

Factors that Determine Bioremediation of Organic Compounds in the Soil

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Abstract

Man's quest for technological advancement and the need to meet food supply for growth have distorted the natural balance of the soil constituents. Year round, waste products find their way to the soil from natural and anthropogenic sources. When these waste products enter the soil; they are subjected to physical, chemical and biological processes that ultimately determine their fate and transport characteristics. Organic compounds are among these waste products. Knowledge of factors that determine fate of organic compounds in the soil became quite apt to know the condition under which biodegradation processes can be effective. In this study therefore various factors have been discussed. Also, requisite information about the design of bioremediation system for organic compounds had been explained to allow for better understanding of potential toxicity of the organic compound to micro organisms, nutrient requirement for biodegradation activity and the compatibility of site geochemistry with nutrient solution proposed for addition.

Keywords: Bioremediation, determine, factors, Organic compounds, and soil.

1. Introduction

The production soil is made up of 5% organic matter. The biological active components of the organic soil include polysaccharide, amino acids, nucleotide, organic sulphur and phosphorus compounds. These organic matter determines the productivity of the soil, it serves as a source of food for micro organisms and influences the physical properties of the soil. However, due to the excesses of human activities on the soil, the once balanced natural equilibrium of the soil had been heavily bombed by the production and discharge of waste organic compounds are (classified into (i) conventional pollutants (aldehydes, ketone, alcohols) (2) Aromatic hydrocarbons (3) polynuclear aromatic hydrocarbon (PAHs) and (4) synthetic organic compounds (organo pesticides, fungicides and herbicides) and organic fertilizers. The biodegradation of these organic pollutants in soil is depended on the microbial transformation in the soil, the microbial ecology of the soil, environmental factors and the rate of biological reaction kinetics and substances required for bioremediation.

2. Aim

The major aim of this study is to identify the various factors that influence the bioremediation of organic pollutants in the soil.

3. Specific Objectives

To provide information for the design of bioremediation system and information to indicate whether or not bioremediation is an important treatment technology

4. Factors that Affect Bioremediation of Organic Pollutants in the Soil

The main presence of microbial ecology had a link with bioremediation in that organic compounds are the source of carbon and energy for most micro organisms.

When appropriate concentrations and environmental conditions are not harsh to the microorganisms, many of the organic compounds considered harmful can be degraded in the soil.

Knowledge of biological responses to organic compounds provides an understanding of metabolic potential by which micro organism may transform these organic compounds. The observation of microbial intermediate indicates a biological response to the parent compound has taken place and that the possibility for the remediation by biological process exists. This factor determines the principles of microbial ecology as related to the soil.

5. Microbial Ecology of the Soil

It is now established that quite significant numbers of micro organisms are distributed in the soil (Back, 1989). It was once suggested that members of microorganisms in soil decreased with depth (Waksman, 1916). Evidence of that point was aptly captured in the development of technique to investigate water table aquifer used as an instrument for the education of microbial ecology of the subsurface (Mc Nabb and Mallard 1984). The analyses of the subsurface samples indicate that micro organisms predominate on the subsurface of soil particles. Biochemical diversity of micro organisms present in the subsurface was evident by variety of organic and compound reportedly metabolized. Petroleum hydrocarbon (fields and products of gasification) are reported to be substrate for soil micro organisms under varied growth conditions.

6. Environmental Factor

Micro organisms require a suitable set of environment factors in order to grow, these factors include, chemical and physical properties of pH, osmotic pressure, temperature and absence of poisonous conditions.

The pH of the environment indicates the potentials for microbial activity. Growth of micro organism can raise or lower the pH producing end products that correspondently affect pH or remove the parent organic compounds. The measurement of pH in soil could indicate the potential for microbial growth. Temperature affects microbial growth in that an increase in temperature results in an increase in microbiological growth. Many micro organisms in the soil have optimum temperature for growth between 10⁰ - 30⁰c.

Micro organisms require adequate water for active growth. The availability of water depends on the number of molecules present in the solution. An increase in the concentration of the molecules of water relative to the concentration of molecules in the microbial cells results in the movement from the cell to the water environment (Osmosis). The soil moisture content is critical to the growth of micro organisms. If the soil is dry microbial growth will be limited. When the moisture content is near saturation, oxygen transfer because growth limiting factor.

