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ENVIRONMENTAL MANAGEMENT:- BIOREMEDIATION OF POLLUTED ENVIRONMENT

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Abstract

Environmental biotechnology employs the application of genetic engineering to improve efficiency and cost, which are central to the future of widespread exploitation of microorganisms to reduce the environmental burden of toxic substances. It is hoped that in future, the application of microorganisms coupled with genetic engineering techniques, will make a major contribution to improve the quality of our environment.

Introduction

The population explosion in the world has resulted in an increase in the area of polluted soil and water. As the number of people continues increasing day by day it also brings with it a growing pressure on air, water and land resources. In order to cater to the demands of the people, the rapid expansion of industries, food, health care, vehicles, etc. is necessary. But it is very difficult to maintain the quality of life with all these new developments, which are unfavorable to the environment in which we live, if proper management is not applied. In nature there are various fungi, bacteria and microorganisms that are constantly at work to break down organic compounds but the question arises when pollution occurs, who will do this clean up job? Since the quality of life is inextricably linked to the overall quality of the environment, global attention has been focussed on ways to sustain and preserve the environment. This endeavor is possible by involving biotechnology.

Role of Environmental Biotechnology in Pollution Management

Biotechnology can be used to assess the well being of ecosystems, transform pollutants into benign substances, generate biodegradable materials from renewable sources, and develop environmentally safe manufacturing and disposal processes. Environmental biotechnology employs the application of genetic engineering to improve the efficiency and cost, which are key factors in the future widespread exploitation of microorganisms to reduce the environmental burden of toxic substances.

In view of the urgent need of an efficient environmental biotechnological process, researchers have devised a technique called bioremediation, which is an emerging approach to rehabilitating areas fouled by pollutants or otherwise damaged through ecosystem mismanagement.

Bioremediation

"Remediate" means to solve a problem, and "bio-remediate" means to use biological organisms to solve an environmental problem such as contaminated soil or groundwater.

Bioremediation is the use of living microorganisms to degrade environmental pollutants or to prevent pollution. In other words it is a technology for removing pollutants from the environment thus restoring the original natural surroundings and preventing further pollution.

The rapid expansion and increasing sophistication of the chemical industries in the last century has meant that there has been increasing levels of complex toxic effluents being released into the environment. Many major incidents have occurred in the past which reveal the necessity to prevent the escape of effluents into the environment, such as the Exxon Valdez oil spill, the Union-Carbide (Dow) Bhopal disaster, large-scale contamination of the Rhine River, the progressive deterioration of the aquatic habitats and conifer forests in the Northeastern US, Canada, and parts of Europe, or the release of radioactive material in the Chernobyl accident, etc.

Types of Bioremediation

On the basis of removal and transportation of wastes for treatment there are basically two methods:

1. In situ bioremediation
2. Ex situ bioremediation

"In Situ" *bioremediation means there is no need to excavate or remove soils or water in order to accomplish remediation.*

Most often, *in situ* bioremediation is applied to the degradation of contaminants in saturated soils and groundwater. It is a superior method to cleaning contaminated environments since it is cheaper and uses harmless microbial organisms to degrade the chemicals. ***Chemotaxis*** is important to the study of in-situ bioremediation because microbial organisms with chemotactic abilities can move into an area containing contaminants. So by enhancing the cells' chemotactic abilities, in-situ bioremediation will become a safer method in degrading harmful compounds.

In situ bioremediation methods have many potential ***advantages-*** it does not require excavation of the contaminated soil and hence proves to be cost effective, there is minimal site disruption, so the amount of dust created is less, and simultaneous treatment of soil and groundwater is possible.

In situ bioremediation also poses some ***disadvantages –*** the method is time consuming compared to the other remedial methods, seasonal variation of the microbial activity due to direct exposure to changes in environmental factors that cannot be controlled, and problematic application of treatment additives. Microorganisms act well only when the waste materials present allow them to produce nutrients and energy for the development of more cells. When these conditions are not favourable then their capacity to degrade is reduced. In such cases genetically engineered microorganisms have to be used, although stimulating indigenous microorganisms is preferred.

Types of In Situ Bioremediation

Intrinsic bioremediation:

This approach deals with stimulation of indigenous or naturally occuring microbial populations by feeding them nutrients and oxygen to increase their metabolic activity.

Engineered in situ bioremediation:

The second approach involves the introduction of certain microorgansims to the site of contamination. When site conditions are not suitable, engineered systems have to be introduced to that particular site. *Engineered in situ* bioremediation accelerates the degradation process by enhancing the physico-chemical conditions to encourage the growth of microorganisms. Oxygen, electron acceptors and nutrients (eg: nitrogen and phosphorus) promote microbial growth.

Ex Situ Bioremediation processes require excavation of contaminated soil or pumping of groundwater to facilitate microbial degradation. This technique has more disadvantages than advantages.

