Remediation of soil and groundwater
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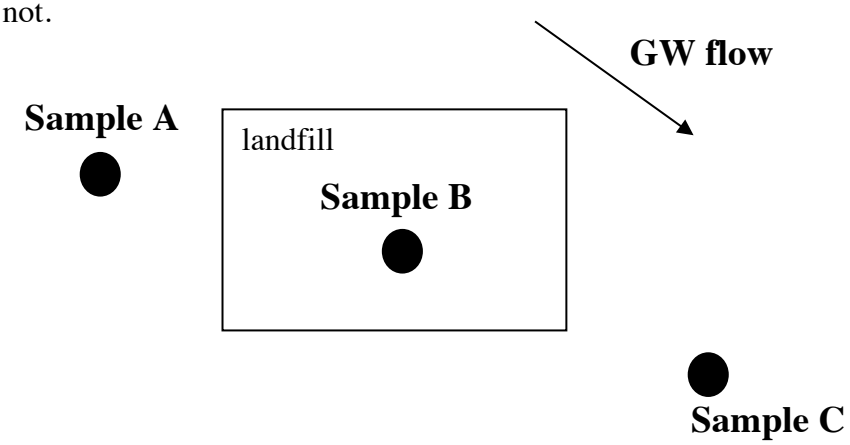
Problem set #7: in situ bioremediation

Problem 1:

A variety of chemicals have been leaching from an old abandoned landfill potentially over the past 10 years. Looking for preliminary indications of biologically-driven natural attenuation, soil and groundwater samples were removed from the locations below and analyzed.
Potential contaminants leaked from the landfill include: PCE, TCE, benzene, toluene, chlorobenzene, pentachlorophenol.
For each of the scenarios below, indicate if there is strong (S), potential (P) or no (N) evidence for biodegradation of the contaminant compounds. State briefly why or why not.



Case	Parameter	Measured values	Bio?	Why?
A	Dissolved O_2 in GW	A=B>C		
B	Dissolved O_2 in GW	A>B>C		
C	Chloride in GW	A>B>C		
D	PCE	B>C>A=0		
E	Vinyl Chloride	C>B=A=0		
F	% BTEX degraders	B<A<C		
G	Oxygenase activity	A<C<B		
H	H_2S in soil gas	B>A=C		

Problem 2:

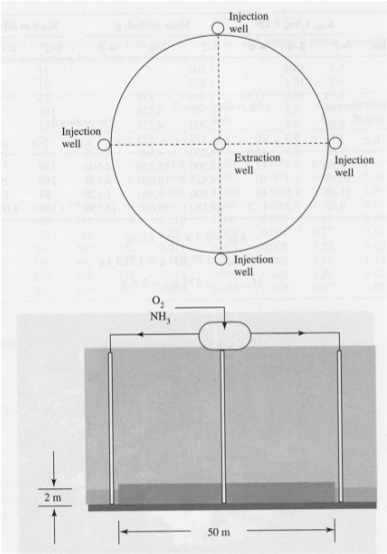
A saturated soil zone has been contaminated with 5,000 L of diesel (4,000 kg) from a leaking underground storage tank. The soil is fairly high in organic matter (5% by weight), has a porosity of 0.4, wet bulk density ρ_{wb}=1,700 kg/m^3. The K_d of the soil and diesel is quite high (0.01 L/mg) and the diesel is not very mobile. The groundwater is not moving and contamination is spreading only by diffusion. The diameter of the cylindrical plume is 50m and its height is 2m.

a- determine the liquid- and solid-phase concentrations of the diesel (assume they are constant at all points in each phase)

b- The water is pumped out at a flow rate of 111 m^3/day and reinjected after enrichment with 47 g/m^3 O_2 and 10 mg/L NH_4Cl at four points around the periphery (see diagram below). Assume the degradation of diesel requires 2.5 g O_2 per g diesel.

Determine the rate of diesel degradation possible in kg/day treated (assuming O_2 is limiting) and how long the remediation will take.

c- Do you think this is an appropriate remediation technology for this site?



Problem 3:

An aquifer is impacted by gasoline and the average dissolved gasoline concentration is 20 mg/L. In situ bioremediation is being considered for the aquifer with the following characteristics:

Porosity= 0.35

Organic content= 0.02

Dry bulk density of aquifer materials= 1.6 g/cm^3

DO concentration in the aquifer= 4 mg/L

DO concentration in O_2-saturated aquifer= 9 mg/L

Karickhoff expression:

$$K_D = K_{ow} \times f_{oc} \times 0.63 \times 10^{-6} \frac{m^3}{g}$$

How much oxygen is needed for the aerobic degradation of the gasoline? Would bioremediation require the additional input of oxygen? (use toluene as a proxy for gasoline)

Toluene (C_7H_8):
Log K_{ow}= 2.73

1. Determine the concentration of toluene adsorbed onto the solid
2. Determine the total mass of toluene in the aquifer
3. Calculate the amount of dissolved oxygen in the groundwater
4. Write a balanced equation for the complete aerobic oxidation of toluene. Calculate the mass ratio of O_2 to toluene needed.
5. Calculate whether oxygenating the entire volume of contaminated groundwater once would be sufficient to deliver enough O_2 to oxidize the toluene. If not, how many times will the groundwater need to be oxygenated.
6. Can you think of any issues with this strategy?