

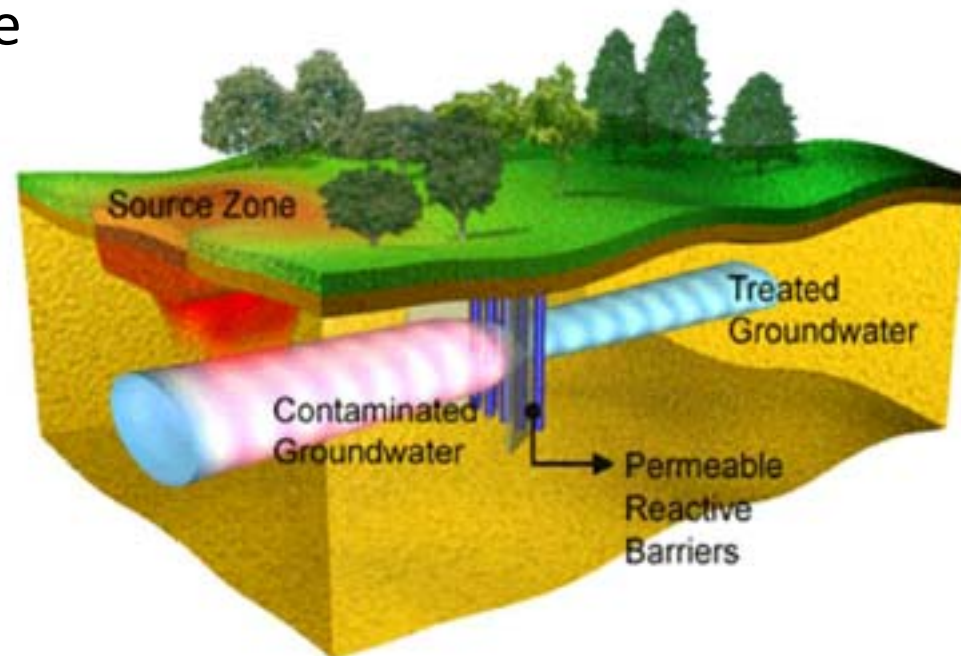
Hazardous waste management II

Today's lecture

- Soil and groundwater remediation techniques
 - Permeable reactive barrier
 - Soil washing
 - Thermal desorption
 - Landfarming
 - In situ bioremediation

Soil and groundwater remediation techniques

- Permeable reactive barrier (PRB)
 - Place reactive materials in the subsurface at the pathway of contaminated groundwater
 - The contaminants in groundwater are transformed into environmentally acceptable forms

