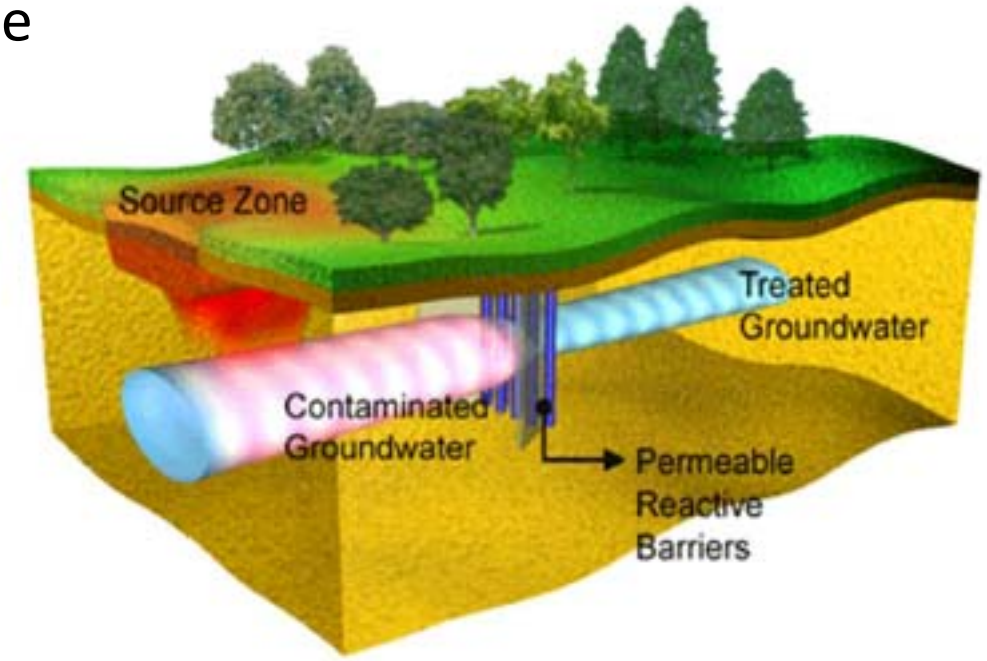
Hazardous waste management II

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

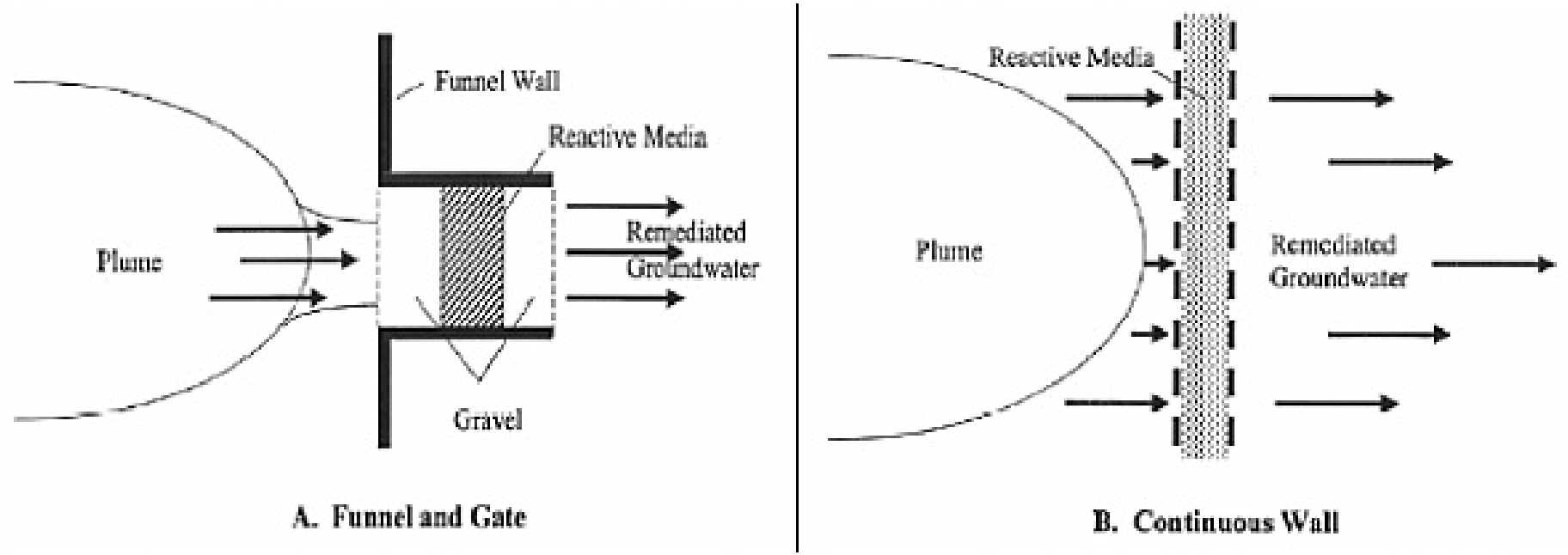


Soil and groundwater remediation techniques

- 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)



