

# Soil Bioremediation: An Introduction

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**PASSION FOR CHEMISTRY**

# Definition

- Soil bioremediation is a process that uses naturally occurring organisms to break down or remove hazardous substances in soil. These organisms can be bacteria, plants or fungi.

# Types of Pollutants

- Naturally Organic pollutants → catabolized to CO<sub>2</sub>
- Xenobiotics - substances foreign to an entire biological system, i.e. artificial substances, which did not exist in nature before their synthesis by humans. Ex. Chlorinated solvents
- Heavy Metals from ore extraction and manufacturing

# Mechanism of Action of Bacterial Bioremediation

- Aerobic metabolism
  - Microbes use  $O_2$  as electron acceptor in their metabolism to degrade contaminants
- Anaerobic metabolism
  - Microbes substitute another chemical for  $O_2$  to degrade contaminants
    - Nitrate, iron, sulfate, carbon dioxide, uranium, technetium, perchlorate
- Anaerobic degradation is much slower (up to x 365)

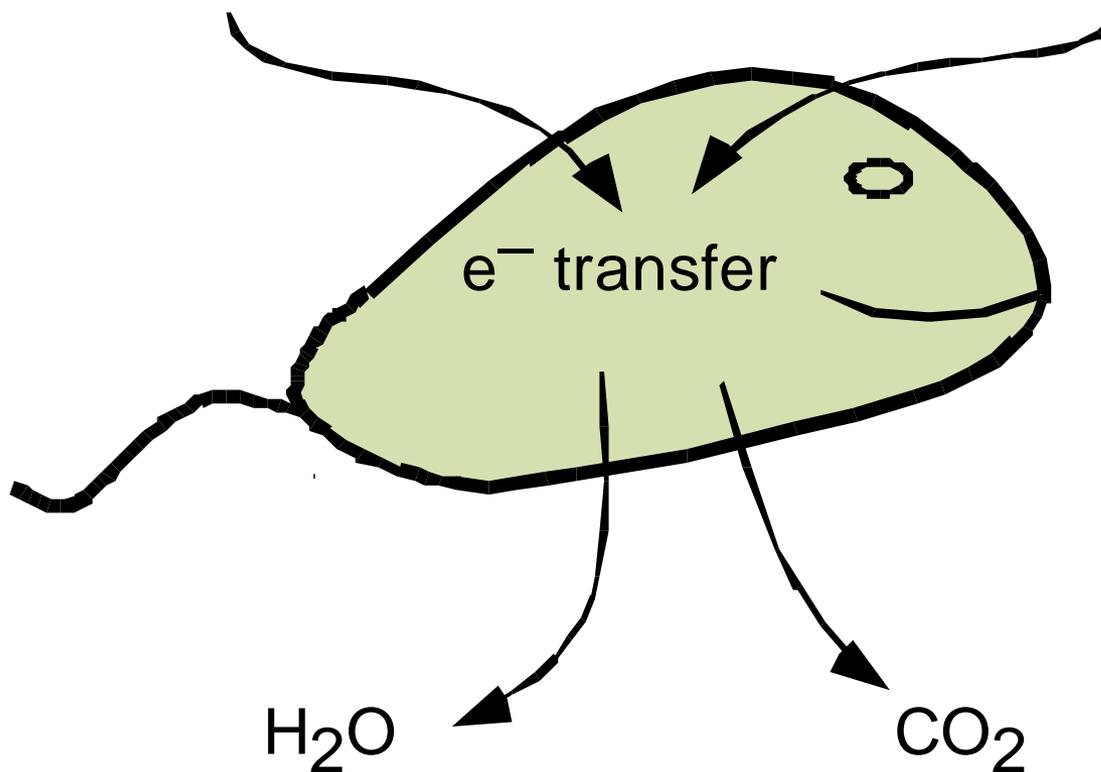
# Required Conditions

- Electron acceptor for the ReDox reaction
- pH
- Nutrients (N, P, K)
- Carbon source (electron donor and carbon source for cell building)
- Temperature
- Moisture

# Schematic

Electron Acceptor  
( $O_2$ ,  $NO_3^-$ ,  $SO_4^{2-}$ , etc.)

Carbon/Energy Source  
Electron Donor



# Biostimulation

- Biostimulation is the process by which the missing ingredient for biological breakdown or take up is added: for example, soil aeration adds  $O_2$ , adding N or P if the soil is poor in these elements or simply adding water if the soil is dry.

# InSitu or ExSitu

- Bioremediation can be performed InSitu which means in the contaminated site itself or the soil can be excavated, shipped offsite and the bioremediation performed ExSitu.

