BIOREMEDIATION

A SUSTAINABLE APPROACH TO POLLUTION

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I. INTRODUCTION

The increasing population is leading to a higher rate of urbanization and demand for the production of daily household materials. Industrial productions release harmful pollutants such as particulate matter, carbon monoxide, heavy metals, plastic wastes, and microplastics which accumulate in the environment over a period of time. Some of the other types of waste materials like raw sewage, sanitary napkins, diapers, and plastic bags are dumped into landfills leading to decreased soil fertility, a pungent smell in the neighborhood, etc.

II. WHAT IS BIOREMEDIATION

To reduce the harmful levels of such pollutants many physical, chemical, and biological techniques such as incineration, and photodegradation. One such biological technique is Bioremediation. Bioremediation was discovered by George. M. Robinson in the year 1960. He worked on oil-degrading microbes and was used on a large scale for cleaning of sun oil pipeline spill at Ambler, Pennsylvania in the year 1972. It is a process that uses living organisms such as microorganisms, to reduce levels of pollutants in the environment. 'Bio' means living and 'remediation' means to resolve (which literally translates to resolve using living organisms.) The biological agents used for the degradation of contaminants are known are bioremediates.

III. TYPES OF BIOREMEDIATION

Bioremediates can be of different types, some of the important ones are using bacteria, fungi, worms, and plants. Bioremediation using bacteria is known as microbial remediation, bioremediation using fungi is known as myco remediation, bioremediation using worms is known as vermiremediation, and bioremediation using plant is known as phytoremediation. A number of criteria, including the concentration and chemical characteristics of the contaminant, the site of occurrence, and the nutritional, atmospheric, and temperature requirements needed for optimal growth must be taken into consideration for bioremediation to be effective.

IV. MICROBIAL BIOREMEDIATION

Bacteria are microorganisms belonging to the Kingdom Monera. Microbial bioremediation uses these bacteria that are either aerobic or anaerobic in nature that help in the biodegradation of contaminants, by which their concentrations can be brought to safer limits. This type of bioremediation uses microorganisms or their derivatives to reduce the concentration of toxic elements. Different bacteria such as *Pseudomonas sp., Dechloromonas sp., Bacillus* etc., are mostly used in bioremediation. These bacteria break down or degrade the pollutants by their inherited natural mechanisms resulting in biodegradation or biotransformation which in turn convert harmful substances present in wastewater, polluted soil, and oil spills*(Fig.1)* into simpler hydrocarbons.

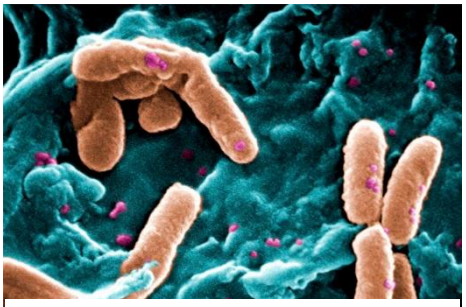

Fig .1. oil-eating bacteria

Different pathways can be adapted by the microbe for detoxification such as:

A. **Biosorption by bacterial cells** through cell surface adsorption, extracellular precipitation, and intracellular accumulation through special components- biosorption is a process of binding of heavy metals, dyes or other metals to the cell walls of bacteria. Volesky defined biosorption as the adsorption of substances from a solution by biological materials using physiochemical pathways of uptake, such as electrostatic forces and ion/proton displacement. The accumulation of substances by biosorption is known as bioaccumulation. Eg: Gram-positive bacteria such as *Bacillus* have shown to be more effective in the bioaccumulation process due to their thick peptidoglycan layer in the cell wall.

B. **Remediation via siderophore formation-** siderophores are formed by bacteria due to iron deficiency in them. These siderophores pick up iron from their environments and bind to them, which the bacteria intakes. This method can be exploited for microbial bioremediation.

C. **Mechanism of bacteria through biosurfactant production**- biosurfactants are microbial excretes that the bacteria produce to reduce intersurface tension. Products such as glycolipids and fats can be obtained. This mechanism is mainly used by bacteria like *Pseudomonas putida* for bioremediation of oil spills.

V. MYCO REMEDIATION

Fig.2. White rot wood fungus

Fungi are known as the ultimate degraders of complex organic matter, involved in decay processes, and known to degrade wood including lignin and cellulose, and other plant-based materials, which are common waste products in agriculture. They can also degrade a variety of pollutants, such as heavy metals, insecticides, and petroleum compounds. They are useful for cleaning up the environment since they can absorb and store pollutants in their fruiting bodies. Most of the fungi are aerobic and are present in marine environments which degrade microplastics present in oceans. Mycoremediation, the practice of employing fungi to break down and remove pollutants from soil, water, and air, involves a considerable contribution from fungi species. Fungi are useful in this process because they possess special qualities for metabolizing different types of contaminants. Fungi have enzymatic machinery both inside and outside of their cells, and they can secrete acids, which allows them to attack and metabolize a variety of compound types, including both inorganic and organic contaminants. Highly used fungi are mushrooms of different kinds and white rot wood fungus *(Fig.2).* These help in bioremediation by degrading lignocelluloses using extracellular enzymes. They can also be grown on any carbon source, which will be utilized and bio-transformed into other simpler substances. Furthermore, advances in Recombinant DNA technology and Genetic engineering have opened up new possibilities for improving the efficiency and specificity of bioremediation using bacteria and fungi. For example, they can be engineered to produce enzymes that break down specific substances and can be further exploited.

VI. PHYTOREMEDIATION

Phytoremediation is the use of plants and soil-associated microorganisms to reduce the toxicity of contaminants. Plants are able to absorb and break down pollutants through a variety of mechanisms, including Phyto stabilization, phytoextraction, and biofiltration. These processes involve the use of specific plant species that are able to tolerate and accumulate high levels of contaminants.

Fig.3. *Brassica juncea*

A. Phyto stabilization: In this process, plants tend to accumulate metals near their rhizosphere and help stabilize it by mobilizing it with a substrate.

B. Phytoextraction: In this process, the plants accumulate pollutants in their rhizosphere and mobilize them for uptake by plant roots to aerial parts of a plant and destroy organic pollutants by phytodegradation.

C. Biofiltration: This process is carried out by water plants which help in the uptake of water contaminants to the aerial parts of the plant.

Phytoremediation has been used successfully to clean up contaminated sites, such as abandoned industrial areas and landfills. It has also been used to treat wastewater and air pollution. White willow, Indian grass, poplar trees, Indian mustard, sunflower, and water hyacinth are the best plants for phytoremediation. These plants clean the soil and water of pollutants and heavy metals.

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