Fate and Transport of Chemicals

A Presentation by
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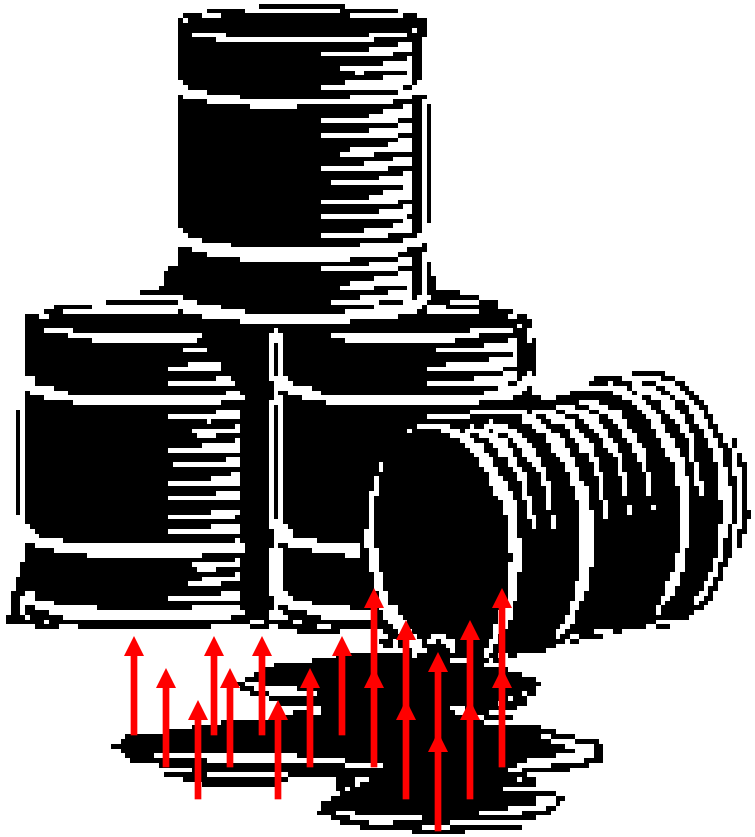
What Happens when Chemicals Spill?

- volatilize into the air
- stick to the soil
- run off into streams or lakes
- percolate down through the soil
  - float on the water table
  - sink under the aquifer
  - dissolve in the groundwater
- destroyed by bacteria

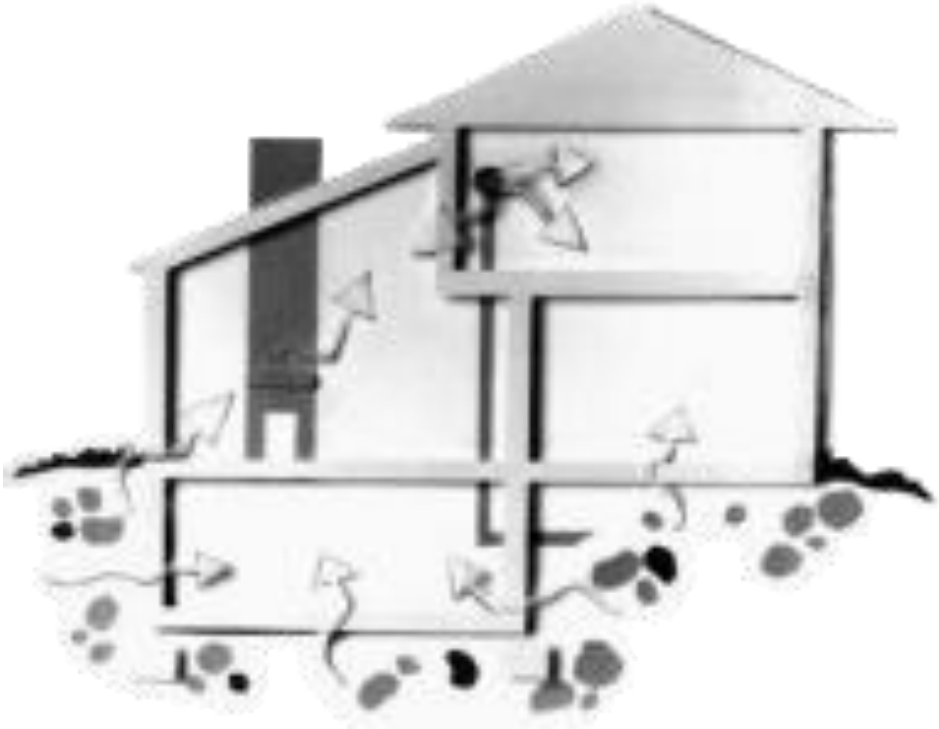
Volatilization

- When chemicals volatilize into the air the concentrations may become dilute enough to cause no harm.
- Risk depends on the concentration of exposure and the type of chemical



