Phytoremediation of Organic and Inorganic Contaminants

Urban Forestry Commission Meeting
6/11/2014

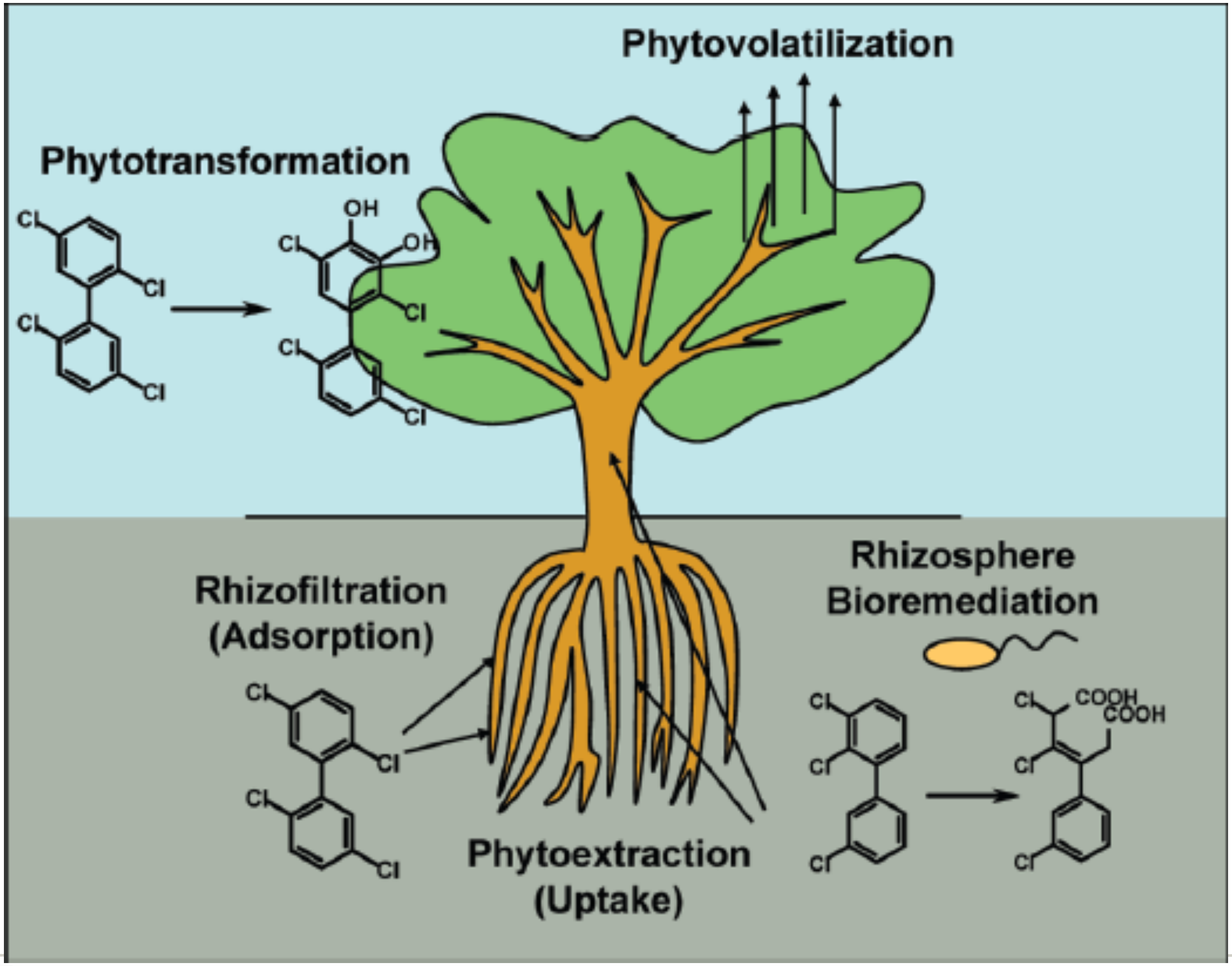
Outline

- Phytoremediation
- Research Focus
- Broader Applications

Phytoremediation

- Definition
- Benefits to bacteria
  - Root exudates:
    - Decrease competition
    - Co-substrates for oxidation/degradation
    - Compounds that modify pollutant mobility

