Suggested References:

Oil in the Sea
National Academy Press, 1985
National Response Team
www.nrt.org/

Bioremediation Effectiveness Exxon Valdez Spill Proceedings of the International Oil Spill Conference, 1993

Enzymes for Enhancing Bioremediation of Petroleum Contaminated Soil
Journal of Air & Waste Management Assn
June, 1995

Guidelines for the Assessment and Remediation of Petroleum Contaminated Soil Florida DEP, May 1994

Bioremediation: Application of Slow Release Fertilizers on Low Energy Shorelines Proceedings of Intl Oil Spill Conf. 1993

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Oil or Chemical Spill Notification

Call the National Response Center at
800-424-8802

Oil Spill Response

in the Region IV Coastal Zone, contact the U.S. Coast Guard Marine Safety Office (MSO):

MSO Wilmington, NC
910-792-8408

MSO Charleston, SC
843-724-7616

MSO Savannah, GA
912-652-4353

MSO Jacksonville, FL
904-247-7310

MSO Miami, FL
305-732-0160

MSO Tampa, FL
813-228-2189

MSO Mobile, AL
334-441-5121

In the Region IV Inland Zone, contact the U.S. Environmental Protection Agency:
404-562-8700

Inland Zone U.S. Coast Guard Offices are:

MSO Huntington, WV
800-253-7465

MSO Louisville, KY
800-253-7465

MSO Paducah, KY
502-442-1621

MSO Memphis, TN
901-544-3912

State Pollution Response Contacts are:

North Carolina
919-733-3867

South Carolina
Spill: 888-481-0125
Office: 803-896-4000

Georgia
404-656-4300

Florida
850-413-9911

Alabama
334-242-4378

Mississippi
601-352-9100

Tennessee
800-258-3300

Kentucky
800-928-2380

Bio-remediation in Oil Spill Response

Bioremediation Regulatory Requirements
Persons seeking to use in-situ bioremediation as a remedial countermeasure should check with applicable state or local regulatory requirements. Federal requirements are in Subpart J of the National Contingency Plan (NCP) which requires the federal On-scene Coordinator (OSC), in the case of an inland release the U.S. Environmental Protection Agency and for a coastal release the U.S. Coast Guard (USCG), to approve the use of bioremediation agents on spills not threatening human life. The federal OSC must have the concurrence of the Region IV Regional Response Team (RRT) for any in-situ bioremediation use unless specifically delegated to a state/local agency.

The NCP Product Schedule
The NCP Product Schedule is a list of chemical and biological based products that may be authorized for use on oil discharges in accordance with the NCP. The federal OSC, state, and the RRT will only consider approve for use bioremediation products on the NCP Product Schedule. The exception would be biostimuation agents which still require RRT approval.

Bioremediation as a Technology
In-situ bioremediation has been used successfully for a number of years. Biodegradation of hydrocarbons is a time consuming process. Therefore, bioremediation should generally not be considered as a rapid primary response countermeasure, but to be used in conjunction with other remedial actions. The exception to this is when the option of do nothing is considered or conventional cleanup/treatment methods are not feasible. In those cases, in-situ bioremediation may be a cost effective substitute for the traditional cleanup technology.

