Chapter 10

Bioremediation

Bioremediation, biodegradation and environmental sustainability

- Hanahan Bioremediation Project
- In 1975, a massive leak from a military fuel storage facility released about 80,000 gallons of kerosine-based jet fuel
- In 1992, this theory was put into practice by USGS scientists
- By the end of 1993, contamination in the residential area had been reduced by 75%

Bioremediation

- The use of microorganismmetabolism to remove pollutants
- Bioremediation can be defined as any process that uses microorganisms or their enzymes to return the environment altered by contaminants to its original condition or into less toxic substance

- The *Deinococcus radiodurans* has been modified to consume and digest toluene and ionic mercury from highly radioactive nuclear waste
- 2 Classification of bioremediation:
  - *In situ* bioremediation involves treating the contaminated material at the site
  - E*x situ* involves the removal of the contaminated material to be treated elsewhere

Organism involved

- Gluttonous microbes
- These naturally occurring microbes are placed within the contaminated site in which they immediately begin to start breaking down the organic contaminant
- The most vital factors that control the effectiveness of bioremediation are the permeability of the soil and the biodegradability of the organic compound

Advantages

- Cost effective where can be employed in areas that are inaccessible without excavation
  - For example, hydrocarbon spills (specifically, petrol spills) or certain chlorinated solvents may contaminate groundwater
  - Therefore introducing the appropriate electron acceptor or electron donor amendment, as appropriate, may significantly reduce contaminant concentration after a long time allowing for acclimation

- Less expensive than excavation followed by disposal elsewhere, incineration or other *ex situ* treatment strategies
- Less expensive than other technologies, and can be used where the problem is located
- Reduces or eliminates the need for "pump and treat", a practice common at sites where hydrocarbons have contaminated clean groundwater

- However, the disadvantages of bioremediation include the fact that little is still known concerning specifics on its effects in areas having multiple contaminations
- It often takes longer than other treatment methods, and that it requires constant monitoring to ensure effectiveness

Where to Use?

- Oil spills, gasoline contaminations, chlorinated solvents and other toxic chemical leaks
- Gasoline contamination in Galloway, New Jersey, the crude oil spill in Bemidji, Minnesota, the fuel leak in Hanahan, South Carolina, and the sewage effluent in Cape Cod, Massachusetts

Wastewater and ground water treatment

- Remove human sewage or clean uo ground water
- Household waste (detergents, soaps, paper waste)
- Microbe: *Brocadia anammoxidans* : degrade ammonium
- Clogged septic tanks : Rid-X
  - Freeze dried bacterial: rich in enzymes

Mycoremediation

- A form of bioremediation in which fungi are used to decontaminate the area
- The mycelium secretes extracellular enzymes and acid that break down lignin and cellulose, the two main building blocks of plant fiber
- The key to mycoremediation is determining the right fungal species to target a specific pollutant

Oil-eating bacteria

- . The *Deepwater Horizon* oil spill (also referred to as the BP spill, the Gulf of Mexico oil spill, the BP oil disaster or the Macondo blowout)
- *Alcanivorax borkumensis* is a rod-shaped bacteria that relies on oil to provide it with energy

Biosensor

- GM bacteria: *Pseudomonas flurescens*
- Effectively degrade complex structure polycyclic aromatic hydrocarbons
- Bacteria release light (fluorescent) for use to monitor biodegradable process

GMP and Phytoremediation

- Plant remove chemicals from military explosives contaminants
- RDX, TNT : pose threat to health
- Convert TNT to less toxic compound: Transgenic tobacco have nitro reductase gene
- RDX-degrading enzyme in GMP. Extract from *Rhodococcus rhodochorus*

Bioaccumulation

- Mercury and related compound can accumulate in organism
- Include all heavy metals : copper, lead, cadmium, cromium and mercury
- Serious health defects if consume food contaminated with heavy metals for long periods
- Use protein to bind heavy metals such as metallothioenins and phylochelatins

Future Strategies

- Potential of recovering valuable metals such as copper, nickel,boron and gold
- Marine bacteria: Potential for precipitation precious metals
- Bacteria: potential microbe to recover hazardous metals
- Bioremediation of radioactive waste
  - Remove radioactive wastes

- DOE,USA: identify over 100 sites in 30 states : contaminated with weapons production and nuclear reactor
- *Geobacter* : reduce uranium solubility
- But not yet completely metabolize radioactive elements into harmless products
- *Deinococcus radiodurans*: Can endure high doses of radioactive: may use novel DNA repair mchanism