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Role of plant microbe interactions in Pollutant degradation

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Globally, increasing population has led to the escalation of pollution levels which has become a major issue of environmental concern and is basically a consequence of industrialization and pesticide residues *etc*. These pollutants may include hydrocarbons, heavy metals, chlorinated compounds *etc*. These pollution needs to be kept under check and hence plants and microbes play a very important role in this purview. As, microorganisms are ubiquitously present in nature they play a crucial role in biogeochemical cycles of metal transformations between soluble and insoluble species. Bioremediation is a technique for removing/converting harmful contaminants like heavy metals into less harmful substances; and/or removing toxic elements from the contaminated environment; or degrading organic substances and ultimate mineralization of organic substances into carbon dioxide, water, nitrogen gas, *etc*., by employing dead or alive biomass.

Microbes can grow at below zero temperature as well as extreme heat in the presence of hazardous compounds or any waste stream. These two characters of microbes are adaptability in the biological system made them suitable for remediation process. In the process of execution of the process of bioremediation, microorganisms like Bacteria and Fungi play important role. Bacteria break down the waste into nutrients and organic matter and hence they are the most crucial microbes in this process. Despite the fact that this is an efficient process of waste management but it cannot destroy 100% contaminants.

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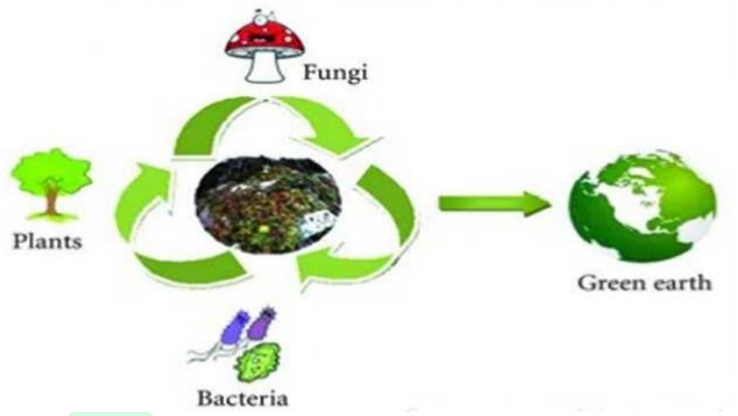

Bioremediation

Types of Bioremediation

Based on the site of remediation

1. **Insitu Bioremediation:**

The process of conversion of environmental pollutants into harmless forms through the innate capabilities of the naturally occurring microbial population is called intrinsic bioremediation.

2. Exsitu Bioremediation:

Transportation of soil to faraway place to accelerate the microbial degradation done by solid and slurry phase systems, whereby treatments of domestic, industrial, and organic waste are done by ex situ bioremediation.

Methods of Bioremediation:

1. Biostimulation
2. Bioaugmentation
3. Phytoremediation
4. Bioventing
5. Bioleaching
6. Biosparging
7. Rhizofiltration

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1) Biostimulation:

In the process of **biostimulation,** the bacteria is stimulated to initiate the process. First, the contaminated soil is mixed with special nutrient substances including other vital components either in the form of liquid or gas. The growth of microbes is thus stimulated and results in efficient and quick removal of contaminants by them.

2) Bioaugmentation

The process of adding cultured microorganisms into the subsurface for the purpose of biodegrading specific soil and groundwater contaminants is called as **bioaugmentation.** For example – municipal wastewater.

3) Phytoremediation

In this scenario, plants are directly used to clean up or contain contaminants in the soil. This method of bioremediation will help mitigate the environmental problem without the need to excavate the contaminant material and dispose of it elsewhere.

Rhizosphere soil: Plant roots releases various compounds into the root zone these compounds contains carbohydrates, organic acids, vitamins, nucleic acids and sugars etc these compounds attracts the soil microorganism because microorganism utilizes these compounds as a nutrient hence we can see more microbial population in the rhizosphere soils than non-rhizosphere soils where in microorganisms may be Bacteria, Fungi, And Actinomycetes these organism may involve in the activities of degradation like toxic materials, industrial, organic wastes and mineralization when get sufficient food or nutrient from the plant root exudates etc

There are several different types of phytoremediation mechanisms.

- ✓ Rhizosphere biodegradation
- ✓ Phyto-stabilization
- ✓ Phyto-accumulation Hydroponic Systems for Treating Water Streams (Rhizofiltration)
- ✓ Phyto-volatilization

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- ✓ Phyto-degradation
- ✓ Hydraulic Control.

4) Bioventing:

The process that increases the oxygen or air flow into the unsaturated zone of the soil, which in turn increases the rate of natural in situ degradation of the targeted hydrocarbon contaminant is called as Bioventing.