Phytoremediation



Phytoremediation - Advantages

- Environmental impact
- Cost
- Effectiveness
- Contamination type
- Monitoring
- Erosion control
- Carbon sequestration

Phytoremediation - Challenges

- Acceptability
- Knowledge
- Phytotoxicity
- Efficiency

Gas Works Park Research

- Background
  - Gas production from 1905-1956
  - Residual contamination under soil cap
  - Polycyclic Aromatic Hydrocarbons (PAHs)
  - Prior remediation

- Endophyte-assisted phytoremediation of PAHs

Endophyte-Assisted Phytoremediation

- Endophyte = microbe that lives within a plant without causing apparent disease
- Plant-endophyte partnerships → increased remediation, protective effects on plants
- Applications to Gas Works Park

Endophyte-Assisted Phytoremediation of PAHs

- Willow
  - 3 PAHs: naphthalene, phenanthrene, pyrene
- Willow + endophytes
  - PD1 (*Pseudomonas putida*)
    - Isolated from *Populus deltoides*
  - Degradation of phenanthrene, decreased phytotoxicity
- Grass + PD1

Social Component

- Important in public spaces

- Landscape preference
  - Values
  - Study site

Applications to Other Contaminants

- Organic
  - PCBs
  - DDT
  - Dieldrin
- Inorganic
  - Arsenic
  - Lead

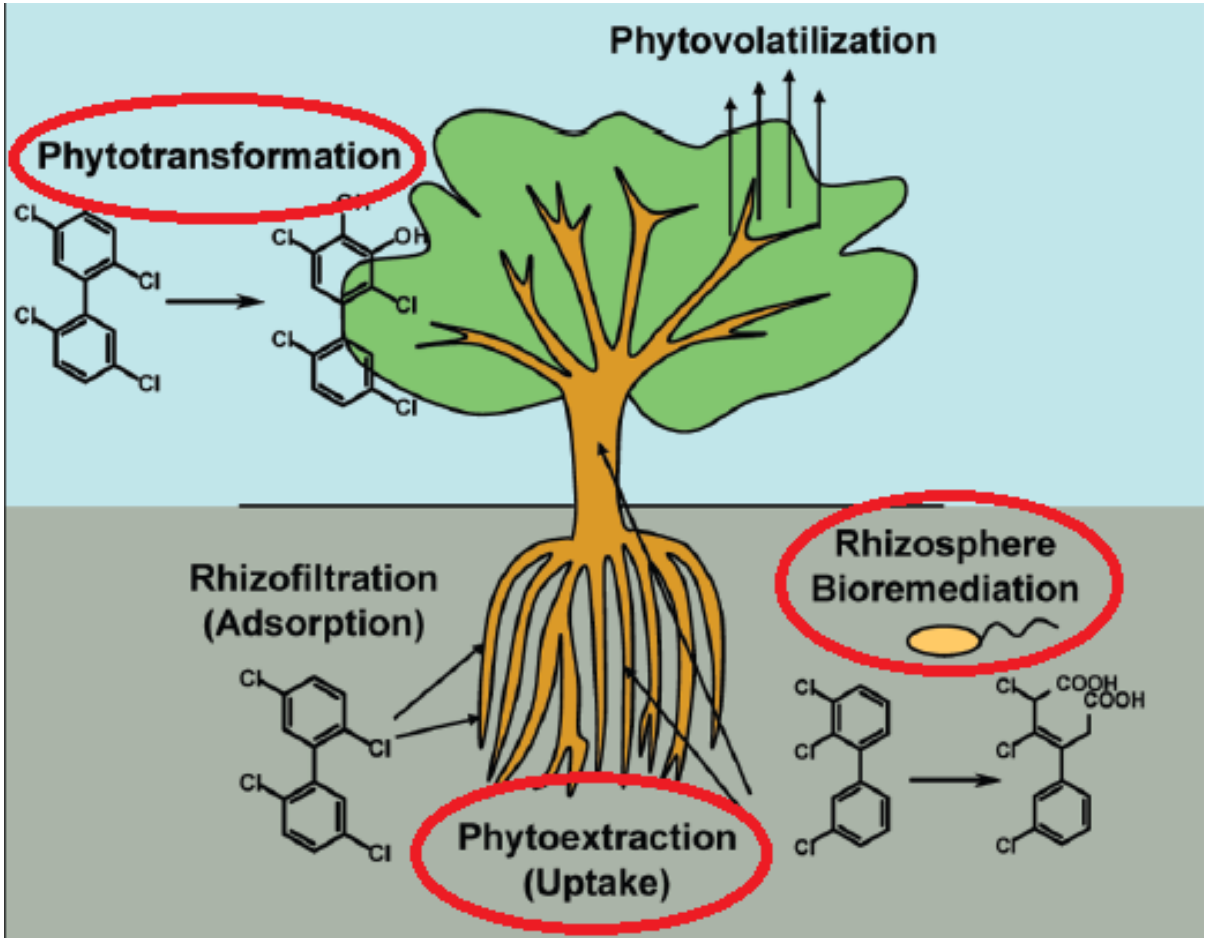
Organic Contaminants

- Bioremediation
  - Plants improve bioremediation
    - Root exudates
  - Plant-microorganism cooperation can be stronger and more effective
- Soil-plant transfer, phytoextraction, phytodegradation, rhizodegradation, rhizofiltration

PCB Remediation Research

- Legumes and grasses (Chekol et al., 2004)
  - 3 legumes, 4 grass species
  - >60% of PCBs removed from all planted soil
- Rice, alfalfa, ryegrass, tall fescue (Shen et al., 2009)
  - PCB degradation in all planted conditions
- Squash, legumes, grasses, sedge (Zeeb et al., 2006)
  - PCB removal
  - Phytoextraction

