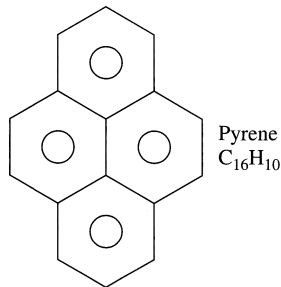


Remediation of soil and groundwater
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Problem set # 6: soil treatment and washing

Problem 1:

Sludge contaminated with pyrene (20,000 ppm) is to be treated in a compost pile that weighs approximately 2,500 kg (including the sludge). The pile was prepared such that the sludge makes up 25 % by mass of the pile. Treatment will be in two stages, an active composting stage, for 40 days, and a curing stage (during which the pile is turned periodically) for 90 days. If the half-life for pyrene during the active stage is 30 days and during the curing stage is 55 days, determine the expected final concentration of pyrene in the pile (assuming first-order degradation rates). Can you estimate the effect of a loss of 30% of the compost (but not the sludge) mass during the active stage on the final concentration?



Problem 2:

The owner of a property contaminated with petroleum must remediate the site completely in one year. Approximately 40,000 m³ of soil with a mean total petroleum hydrocarbon contamination (TPH) of 10,000 mg/kg (maximum of 98,000 mg/kg) must be remediated to a mean of 100 mg/kg (maximum 500 mg/kg). The owner is considering windrow composting. Laboratory tests show the following results for degradation of TPH. Assuming first order degradation rate, can the goal be achieved?

	Concentration of TPH, mg/kg					
Day	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
0	18,600	9,100	4,500	98,300	8,100	6,900
3	16,400	5,500	4,200	87,700	5,800	2,600
6	13,200	2,100	3,000	55,800	5,100	2,500
10	11,200	1,900	1,600	43,600	3,200	2,100

Problem 3:

A laboratory experiment was conducted to simulate land treatment of diesel fuel-contaminated soil. Results monitored over 46 days showed a drop in concentration from 900 to 300 ppm. Assuming first-order rate kinetics ($C=C_0e^{-kt}$):

- Find the degradation constant of the contaminant
- Find the half-life of the contaminant
- Considering that the experiment was conducted at room temperature (22 °C), you are asked to estimate the degradation rate constant at a field temperature of 27°C. Use the Arrhenius equation $k_T=k_{22} \Theta^{T-22}$ with $\Theta=1.02$
- What is the half-life for diesel degradation at field temperatures?

Problem 4:

Acidic petroleum sludge-impacted soils from an oil refinery in Poland requires treatment. The soil was contaminated with PAHs and BTEX compounds. A volume of 3,300 m³ of soil with a concentration of 30,000 ppm TPH (hexane-equivalent) was targeted for treatment.

Based on hexane (C₆H₁₄) as a proxy for other organic compounds, what volume of air-saturated water would be needed to degrade 1 gram of hexane? Considering the soil to treat, how much oxygen-saturated water is needed to degrade 90% of the contaminant? Is flow-through slurry phase treatment a feasible option?

Assume a soil density of 1,440 kg/m³.

The soil was treated with an active biopile system. There were 5 operation campaigns: OC1: Mobilization and air injection startup (2 months); OC2: Air injection (2.5 months). OC3: Air injection + fertilizer (2 months); OC4: Air injection + fertilizer + leachate recirculation (3 months); and OC5: Air injection + fertilizer + leachate recirculation + surfactant (Triton N-101) (3 months).

Given the data below, what is the removal rate per operating condition and the average removal rate over the entire operation in day⁻¹? What is the total percent TPH removed over the entire operation? What is the best operating condition for optimal TPH removal? Can you speculate on why that might be?

OC	Concentration of TPH, mg/kg	
	Initial concentration	Final concentration
1	30,000	22,100
2	22,100	15,300
3	15,300	15,000
4	15,000	13,500
5	13,500	5,200

Problem 5:

A contaminated soil is to be remediated in a batch slurry reactor. The soil contaminant concentration, measured as COD, is 800 mg/kg dry soil and the allowable concentration

(because of toxicity) is 40 mg/kg. Based on laboratory studies, $K_D = 0.2 \text{ m}^3/\text{kg}$ and biodegradation can be described as a first-order function of the dissolved COD concentration. A value of the first order rate coefficient of 0.05 per day has been determined. Adequate mixing can be achieved at a solids concentration of 10 kg dry soil/ m^3 slurry. Determine the time required to remediate the soil knowing that the solid density is 2,600 kg/m^3 .