5) Bioleaching (or biomining):

It is a process in mining and biohydrometallurgy (natural processes of interactions between microbes and minerals) that extracts valuable metals from a low-grade ore with the help of microorganisms such as bacteria or archaea.

6) Biosparging:

This process involves high-pressure air injection forced into the soil or under the groundwater table. This process increases oxygen concentration and enhances biological Air sparging is highly effective and affordable, compared to excavating and tilling contaminated soil or circulating polluted water through pumps and filter tanks.

7) Rhizofiltration:

It is adsorption of contaminants onto plant roots or absorption into plant roots that are in solution surrounding the root zone (rhizosphere) is called as Rhizofiltration. It is used to decontaminate groundwater.

Microorganisms used in bioremediation:

Bioremediation process was carried out by microbial consortium in different environments. These microorganisms comprise *Achromobacter, Arthrobacter, Alcaligenes, Bacillus, Corynebacterium, Pseudomonas, Flavobacterium, Mycobacterium, Nitrosomonas, Xanthobacter, etc.*

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Pseudomonas aeruginosa

Achromobacter

Process of bioremediation

The process of bioremediation **(Fig:2)** enhances the rate of the natural microbial degradation of contaminants by supplementing the indigenous microorganisms (bacteria or fungi) with nutrients, carbon sources, or electron donors (biostimulation, biorestoration) or by adding an enriched culture of microorganisms that have specific characteristics that allow them to degrade the desired contaminant at a quicker rate (bioaugmentation).

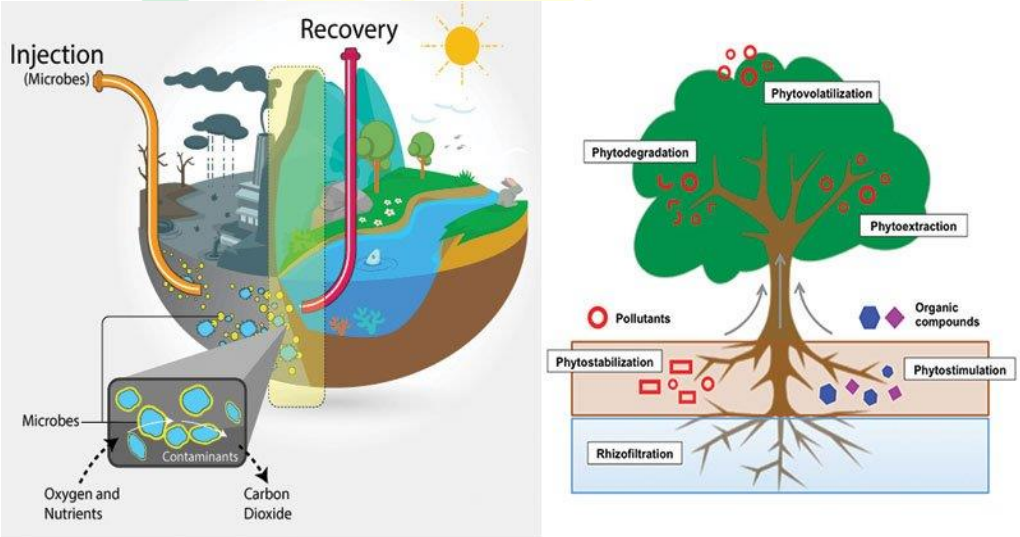

Fig: 2 Process of Bioremediation

Critical conditions for bioremediation include:

1. Host microbial contaminants that provide fuel and energy to parasitical microbes
2. Parasitical microbes that feed off their harmful hosts and destroy them

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3. Oxygen in sufficient amounts to support aerobic biodegradation
4. Water, either in liquid form or in soil moisture content
5. Carbon is the foundation of microbial life and its energy source
6. Temperature, not too cold or hot for microbial life to flourish
7. Nutrients like nitrogen, phosphorous, potassium and sulfur to support microbe growth
8. Acid and alkaline proportions or pH ratio in the range of 6.5 to 7.5

Advantages of bioremediation

1. Natural process: Bioremediation being a natural process is accepted by the public as waste treatment method for contaminated material such as soil.

2. Complete destruction: Bioremediation is employed for the complete destruction of a wide variation of contaminants.

3. Economic process: Bioremediation is cost effective in comparison to other methods that are used for removal of hazardous waste.

Applications of bioremediation:

- ✓ Used for the remediation of metals, radionuclides, pesticides, explosives, fuels, and volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs).
- ✓ Used to clean up contaminants found in soil and groundwater.
- ✓ Chelating agents are used sometimes to make the contaminants amenable to plant uptake.

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