Volatilization

- When chemicals in soil volatilize into the air people in nearby structures may be affected by increasing concentrations



Soil Contamination

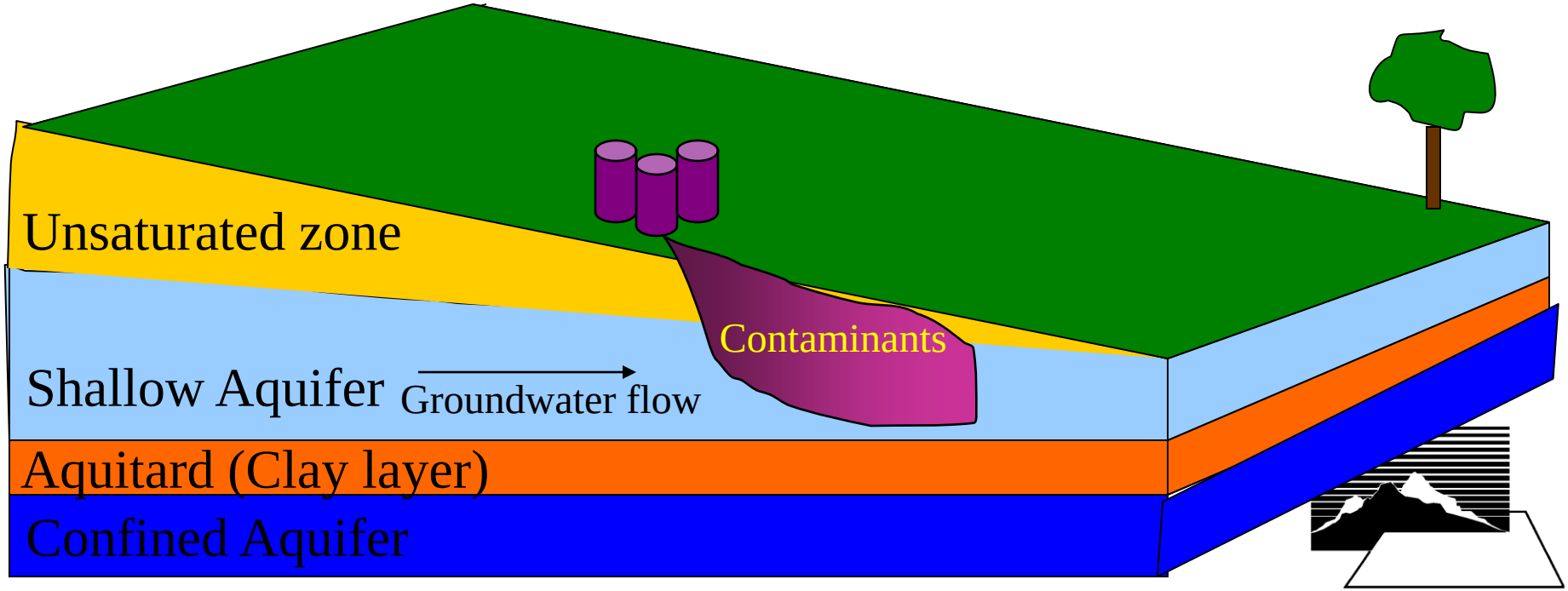
- When toxic chemicals remain in the soil contact with the soil may be harmful to people

Runoff

- Chemicals that run off into streams, lakes or the ocean may harm wildlife or contaminate drinking water

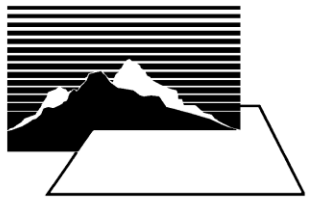
Groundwater Contamination

- Chemicals may move through the soil and dissolve in groundwater
- People using groundwater for drinking may be at risk



What Determines How Chemicals Move?

- Nature of the chemical
  - some chemicals react with soil material and precipitate (become solid)
  - some react and become more mobile
  - some are more easily degraded in the environment
  - some dissolve in water
- Hydrologic cycle
  - climate and the water cycle influence how chemicals are carried through the environment
    - precipitation
    - depth to groundwater
    - rate of groundwater flow



What Determines How Chemicals Move?

- Geology
  - layers and areas of higher and lower permeability
    - » clay and unfractured rock are less permeable
    - » gravel and sand are more permeable
- Amount of organic material in the soil
  - certain chemicals tend to stick to organic material and don't move so quickly or so far

Trichloroethylene (TCE)

- high volatility— volatilizes easily in air
  - remediation sometimes consists of bubbling air through TCE contaminated water
    - » in-well vapor extraction
    - » pump and treat with air stripping
- low solubility— dissolves slowly in water
  - free product tends to pool in the subsurface and then slowly dissolve into groundwater
  - may provide a continuous source of contamination over a long time period

TCE

- biodegrades anaerobically
  - bacteria that live without oxygen can break down TCE while living on other nutrients in the soil
  - breaks down into cis-DCE or trans-DCE, then into vinyl chloride (VC) in a very slow step-wise fashion when conditions are right
  - sometimes see build up of VC at older sites

TCE → cis-DCE → VC → ethylene (?)

