Bioremediation and its types

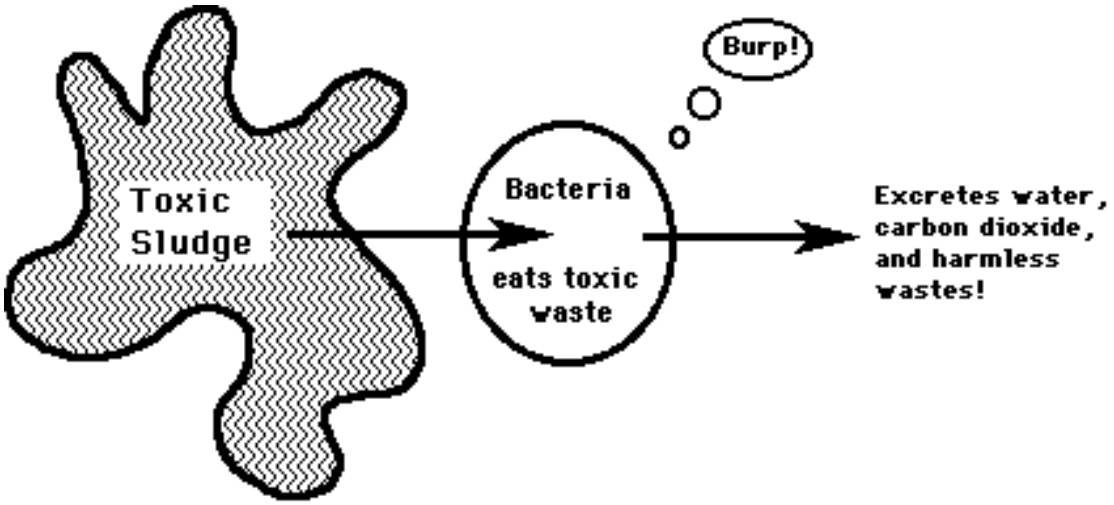
Bioremediation is a waste management technique that involves the use of living organisms to remove or neutralize environmental pollutants from a contaminated site. According to the United States EPA, bioremediation is a "treatment that uses naturally occurring organisms to break down hazardous substances into less toxic or nontoxic substances. Bioremediation may occur on its own (natural attenuation or intrinsic bioremediation) or may only effectively occur through the addition of fertilizers, oxygen, etc. that help in enhancing the growth of the pollution-eating microbes within the medium (**biostimulation**). Microorganisms used to perform the function of bioremediation are known as **bioremediators**.

Types of Bioremediation

1. **Microbial bioremediation**
2. **Phytoremediation**
3. **Mycoremediation**

1. Microbial bioremediation

Microbial bioremediation serves as an alternative and effective strategy to remove toxic contaminants from a polluted environment. It could be achieved through the interaction of microbes with the toxic contaminants, which leads to immobilization, compartmentalization, and concentration of pollutants rather than their degradation and elimination from the environment. Bioremediation of the contaminated sites employing indigenous microbes is highly advantageous as it is ideally adapted to the environmental conditions prevailing at the site to be remediated. Traditional culture-based approaches have provided only limited information on the metabolic potential and the functional activity of the indigenous microbial communities living in the contaminated environment. Recent development of metagenomic approaches and advancement of high-throughput DNA sequencing technology provides insight into the total microbial community and in-depth knowledge of the metabolic capabilities of the indigenous microbial community prevailing in contaminated sites. Metagenomic approaches could address environmental issues by exploring the phenomenal resources of the uncultivable microorganisms. The bacterium *Deinococcus radiodurans* (the most radioresistant organism known) has been modified to consume and digest toluene and ionic mercury from highly radioactive nuclear waste.



Factors Responsible for Microbial Bioremediation

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).