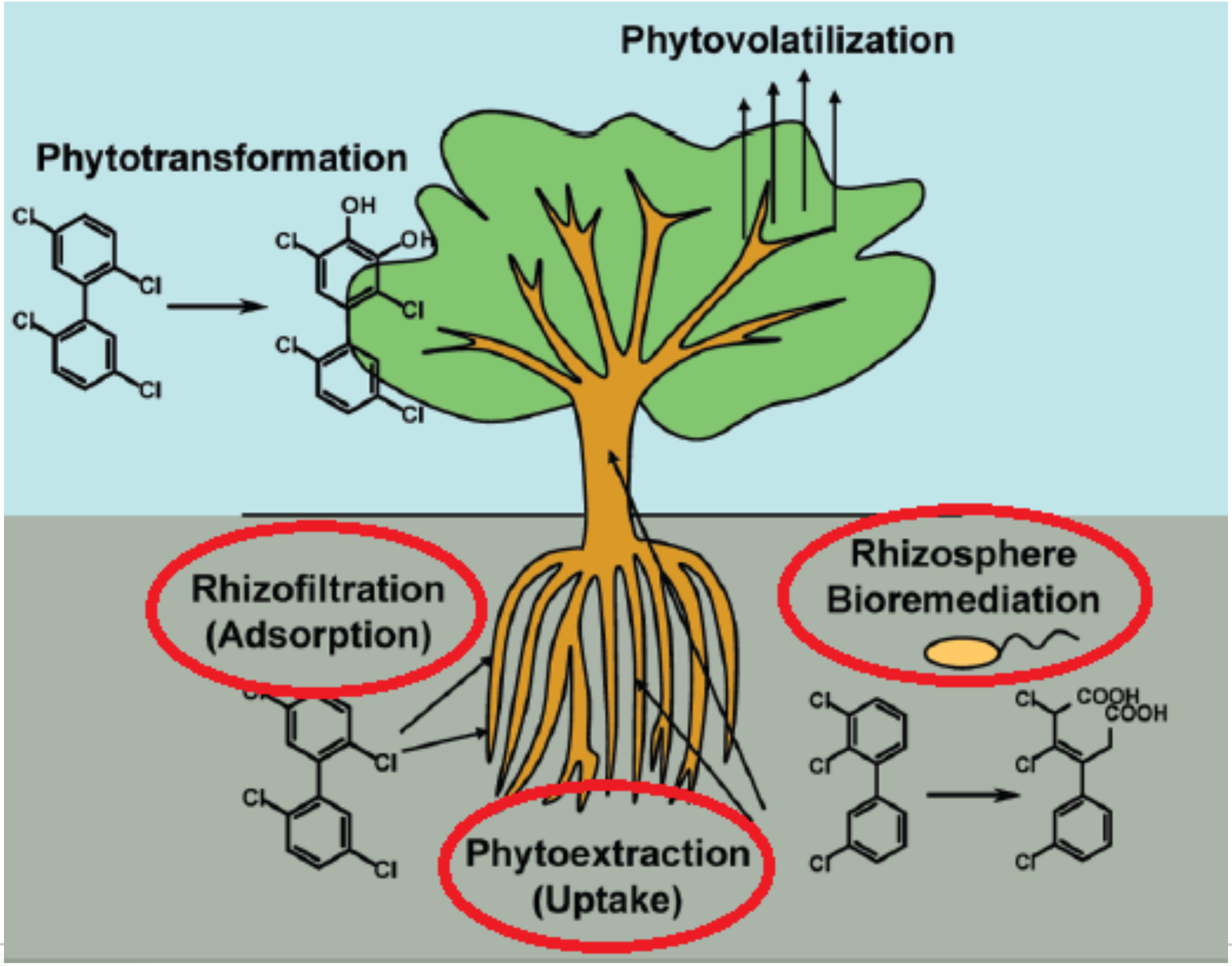
Phytoremediation of PCBs



DDT Remediation Research

- Wild plants (Nurzhanova et al., 2011)
  - All able to degrade DDT
  - Squash especially effective (73% removal)
- Zucchini, pumpkin (White, 2001)
  - Significant decreases in soil concentration
- Zucchini, pumpkin, tall fescue, ryegrass, alfalfa (Lunney et al., 2004)
  - Accumulation in roots and shoots
  - Removal from soil

