

BIOREMEDIATION:

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Bioremediation allows natural processes to clean up harmful chemicals in the environment. Microscopic “bugs” or microbes that live in soil and groundwater like to eat certain harmful chemicals, such as those found in gasoline and oil spills. When microbes completely digest these chemicals, they change them into water and harmless gases such as carbon dioxide.

In order for microbes to clean up harmful chemicals, the right temperature, nutrients (fertilizers), and amount of oxygen must be present in the soil and groundwater. These conditions allow the microbes to grow and multiply—and eat more chemicals. When conditions are not right, microbes grow too slowly or die. Or they can create more harmful chemicals. If conditions are not right at a site, EPA works to improve them. One way they improve conditions is to pump air, nutrients, or other substances (such as molasses) underground. Sometimes microbes are added if enough aren't already there.

The right conditions for bioremediation cannot always be achieved underground. At some sites, the weather is too cold or the soil is too dense. At such sites, EPA might dig up the soil to clean it above ground where heaters and soil mixing help improve conditions. After the soil is dug up, the proper nutrients are added. Oxygen also may be added by stirring the mixture or by forcing air through it. However, some microbes work better without oxygen. With the right temperature and amount of oxygen and nutrients, microbes can do their work to “bioremediate” the harmful chemicals.

Why Use Bioremediation

Groundwater can be cleaned at the site without having to move them somewhere else. If the right conditions exist or can be created underground, soil and groundwater can be cleaned without having to dig or pump it up at all. This allows cleanup workers to avoid contact with polluted soil and groundwater. It also prevents the release of harmful gases into the air. Because microbes often bioremediation does not require as much equipment or labor as most other methods, and is being used at 50 Superfund sites across the country. EPA uses bioremediation because it takes advantage

Bioremediation of oil & hydrocarbon



Box A—bioremediation v. Biodegradation

Biodegradation refers to the natural process whereby bacteria or other microorganisms alter and break down organic molecules into other substances, such as fatty acids and carbon dioxide.

bioremediation is the act of adding materials to contaminated environments, such as oil spill sites, to cause an acceleration of the natural biodegradation process.

Fertilization is the bioremediation method of adding nutrients, such as nitrogen and phosphorus, to a contaminated environment to stimulate the growth of indigenous microorganisms. This approach is also termed nutrient enrichment.

Seeding refers to the addition of microorganisms to a spill site. Such microorganisms may or may not be accompanied by nutrients. Current seeding efforts use naturally occurring microorganisms. Seeding with genetically engineered microorganisms (GEMs) may also be possible, but this approach is not now being considered.

of natural processes. Polluted soil and change the harmful chemicals into water and harmless gases, few if any wastes are created. Therefore, it is usually cheaper. Bioremediation has successfully cleaned up many polluted sites.

Bioremediation for Sludge

Oily sludge materials from oil wells drilling, tank bottom, and refinery operation are headaches for managers with run-away treatment costs and ever-tighter regulations. The global warming concern discourages processors to incinerate oily sludge materials. With limited land-fill space available, one alternative is to perform bioremediation.

GAET'S Ramsorb -a premiere Oil absorbent with Bioremediation has come to combat hydrocarbon pollution without giving any adverse effects on flora-Fauna & Overall Ecology.

However, The oily sludge materials may contain uncertain amount of aromatic chemicals and increase the difficulty to do the bioremediation. Through years of field experience, we found that Ramsorb treatment technology will kill each and every kind of hydrocarbon pollution. It is the new biotechnological and microbial technology going to serve to the refineries for sludge treatment, saving the environment, saving the nation. so move for BIOREMEDIATION-a natural way to decompose HC pollution. SAVE THE ENVIRONMENT IN ECO-FRIENDLY MANNER,SAVE THE NATION.

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Bioremediation for Marine Oil Spill

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Fertilization is the bioremediation method of adding nutrients, such as nitrogen and phosphorus, to a contaminated environment to stimulate the growth of indigenous microorganisms. This approach is also termed nutrient enrichment. *Seeding* refers to the addition of microorganisms to a spill site. Such microorganisms may or may not be accompanied by nutrients. Current seeding efforts use naturally occurring microorganisms. Seeding with genetically engineered microorganisms (GEMs) may also be possible, but this approach is not now being considered for remediating oil spills.

Bioremediation may have a role in settings such as salt marshes and sensitive ecosystems where the use of mechanical or other approaches might do more harm than good. Just as for open water spills, however, appropriate protocols need to be developed for testing and applying bioremediation technologies in these situations, and more research is required to prove their effectiveness.