Methods Involved in Treatment of Waste Materials

Depending on the state of the contaminant to be removed, **ex situ** bioremediation is classified as;

- Solid phase system (including land treatment and soil piles)
- Slurry phase systems (including solid-liquid suspensions in bioreactors)

Solid phase treatment:- it includes organic wastes (eg: leaves, animal manures and agricultural wastes) and problematic wastes (eg: domestic and industrial watses, sewage sludge and municipal solid wastes). Solid-phase soil treatment processes include landfarming, soil biopiles, and composting.

Slurry-Phase Bioremediation:- Slurry phase bioremediation is a relatively more rapid process compared to the other treatment processes.

Contaminated soil is combined with water and other additives in a large tank called a bioreactor and mixed to keep the microorganisms, which are already present in the soil, in contact with the contaminants in the soil. Nutrients and oxygen are added, and conditions in the bioreactor are controlled to create the optimum environment for the microorganisms to degrade the contaminants. When the treatment is completed, the water is removed from the solids, which are disposed of or treated further if they still contain pollutants.

Microorganisms Involved in Bioremediation Process

Many different types of organisms such as plants can be used for bioremediation but microorganisms show the greatest potential.

Microorganisms (primarily bacteria and fungi) are nature's original recyclers. Their capability to transform natural and synthetic chemicals into sources of energy and raw materials for their own growth suggests that expensive chemical or physical remediation processes might be replaced with biological processes that are lower in cost and more environmentally friendly.

Microorganisms therefore represent a promising, largely untapped resource for new environmental biotechnologies. Research continues to verify the bioremediation potential of microorganisms. For example, a recent addition to the growing list of bacteria that can reduce metals is ***Geobacter metallireducens***, which removes uranium, a radioactive waste, from drainage waters in mining operations and from contaminated groundwaters. Even dead microbial cells can be useful in bioremediation technologies. These discoveries suggest that further exploration of microbial diversity is likely to lead to the discovery of many more organisms with unique properties useful in bioremediation.

The use of microorganisms is not limited to one field of study of bioremediation, it has an extensive use; Petroleum, its products and oils constitute **hydrocarbons** and if present in the environment causes pollution. Oil slicks caused by oil tankers and petrol leakage into the marine environment is now a constantly occurring phenomenon. A number of microorganisms can utilize oil as a source of food, and many of them produce potent surface-active compounds that can emulsify oil in water and facilitate its removal. Unlike chemical surfactants, the microbial emulsifier is non-toxic and biodegradable. The microorganisms capable of degrading petroleum include pseudomonads, various corynebacteria, mycobacteria and some yeasts.

Apart from degrading hydrocarbons, microbes also have the ability to remove industrial wastes, reduce the toxic cations of ***heavy metals*** (such as Selenium) to a much less toxic soluble form. For example, plants like locoweed remove large amounts of the toxic element selenium. The selenium is stored in plant tissues where it poses no harm until and unless the plant is eaten. Many algae and bacteria produce secretions that attract metals that are toxic in high levels. The metals are in effect removed from the food chain by being bound to the secretions. Degradation of ***dyes*** are also brought about by some anaerobic bacteria and fungi.

To boost the world's food production rate to compensate for the increasing population, pesticides are being used. The extensive use of these artificial boosters have lead to the accumulation of artifical complex compounds called ***xenobiotics***. By introducing genetically altered microbes, it is possible to degrade these compounds. Once again thanks to the bioremediation technology!

Disadvantages

Bioremediation, although considered a boon in the midst of present day environmental situations, can also be considered problematic because, while additives are added to enhance the functioning of one particular bacteria, fungi or any other microorganisms, it may be disruptive to other organisms inhabiting that same environment when done in situ. Even if genetically modified microorganisms are released into the environment after a certain point of time it becomes difficult to remove them. Bioremediation is generally very costly, is labor intensive, and can take several months for the remediation to achieve acceptable levels. Another problem regarding the use of in situ and ex situ processes is that it is capable of causing far more damage than the actual pollution itself.

Technologies Using Bioremediation Treatments

Technologies using bioremediation treatment include bioaugmentation, biofilters, bioreactors, biostimulation, bioventing, composting and landfarming.

Conclusion

Despite its short-comings, its pertinence in this world is unquestionable in the light of present day environmental hazards. Bioremediation provides a technique for cleaning up pollution by enhancing the same biodegradation processes that occur in nature. So by developing an understanding of microbial communities and their response to the natural environment and pollutants, expanding the knowledge of the genetics of the microbes to increase capabilities to degrade pollutants, conducting field studies of new bioremediation techniques which are cost effective, and dedicating sites which are set aside for long term research purpose, these opportunities offer potential for significant advances. There is no doubt that bioremediation is in the process of paving a way to greener pastures!