BIOREMEDIATION

"use of living organisms (e.g., bacteria) to clean up oil spills or remove other pollutants from soil, water, and wastewater.“

“clean-up of pollution from soil, groundwater, surface water and air, using biological, usually microbiological processes”
Philp et al., 2001

- Using subsurface microorganisms to transform hazardous contaminants into relatively harmless byproducts, such as ethene and water
  - Biodegrade
  - Mineralize
  - Bio-transform
- Techniques or types of bioremediation:
  - A component of Natural Attenuation
  - Enhanced Bioremediation
  - Bioaugmentation

- Natural Attenuation is **Not fast enough, Not complete enough, Not frequently occurring enough** to be broadly used for some compounds, especially chlorinated solvents
- The current trend is to stimulate/enhance a site's indigenous subsurface microorganisms by the addition of nutrients and electron donor
- In some cases, bioaugmentation is necessary when metabolic capabilities are not naturally present.

A complex process depending on many factors including:

ambient environmental conditions

composition of the microbial community

nature and amount of pollution present

What Makes Bioremediation a Promising Approach?

- permanence
  - contaminant is degraded
- potentially low cost
  - 60-90% less than other technologies
- No additional disposal costs
- Low maintenance
- Does not create an eyesore
- Capable of impacting source zones and thus, decreasing site clean-up time

Ambient environmental conditions

pH

temperature

Lack of nutrients & molecular oxygen

Types of pollutants

Types of pollutants

Organic pollutants → catabolized
Naturally occurring

Xenobiotics - substances foreign to an entire biological system, i.e. artificial substances, which did not exist in nature before their synthesis by humans

Metals from ore extraction and manufacturing

Contaminants Potentially Amenable to Bioremediation

Readily degradable	Somewhat degradable	Difficult to degrade	Generally recalcitrant
fuel oils, gasoline	creosote, coal tars	chlorinated solvents (TCE)	dioxins
ketones and alcohols	pentachloro-phenol (PCP)	some pesticides and herbicides	polychlorinated biphenyls (PCB)
monocyclic aromatics			
bicyclic aromatics (naphthalene)			

