

Bioremediation

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Introduction

- Bioremediation is a biological process by which environmental pollutants are eliminated or converted to less toxic (or even useful) substances.
- It is a technology employing living organisms for removal of pollutants from the environment.

Primary targets of bioremediation

- 1 Pesticides (especially halocarbons s.a. DDT, 2,4-D).
- 2 Recalcitrant nitroaromatic compounds (*e.g.* explosives s.a. TNT)
- 3 Polychlorinated biphenyls (PCBs) and Dioxins
- 4 Petroleum hydrocarbons (Contaminated storage areas or oil spills).
- 5 Heavy metals and radionuclides

Degradation of pollutants in the environment

- Oxidation (reaction with atmospheric O_2)
- Hydrolysis (reaction with H_2O)
- Photodegradation (by sunlight, particularly UV radiation)
- Biodegradation, especially by bacteria, fungi *etc.*
- Bioaccumulation of heavy metals and radionuclides by plants and microorganisms.

Degradation of pollutants is fastest on the soil surface due to presence of all the above factors.

Microbial degradation is the major factor involved in breakdown of xenobiotics in soil.

Biodegradation vs mineralization

Biodegradation encompasses both the complete oxidation of a compound to inorganic forms such as CO_2 , NO_3^- etc. as well as transformations that yield more complex products from the starting compound.

Mineralization refers only to the complete degradation of an organic compound to inorganic products.

Mechanisms of xenobiotic biodegradation

- 1 Utilization of xenobiotic compounds as a substrates for growth and energy.
- 2 Biotransformation of xenobiotic compounds by co-metabolism.

Bioremediation is the most effective method for decontamination of soil from such xenobiotics.

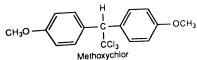
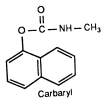
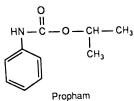
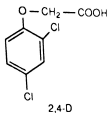
Factors affecting bioremediation

Biodegradation is a naturally occurring process, and is affected by the following factors:

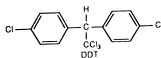
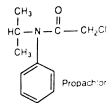
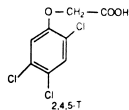
- Biochemistry - Presence of metabolic pathways capable of converting the pesticide to less toxic products.
- Bioavailability - Accessibility of contaminant to microorganisms.
- Bioactivity - Opportunity for optimization of biological activity.

Factors affecting bioremediation

Biodegradable



Recalcitrant



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Bioremediation Strategies

in situ treatment

- Biostimulation : Provide extra nutrients to the native microbial community, allowing it to proliferate and metabolize or co-metabolize the pollutant.
- Bioaugmentation : Addition of specialized pollutant degrading microbes to the environment to help in faster biodegradation of pollutant.

Only option for bioremediation in aquatic ecosystems.

Bioremediation Strategies

ex situ treatment

- Composting : Contaminated material is transported to open areas, mixed with biodegradable wastes and composted.
- Land farming : Contaminated soils are mixed with nutrients and tilled into uncontaminated soil.
- Above ground reactor systems : Solid state or slurry systems. Expensive but easier to control parameters such as temperature and pH. Allow for more exotic microorganisms to be used.