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What is 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 means to use a biological remedy to abate or clean up contamination.
- **Bioremediation** is a waste management technique that involves the use of organisms to remove or neutralize pollutants from a contaminated site.
- According to the EPA, **bioremediation** is a "treatment that uses naturally occurring organisms to break down hazardous substances into less toxic or non toxic substances".

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What is Bioremediation?

- Bioremediation is the a biological degrading processes for the treatment of contaminated soils, groundwater and/or sediments, relying on microorganisms including bacteria and/or fungi to use the contaminant(s) as a food source with resulting degradation of the contaminant.
- Microorganisms used to perform the function of bioremediation are known as bioremediators.



- Bioremediation is one of the most economic remedial techniques presently available for treating most organic fuel based contaminants such as coal tars and liquors, petroleum and other carcinogenic hydrocarbons such as benzene and naphthalene, and some inorganics.

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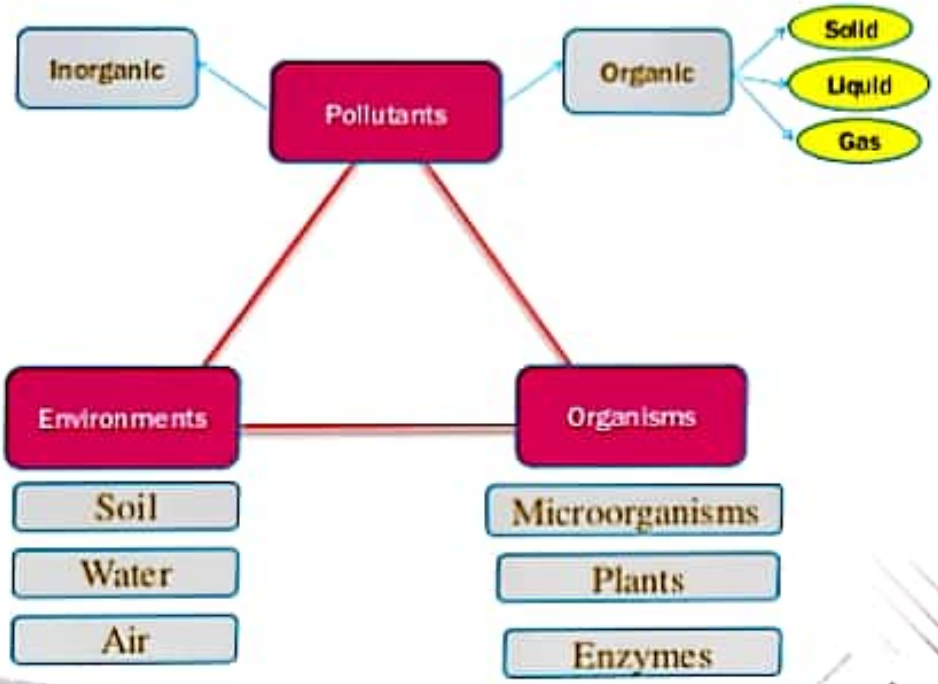
BIOREMEDIATION IS A TRIPLE-CORNERS PROCESS



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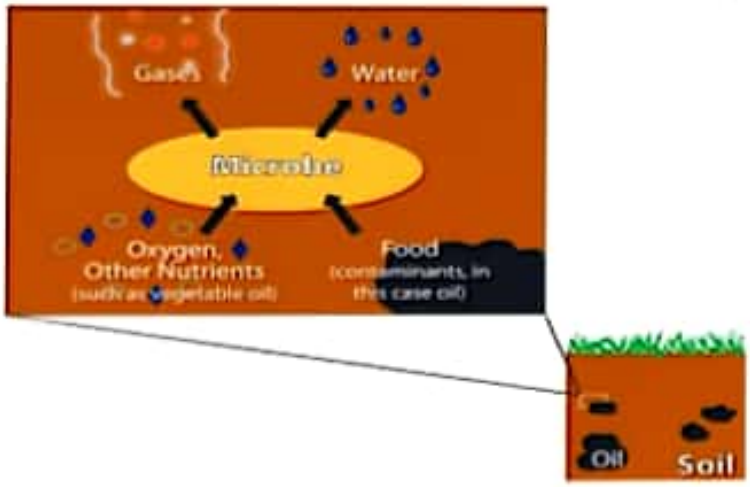
How Does It Work?

