Innovative Environmental Technologies, Inc.

BIOREMEDIATION

Summary/Discussion

Bioremediation is one of the oldest in-situ remedial processes, having first been practiced commercially in 1972. Although the bio-mineralization process had been documented by Tausson (1929), Sisler & ZoBell (1947) and many others, commercialization was delayed in lieu of field proven engineering. Since that time the technology has matured from a novel process to an important and recognized, economical method of remediating soils and groundwater. The targets for bioremediation continue to expand to the higher weight petroleum compounds (greater than C-15), and chlorinated, nitrated, oxygenated and saturated organic compounds

During the bioremediation process, under ideal conditions, organic compounds are converted by soil microorganisms to carbon dioxide, water, biomass and inorganic salts (e.g. chlorinated compounds). Numerous factors affect both the rate and the extent of petroleum derived hydrocarbon mineralization in contaminated soils and water. These factors are: pH, temperature, moisture, aeration, nutrient level, and contaminant and soil characteristics. The key ingredient in any field application of bioremediation is the thoughtful formulation and effective execution of a remedial action plan. This management incorporates experience, technical support and clear objectives, together with sound engineering.

Enormous quantities of organic and inorganic compounds are released into the environment each year as the result of human activities. In some cases, these releases are deliberate and well regulated (e.g., industrial emissions) while in other cases they are accidental and largely unavoidable (e.g., chemical spills). Many of these compounds are both toxic and persistent in terrestrial and aquatic environments. Soil and surface and ground water contamination are the result of the accumulation of these toxic compounds in excess of permissible levels.

The cost of restoring the burgeoning global inventory of contaminated ecosystems is virtually incalculable. As a result, government, industry and the public have recognized the need for more cost effective alternatives to traditional physical and chemical methods of contaminant remediation. Bioremediation, the degradation or stabilization of contaminants by microorganisms (e.g., bacteria, fungi, actinomycetes, and cyanobacteria) is a safe, effective, and economic alternative to traditional methods of remediation.

Bioremediation can also be used in conjunction with a wide range of physical and chemical technologies. Bioremediation alternatives are currently being researched using a combination of physical, microbiological, chemical and molecular based methods. Intrinsic bioremediation, the remediation of contaminants by naturally-occurring biological processes at background rates, is being studied as an avenue for the restoration of contaminated media in cases where other methods of remediation are not feasible.

Bioremediation research in the laboratory includes isolating and characterizing naturally-occurring microbial isolates with bioremediation potential, developing genetically engineered microorganisms and enzymes with contaminant degrading capabilities, studying their catabolic activity in contaminated media through bench-scale experiments, and monitoring the progress of bioremediation through chemical analysis and toxicity testing in chemically-contaminated media. Field applications of bioremediation include the in-situ stimulation of microbial activity by the addition of microorganisms and nutrients and the optimization of environmental factors and the ex situ restoration of contaminated media by landfarming and composting methods.

The science and practice of bioremediation are advancing quickly and information regarding bioremediation is now both voluminous and widely distributed. The challenges facing the vendors of bioremediation products and services shall be to substantiate the marketing claims with field and laboratory data; to support the practitioners of bioremediation with timely and knowledgeable recommendations. Innovative Environmental Technologies, Inc. is uniquely positioned and capable to deliver these products and services more efficiently and effectively than any other vendor in this market.

Critical to establishing and maintaining the activity of the bacteria in the site soil is the control of the inorganic nutrients required by the bacteria for the cellular metabolism. Bacteria require both nitrogen (N) and phosphorus (P) in order to carry out cellular functions. Nitrogen is required by the organism for microbial wall components, nucleic acids and proteins. Nitrogen makes up nearly 15% of the molecular composition of a bacterial cell; any limitation on the nitrogen seriously impacts the metabolic functions of the organisms. Bacteria utilize only that nitrogen which is in the ammonia (NH4) form, N in other forms cannot be incorporated into the organisms organelles. Instead, improperly monitored, other N sources may lead to field and laboratory results which mislead the practitioner of bioremediation into believing that the inorganic N level is satisfactory

Phosphorus, in the form of inorganic phosphates, is used by the microorganisms in the synthesis of phospholipids and nucleic acids. Phosphorus is also essential for the energy transfer reactions of ATP. The enzymes that hydrolyze the phosphate ester are present in nearly all organisms. In P limiting environments the metabolism of microorganisms decreases sharply, reducing their capacity to utilize the hydrocarbons in the soil as an organic carbon source. Inorganic phosphorus sources should be applied with the nitrogen sources in order to stimulate and maintain the remediation project.

Micronutrients are also required for microbial growth. These micronutrients include potassium, iron, sulfur, magnesium, calcium and sodium. In IET's experiences these trace elements are present in nearly all soils, and due to the small amount required for microbial metabolism, further addition of these compounds at the site will not be required. However, should the monitoring program indicate that the degradation rates have changed significantly; micronutrients should be examined as a potential rate limiting variable.