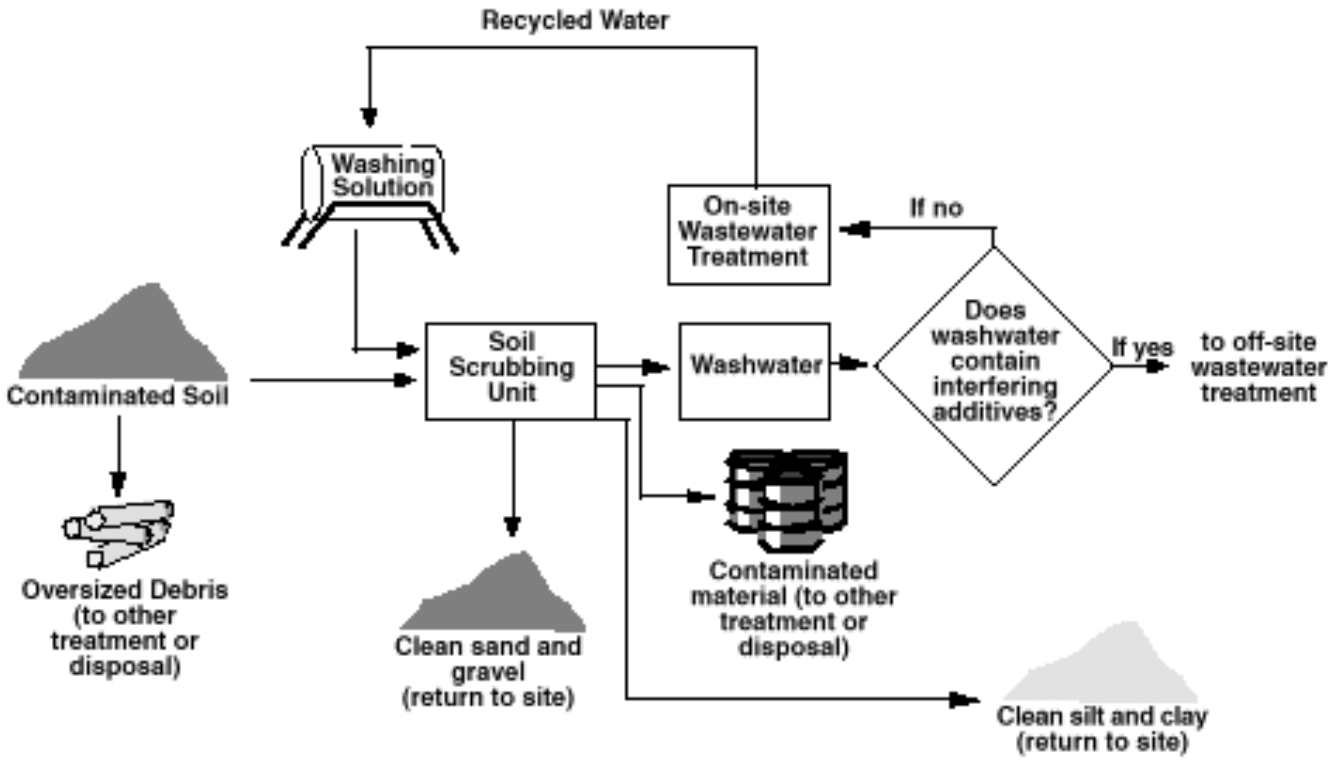
http://www.geoengineer.org

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

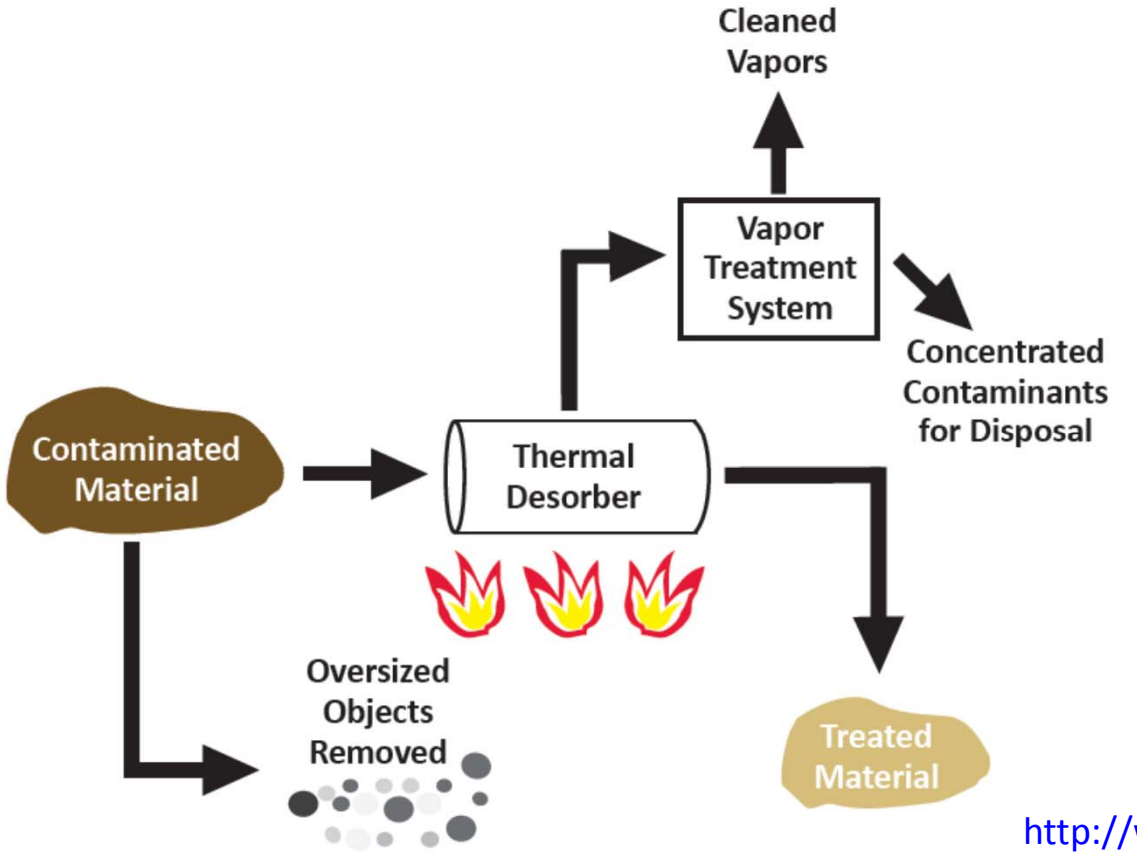
- Soil washing
  - Advantages
    - Simple technique
    - The unit can be made transportable (a soil washing truck)
    - Can make sure that soil is being cleaned
  - Disadvantages
    - High excavation cost
    - Additional treatment may be required for wastewater, and silt & clay

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

- Thermal desorption