- Waste material is examined & certain bacteria are isolated based on their efficacy at digesting and converting the waste.
- Indigenous or local bacteria is to be used!
- The bacteria then go through several steps of cultures and process for performance testing.
- The suitable bacteria are placed back in the waste environment.
- They grow & thrive & in the process digest & convert the waste into Carbon dioxide & water.
- The right temperature, nutrients, and food also must be present.
- Conditions may be improved by adding "amendments."



Microbe takes in oil, oxygen, and nutrients and releases gases and water.

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ESSENTIAL FACTORS FOR MICROBIAL BIOREMEDIATION

Factor	Desired Conditions
Microbial population	Suitable kinds of organisms that can biodegrade all of the contaminants
Oxygen	Enough to support aerobic biodegradation (about 2% oxygen in the gas phase or 0.4 mg/liter in the soil water)
Water	Soil moisture should be from 50–70% of the water holding capacity of the soil
Nutrients	Nitrogen, phosphorus, sulfur, and other nutrients to support good microbial growth
Temperature	Appropriate temperatures for microbial growth (0–40°C)
pH	Best range is from 6.5 to 7.5

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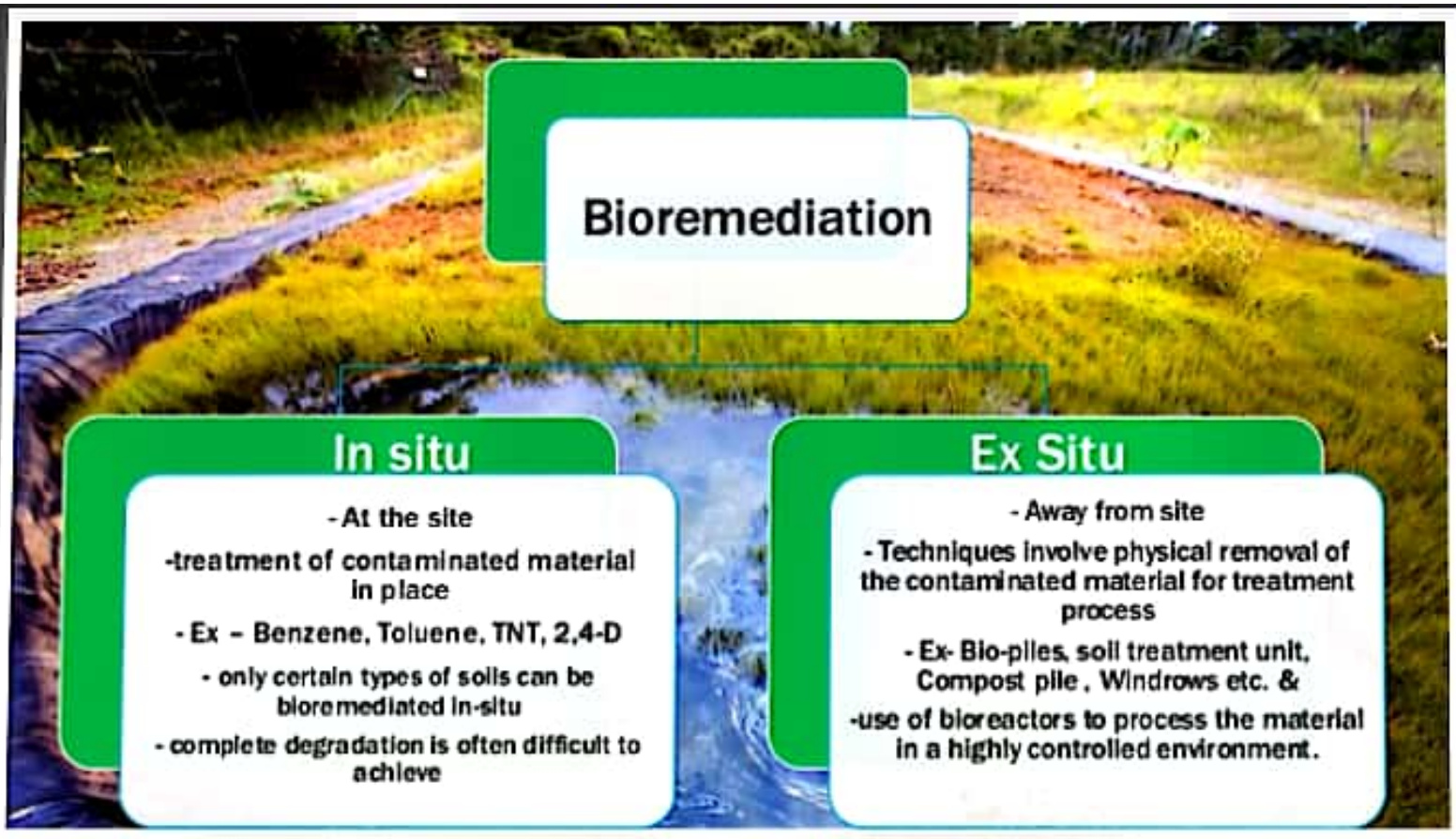

