Phytoremediation of Recalcitrant Pesticides
Topics

• Problem Statement
• Physical Constraints Imposed by Organochlorine pesticides
• Limitations of Engineered Systems
  – Case Studies
• Goal of Phytoremediation
• Phytoremedation Mechanisms
• Specific Experience at Twin Sites
  – Description of Site Activity
  – Performance Measurements
    • Water Balance Measurements
    • Contaminant Concentration Trends
• Conclusions
Problem Statement

Transport Processes that Created the Problem Cannot be Reversed
Physical Constraints Imposed by Organochlorine pesticides

- Subject to facilitated transport from solvents
- Tightly partitioned to soil
Physical Constraints Imposed by Organochlorine pesticides

- Subject to facilitated transport from solvents
- Tightly partitioned to soil
- Subject to colloidal transport
Physical Constraints Imposed by Organochlorine Pesticides

- Subject to facilitated transport from solvents
- Tightly partitioned to soil
- Subject to colloidal transport
- Very low concentrations are considered problematic

[Bar chart showing regulatory standards for tap water, with concentrations in ppb: Xylenes at 10,000 ppb, TCE at 5 ppb, Dieldrin at 0.03 ppb, Gamma BHC at 0.05 ppb, DDT at 0.2 ppb, Toxaphene at 0.06 ppb.]
Limitations of Engineered Systems

Three Classes of Engineered Systems Examined

• Hydraulic Control – Traditional Pump & Treat

• Barriers – Physical & Hydraulic Control
  • Reinjection – Well or Drain

• Enhanced Natural Process
  • In-situ treatment
Hydraulic Control – Traditional Pump & Treat

Case Study

- Pumping rates range from 190 to 250 cubic meters per day
- Avg Dieldrin concentrations in 2004 are indistinguishable from concentrations nine years earlier
- Variability in concentrations has increased
Barriers – Physical & Hydraulic Control

Case Study Rocky Mountain Arsenal

• Northern Boundary Containment System (NBCS) operational in 1982

• Northwest Boundary Containment System (NWBCS) operational in 1984

• Slurry barrier walls with extraction wells upgradient of the wall and recharge wells downgradient

• Between 1988 and 1990 NBCS system expanded with recharge trenches between the barrier wall and recharge wells
• **Upgradient** - negative impact, barrier must pump forever

• **Downgradient** - potentially short term benefit

• **Reinjection** - can dilute the material out with enough water question don’t know if rebound may occur
Barriers – Physical & Hydraulic Control

Case Study RMA
Barriers – Physical & Hydraulic Control
Case Study RMA

UPGRADIENT

Yearly average groundwater dieldrin concentrations with 95% confidence limits

Legend
- Upper 95% Confidence Limit
- Mean
- Lower 95% Confidence Limit

Control Area

NWBCS Upgradient

Control

NWBCS Upgradient
Enhanced Natural Process
Case Study HRC APDS

- HRC Borings Intersect Flow
- Wells monitored in transect along groundwater flowpath
- Control wells monitored
HRC System Operation

- TOC and Organic Acid Data Showed HRC Operated as Designed
HRC System Operation

- HRC did not enhance degradation above natural attenuation rates across site.
Goal of Phytoremediation
(Twin Sites Case Study)

• Intercept potentially contaminated groundwater
• Maintain conditions that enhance degradation of organic contaminants
Phytoremediation Mechanisms
(Twin Sites Focus)

1. Stabilize Surface Soils
2. Enhanced Biological Activity
3. Phyto-Stabilization
4. Phyto-Pumping
Specific Experience at Twin Sites
Planting – Site Preparation
Planting – Site Preparation

Hybrid Poplars Used
Depth to Groundwater <3 meters

Deep Plantings
Plantings after 14 months
Dieldrin Trends in PhytoMass Planting
Total BHC Trends in PhytoMass Planting
# Statistical Analysis

## Total BHC

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<tr>
<th>Parameters</th>
<th>Outside Phyto</th>
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<tr>
<td>R</td>
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<td>K</td>
<td>-0.13</td>
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<td>Half-Life (Years)</td>
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## Correlation Coefficient

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<td>Trend</td>
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## Dieldrin

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## Limitations

- **Depth to groundwater**
  - Typically limited to less than 7 meters unless the soil is clay or silty fines in which the depth may extend

- **Space limitations and Soil Characteristics**

- **Seasonal influence**
  - Band has to be wide enough to prevent breakthrough during the dormant season

- **Doesn’t directly treat**-primarily a water balance tool
Benefits

- A tool for water balance that maintains beneficial equilibriums
- Thousands of micro flow pumping systems as opposed to a few high flow pumping systems
- Minimal disruption of water table
- Keeps smear zone saturated which helps to maintain soil to water partitioning rates
- Adds carbon to groundwater as additional binding element
- Requires no human intervention-self sustaining
Phytoremediation under certain situations provides a tool for managing recalcitrant pesticides that is superior to conventional mechanical systems.