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

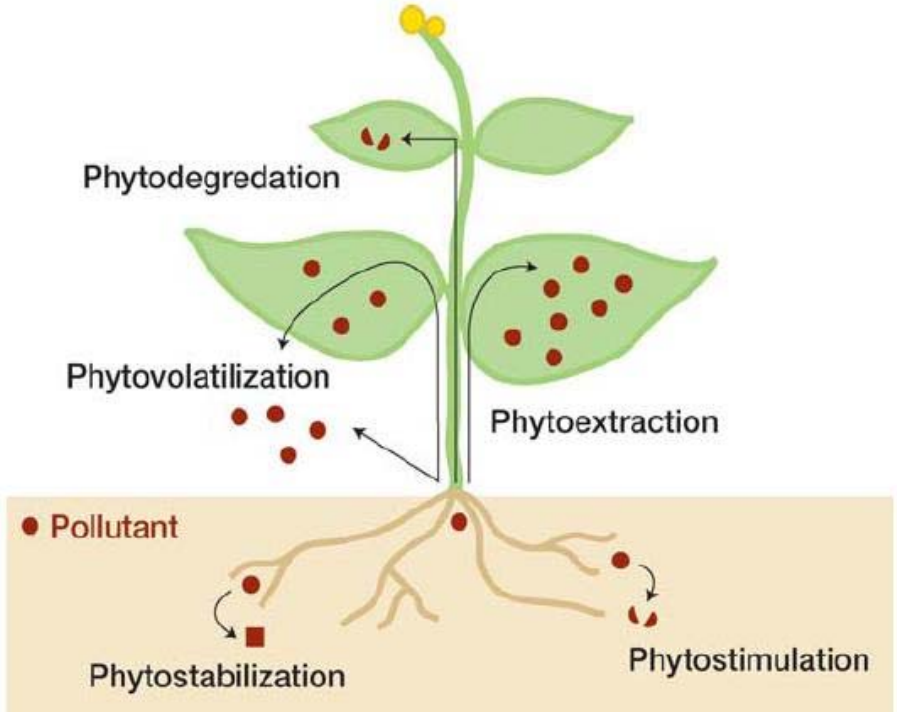
- In situ bioremediation
  - "In situ" means "situated in the original, natural, or existing place or position" (↔ ex situ)
  - Application of biological treatment for the in situ cleanup of hazardous chemicals present in the subsurface
  - Usually for organic contaminants → needs electron acceptors (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 O_2
  - 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