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TECHNICAL UPDATE

UNDERSTANDING BIOREMEDIATION OF SOILS CONTAMINATED BY PETROLEUM BASED OILS

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Natures Process:

Oils and hydrocarbons are released every day from the ocean floor and are degraded through natural processes. Over time natural selection has allowed certain bacterial strains to specialize in utilizing oils and hydrocarbons. These microbes produce enzymes which allow the bacteria to break down hydrocarbons into shorter chains, simpler molecules, and fatty acids. The final result of this process is conversion to bacterial biomass, CO2 and water. In any spill, this process is acting on millions of molecules, simultaneously, and at different rates. It takes an entire community of bacteria working together to fully break down these hydrocarbons. Generally, the longer and more complex the targeted compound is, the more slowly it will be degraded. Shorter chain molecules like gasoline and diesel will degrade much faster than longer chain crude oils.

Reality:

Despite the relative ease of allowing nature to take its course, natural attenuation takes too much time. While waiting for a spill to attenuate naturally the spill could contaminate drinking water and groundwater, or result in exposure of hazardous substances to people and wildlife. Regulatory agencies may also require more aggressive action to prevent these negative outcomes. There are several options for dealing with hydrocarbon contaminated soils, including bioremediation, chemical oxidation, incineration, or disposal at a permitted landfill. Each spill will have unique attributes that will guide the decision makes towards the best approach. For spills that are near the soil surface, or where stockpiling of the affected soils is an option, bioremediation is a very cost effective approach. Our VitaStim Refinery works with, and enhances natures process for the fastest results.

There are 4 important keys to successful bioremediation.

Moisture Content

Bacteria will be at their most active if the soil is kept between 40 to 70 percent of its water holding capacity. Moisture is required for bacteria to sustain activity and degrade the spill. If left to nature, an oil spill in the desert will take decades longer to degrade than a spill in the rainforest. Moisture keeps

the bacteria active and, is required for the production of important enzymes. Soil moisture can be kept up by regular watering, mulching, or covering with a tarp. However, complete saturation for an extended period of time will inhibit microbial activity due to lower oxygen availability.

Oxygen

The fastest pathway for hydrocarbon degradation utilizes aerobic bacteria. There are some facultative bacteria stains which are also capable of degrading hydrocarbons, but at a slower rate. The relative amount of pore space in a soil will affect oxygen availability. Silty clays with lower pore space will transfer oxygen less efficiently than sands or gravels with greater pore space. Oxygen is generally available up to 1 meter below the ground surface (David, 96), but is not available in great enough supply at these depths for efficient bioremediation. To ensure adequate oxygen, soils can be tilled or rotated on a monthly basis. For subsurface treatment deeper than 1 meter, oxygen is sometimes introduced in the form of hydrogen peroxide. However chemical oxygen additions are not necessary for stockpiled soils, or soils near the ground surface, if tilling or rotation can be implemented.

Soil Temperature

One of the easiest ways to increase soil temperature is by tilling or rotating the soil. The bacteria responsible for bioremediation perform best at temperatures over 50 degrees fahrenheit. In colder climates covering the soil with a tarp or plastic can help to raise the temperature. This technique also helps to retain soil moisture. When tarping or covering the soils, it is also important to consider the impact the tarp will have on available oxygen. As the bacteria respire they release CO2, and consume oxygen. A well tarped stockpile may become deficient in oxygen over time, so the tarp should be removed periodically to allow oxygen in.

Key Nutrients and Biostimulants

Adding nitrogen and stimulants is often required for hydrocarbon degrading bacteria to function efficiently. As the bacteria consume hydrocarbons, the hydrocarbon itself provides the majority of food required. A general rule of thumb is that the ratio of carbon (hydrocarbons in this case), nitrogen, and phosphorus should be approximately 100:10:1. This means that a higher concentration of hydrocarbons will have a greater demand for nitrogen and phosphorus. Nitrogen is commonly added in the form of

ammonium nitrate or urea. Additional vitamins and trace minerals, such as those found in our VitaStim Refinery provide an added boost in microbial activity that nitrogen and phosphorus cannot.

VitaStim Refinery

Inoculation with a product like our VitaStim Refinery allows for a rapid expansion in the bacterial population. The bacterial cultures in this product were isolated and selected for their ability to quickly and effectively degrade hydrocarbons. These cultures work well with the native bacteria to accomplish compete bioremediation. The nutrients in VitaStim Refinery infuse bacteria and stimulate healthy and productive cell development. Additional nitrogen may still be required, but this is dependent on the level of hydrocarbons present. For small spills, and soils with low concentrations of easily degraded hydrocarbons the nutrients in VitaStim Refinery will be sufficient.

In Summary

Effective bioremediation requires more inputs than natural attenuation, but results are achieved much more quickly. Natural attenuation is very rarely an acceptable clean up strategy. Paying attention to how soil moisture, oxygen availability, and nutrients affect bacterial activity and performance will ensure the best results. Inputs of time and labor are required to ensure an optimal environment for bioremediation, but the capital costs of these items are relatively low. Introducing additional and efficient bacterial strains will accelerate the process, and may be the only way to degrade complex or difficult hydrocarbons.

Clean Up Strategy

Add .25 lb to 1 lb of VitaStim Refinery per cubic yard of impacted soil. Mix into the soil by tilling in, or rotating stockpiled soil. Add water and keep moist, 40-70 percent of water holding capacity is ideal. If soil temperature is below 50 degrees Fahrenheit, cover or mix soil to raise the temperature. As the conditions of the soil fluctuate some bacteria will naturally die off. During the months when soil temperature is above 50 degrees VitaStim Refinery should be reapplied approximately once per month.

For small surface spills, mix 1 lb of VitaStim Refinery with enough water to saturate the impacted media, spray on the surface, and work in.

Reference:

Friend, David J. Remediation of Peteroleum contaminated Soils, National Academies Press 1996.