



What is Bioremediation?

Bioremediation is the term applied to biological degradation of contaminants present in the environment, or, more correctly, microbial degradation of these contaminants. The type of contaminants can vary widely, encompassing almost all organic compounds, especially synthetic organic chemicals and refined petroleum products. The contaminants may be found in soils, wastes, groundwater or surface waters.

The microbes that perform all of the work are naturally-occurring microorganisms that have, over many generations, evolved the ability to digest the organic compounds that are such a concern to modern industry, converting the compounds into cell mass, carbon dioxide and water. These microorganisms were first isolated from contaminated soils, selected for their ability to degrade the contaminants in the soils. Further research has led to culturing techniques that allow for volume production of these organisms, thus making these microorganisms available in the quantities needed for environmental restoration.

There are 5 key ingredients for successful bioremediation: oxygen, moisture, food source, macronutrients and micronutrients. These all must be present in the proper amounts. Food source is the easiest – it is merely the contamination to be degraded! However, the other 4 key ingredients may need to be added and their concentrations monitored in order to maintain acceptable degradation rates.

Air and water are readily supplied by the treatment process, natural processes such as rainfall or by addition. For soils, the treatment process involves the active tilling and watering of the soil during the treatment period. The tilling provides mixing and aeration of the soil, which provides much of the oxygen required to successfully degrade the hydrocarbons present. Watering of the soil provides the required moisture to maintain healthy colonies of bacteria. The water concentration must be monitored carefully. If the soil becomes too dry the microbes will not grow and will go into a dormant state, whereas over-watering may lead to rapid depletion of nutrients and oxygen. In water oxygen is present in its dissolved form (dissolved oxygen, or DO). While there is obviously no lack of water, oxygen levels may be a concern, especially in low DO aquifers. In these cases chemical forms of oxygen may need to be added in order to maintain sufficient dissolved oxygen levels for hydrocarbon degradation.

The specific mechanism of degradation varies for different types of compounds. However, in general hydrocarbons are degraded metabolically through a series of intermediates. The intermediates typically are fatty acids, which are produced enzymatically by the microbes from the addition of oxygen to the hydrocarbons, which are then used in other enzymatic energy-production cycles to ultimately produce carbon for cell mass, carbon dioxide and water. The more energy dense the material, the more readily it is consumed; thus, aromatic and olefinic hydrocarbons (unsaturateds) will be degraded preferentially over aliphatic (saturated) hydrocarbons. Since most of the non-

chlorinated compounds of environmental concern are aromatic in nature, bioremediation is an excellent solution for this type of contamination.

Chlorinated hydrocarbons are degraded following different metabolic pathways, and typically exploit the energy present in the carbon-chlorine bond. For anaerobic degradation this means that a densely chlorinated compound, such as tetrachloroethene (perc) will be successively degraded to lesser chlorinated compounds, and then ultimately to carbon dioxide and water. For aerobic degradation the metabolic pathways are similar to those seen for non-chlorinated hydrocarbons, with initial removal of one or more chlorines prior to formation of the fatty acids. Nature has exploited the energy present in the compounds that we consider environmental contaminants. This allows us to use natural methods for environmental restorations, creating no new wastes in the process. The keys to successfully using these methods are straightforward. Proper selection of the correct microorganisms, proper formulation of bioremediation mixtures, proper application of the materials, and continued monitoring and addition of essential nutrients and oxygen will lead to a successful, complete and environmentally sound remediation.