Different Biological Solutions

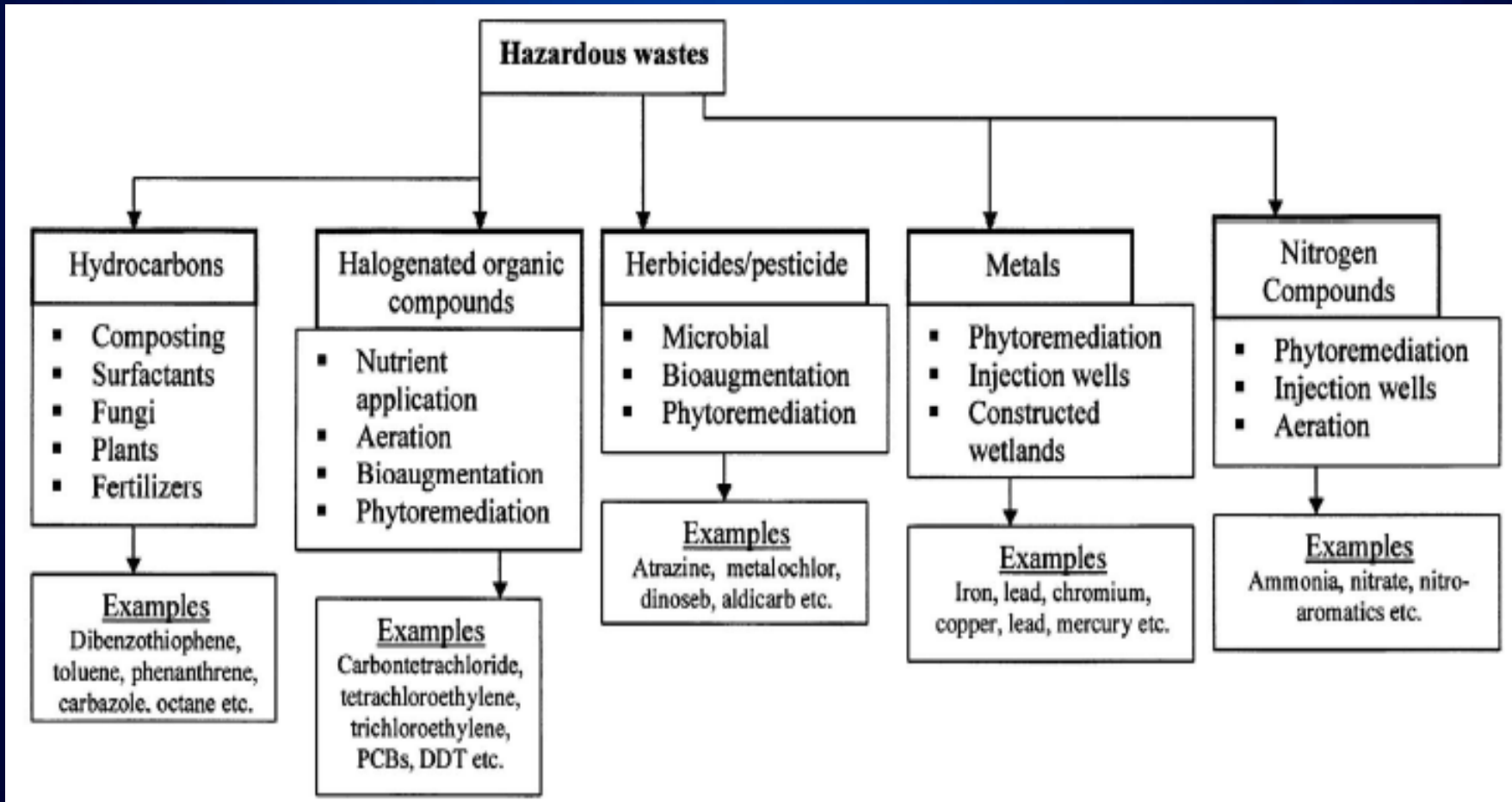
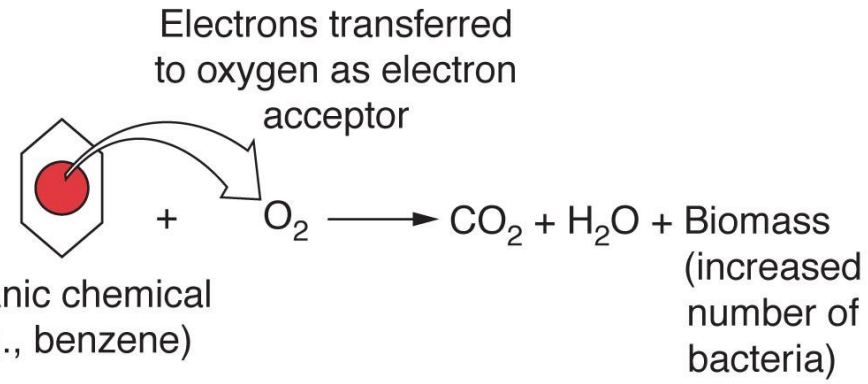
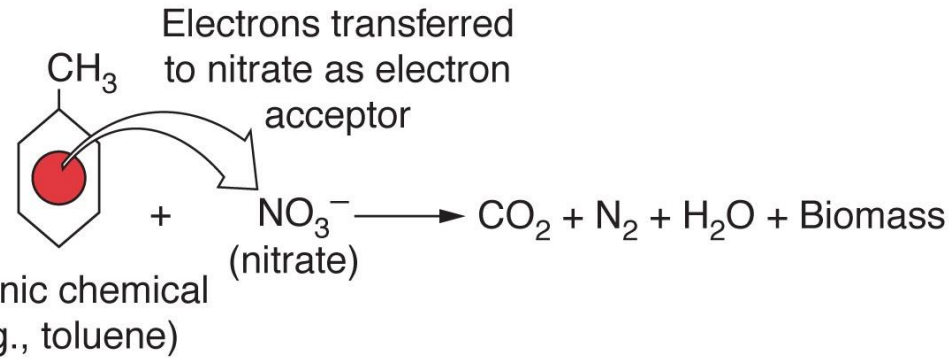


Fig. 1. Summary of different bioremediation strategies for typical hazardous wastes

Aerobic biodegradation



Anaerobic biodegradation



Bioremediation Research

Bioaugmentation vs. biostimulation:

Biostimulation involves the modification of the environment to stimulate existing microorganisms capable of bioremediation.

Indigenous populations may not be capable of degrading the xenobiotics or the wide range of potential substrates present in complex pollutant mixtures.

Bioaugmentation is the introduction of a group of natural microbial strains or a genetically engineered variant to treat contaminated soil or water.

Biotic Transformations

- Result of metabolic activity of microbes
- Aerobic and anaerobic biodegradation
- Reduces aqueous concentrations of contaminant
- Reduction of contaminant mass
- Most significant process resulting in reduction of contaminant mass in a system

Bioremediation Processes

- Conversion of contaminants to mineralized (e.g. CO_2, H_2O, and salts) end-products via biological mechanisms
- Biotransformation refers to a biological process where the end-products are not minerals (e.g., transforming TCE to DCE)
- Biodegradation involves the process of extracting energy from organic chemicals via oxidation of the organic chemicals

Bioremediation Practice

- Understand physical and chemical characteristics of the contaminants of interest
- Understand the possible catabolic pathways of metabolism and the organisms that possess that capability
- Understand the environmental conditions required to:
  - Promote growth of desirable organisms
  - Provide for the expression of needed organisms
- Engineer the environmental conditions needed to establish favorable conditions and contact organisms and contaminants