# Quadrant II – Transcript and Related Materials

**Programme:** Bachelor of Science (Third Year)

**Subject:** Botany

**Paper Code:** BOC 107

**Paper Title:** Microbiology & Plant Pathology

**Unit:** 05 (Applications of Microorganisms)

**Module Name:** Role of Microorganisms in Bioremediation

**Module No:** 30

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**Notes:**

**Bioremediation** is defined as the use of biological processes to degrade, transform, and/or essentially remove contaminants or toxic pollutants that impair the quality of soil and water to environmentally safe level. It is a natural process that relies on microorganisms capable of using contaminants as an energy source to carry out their normal life processes.

**Types of Bioremediation:**

Bioremediation can be done in 2 ways: 1. *In situ* Bioremediation
2. *Ex situ* Bioremediation

***In situ* Bioremediation** is the treatment of contaminants at site or in its natural location. It involves treating the contaminated soil in its natural location. It causes minimal disturbance to the environment. It is less expensive as transport of contaminated material is not needed.
*In situ* Bioremediation can be performed in the following ways:

**1. Bioventing - I**t is the most common *in situ* treatment method involving supply of air and nutrients through wells/vents to the contaminated soil to stimulate

growth of naturally occurring aerobic bacteria. This method is more effective in sandy soils.

**2. Biostimulation -** It involves supplying oxygen and nutrients by circulating aqueous solutions through contaminated soils to stimulate naturally occurring bacteria to degrade organic contaminants.

**3. Biosparging -** It involves the injection of air under pressure below the water table to increase groundwater oxygen concentrations and enhance the rate of biological degradation of contaminants by naturally occurring bacteria.

**4. Bioaugmentation (seeding) -** It involves the addition of microbial inoculants developed in the laboratory to the contaminated site to detoxify a particular contaminant, sometimes employing genetically altered microorganisms.

***Ex situ* Bioremediation** involves the excavation of contaminated material from the site and treatment elsewhere. It is also called as 'Pump and treat' method as the contaminated material/soil is removed from its original site and treated elsewhere. This method is used when contaminated soil is inaccessible. It is an expensive method as soil is physically removed.

*Ex situ* Bioremediation can be performed in the following ways:

**1. Land farming -** It involves spreading of contaminated soil in thin layers over a prepared bed. The soil is supplemented with nutrients, microorganisms and proper pH until the pollutants are degraded.

**2. Composting -** It involves mixing contaminated soil with soil amendments such as manure or agricultural wastes. These organic materials support the development of a rich microbial population at elevated temperatures characteristic of composting.

**3. Biopiles -** It is a combination of land farming and composting methods. It involves mixing contaminated soil with soil amendments and spreading it in thin layers over a prepared bed and providing conditions suitable to growth of microorganisms.

**4. Bioreactors -** Contaminated soil/sediment/sludge/soil leachates/ground water is pumped to the surface. It is mixed with water and nutrients, agitated and

treated under controlled conditions in a bioreactor to stimulate action of microorganisms.

**Use of Bacteria in Bioremediation:**

Bacterial species are used to remediate contaminated sites. *Escherichia coli* is used to clean up heavy metals such as copper, cadmium, chromium and mercury. For bioremediation to be effective, microorganisms must enzymatically attack the pollutants and convert them to harmless products. Contaminant destruction is done by synthesis of enzymes such as oxido-reductases, hydrolases etc. by bacteria that use environmental contaminants as an energy source.

**Microbes in cleaning-up of oil spills:**

Marine oil spills contain complex hydrocarbons that are a great threat. Most microorganisms used as inoculum for seeding to breakdown hydrocarbons are usually obtained from enriched cultures (from a previously contaminated site). Controlled use of genetically modified organisms may be also used. *Pseudomonas putida* is involved in the bioremediation of toluene, naphthalene, a product of petroleum refining in contaminated soils. *Dechloromonas aromatica* can oxidize benzene.

**Use of Fungi in Bioremediation:**

Fungi are effective in removal of a wide array of toxins from damaged environments or wastewater. *Fusarium* sp., *Aspergillus niger* and *Candida glabrata* are used in degradation of crude oil. *Aspergillus niger* mycelium can absorb silver from effluents. *Aspergillus oryzae* is used to remove cadmium from effluents.

**Use of Algae in Bioremediation:**

Algae are capable of absorbing heavy metals. *Chlorella vulgaris* is used to remove uranium from sea water. *Sargassum natans* can absorb cadmium and lead from effluents.

**Advantages of Bioremediation:**

*In situ* bioremediation is an acceptable method as there is less disruption of the contaminated environment when compared to other clean-up methods. Bioremediation is useful for the complete destruction of a wide variety of contaminants. It is safe as residues are usually harmless.

**Disadvantages of Bioremediation:**

The process of bioremediation is sensitive to the level of toxicity and environmental conditions (temperature, pH etc.) for microbial growth and activity in the field. Field monitoring to track the rate of biodegradation of the organic contaminants is difficult. In certain cases, incomplete breakdown of organic contaminants may result in toxic by-products.

**Summary:**

Bioremediation is a technique that employs biological processes to clean-up toxic contaminants. Microbial communities are fundamental components which play a critical role in biodegradation of contaminants. Bioremediation can be done by *in situ* or *ex situ* methods depending on the nature of the contaminant. The method employed should be cost effective and environmentally safe.