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An overview of bioremediation

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DESCRIPTION

Bioremediation is a field of biotechnology that removes contaminants, pollutants and toxins from the soil, water and other environments using microorganisms such as bacteria and Microorganisms. Bioremediation is a technique that can be used to clean up contaminated groundwater or environmental issues like oil spills. Microbes break down contaminants by using them as an energy source or by chemotabolizing them with an energy source. More specifically, bioremediation involves the production of energy during the redox reaction in microbial cells. These reactions include respiratory and other biological functions necessary for cell maintenance and reproduction. A delivery system that provides one or more of the following is usually required: energy source (electron donor), electron receiver, and nutrients. Biodegradation involves the electron acceptance classes of a variety of microorganisms, such as oxygen, nitrate, manganese, iron (III), sulfate or carbon dioxide-reducing and their associated redox potentials. Redox potentials provide an indication of the relative dominance of electron acceptance classes. Typically, the two most typical components in a delivery system are electron optics and nutrition. (Stroo HF, 2010.)

To stimulate and enhance microbial activity, microbial (bioaggmentation) or modifications (biostimulation), air, organic substrates or other electron donors / receptors, nutrients and other compounds that may affect and limit treatment in their absence are added. Biostimulation can be used where bacteria are needed to deplete the contaminants, but the conditions are not conducive to their growth (e.g., anaerobic bacteria in anaerobic reservoir, aerobic bacteria in anaerobic reservoir, or suitable donors/receivers). Bio Augmentation can be used when the bacteria needed to degrade the contaminants do not occur naturally at a site or in a very small population to remain effective. Biostimulation and bioagmentation can be used to treat soil and other solids, groundwater or surface water. Under the right circumstances, Monitored Natural Attenuation (MNA), an internal biodegradation process that relies on native microorganisms to degrade contaminants without any modification, may be an appropriate approach to the site.

Bioremediation can be performed on or off site. *In-situ* processes purify the soil and groundwater without removing or transporting it out. This approach can be beneficial as it can reduce material handling costs and some environmental impacts. However, *in situ* processes may be limited by their ability to regulate or modify the physical and chemical environment during bioremediation. *Ex situ* procedures, on the other hand, are the removal of contaminated media to the treatment area.

The first step in any bioremediation program is to develop a Conceptual Site Model (CSM) to assess the likelihood of applying bioremediation on a site. CSM takes into account the nature and extent of pollution and site characteristics; Site hydrogeology, geochemistry and oxidation-reduction conditions; Probability of biodegradation; contaminated duty and transport; and receptor and exposure pathways. Once a CSM has been established and refined, the classification of an existing microbial community or the characteristics required for the establishment of an appropriate microbial community can be determined. Activities undertaken prior to the implementation of the bioremediation program often include treatable studies, soil comparison and the structure and function of the microbial community to ensure that undesirable reactions with contaminants or their degradation products are prevented. (EPA 2004)The success of a bioremediation application depends largely on the characterization and monitoring completed before and during its implementation.

The kind of bioremediation which are an aerobic bioremediation involves microbial reactions that require oxygen to move forward. Bacteria use carbon substrates as electrons and oxygen as electrons. Anaerobic bioremediation involves microbial reactions that occur in the absence of oxygen and involves a number of processes, including fermentation, methanogenesis, reductive dechlorination, and sulfate and nitrate reduction conditions. A subset of these activities may be cultivated depending on the pollutant. In anaerobic metabolism, nitrate, sulfate, carbon dioxide, oxidized substances, or organic compounds replace electrons electronically. In cometabolic bioremediation, microorganisms derive no energy or carbon from degrading contaminants. Instead, pollution is degraded by a side reaction (EPA 2006). The best bioremediation method (aerobic, anaerobic or cometabolic) largely depends on the type of contaminant (s) and the current site conditions. The table below provides an overview of the biodegradability and degradation (aerobic or anaerobic) conditions of many contaminants.

There are some factors affecting to Bioremediation which includes

Contaminant concentrations directly affect the activity of microorganisms. When concentrations are very high, contaminants may have toxic effects on existing bacteria. In contrast, low contaminant concentrations can inhibit bacterial degradation enzyme stimulation. The bioavailability of contaminants depends on the degree to which they are absorbed into solids or separated by molecules in the contaminated medium, diffused into the macropores of soil or sediment, and whether other contaminants are in the non-aqueous phase liquid (NAPL) form or not. Bioavailability to microbial reactions is low, they are more strongly absorbed into solids, covered with molecular molecules in the contaminated medium, diffused into soil and sediment macropores or in the form of NAPL (Adamson DT, 2000).

The efficiency of any bioremediation approach can be influenced by site characteristics. pH, temperature, water content, nutrient availability, and redox potential are all important site environmental factors to consider for bioremediation applications. The pH affects the solubility and bioavailability of nutrients, metals and other components; for optimal bacterial growth, the pH must be within the target microbial tolerance. Bioremediation processes are preferred at pH 6-8. Redox refers to conditions that oxidize or reduce the potential and oxygen content. The presence of electron acceptors such as nitrate, manganese oxides, iron oxides, and sulphate affects redox potential. Nutrients are required for microbial cell development and division. Adequate amounts of trace nutrients are usually available for microbial growth, but the nutrients can be added in a usable form or by modification of the organic substrate, which also acts as an electron donor to induce bioremediation. Temperature directly affects the metabolic rate of microorganisms and consequently the activity of microorganisms in the environment. (Hazen TC, 2010.) The rate of biodegradation increases somewhat with increasing temperature and slows with decreasing temperature.

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