No significant adverse impacts related to the use of bioremediation technologies for oil spill cleanup have been identified in recent field applications. Effects that have been measured have been short-lived and minor. On beaches, in particular, bioremediation may be a less intrusive approach than other alternatives. However, experience with bioremediation in marine settings is limited, and it is premature to conclude that the use of bioremediation technologies will be safe in all circumstances

Biodegradation and the Chemical Nature of Petroleum Far from being a homogeneous substance, crude oil is a complex mixture of thousands of different chemical compounds. In addition, the composition of each accumulation of oil is unique, varying in different producing regions and even in different unconnected zones of the same formation.²⁶ The composition of oil also varies with the amount of refining. Significantly, the many compounds in oil differ markedly in volatility, solubility, and susceptibility to biodegradation. Some compounds are readily degraded; others stubbornly resist degradation; still others are virtually nonbiodegradable. The biodegradation of different petroleum compounds occurs simultaneously but at very different rates. This leads to the sequential disappearance of individual components of petroleum over time and, because different species of microbes preferentially attack different compounds, to successional changes in the degrading microbial community.²⁷ Since components of petroleum degrade at different rates, it is difficult and misleading to speak in terms of an overall biodegradation rate. Petroleum hydrocarbons can, in general, be divided into four broad categories: saturates, aromatics, asphaltenes, and resins.²⁸ Saturated hydrocarbons—those with only single carbon-carbon bonds—usually constitute the largest group. Of these, the normal or straight-chain alkane series is the most abundant and the most quickly degraded. Compounds with chains of up to 44 carbon atoms can be metabolized by microorganisms, but those having 10 to 24 carbon atoms (C₁₀-C₂₄) are usually the easiest to metabolize. Shorter chains (up to about C₁₂) also evaporate relatively easily. Only a few species can use C₁-C₄ alkanes; C₅-C₉ alkanes are degradable by some microorganisms but toxic to other nutrients. Resins include petroleum compounds containing nitrogen, sulfur, and/or oxygen as constituents. If not highly condensed, they may be subject to limited microbial degradation. Asphaltenes and resins are difficult to analyze and, to date, little information is available on the biodegradability of most compounds in these groups.³⁷ Light oils may contain about 1 to 5

percent of both asphaltenes and resins; heavy or weathered oils may have up to 25 percent asphaltenes and 20 percent resins.

Microbial Processes and the Degradation of Petroleum Despite the difficulty of degrading certain fractions, some hydrocarbons are among the most easily biodegradable naturally occurring compounds. Altogether, more than 70 microbial genera are known to contain organisms that can degrade petroleum components (table 1). Many more as-yet unidentified strains are likely to occur in nature.⁴³ Moreover, these genera are distributed worldwide. All marine and freshwater ecosystems contain some oil-degrading bacteria. No one species of microorganism, however, is capable of degrading all the components of a given oil. Hence, many different species are usually required for significant overall degradation.⁴⁴ Both the quantity and the diversity of microbes are greater in chronically polluted areas. In waters that have not been polluted by hydrocarbons, hydrocarbon-degrading bacteria typically make up less than 1 percent of the bacterial population, whereas in most chronically polluted systems (harbors, for example) they constitute 10 percent or more of the total population.⁴⁵ Microorganisms have evolved their capability to degrade hydrocarbon compounds over millions of years. These compounds are a rich source of the carbon and energy that microbes require for growth. Before that carbon is available to microorganisms, however, large hydrocarbon molecules must be metabolized or broken down into simpler molecules suitable for use as precursors of cell constituents. The activity of microorganisms at a spill site is governed by the organisms' ability to produce enzymes to catalyze metabolic reactions. This ability is, in turn, governed by their genetic composition. Enzymes produced by microorganisms in the presence of carbon sources are responsible for attacking the hydrocarbon molecules. Other enzymes are utilized to break down hydrocarbons further. % Lack of an appropriate enzyme either prevents attack or is a barrier to complete hydrocarbon degradation.

Table 1—Major Genera of Oil-Degrading Bacteria and Fungi

Bacteria	Fungi
Achrornobacter	Allescheria
Acinetobacter	Aspergillus
Actinomyces	Aureobasidium
Aeromonas	Botrytis
Alcaligenes	Candida
Arthrobacter	Cephalosporium
Bacillus	Cladosporium
Beneckea	Cunninghamella
Brevebacterium	Debaromyces
Coryneforms	Fusarium
Erwinia	Gonytrichum
Flavobacterium	Hansenula
Klebsiella	Helminthosporium
Lactobaoillus	Mucor
Leumthrix	Oidiodendrum
Moraxella	Paecylomyces

Nocardia	Phialophora
Pseudomonas	Penicillium
Sarcina	Rhodospiridium
Spherotilus	Rhodotorula
Spirillum	Saccharomyces
Streptomyces	Saccharomycopsis
Vibrio	Scopulariopsis
Xanthomyces	Sporobolomyces
Pseudomonas	Torulopsis
Sarcina	Trichoderma