Biodegredation of Petroleum Products
Bioremediation is the process by which microorganisms metabolize hydrocarbons to produce energy for their synthesis, movement, respiration, and reproduction. This results in the production of new cells, carbon dioxide, and water. To consume this food to any appreciable degree, microorganisms must also have access to adequate oxygen, moisture, and inorganic nutrients, with a favorable living environment. Oil metabolizing microbes are found over most of the planet. All are common in surface soils and waters. They are ubiquitous in the marine environment, or anywhere there are free hydrocarbons in the environment Various stains of bacteria appear to be principally involved in the degradation process. There are two types of bacteria, aerobic and anaerobic. Most hydrocarbon degradation is the result of aerobic bacteria. This is largely because of the great energy yielding capability of aerobic respiration relative to both anaerobic respiration or fermentation. Aerobic bacteria require free oxygen to fuel their activities and have been found in permeable formations to the depths of several thousand feet. Their activities at such depths are limited due to the low levels of free oxygen though. Anaerobic bacteria live in the absence of free oxygen. Anaerobic bacteria degrade material at a much slower rate than aerobic bacteria. Successful in-situ bioremediation programs will require application methodologies specifically tailored to the current environmental conditions. Because petroleum components differ chemically, they differ in their susceptibility to microbial attack. Crude oils consist of paraffinic, cycloparaffinic, and aromatic hydrocarbons as well as non-hydrocarbon compounds. The components of petroleum generally most susceptible to biodegradation are the straight-chained paraffinic hydrocarbons. Branched-chained paraffins and cycloparaffins are attacked more slowly, while many of the aromatic hydrocarbons and non-hydrocarbon compounds, particularly those of high molecular weight, are decomposed very slowly. To consume hydrocarbons to any appreciable degree the microbes must have access to adequate oxygen, moisture, and nutrients in addition to the carbon. The addition of specialized microbes is usually not necessary in most circumstances. Although in some areas, the introduction of acclimated microorganisms can be an effective technology. Wherever hydrocarbons would be expected to be found (for example along highways, retention ponds draining parking lots, or marinas and associated coastal areas) indigenous hydrocarbon degrading microbes would expect to be found in numbers sufficient to degrade petroleum. Often, all that is needed is to stimulate the population of microbes is the addition of one or more of the limiting factors (such as nutrients, oxygen, etc.).

Biodegradation of Hydrocarbons in Soil
Microbes attack petroleum at the interface between the petroleum and the soil particles on which it is absorbed. This surface also must be in contact with moisture. The total interfacial area between the petroleum and soil and petroleum and water is thus one of the most important factors in biodegradation of hydrocarbons on the soil. The greater the area, the higher the rate of degradation. The rate of biodegradation will be highest near the surface of the contaminated soil. This will be true especially if the soiil is turned and mixed to aerate it properly and if adequate nutrients and moisture is maintained. Deeper in the contaminated soil the rate of biodegradation will slow as free oxygen and nutrient supply decline.

Navigable Water Releases
The use of bioremediation on spills or releases impacting navigable waters requires the federal OSC to obtain the concurrence of the Region IV RRT. The request should involve the state OSC and contain the following information:

- Exact location of spill or release;
- Type of material spilled or released;
- Amount spilled or potentially spilled;
- Name of product to be used;
- MSDS on product;
- Rate and method of application;
- Nearest surface waters;
- Forecasted weather conditions; and
- Monitoring strategy.

Bioremediation Products
Microbial agents are concentrated cultures of oil-degrading microorganisms grown on a hydrocarbon medium, then freeze-dried or air-dried onto a carrier. All commercially available agents use naturally occurring microorganisms. Some agents may contain nutrients to assure it will not be the limiting factor. This type of agent is intended to provide a massive inoculum of oil-degrading microbes to the affected area thereby increasing the oil-degrading population to a level where the spilled oil will be used as a primary source of food and energy. Microbial agents are designed to enhance biodegradation (the process is known as bioaugmentation) of oil at any location and would be most useful where the population of indigenous microbes are small. One controlling factor which has often been neglected is the proper selection of specific microbes for a given pollutant. Sometimes vendors can supply this information, but the best way is to test the material prior to usage, although this is not always feasible during an emergency response situation. When using microbial agents, keep in mind that other factors (such as nutrients, moisture, or oxygen) can play an important role in the success or failure of the application. The microbes may have to be augmented with fertilizer or tilling the area to ensure a vigorous population.

Fertilizers. Applying fertilizers on shorelines to stimulate growth of indigenous oil-degrading microbes has been used as a bioremediation technique. Fertilizers that release their nutrients slowly provide a number of advantages. These include increased efficiency of uptake by the biota, decreased cost of application (fewer), minimization of losses due to leaching, fixation, or decomposition, and elimination of luxury consumption.

Enzymes. Enzyme accelerated bioremediation of hydrocarbons shows promise. Enzymes are complex proteins that function as bio-oxidation catalysts that accelerate the chemical reaction rate by lowering the activation energy for a particular reaction.

Surfactants. There are numerous bioremediation products that are nothing more than surfactants or dispersants. These agents are water-based products that claim to enhance the rate of biodegradation by emulsifying spilled oil thereby making it more available to microbes. The use of these products as a bioremediation method should be avoided.

Safety Considerations. Follow all safety procedures for the contaminant that will be treated. Additionally, follow the safety instructions on the MSDS for the bioremediation agent used.