

Welcome students I am Dr James D'souza, Assistant professor St Xavier's college Mapusa Goa.

Coming to outline of module concept of bioremediation and various type of bioremediation. In learning outcomes student will be able to explain process of bioremediation. List advantages of bioremediation.

Bioremediation is the process of cleaning the polluted areas using biological organisms such as microorganisms and plants. In this process Microorganisms are used to reduce and transform contaminants into non-toxic substances, in the environmentally friendly manner.

Parameters- required for the success of bioremediation process. Existence of a microbial population capable of degrading the pollutants. Availability of contaminants to the microbial population. Bioremediation can be done in two methods known as *in situ* and *ex situ*. The key difference between *in situ* and *ex situ* bioremediation lies on the place where the process is carried out. In *in situ* bioremediation, contaminants are degraded at the same site where it's found while the contaminants are treated in a different place in *ex situ* bioremediation.

Methods of Bioremediation

It is done by using two methods *in situ* bioremediation and *ex situ* bioremediation. The difference between *in situ* and *ex situ* bioremediation lies in the place where the process is carried out. In *in situ* bioremediation, contaminants are degraded at the same site where they are found, while in *ex situ* bioremediation, contaminants are treated in a different place. In *in situ* bioremediation, we have various processes such as-

Bioventing- Bioventing is involved in venting of oxygen through soil to stimulate growth of natural or introduced bacteria and fungus in the soil by providing oxygen to existing soil microorganisms.

Bioslurping combines elements of bioventing and vacuum-enhanced pumping of free-product to recover free-product from the groundwater and soil, and to bioremediate soils.

Bio-attenuation or **natural attenuation** is the eradication of pollutant concentrations from surrounding. It is carried out with in biological processes.

If the organisms we are relying on for bioremediation need some nutrient whose absence is limiting their growth, this can significantly slow down bioremediation. This process of accelerating bioremediation by supplying key nutrients to boost their growth is called **bio-stimulation**. Concentration of other contaminants, microbial community of the site, temperature, pH of the medium, moisture content are other factors which are required for successful process.

In this picture ***In situ* Bioremediation**.

Ex situ In this method, contaminants are treated away from the location where they were found. Contaminants are excavated or pumped out from the original site and treated inside the controlled environments. It is also called as **Pump and treat method**. Contaminated soils are excavated and placed on the surface of the ground and treated using indigenous microorganisms. *Ex situ* bioremediation can be controlled and managed by providing required conditions. **Biopiles-** are used to reduce concentrations of petroleum pollutants in excavated soils. Biopiles (also known as biocells, bioheaps, biomounds, and compost Piles). The microbial activity is enhanced through microbial respiration then the result in degradation of adsorbed petroleum pollutant became high. On the basis of phases of

contaminated materials under treatment *ex situ* bioremediation is classified into two: (i) solid-phase system (including land treatment) i.e. composting (ii) slurry-phase systems (involving treatment of solid-liquid suspensions in bioreactors).

Bioaugmentation -is the process of adding engineered microbes in a system which act as a bioremediators to quickly eliminate complex pollutants.

Composting - refers to the use of a biological system of micro-organisms in a **compost** to sequester or break down contaminants in water or soil.

The contaminants are digested, metabolized, and transformed into humus and inert byproducts, such as carbon dioxide, water, and salts.

Bioreactor represent highly controlled method of treating contaminated soils and groundwater.

Temperature, pH, nutrient levels, and agitation can be controlled in constructed batch- or continuously-fed reactors, microbial activity, and thus contaminant degradation, can be optimized.

Types of Bioremediation

Bacterial Bioremediation- bacteria is used for bioremediation; Use of Bacterial species in bioremediation process. Contaminant destruction is done by **enzymes** (Oxido-reductases, hydrolases etc) present in bacterial species by using environmental contaminants as a food. For bioremediation to be effective, microorganisms must enzymatically attack the pollutants and convert them to harmless products.

In this image we can see MO -use the hydrocarbons and organic compounds in petroleum as energy while simultaneously denaturing toxic compounds. Some of bacterial species.

Alcanivorax* bacteria or *Methylocella silvestris-- used to break down or remove oil.

Pseudomonas putida- a gram-negative soil bacterium that is involved in the bioremediation of toluene, naphthalene, a product of petroleum refining in contaminated soils.

Dechloromonas aromatica- is a rod-shaped bacterium which can oxidize aromatics benzene anaerobically & is especially useful for *in situ* bioremediation of this substance.

Myco-remediation is a form of bioremediation in which fungi -based technology is used to decontaminate the environment.

Fungi is effective to remove a wide array of toxins from damaged environments or wastewater.

Phanerochaete chrysosporium, *Trametes versicolor*, *Bjerkandera adusta* and *Pleurotus* sp., produces ligninolytic enzymes such as laccases and peroxidases.

Fusarium sp, *Aspergillus niger*, *Candida glabrata*, *Candida krusei* and *Saccharomyces cerevisiae* are used in degradation of crude oil.

& phyto remediation- plants are used.

Metal –Microbe interactions & mechanism of metal removal.

Adsorption- Negatively charged cell surfaces of MO binds to the metal ions.

Complexation- MO produce organic acids (citric acid, oxalic acid malic acid) which chelate metal ions.

Precipitation- MO produces Ammonia & organic basis which precipitate metals as hydroxides or sulfates. Eg. *Klebsiella aerogenes*.

Volatilization-causes methylation of mercury & convert it into volatile compound (dimethyl mercury).

Genetically Engineered Microorganisms (GEMs)

Genetically modified microorganisms increases the degradative efficiency of a wide range of environmental pollutant & change pollutants into less complex and harmless end products. Natural species are not fast enough to break down certain compounds & hence genetically modified through DNA manipulation. They compete with the indigenous species, predators and also various abiotic factors. Eg. *Pseudomonas putida* containing hybrid plasmid.

Advantages of Bioremediation- The benefit of bioremediation include less disruption of the contaminated environment when compared to other clean up methods.

If biodegradation is complete (i.e. mineralization) the products from treatment are harmless. Bioremediation can be a cheaper alternative to other technologies used for pollution mitigation.

Disadvantages of bioremediation -If the process is not controlled -organic contaminants may not be broken down fully, resulting in toxic by-products. The process is sensitive to the level of toxicity and environmental conditions on the ground. The conditions must be conducive to microbial activity e.g. need to consider temperature, pH etc. Field monitoring to track the rate of biodegradation of the organic contaminants is advised.

Summary - Bioremediation is an ecologically friendly technique that employs biological processes to eliminate toxic contaminants.

Microbial communities are fundamental components which play critical role biodegrading the pollutants.

Better understanding of physico-chemical characterization of contaminated environment, detailed exploration of microbial diversity & identifying potential Mos is very much essential.

Bioremediation processes are cost effective, safe and nature-based methods over the chemical and physical methods.

This are references

Thank you.