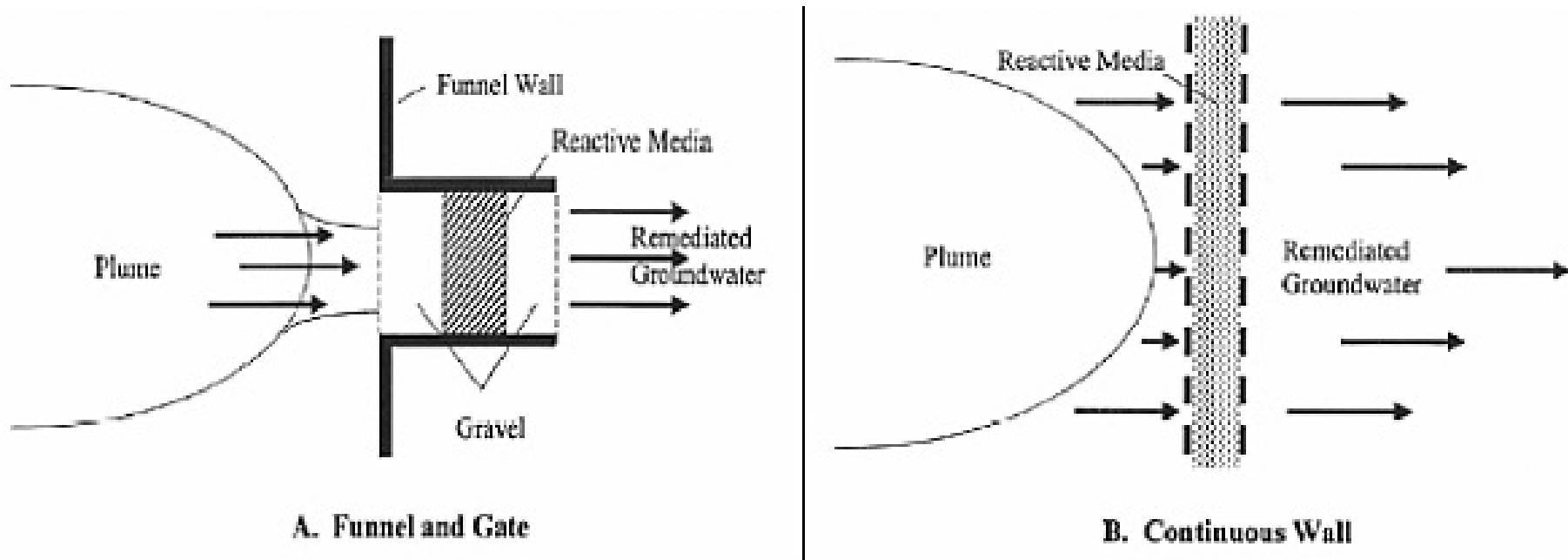


Soil and groundwater remediation techniques

- Permeable reactive barrier (PRB)
 - Reactive materials
 - Zero-valent iron (ZVI): works for PCE, TCE, NO_3^- , and Cr^{6+}
 - Zeolite: works for NH_4^+ and heavy metals
 - Advantages
 - No maintenance cost → cost-effective
 - No equipment necessary on the ground → the site can be used during remediation
 - Disadvantages
 - Cannot eliminate the contaminant source
 - Do not work if the groundwater flow changes

Soil and groundwater remediation techniques

- Permeable reactive barrier (PRB)



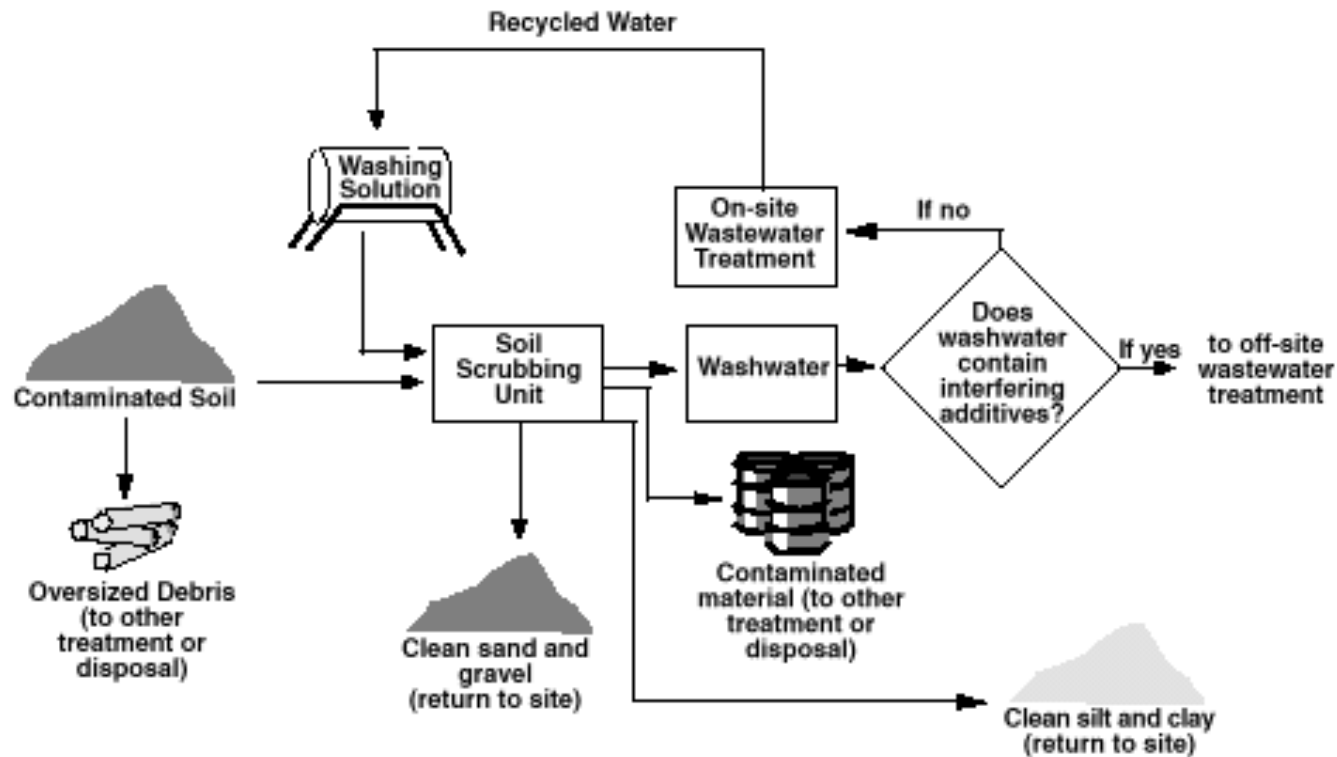
<http://www.geoengineer.org>

Soil and groundwater remediation techniques

- Soil washing
 - A mechanical process that uses liquids, usually water, to remove pollutants from soils
 - The pollutants are usually attached to small particles such as silt and clay
 - Pollutants are removed by i) separating silt and clay from sand or gravel and ii) transfer of contaminants from soil to water
 - The wastewater should be treated; the silt and clay should be treated if contaminants are not sufficiently removed

