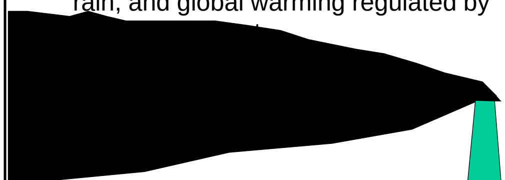
CVEN 4474/5474 Haz Waste Outline

- Contaminant fate and transport
  - Air dispersion
- Radioactive elements

Typical Air Pollution Issues

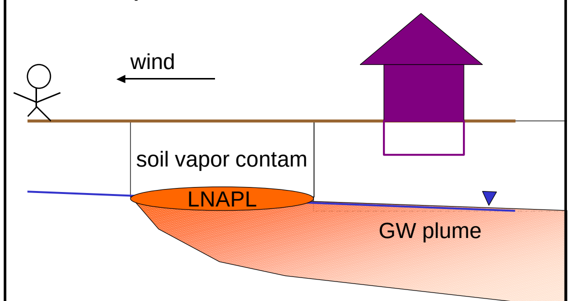
- Emissions from a stack (point source)
- CO, NOx, SOx as related to smog, acid rain, and global warming regulated by



Hazardous Air Pollutants (HAPs)

- At contaminated sites HAPs often originate from soil at ground level over an area
- Sometimes will (also) have a point source (emissions from soil vapor extraction)
- Remediation activities frequently disturb the can (such as excavation) and can increase HAP emissions

Example of Air Contam. from Site



- Contaminants must volatilize from the groundwater into the vadose zone air (H, ΔC)
- Contaminants must diffuse through the air-filled pores of the soil
  - sorb, dissolve in moisture
- Contaminants diffuse out of the ground surface
- Contaminants are dispersed and transported in bulk air flow
  - Wind speed, solar radiation, etc. affect stability/turbulence -> more variable on a daily basis and time of day basis than groundwater
  - Height and distance from source affect concs

Air Dispersion

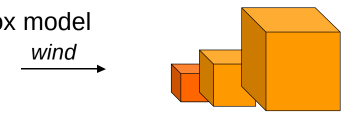
- Example: estimate the concentrations of TCE, benzene, and Cr+6 in the air above a gw contaminant plume containing 10, 15, and 20 mg/L, respectively (similar to Lowry Air Force Base)
- Advection, dispersion, diffusion still important
- More difficult to predict based on wind conditions, temperature, etc.

Diffusion through Soil Vapor

- $J = - D\,(dC/dx)$
- J = flux, mass/area/time
- D = diffusion coefficient of the cmpd in AIR, cm2/s
  - Appendix B of text
  - Estimate based on mol. wt. & known cmpd
- dC/dx = concentration gradient; mass/vol/length
  - Low conc at ground surface if windy (0 conservative)
  - Close to equilibrium near the source (vapor pressure if NAPL or Henry's with GW conc)

Dispersion and Advection in the Atmosphere (above ground)

- Box model



- Gaussian distribution

3D Model of Above Ground Contam. Mvmt

- $C(x,y,z) = \frac{Q}{2\pi\sigma_y\sigma_z u} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \left\{\exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right]\right\}$
- Q = emission of pollutant = J A = mass/time
- σ_y σ_z = horizontal and vertical std dev. based on disperion conditions (temp, turbulence)
- x = downwind on centerline (wind direction)
- y = horizontal distance ⊥ to wind direction to pt of interest
- Z = height above ground of point of interest
- H = height of emission/source (= 0 at ground)

3D Model of Above Ground Contam. Mvmt

- Txtbk eqn on previous page assumes:
- No photoreactions
- No rain deposition (washout)
- Flat level ground
- ROUGH estimate only

Superfund Air Pathway Analysis (APA) 1992

1. Define APA objectives
   What are the goals & needs
   Ex: determine max. fenceline short-term conc. of benz in air
   Collect info. needed during RI/FS to help answer ?s
2. Design & Conduct site scoping →No risk?
   Potential for signif air contam. either undisturbed or during potential remed
   ↓ risk
3. Screening Assessment
   Modeling and data collection
   ↓ risk
4. In Depth APA
   Modeling & data collection
   Establish a baseline…
   Also establish remediation impacted air concs
   Monitor during site activities

Measuring Air Concs

- Tricky procedures
  - "dome" on ground
  - Pump air to carbon trap [time averaged conc]
  - Analysis on-site vs. send to off-site lab
- Concentrations highly variable
- Can be expensive

Particulate Air Pollution

- Particles themselves are regulated "PM10"
  - Size matters: smaller particles penetrate deeper into lungs
- Hazardous compounds sorbed to small "soil" solids… inhaled?
- Wind entrained dust much more complex to model due to capture/deposition patterns

Radioactives - background

- Atoms are composed of a nucleus with protons (P; +, 1 amu) and neutrons (N; 1 amu) orbited by electrons (e; -)
- Element determined by the # of protons
- Atomic mass = # P + # N
- Isotopes: same element with different atomic weight
- Radio-isotopes have an unstable nucleus and spontaneously emit particles &/or energy (aka radiation)

Example:

- Carbon: ^{12}C stable, ^{14}C radioactive
  - Both are naturally present in environment
  - ^{12}C much more common in nature

Types of Nuclear Decay

- Alpha (α) - 2 P + 2 N; ^{4}He nucleus
  - Spontaneously emitted from many heavy nuclei with mass >150 amu
  - Very short range (few inches) in air, interact with matter, only harmful if ingested
- Beta (β) - fast electron
  - Does not change mass of the atom, but increases atomic # by 1
  - Medium range in air, stopped by glass or aluminum foil
- Gamma (γ) - high energy photon; *
  - No change in atomic composition
  - More penetrating than α or β

Related...

- X-rays are high energy photons of non-nuclear origin (electromagnetic) - very penetrating

- Each isotope has a characteristic decay pattern (particle, time)
- Rate of decay is a first order reaction
  - $dN/dt = -\lambda N$; N = # atoms;
    λ = decay const.
- Half life
  - $T1/2 = \ln 2 / \lambda = 0.693 / \lambda$

- Formation rate of daughter product = decay rate of parent
  - If stable daughter, $N_2 = N_{1o} (1 - e^{-\lambda 1t})$
- Daughter products are often also unstable and decay
- $N_2 = \frac{\lambda_1 N_{1o}}{\lambda 2 - \lambda 1} (e^{-\lambda 1t} - e^{-\lambda 2t})$

Example: Decay of U-238

Element	Atomic #	Mass #	1/2 life	decay
U	92	238	4.5E9 yr	α
Th	90	234	24 d	β
Pa	91	234	1 min	β
			2.5E5 yr	α
			7.5E4 yr	α