Bioremediation

Bioremediation is the use of microorganism metabolism to remove pollutants. Bioremediation can occur on its own or can be encouraged via the addition of fertilizers to increase the bioavailability within the medium (biostimulation).
Microorganisms used to perform the function of bioremediation are known as bioremediators.

It can be classified as: 1) in situ: can be used at the site of contamination

2) ex situ: contamination removed from the original site

Some of bioremediation technologies are phytoremediation, bioventing, bioleaching, landfarming, bioreactor, composting, bioaugmentation, rhizofiltration, and biostimulation.

For bioremediation to be effective, microorganisms must enzymatically attack the pollutants and convert them to harmless products. As bioremediation can be effective only where environmental conditions permit microbial growth and activity, its application often involves the manipulation of environmental parameters to allow microbial growth and degradation to proceed at a faster rate.

Factors of Bioremediation:- The control and optimization of bioremediation processes is a complex system of many factors. These factors include:
1) The existence of a microbial population capable of degrading the pollutants
2) The availability of contaminants to the microbial population
3) The environment factors (type of soil, temperature, pH, the presence of oxygen or otherelectron acceptors, and nutrients).

Microorganisms for Bioremediation

Microorganisms can be isolated from almost any environmental conditions. Microbes will adapt and grow at subzero temperatures, as well as extreme heat, desert conditions, in water, with an excess of oxygen, and in anaerobic conditions, with the presence of hazardous compounds or on any waste stream. The main requirements are an energy source and a carbon source, these can be used to degrade or remediate environmental hazards.

These microorganisms can divided into the following groups:

1) Aerobic: In the presence of oxygen. Examples of aerobic bacteria recognized for their degradative abilities are *Pseudomonas*, *Alcaligenes*, *Sphingomonas*, *Rhodococcus*, and *Mycobacterium*. These microbes have often been reported to degrade pesticides and hydrocarbons, both alkanes and compounds. Many of these bacteria use the contaminant as the sole source of carbon and energy.

2) Anaerobic: In the absence of oxygen. Anaerobic bacteria are not as frequently used as aerobic bacteria. There is an increasing interest in anaerobic bacteria used for bioremediation of polychlorinated biphenyls (PCBs) in river sediments, dechlorination of the solvent trichloroethylene (TCE), and chloroform.

3) Ligninolytic fungi: Fungi such as the white rot fungus *Phanaerochaete chrysosporium* have the ability to degrade an extremely diverse range of persistent or toxic environmental pollutants. Common substrates used include straw, saw dust, or corn cobs.

4) Methylotrophs: Aerobic bacteria that grow utilizing methane for carbon and energy. The initial enzyme in the pathway for aerobic degradation, methane monooxygenase, has a broad substrate range and is active against a wide range of compounds, including the chlorinated aliphatics trichloroethylene and 1,2-dichloroethane.

Bioremediation strategies

1) *In-Situ* Bioremediation: *In situ* bioremediation is the application of biological treatment to the cleanup of hazardous chemicals present in the subsurface. And can be divided:

a) Biosparging: 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.

b) Bioventing: is a promising new technology that stimulates the natural *in-situ* biodegradation of any aerobically degradable compounds within the soil by providing oxygen to existing soil microorganisms.

c) Bioaugmentation: Bioaugmentation is the introduction of a group of natural microbial strains or a genetically engineered variant to treat contaminated soil or water. At sites where soil and groundwater are contaminated with chlorinated ethenes, such as tetrachloroethylene and trichloroethylene**,** bioaugmentation is used to ensure that the *in situ* microorganisms can completely degrade these contaminants to ethylene and chloride, which are non-toxic.

d) Biopiling: Biopile treatment is a full-scale technology in which excavated soils are mixed with soil amendments, placed on a treatment area, and bioremediated using forced aeration.

Biopile

2) *Ex-Situ* Bioremediation

a) Composting: is a process by which organic wastes are degraded by microorganisms, typically at elevated temperatures. Typical compost temperatures are in the range of 55° to 65° C. The increased temperatures result from heat produced by microorganisms during the degradation of the organic material in the waste.

b) Bioreactors: Slurry reactors or aqueous reactors are used for *ex situ* treatment of contaminated soil and water .

Note: In general, the rate and extent of biodegradation are greater in a bioreactor system than *in situ* or in solid-phase systems because the contained environment is more manageable and hence more controllable and predictable.

Bioslurry reactor

Water and gas bioremediation

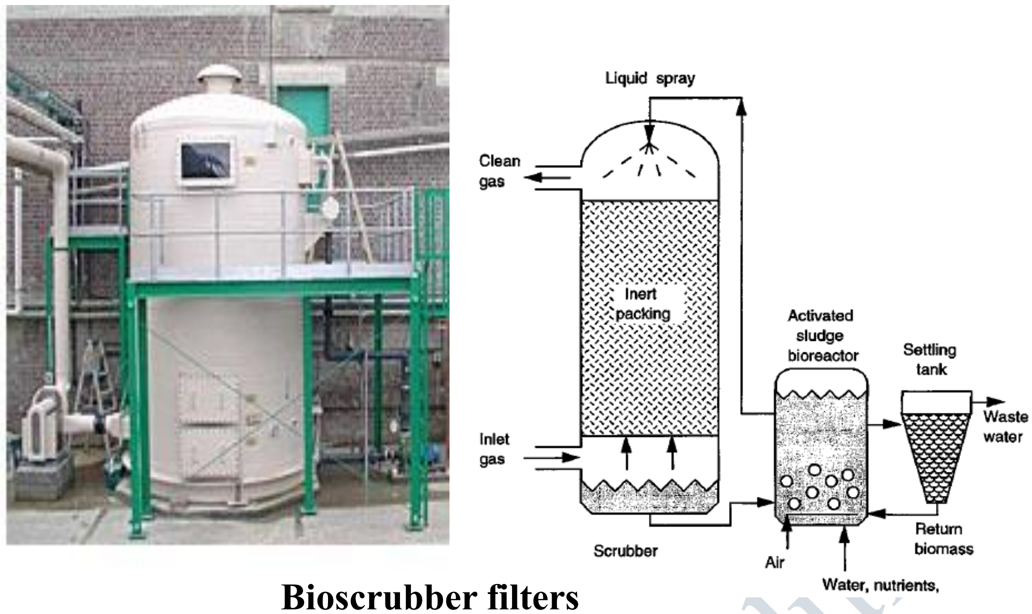
Biofiltration is a process, in which, microorganisms supported on inert materials are used to degrade organic pollutants for air, gas and water bioremediation.

Types of biofilters:

1- Bioscrubbers.

2- Biotrickling filters.

3- Slow sand or carbon filters.



Bioscrubber filters

Advantage of Bioremediation

1) It is a natural process

2) It is requires a very less effort and can often be carried out on site, often without causing a major disruption of normal activities.

3) It is less cost effective process than the other conventional methods

4) It is helps in complete destruction of the pollutants

5) It does not use any dangerous chemicals.

Disadvantage of Bioremediation

1) It is limited to those compounds that are biodegradable. Not all compounds are susceptible to rapid and complete degradation.

2) It is takes longer than other treatment options, such as excavation and removal of soil or incineration.

3) There are some concerns that the products of biodegradation may be more persistent or toxic than the parent compound.

4) Contaminants may be present as solids, liquids, and gases so are needed to develop and engineer bioremediation technologies that are appropriate for sites with complex mixtures of contaminants.