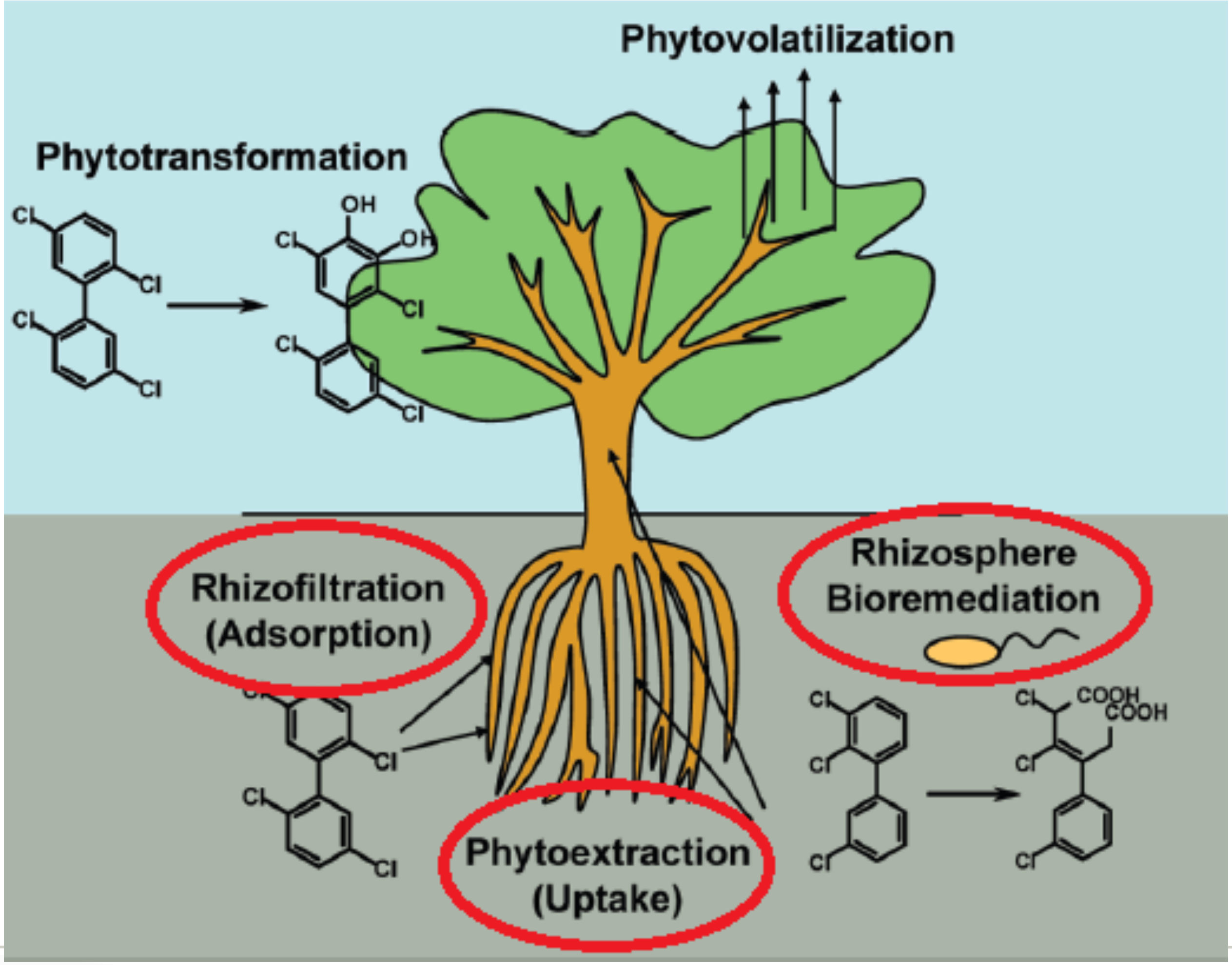
Phytoremediation of DDT



Dieldrin Remediation Research

- Poplar trees (Skaates et al., 2005)
  - Remediation successful
  - Adsorption of 66% of contaminant
- *Curcubita* sp (Otani et al., 2007)
  - Removal from soil
  - All had high uptake of dieldrin, zucchini highest
- Fungus (Takagi et al., 2011)
  - Dieldrin-degrading soil fungus
  - 95.8% degradation by strain DDF

Dieldrin Phytoremediation



Inorganic Contaminants

- Metals – arsenic, lead
- Phytoextraction/hyperaccumulation
- Phytomining
- Disposal