# InSitu

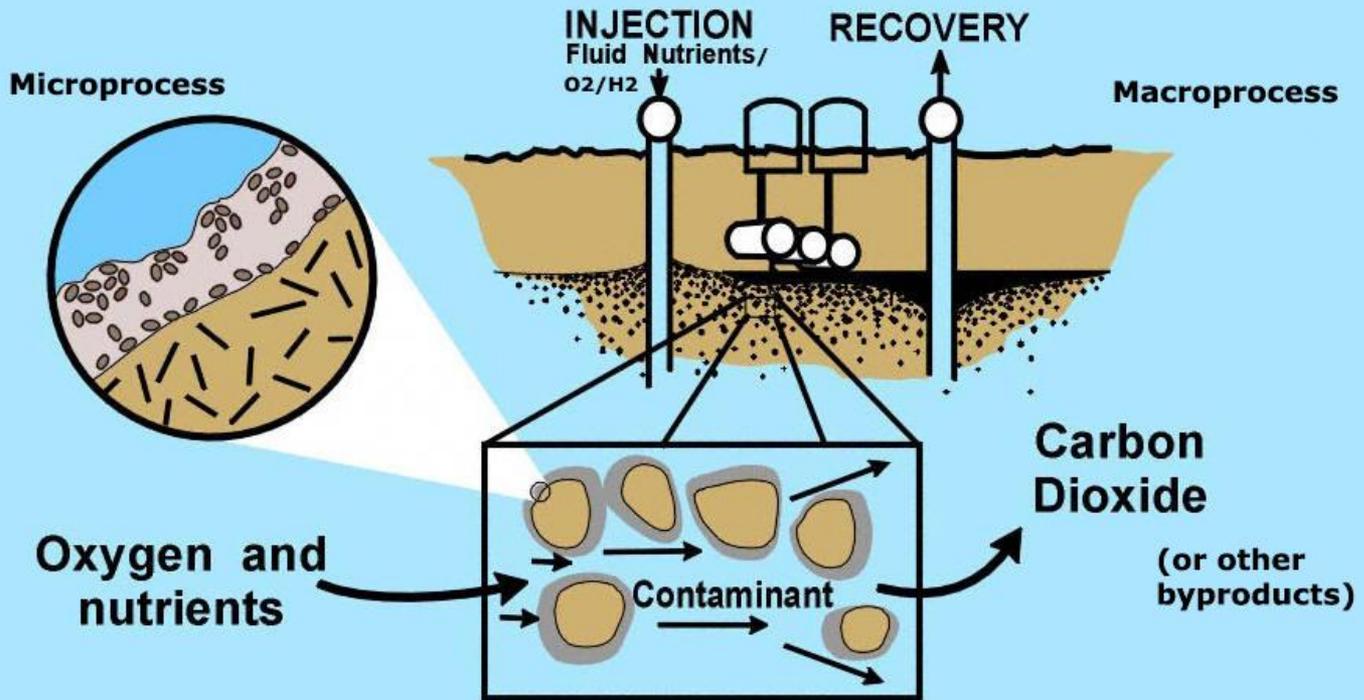
- *In situ* bioremediation refers to treatment of soil in place. *In situ biostimulation* treatments usually involve bioventing, in which oxygen and/or nutrients are pumped through injection wells into the soil. It is imperative that oxygen and nutrients are distributed evenly throughout the contaminated soil. Soil texture directly affects the utility of bioventing, in as much as permeability of soil to air and water is a function of soil texture. Fine-textured soils like clays have low permeability, which prevents biovented oxygen and nutrients from dispersing throughout the soil.

# ExSitu

- ***Ex situ*** bioremediation approaches include use of bioreactors, land farming, and biopiles. In the use of a bioreactor, contaminated soil is mixed with water and nutrients and the mixture is agitated by a mechanical bioreactor to stimulate action of microorganisms. This method is better-suited to clay soils that do not lend themselves to InSitu Bioventing.

# Technology

## Bioremediation



# Phytoremediation

- **Phytoremediation** is the direct use of living green plants/trees for in situ, or in place, removal, degradation, or containment of contaminants in soils, sludges, sediments. It is a low cost, solar energy driven cleanup technique.

# Best Plants for Phytoremediation

- Indian mustard (*Brassica juncea* L.)
- Willow (*Salix* species). (White Willow)
- Poplar tree (*Populus deltoides*).
- Indian grass (*Sorghastrum nutans*)
- Sunflower (*Helianthus Annuus* L.)

These plants can remove heavy metals, chlorinated solvents, and pesticides.

# Mycoremediation

- **Mycoremediation** is a form of bioremediation in which fungi are used to decontaminate the area. One of the primary roles of fungi in the ecosystem is decomposition (basically breakdown of cellulose), which is performed by the mycelium (the mass of branched, tubular filaments of fungi).

# Mycoremediation

- White rot fungus is known to degrade polyaromatic hydrocarbons (PAHs)



# Further Reading

- State of Mississippi. Department of Environmental Quality. *Fundamental Principles of Bioremediation*. April 1998. 27 Nov 2006
- United States. Environmental Protection Agency. 2006. *A Citizen's Guide to Bioremediation*. April 1996. 24 Nov 2006
- Microbes and their biodegradation pathways:  
<http://umbbd.ethz.ch/servlets/pageservlet?ptype=allmicros>