

PHYTOREMEDIATION

- I. Introduction
 - A. Definition of the Problem: Toxic wastes in the form of poisonous organics and pathogens, heavy metals, radioisotopes, and even explosives found in soils impose a serious threat to human health and disrupt existing ecosystems.
 - B. Proposed Solution(s)
 - 1. Remediation through removal (and/or relocation), neutralization, or dilution of toxic substances using industrial or biological systems
 - a) Industrial collection/extraction/neutralization - EXPENSIVE
 - b) Bioremediation - LESS EXPENSIVE
 - 1) Use of bacteria and other microbes
 - 2) Use of fungi
 - 3) Use of plants - PHYTOREMEDIATION
 - C. Definition of Phytoremediation: The use of plants to remediate contamination of soil with organic or inorganic wastes
- II. Sources of Toxic Waste(s)
 - A. Sewage sludge from human, cattle, swine or other waste (pathogens, heavy metals)
 - B. Toxic dump from industrial sites (poisonous organics, heavy metals, radioisotopes, explosives)
 - C. Garbage processing (poisonous organics and pathogens, heavy metals, radioisotopes, you name it!)
- III. Types of Toxic Waste(s)
 - A. Pathogens: Animal diseases that persist in the soil
 - B. Poisonous organics: Herbicides and insecticides
 - C. Heavy metals: Cadmium, chromium, copper, lead, manganese, nickel, tin
 - D. Radioisotopes: Uranium
 - E. Explosives: TNT
- IV. Types of Organisms used in Bioremediation
 - A. Bacteria: *Arthrobacter sp.*, *Flavobacterium sp.*, *Pseudomonas cepacia* (for poisonous organics); *Thiobacillus ferrooxidans* (for recovery of uranium by leaching); *Acinetobacter*, *Bacillus*, *Bradyrhizobium*, *Flavobacterium*, *Mycobacterium* (for heavy metal accumulation)
 - B. Fungi: *Hebeloma cylindrosporium*, *Penicillium asperum*, *Rhizopus stolonifer*, *Suillus bellini*, *Trichoderma viride* (for poisonous organics)
 - C. Plants: Barley (*Hordeum vulgare*), Corn (*Zea mays*), Perennial Ryegrass (*Lolium perenne*), Swiss chard (*Beta vulgaris*), Wheat (*Triticum aestivum*) - for heavy metals and other(s)
- V. Types of Phytoremediation
 - A. Phytodecontamination (removes the contaminant from the soil)
 - 1. Phytoextraction: Absorption of the contaminant into the plant tissue and subsequent harvesting for destruction.
 - 2. Phytovolatilization: Plants and their associated microbial activity help to increase the rate of volatilization of a contaminant from the soil. The volatilization occurs from plant shoots or roots, as well as from the soil surface.
 - 3. Phytodegradation: Plants take up the contaminant and metabolize it to an environmentally benign material.
 - 4. Rhizo(sphere)degradation: Plant roots, their associated microflora and/or excreted products destroy the contaminant in the root zone.
 - B. Phytostabilization (sequesters the contaminant into the matrix)
 - 1. Humification: Incorporation of the contaminant into soil humus resulting in lower bioavailability.
 - 2. Lignification: Toxic components become irreversibly trapped in the plant cell wall constituents.
 - 3. Irreversible binding (soil sequestration): Compounds become increasingly unavailable due to binding in the soil.
- VI. Example of Phytoremediation: Mei-Chen Sung's Literature Thesis: "Plant Bioremediation of Heavy Metal-Contaminated Soil as a Treatment of Sewage Sludge."