7. Biological Reaction Kinetics

The rate at which micro organism can remove organic confounds from the soil can be expressed mathematically to ascertain the time required for remediation. The first order rate constant is based on the observations that as the concentration of the organic compound increases, the rate of degradation increases. The first order rate constant, k is calculated as follows:

$$K = [2.303/t] \log [C_0 / (C_0 - C_1)]$$

Where t = time, C₀ is initial concentration, C₁ IS the concentration at time, t and t_{1/2} is the half life of the compound to be degraded and is expressed as;

$$t_{1/2} = (0.693/k).$$

At the start of evaluation of bioremediation at a site, existing information should be considered and such information include:

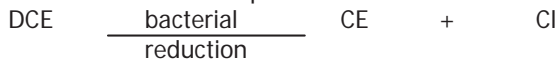
- The solubility of the compound to be biodegraded. This indicates the potential availability of the compound to the micro organisms.
- Information about the environmental factors that upon stimulation were critical to degradation must be available. Dragun (1988), for instance, contains a list of organic compounds and provides information about condition requisite for evaluation to develop the rate of biodegradation presented.

Generally, hydrocarbons are good compounds for bioremediation. The edited paper by Gibson (1984) and Atlas (1984) provided an overview of microbial degradation of petroleum hydrocarbon. The complex mixture of hydrocarbons has components that are biodegradable with degradation rate decreasing as molecular weight of the hydrocarbon increases. Equally, hydrocarbons with three or less rings degrade at greater rate than those with complex rings. Example is polynuclear hydrocarbons (PAH). Hence, increasing the molecular weight or branching of organic compound may tend to slow the rate of biodegradation of organic compound soil.

Most organic compound tends to persist in the soil under anaerobic conditions. Example, chlorinated compounds. Such compounds undergo biodegradation under environmental condition that would promote the growth of anaerobic bacteria,



The removal of chlorine atom above enhances the potential for anaerobic micro organisms. To enhance the degradation of dichloroethane (DCE), an environment for the growth of methane - utilizing bacteria must be created. The addition of methane to the soil results in the growth of these bacteria with a short period.



It therefore means that both anaerobic and aerobic degradation may be a good mechanism to remove such persistent organic compounds from the soil

8. Conclusion

The basic premises of microbial ecology are related to bioremediation in that many organic compounds can be used by micro organisms as a source of carbon and energy. Many of the organic compounds are, no doubt, hazardous to the soil, hence the need for bioremediation. Bioremediation of organic compounds in the soil based on the understanding of the carbon cycle and extrapolation of compound mineralization in environment to the soil. Environmental factors such as PH, redox potential and temperature play important role in determining the potential for bioremediation. Equally, biological reaction kinetics, and the type of nutrients (organic compounds), that can be delivered to the micro organisms would determine whether or not bioremediation will be feasible.

Before designing a bioremediation system, there is need for the assessment of the site to evaluate the history, ecology and hydrology; and laboratory assessment of the microbiology to provide information to show whether bioremediation is an appropriate measure treatment technology. The success of bioremediation is achieved when there is reduction of concentration of the organic compounds in the soil, increase in microbial activities of compounds degraded and the presence of metabolic intermediates in the soil.

References

- Atlas, R. M. (1984). Petroleum Microbiology. McMillan N. Y.
Back, W. (1989). Early Concepts of the role of micro organisms in Ground water 27:618-622.

- Dragun, J. (1988). The soil chemistry of Hazardous materials. Hazardous materials control research inst. Silver MD
- Gibson, D. T. (ed) (1984). Microbial Degradation of organic compounds. Marcel Dekker. H. Y.
- Mc Nabb, J. F. and Mallard (1984). Microbiological sampling in the assessment of Ground water pollution. In Ground Water Pollution microbiology. G. Britton and C. P. Gerba (eds). John Wiley and Sons. N. Y. pp. 235-260.
- Naranyanan P. (2009): Environmental Pollution: principles, Analysis and Control. CBS Publishers and Distributors Pvc. Ltd. New Delhi pp. 642.
- Waksman, S. A. (1916). Bacterial numbers in soil, at different depths, and in different season of the year. Soil science 1:363-380.