Definition of Soil Land Farming

Land farming of soil containing petroleum hydrocarbons, also known as land treatment or land application, is an aboveground remediation technology for soils reducing concentrations of petroleum constituents through biodegradation and volatilization. This technology usually involves spreading PCS in a thin layer (less than two feet in thickness) on the ground surface inside the treatment cells and stimulating aerobic microbial activity within the soils through aeration. The enhanced microbial activity results in degradation of adsorbed petroleum product constituents through microbial respiration. Soil manipulation also allows petroleum hydrocarbon volatilization.

Soil land farming has been proven effective in reducing concentrations of nearly all the constituents associated with petroleum products. Petroleum products generally encountered at underground storage tank (UST) sites range from those with a significant volatile fraction, such as gasoline, to those that are primarily nonvolatile, such as heating and lubricating oils.

Petroleum products generally contain more than one hundred different constituents that possess a wide range of volatility. In general, gasoline, kerosene, and diesel fuels contain constituents with sufficient volatility to evaporate through land farm treatment process. Lighter (more volatile) petroleum products (*e.g.*, gasoline) tend to be removed by evaporation during landfarm aeration processes (*i.e.*, tilling or plowing) and, to a lesser extent, degraded by microbial activity. The mid-range hydrocarbon products (*e.g.*, diesel fuel, kerosene) contain lower percentages of lighter (more volatile) constituents than does gasoline. Biodegradation of these petroleum products is more significant than evaporation. Heavier (non-volatile) petroleum products (*e.g.*, heating oil, lubricating oils) do not evaporate during landfarm aeration; the dominant mechanism that breaks down these petroleum products is biodegradation. Higher molecular weight petroleum constituents such as those found in heating and lubricating oils, and, to a lesser extent, in diesel fuel and kerosene, require a longer period of time to degrade than do the constituents in gasoline.

Soil normally contains large numbers of diverse microorganisms including bacteria, algae, fungi, protozoa, and actinomycetes. In well-drained soils, which are most appropriate for landfarming, these organisms are generally aerobic. Of these organisms, bacteria are the most numerous and biochemically active group, particularly at low oxygen levels. Bacteria require a carbon source for cell growth and an energy source to sustain metabolic functions required for growth. Bacteria also require nitrogen and phosphorus for cell growth. Although sufficient types and quantities of microorganisms are usually present in the soil, recent applications of ex-situ soil treatment include blending the soil with cultured microorganisms or commercial fertilizers.

The metabolic process used by bacteria to produce energy requires a terminal electron acceptor (TEA) to enzymatically oxidize the carbon source to carbon dioxide. Microbes are classified by the carbon and TEA sources they use to carry out metabolic processes. Bacteria that use organic compounds (*e.g.*, petroleum constituents and

other naturally occurring organics) as their source of carbon are heterotrophic; those that use inorganic carbon compounds (*e.g.*, carbon dioxide) are autotrophic. Bacteria that use oxygen as their TEA are aerobic; those that use a compound other than oxygen (*e.g.*, nitrate, sulfate) are anaerobic; and those that can utilize both oxygen and other compounds, as TEA's are facultative. For landfarming applications directed at petroleum products, only bacteria that are both aerobic (or facultative) and heterotrophic are important in the degradation process.

Nearly all constituents in petroleum products typically found at UST sites are biodegradable, the more complex the molecular structure of the constituent, the more difficult, and less rapid, is biological treatment. Most low molecular-weight (nine carbon atoms or less) aliphatic and monoaromatic constituents are more easily biodegraded than higher molecular weight aliphatic or polyaromatic organic constituents.

Soil microorganisms require moisture for proper growth. Excessive soil moisture, however, restricts the movement of air through the subsurface thereby reducing the availability of oxygen necessary for aerobic bacterial metabolic processes. In general, the soil should be moist but not wet or dripping wet. The ideal range for soil moisture is between 40 and 85 percent of the water-holding capacity (field capacity) of the soil or about 12 percent to 30 percent by weight. Periodically, moisture can be added in landfarming operations because soils become dry as a result of evaporation, which is increased during aeration operations (*i.e.*, tilling and/or plowing) see http://www.epa.gov/swerust1/cat/landfarm.htm.