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TYPES OF BIOREMEDIATION :

1. Biostimulation

- The method in which bacteria are motivated to start the process of bioremediation.
- In this method, first the experts release nutrients and other important substances in the soil where there is need or removing the contaminants.
- These are in the form of gas or liquid. It increases the growth of microbes in that area.
- As a result bacteria and other microorganisms remove the contaminants quickly and efficiently.

2. Bioaugmentation

- Microorganisms that can clean up a particular contaminant are added to the contaminated soil and water.
- Bioaugmentation is more commonly and successfully used on contaminants removed from the original site, such as municipal waste water treatment facilities.

3. Intrinsic Bioremediation

- Process takes place in soil and water because these two places are always full of contaminants and toxins.
- This process is also called as natural attenuation.
- Also means use of the microorganisms to remove the harmful substances from soil and water.
- Especially those sites are treated with this method, which are underground, for example underground petroleum tanks.

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Advantages:

- Low cost.
- Minimal site disruption.
- Simultaneous treatment of contaminated water and soil.
- Minimal exposure of public & site personnel.
- Useful for the complete destruction of a wide variety of contaminants.
- Can often be carried out on site, often without causing a major disruption of normal activities
- Can prove less expensive than other technologies that are used for cleanup of hazardous waste.

Disadvantages:

- Time consuming.
- Seasonal variation.
- Problematic addition of additives.
- Limited to those compounds that are biodegradable.
- Not all compounds are susceptible to rapid and complete degradation.
- There are some concerns that the products of biodegradation may be more persistent or toxic than the parent compound.
- difficult to extrapolate (deduce) from bench and pilot-scale studies to fullscale field operations.
- Biological processes are often highly specific microbial populations, suitable environmental growth conditions, and appropriate levels of nutrients and contaminants.