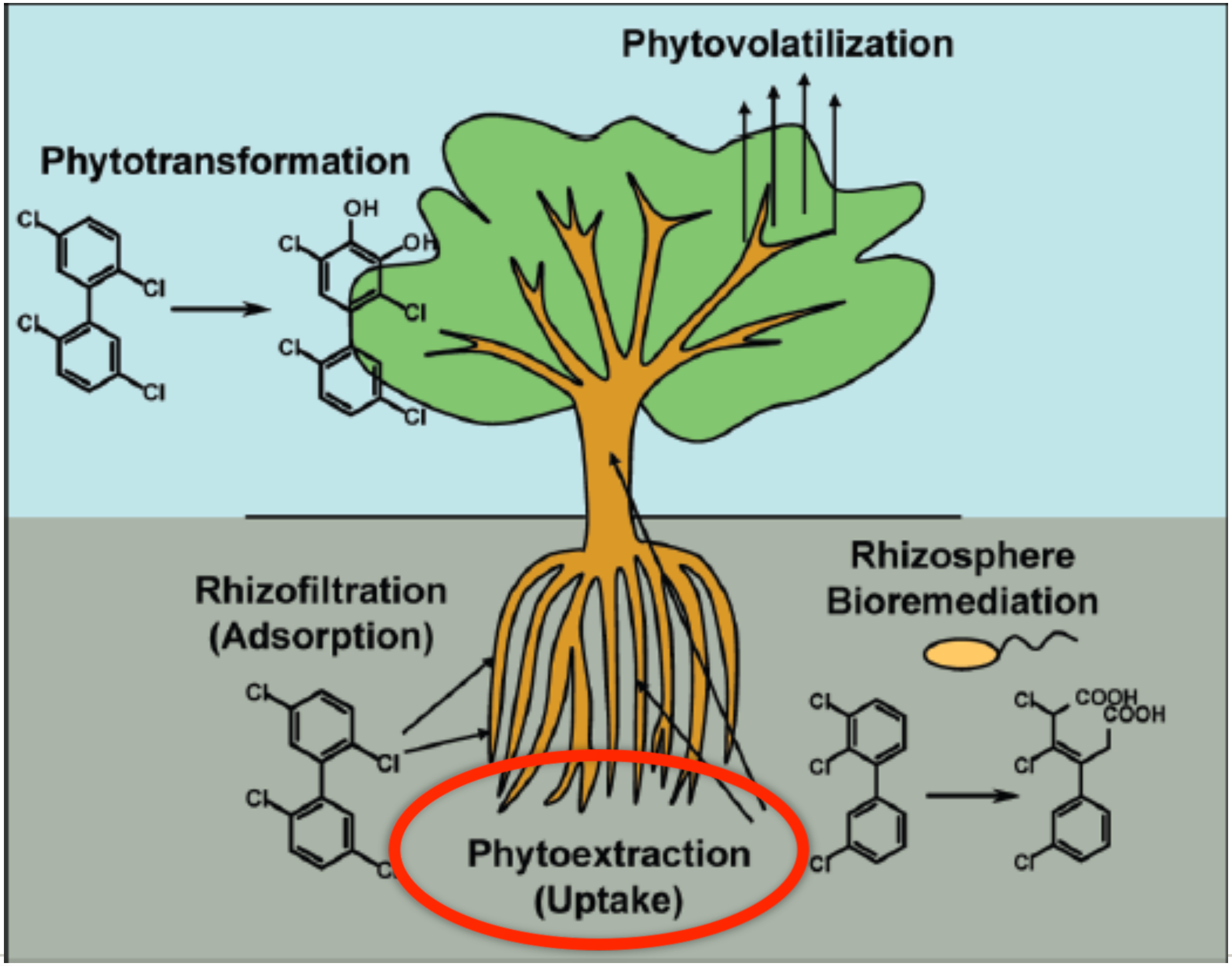
Lead Remediation Research

- 9 food crops (Sekara et al., 2005)
  - Beet and parsnip had highest concentration
- *Salix acmophylla* (Ali et al., 2003)
  - Effective accumulator of lead, nickel, and copper
  - High tolerance
  - Phytoremediation, site monitoring
- Indian mustard (Lim et al., 2004)
  - Electric field stimulation + chelating agent

Arsenic Remediation Research

- Wild plants (Visoottiviseth et al., 2002)
  - Two fern species, an herb, a shrub
  - Ferns by far most effective
- Chinese Brake Fern (Ma et al., 2001)
  - Hyperaccumulates to extremely high concentrations
- Range of species limited by climate
  - Alternatives?

Phytoremediation of Inorganics



Potential for Wider Application

- Likely that many plants are capable of degrading organic contaminants such as PCBs and DDT
- Look for capability in plants that are already thriving on contaminated soil
- Use microbes that evolved in contaminated soil, add those to plants suited to environment