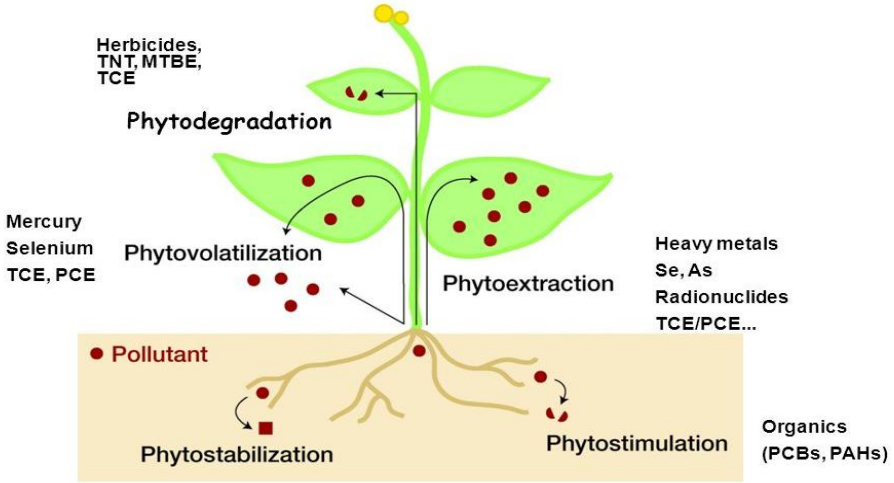
pH: Best range is from 6.5 to 7.5

2. Phytoremediation

Phytoremediation (‘phyto’ means plant) is a generic term for the group of technologies that use plants for remediating soils, sludges, sediments and water contaminated with organic and inorganic contaminants. Phytoremediation can be defined as “the efficient use of plants to remove, detoxify or immobilise environmental contaminants in a growth matrix (soil, water or sediments) through the natural biological, chemical or physical activities and processes of the plants”. Plants are unique organisms equipped with remarkable metabolic and absorption capabilities, as well as transport systems that can take up nutrients or contaminants selectively from the growth matrix, soil or water.

How it Control Pollution

There are several ways in which plants are used to clean up, or remediate, contaminated sites. To remove pollutants from soil, sediment and/or water, plants can break down, or degrade, organic pollutants or contain and stabilize metal contaminants by acting as filters or traps. The uptake of contaminants in plants occurs primarily through the root system, in which the principal mechanisms for preventing contaminant toxicity are found. The root system provides an enormous surface area that absorbs and accumulates the water and nutrients essential for growth, as well as other non-essential contaminants. Researchers are finding that the use of trees (rather than smaller plants) is effective in treating deeper contamination because tree roots penetrate more deeply into the ground. In addition, deep-lying contaminated ground water can be treated by pumping the water out of the ground and using plants to treat the contamination.
Plant roots also cause changes at the soil-root interface as they release inorganic and organic compounds (root exudates) in the rhizosphere. These root exudates affect the number and activity of the microorganisms, the aggregation and stability of the soil particles around the root, and the availability of the contaminants. Root exudates, by themselves can increase (mobilize) or decrease (immobilize) directly or indirectly the availability of the contaminants in the root zone (rhizosphere) of the plant through changes in soil characteristics, release of organic substances, changes in chemical composition, and/or increase in plant-assisted microbial activity.
Phytoremediation is an alternative or complimentary technology that can be used along with or, in some cases in place of mechanical conventional clean-up technologies that often require high capital inputs and are labour and energy intensive. Phytoremediation is an in situ remediation technology that utilizes the inherent abilities of living plants. It is also an ecologically friendly, solar-energy driven clean-up technology, based on the concept of using nature to cleanse nature.



3. Mycoremediation

Mycoremediation is a form of bioremediation in which fungi are used to decontaminate the area.

How it control pollutants

One of the primary roles of fungi in the ecosystem is decomposition, which is performed by the mycelium. The mycelium secretes extracellular enzymes and acids that break down lignin and cellulose, the two main building blocks of plant fiber. These are organic compounds composed of long chains of carbon and hydrogen, structurally similar to many organic pollutants. The key to mycoremediation is determining the right fungal species to target a specific pollutant. Certain strains have been reported to successfully degrade the nerve gases.

In one conducted experiment, a plot of soil contaminated with diesel oil was inoculated with mycelia of oyster mushrooms; traditional bioremediation techniques (bacteria) were used on control plots. After four weeks, more than 95% of many of the PAH (polycyclic aromatic hydrocarbons) had been reduced to non-toxic components in the mycelial-inoculated plots. It appears that the natural microbial community participates with the fungi to break down contaminants, eventually into carbon dioxide and water. Wood-degrading fungi are particularly effective in breaking down aromatic pollutants (toxic components of petroleum), as well as chlorinated compounds. Two species of the Ecuadorian fungus Pestalotiopsis are capable of consuming Polyurethane in aerobic and anaerobic conditions such as found at the bottom of landfills.