

Remediation of soil and groundwater
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Problem set #1: contaminant properties

Problem 1:

A closed bottle contains 10 mL of air and 90 mL of water. Suspended in water is 36 mg of particulate (solid) matter having a specific gravity of 1.0 and an organic carbon fraction of 0.1. The bottle contains 10 mg of tetrachloroethene ($\text{CCl}_2=\text{CCl}_2$) also known as perchloroethylene (PCE), which has the following properties:

$$\text{MW} = 166 \text{ g/mol}; K'_H = 0.6; \log K_{OW} = 2.67$$

The Karickhoff relationship links K_{OW} and K_{OC} in the following manner:

$$\log K_{OC} = 0.989 \log K_{OW} - 0.346 \quad (K_{OC} \text{ units are } \text{m}^3/\text{g} \text{ in this case})$$

Calculate the mass distribution of PCE between the air, the aqueous solution and the suspended solids.

Problem 2:

You have prepared 100 mL of a combined aqueous standard containing 100 $\mu\text{g/L}$ each of benzene, toluene, ethylbenzene and p-xylene (BTEX). You store this solution in a 1L bottle. Calculate the equilibrium concentration ($\mu\text{g/L}$) of each component in the water. Can you suggest a better storage alternative?

$$K'_H = 0.214 \text{ benzene}, K'_H = 0.235 \text{ toluene}, K'_H = 0.322 \text{ ethylbenzene}, K'_H = 0.313 \text{ p-xylene}$$

Problem 3:

A contaminated soil is placed in a sealed reactor with a capacity of 500 m^3 and amended with water. The soil contains 900 mg benzene/kg dry soil. The following information is available:

$$K_D = 0.02 \text{ m}^3/\text{kg}; K'_H = 0.214 \text{ benzene}$$

Solids concentration in reactor: 40 kg dry soil/ m^3 slurry; Volume of slurry: 500 m^3

Soil dry solid density $\rho_s = 2,000 \text{ kg/m}^3$

- a- Calculate the volume of soil and water in the reactor.
- b- Calculate the concentration of benzene in the water.

Problem 4:

The Karickhoff relationship links K_{OW} and K_{OC} in the following manner: $K_D = 0.63 \cdot 10^{-6} \cdot f_{OC} \cdot K_{OW}$ (K_D units are m^3/g in this case).

A- Rivers typically contain suspended solids (floating particles) in the concentration C_{SS}

= 1 to 100 mg/L where C_{ss} is the solids concentration expressed as (mg dry solids/L). What is the fraction of PCBs (polychlorinated biphenyls) in the solid? Given: $K_{ow}(\text{PCB})=10^6$; $C_{ss}= 10 \text{ mg/L}$; $f_{oc}= 0.1$; $\rho_s= 1 \text{ g/cm}^3$. Note: high f_{oc} because particles contain lots of biological matter such as algae.

B- Calculate the distribution coefficient K_D for the partitioning of CCl_4 between water and solids given that $K_{ow}=440$ and the organic carbon content of the solid phase is $f_{oc}=0.02$. Calculate the dimensionless ratio of solid and aqueous concentrations given that the density of solids is $\rho_s= 1.1 \text{ g/cm}^3$

C- Calculate the distribution of CCl_4 mass between the solid and solution phases given that the solid phase is suspended in the water column and occupies 0.01% of the total volume.