Soil and groundwater remediation techniques

- Soil washing



<http://infohouse.p2ric.org>

Soil and groundwater remediation techniques

- Soil washing
 - Advantages
 - Simple technique
 - The unit can be made transportable (a soil washing truck)
 - Can make sure that soil is being cleaned
 - Disadvantages
 - High excavation cost
 - Additional treatment may be required for wastewater, and silt & clay

Soil and groundwater remediation techniques

- Thermal desorption
 - Utilizes heat to increase the volatility of contaminants such that they can be removed from soil
 - The produced gas is collected and treated
 - Advantages
 - Effective for volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs)
 - Relatively fast
 - Can make sure that soil is being cleaned
 - Disadvantages
 - High cost for excavation and treatment
 - Intensive use of energy

Soil and groundwater remediation techniques



<http://www.epa.gov/>

Soil and groundwater remediation techniques

- Landfarming
 - A type of a bioremediation treatment process
 - Contaminated soils are excavated, spread on the ground, and periodically turned over (tilled) for aeration
 - Good for petroleum-contaminated soils



<http://www.matts-bioremediation.tripod.com>

Soil and groundwater remediation techniques

- Landfarming
 - Advantages
 - Relatively simple design and operation
 - Relatively rapid and inexpensive
 - Disadvantages
 - May not be effective for high removal efficiencies (>95%) and high contaminant concentrations
 - Emission of volatile contaminants and dust during treatment
 - Requires a large land area for treatment

Soil and groundwater remediation techniques

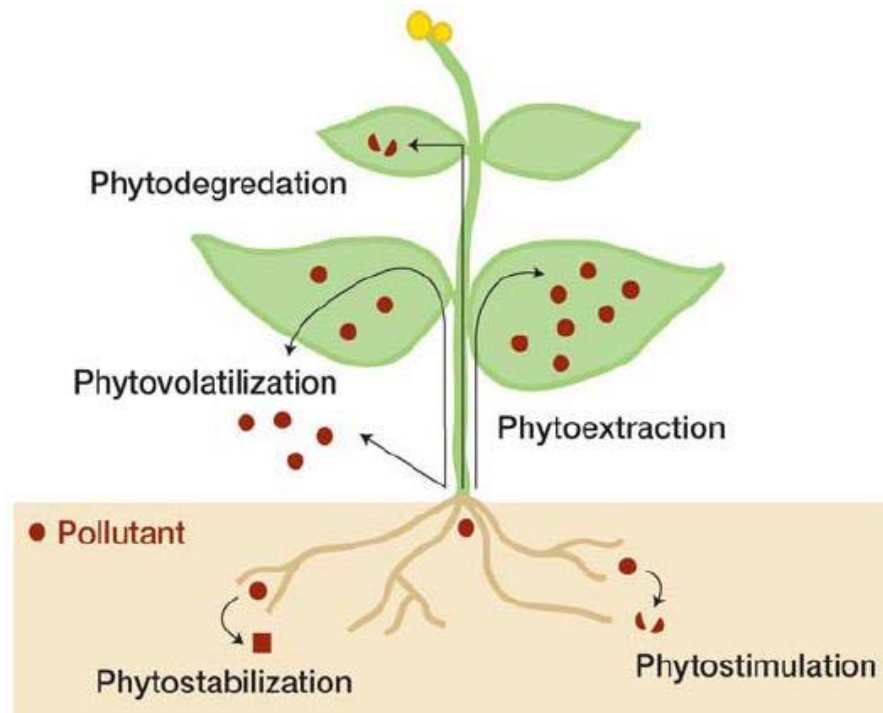
- In situ bioremediation
 - “In situ” means “situated in the original, natural, or existing place or position” (\leftrightarrow ex situ)
 - Application of biological treatment for the in situ cleanup of hazardous chemicals present in the subsurface
 - Usually for organic contaminants \rightarrow needs electron acceptors (usually O_2), nutrients, and microorganisms!

Soil and groundwater remediation techniques

- In situ bioremediation
 - Biostimulation: providing nutrients, electron acceptors, or other chemical agents to stimulate biodegradation by microorganisms
 - Bioaugmentation: injection of microorganisms that have capability of degrading target contaminants
 - Bioventing and bio-sparging: application of soil vapor extraction and air sparging technology, but focus more on stimulating biodegradation by providing O₂
 - Monitored natural attenuation (MNA): rely on natural processes of biodegradation with a monitoring plan

Soil and groundwater remediation techniques

- In situ bioremediation
 - Phytoremediation: use of green plants and their associated microorganisms for the treatment of contaminants



<http://systemsbiology.usm.edu>

Soil and groundwater remediation techniques

- In situ bioremediation
 - Advantages
 - Environmentally friendly
 - Low cost, and low energy consumption
 - Toxic compounds are not just separated, but transformed to non-toxic materials
 - Disadvantages
 - Slow process
 - Mostly not effective for heavy metals
 - Removal efficiency can be low
 - Knowledge gap exists for biodegradation processes in soils and groundwater