbial populations are present and environmental conditions are favorable, contaminant degradation may occur naturally without enhancement. **Passive Bioremediation** often requires a long time frame to achieve adequate degradation but can be effective where other remedial approaches would be difficult or extremely costly to implement. Passive Bioremediation (a form of Monitored Natural Attenuation) typically must be monitored are regular intervals to verify that contaminant migration is controlled, that, the process is resulting in contaminant degradation, and that contaminant byproducts are not being formed that could cause increased toxicity.

In-situ bioremedial approaches involve the application of appropriate nutrients and the adjustment of physical conditions (often by injecting air) to promote microbial growth and contaminant degradation without excavation or physical removal of the contaminated media. Access to the impacted media may be gained via a system of wells, trenches, or infiltration galleries; and a system of blowers, controllers, nutrient reservoirs, and monitoring instrumentation usually is required to promote maximum degradation rates. ***In-situ* Bioremediation** is particularly effective with simple contaminant mixes and may be used to enhace other remedial strategies such as pump-and-treat or air sparging.

***Ex-situ* Bioremediation** includes use of land treatment (farming), soil pile venting, and bioreactors. Removal of the contaminated media and placement in such controlled environments greatly speeds contaminant degradation, but the materials handling increases cost and property disruption.

CLEAN PROPERTIES EXPERIENCE

Clean Properties is experienced in evaluating biotreatability data and in designing the appropriate bioremedial treatment system for your specific conditions. Staff environmental microbiologists, hydrogeologists, and engineers bring in-depth academic training, research, and decades of field experience in applied microbial degradation to your project. Examples of Clean Properties' numerous successful bioremedial projects include *in-situ* bioremediation of soil impacted by chlorinated solvents from leaking floor drains beneath an automotive repair facility, *in-situ* bioremediation of petroleum-impacted soil and groundwater at gasoline service stations, and *ex-situ* bioremediation of oil-contaminated sludge and soil from garage oil-water separator and petroleum refinery operations.

CLEAN PROPERTIES, INC., 111 Boston Post Road, Suite 214, Sudbury, MA 01776
Phone: 800-977-1982 *Email: MBerger@CleanProperties.com*

Clean Properties Inc.
Environmental Assessment & Cleanup

REMEDIATIONS
BIOREMEDIATION
...An Approach That Is Right for You

Bioremedial Option	Relative Cost	Advantages	Disadvantages
PASSIVE TECHNOLOGIES			
Passive Bioremediation	Very Low	Generates no waste streams. Eliminates risks associated with transporting contaminated soils. Substantially less costly.	Requires long time frame. May not be appropriate if potential receptors are nearby. Must be acceptable to regulatory agency. May require groundwater modeling and other risk assessment activities.
***IN-SITU* TECHNOLOGIES**			
In-Situ Bioremediation	Moderate to High	Achieves relatively low cleanup levels for many contaminants. Can be used in areas not accessible for excavation. Eliminates risks associated with transporting contaminated soils.	May take years to achieve cleanup levels in some cases. Complete degradation of complex contaminant mixtures may be difficult. Not effective in soils with low hydraulic conductivity. May require groundwater recirculation. May mobilize contaminants into groundwater.
***EX-SITU* TECHNOLOGIES**			
Land Treatment (Farming)	Low	Relatively moderate to long treatment times (months to years). Simple, inexpensive, and effective.	Large amount of space required. May mobilize contaminants into groundwater unless conducted in a lined treatment area. May generate waste irrigation water requiring separate disposal. May result in enhanced contribution to air.
Soil Venting Piles	Low to Moderate	Short treatment times. Simple and effective. Treated soil may be used on-site as backfill.	Requires extensive soil handling. Leachate control and disposal may be necessary.
Bioreactors	High	Short to very short treatment times. Can treat higher contaminant concentrations. Can uniformly treat most hydrocarbons to non-detectable levels in months. Treated soil may be used as backfill.	Side waste streams may need treatment and disposal. Large amount of space required.

CLEAN PROPERTIES, INC., 111 Boston Post Road, Suite 214, Sudbury, MA 01776
Phone: 800-977-1982 *Email: MBerger@CleanProperties.com*