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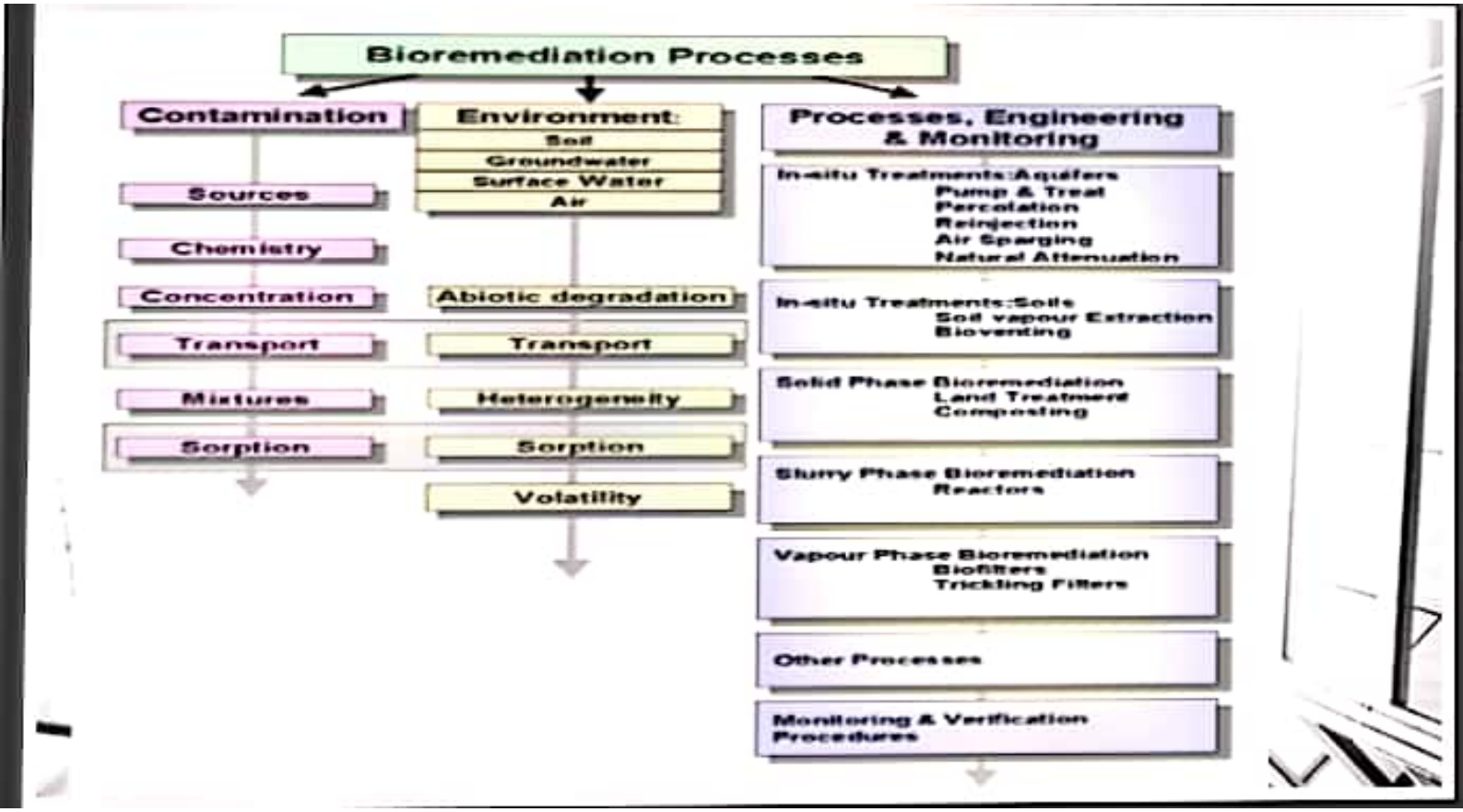

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Technology	Examples	Benefits	Limitations	Factors to consider
In situ	*In situ* bioremediation Biosparging Bioventing Bioaugmentation	Most cost efficient Noninvasive Relatively passive Natural attenuation processes Treats soil and water	Environmental constraints Extended treatment time Monitoring difficulties	Biodegradative abilities of indigenous microorganisms Presence of metals and other inorganics Environmental parameters Biodegradability of pollutants Chemical solubility Geological factors Distribution of pollutants
Ex situ	Landfarming Composting Biopiles	Cost efficient Low cost Can be done on site	Space requirements Extended treatment time Need to control abiotic loss Mass transfer problem Bioavailability limitation	See above
Bioreactors	Slurry reactors Aqueous reactors	Rapid degradation kinetic Optimized environmental parameters Enhances mass transfer Effective use of inoculants and surfactants	Soil requires excavation Relatively high cost capital Relatively high operating cost	See above Bioaugmentation Toxicity of amendments Toxic concentrations of contaminants

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Applications of Bioremediation

Lab

Hairy root system

Medicinal plant cultivation

Production of a variety of valuable metabolites

Hairy root metabolic engineering

Optimization of metabolic pathway utilization

Field

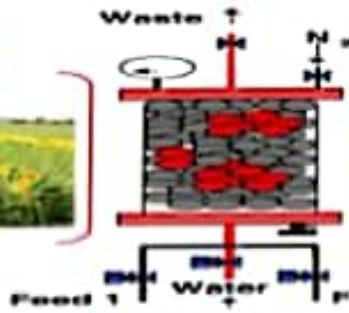
Increased secondary metabolite production

Elicitation, permeabilization trapping

Environmental cleanup

Phytoremediation

Scale-up



Pilot

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