

Bioremediation- an effective tool for protection of the environment

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Introduction :

All biotic and abiotic components and their interactions, together form the environment. The environment works as a system, where occurs the: input-processing- and output. The different ecocycles are the best example of environment as a system. The output that we obtain in the environment depends upon the input. One such output is the wastes that we obtain from variety of natural and man-made activities that take place in the environment. Wastes, due to their disadvantages prove a threat to the environment. Scientists have found various remedies for the decomposition of different types of wastes. But still many of them are not found to be much effective. Among the various waste treatments like biofilters [gases], landfills [solids], burning or incineration [solids], aerobic digestion [liquid] and anaerobic digestion [liquid]; bioremediation is one of the effective tools.

Bioremediation is carried out using different biological organisms such as bacteria, fungi, algae, protozoa and plants, to lower the levels or eliminate completely the toxic pollutants from their sources. Of the various micro-organisms, bacteria play a vital role in the process of breaking down the materials into organic matter and nutrients. Chlorinated pesticides, fertilizers and toxic chemicals like Arsenic etc. are cleaned by bacteria. However, heavy metals like Cd, Pb cannot be decomposed by the micro-organisms. Bioremediation has some limitations such as monitoring and controlling the treatment and uncertainty of performance criteria of micro- organisms.

However due to advances in enzyme technology, molecular biology, biochemistry and genetic engineering it is possible that in near future we could have GEMs that would act as excellent scavengers and leave our planet clean.

Materials used in bioremediation :

Bioremediation with the help of micro-organisms can be done by using three different methods depending upon the wastes. Biostimulation, Bioaugmentation, and Bioattenuation. The compounds that are broken down by the micro-organisms are polychlorinated biphenyl's [PCBs], polyaromatic hydrocarbons [PAHs] , radionuclides and metals. Many factors influence micro-organisms to use pollutants as substrates or cometabolize them, like the genetic potential and certain environmental factors such as temperature, pH and available nitrogen and phosphorous sources etc. that seem to determine the rate and extent of degradation.

The different micro-organisms used for the purpose of bioremediation include bacteria, fungi, algae and protozoa. The following table shows the different species that are used for bioremediation:

Bacteria	Micro-fungi/ Mycorrhiza	Algae & Protozoa
<i>Pseudomonas species</i>	<i>Candida species</i>	<i>Prototheca zopfi</i>
<i>Brevibacillus species</i>	<i>Saccharomyces cerevisiae</i>	Cyanobacteria
<i>Corynebacterium</i>	<i>Deuteromycetes-</i>	<i>Chlorella vulgaris</i>
<i>Staphylococcus</i>	<i>-Cladophiaphora</i>	<i>Scenedesmus platydiscus</i>
<i>Streptococcus</i>	<i>-Enophiala</i>	<i>S. quadricanda</i>
<i>Shigella</i>	<i>-Leptodontium</i>	<i>S. capricornutum</i>
<i>Alcaligenes</i>	<i>Ascomycetes-</i>	<i>Volvox aureus</i>
<i>Acinetobacter</i>	<i>-pseudeurotium</i>	<i>Anabena</i>
<i>Escherichia</i>	<i>-Zonatum</i>	<i>Heteromitaglobosa</i>
<i>Klebsiella</i>	<i>-Cladosporium</i>	
<i>Enterobacter</i>	<i>-Aspergillus</i>	
<i>Mycobacterium</i>	<i>-Penicillium</i>	
<i>Rhodococcus</i>	<i>-Amorphoteca</i>	
<i>Acromonas</i>		
<i>Achromobacter</i>		
<i>Burkholderia</i>		

Methods of Bioremediation : The commonly used methods of bioremediation are briefly discussed here-

- Natural attenuation or Bio-attenuation :
- i. Bio-attenuation occurs when the concentration of contaminants in the environment is lowered or eliminated through biological, physical or chemical means. In bio-attenuation, the biodegradation of contaminants is brought about by microbes which help in the clean-up activity. The most polluted sites are cleaned up naturally through various processes-
 - ii. Contaminants as source of nutrients: Microbes use contaminants as source of nutrients for performing their metabolic activities and to obtain energy. During this energy yielding process, the contaminants are digested chemically, changing them into water and harmless gases.
 - iii. Formation of compounds through various reactions: Some contaminants react with different elements and compounds present in the soil and hence lower the contamination.
 - iv. Seeping of contaminants into ground water: When contaminants seep into soil, they get mixed up with the ground water, hence, diluting the pollution.

- v Through inter-conversion from one state to another: The sublimable solid contaminants escape into the air. The liquid contaminants evaporate into the air, whereas gaseous contaminants escape from ground surface.

Thus, natural attenuation plays a vital role in bioremediation. On the other hand, lowered activity of this method due to various factors, may give rise to adoption of other methods such as Bioaugmentation and Biostimulation.

- **Bio-stimulation:**

It is one of the effective methods practiced in bioremediation. In this method, nutrients, trace minerals and other compounds are deliberately added to the soil contaminants to enhance the biotransformation. A wide range of microbes were found to be effective in degrading the contaminants in the presence of above nutrients. For the bioremediation of bio-diesel contaminated soil, bio-stimulation proves more beneficial than bio-attenuation.

- **Bio-augmentation:**

In the technique of bio-augmentation, the capacity of the soil is improved in order to remove pollution, by the introduction of competent strains of micro-organisms. The basic principle behind introduction of exogenous micro-organisms to the indigenous microbial community is that the biodegradation of the contaminants will be done at an accelerated rate. GEMs can also be added to the polluted strata, to increase the process of biodegradation rendering the intervening abiotic factors such as temperature, pH, moisture and organic matter content, ineffective.

In order to have a geared up bioremediation, the combined strategy of bio-augmentation and bio-stimulation would prove fruitful.

Conclusion :

Bioremediation is an effective tool for the protection of the environment from contamination. The three strategies of bio-attenuation, bio-augmentation and bio-stimulation are found to be useful in eradication of toxic substances from the environment. The wide range of micro-organisms which are employed in this technology include bacteria, fungi, algae and protozoa. Apart from the use of microbes and GEMs for biodegradation, understanding the actual metabolism and the enzymes involved in biodegradation of hydrocarbons, polychlorinated bi-phenyls [PCBs], polyaromatic hydrocarbons [PAHs], radio-nuclides and metals, would be more beneficial. As enzymes play an important role in biodegradation, use of enzymes either in non-immobilized or immobilized form can prove to be a novel approach for bioremediation.

Further researches in the field of bioremediation can lead to a more ecofriendly planet to live upon!

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