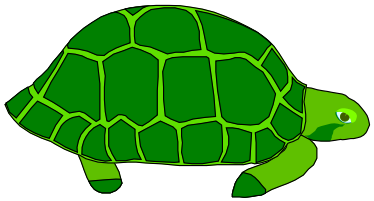
rate limiting step

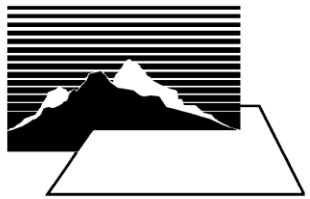
Risk only Exists if...

1. Contaminants exist
2. Concentrations are high enough

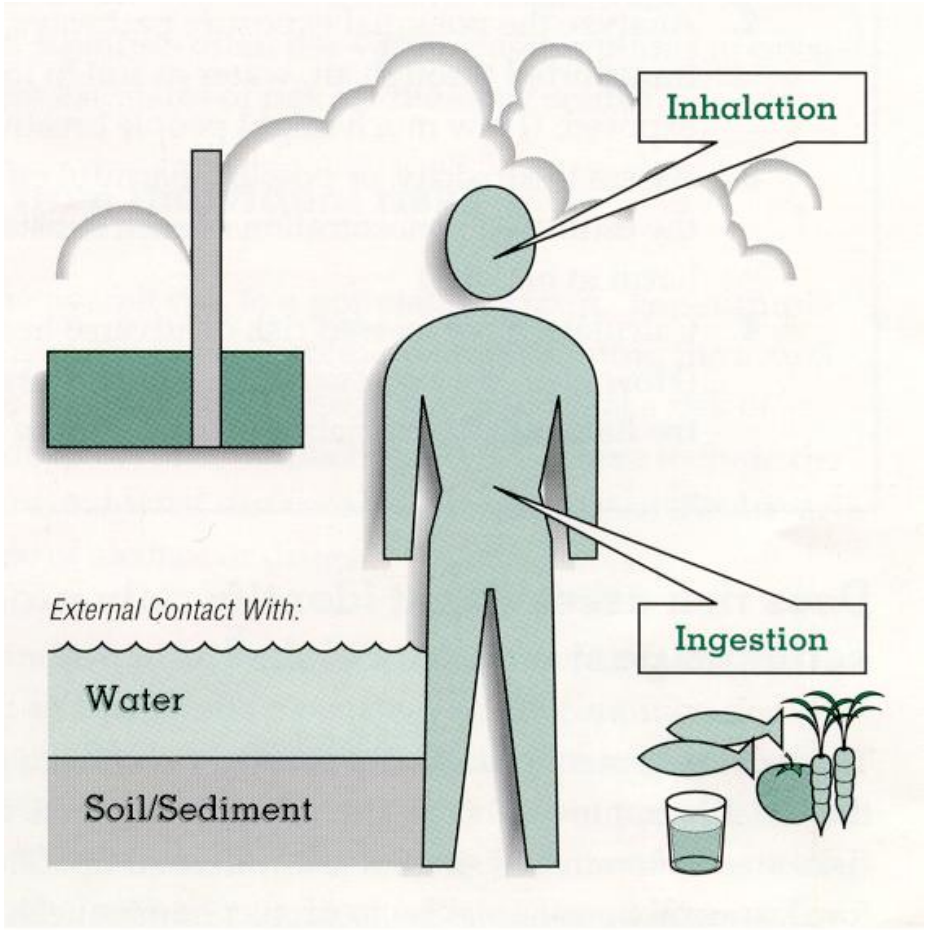
3. There is a pathway for exposure

4. There are receptors (people, animals sensitive ecosystem





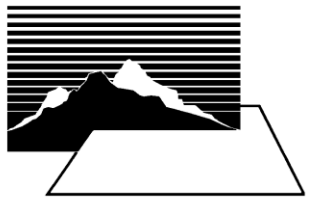
Exposure Pathways



- Inhalation
- Ingestion of soil and groundwater
- Absorption through skin

How to exclude pathways

- Institutional Controls
  - restrict land use, prohibit drinking water wells
- Engineered Barriers
  - parking lots, clean soil cover, clay or man-made caps, barrier walls
- Control Activities
  - groundwater pumping
    - » to prevent groundwater from contacting contaminated soil or to prevent migration of groundwater



Risk Management

- Goal – Reduce concentrations at point of exposure to acceptable levels by...
  - Source removal
    - » removing contaminated soil from the site
  - Treatment and containment
    - » treating and containing soil in monitored landfill
  - Elimination of exposure pathways
    - » engineering and/or institutional controls