Environmental Chemistry, Homework set

Partitioning – part 2

1. Activated carbon for water treatment

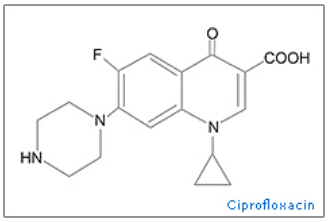
A water supply is contaminated with 1 mg/L of 1,1,1-trichloroethane (TCA), which is a suspected human carcinogen. To comply with drinking water regulations, you want to lower the concentration to below 0.2 mg/L using fresh activated carbon (AC). Assume that a Freundlich isotherm applies, with K_F = 2.5 [mg/g AC]/[mg/L]^n) and n=2.94.

What dose of activated carbon (g/L) must be added?

2. Antibiotics in soil

Ciprofloxacin ("cipro") is an antibiotic that is becoming widely distributed in soils through wastewater sludge disposal on land. Concentrations of this antibiotic below 10 mg/(m^3 water) in the soil pore water are deemed acceptable, and some authorities have indicated a similar threshold of 0.01 mg/(kg dry soil) for its soil content. Given cipro's water solubility of 30 g/L and its molar weight of 385.8 g/mol, what is the minimum soil organic carbon content needed to have both the pore water concentration and the soil content of cipro at safe levels?

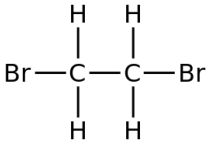
Assume that the K_{oc} of cipro follows the same correlations with K_{ow} as halogenated phenylurea pesticides.



3. EDB groundwater spill

1,2-Dibromoethane (also called ethylene dibromide, EDB) is a heavy, colorless organic liquid. In the past was heavily used as an additive in fuel, as well as a pesticide. Today, EDB is an important environmental contaminant in groundwater, soil and air. EDB is acutely toxic to humans, and it is a probable carcinogen. Human exposure to EDB should therefore be avoided.

In Appendix C from your class notes and in other sources you find the following properties for EDB:



Molar mass: 187.9 g/mol
Density: 2.18 g/mL
log K_{ow}: 1.96
log K_{aw} : -1.55
Maximum contaminant level (MCL) in drinking water: 0.00005 mg/L

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a) If 0.2 L of EDB are spilled into ground water, how many liters of drinking water can it contaminate?

b) EDB is spilled into an aquifer with a solid density ρ_s of 1.2 kg_s/L_s and a porosity Φ of 0.6. (The porosity corresponds to the fraction of the total aquifer volume that is not filled by solids). The fraction of organic carbon in this aquifer is 0.4. Assume that the pores are completely filled with groundwater. What fraction of EDB is present in the groundwater?

c) Now assume that the ground water level drops, and the pore space in this aquifer is filled with air instead of water. What is the fraction of EDB present in the air?

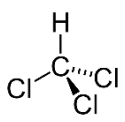
d) A town wants to use the EDB contaminated groundwater as a drinking water source. As an environmental engineer, you are asked to propose an effective and economical method to remove the EDB from the groundwater before it is used as drinking water. You consider two possible methods: adsorption to activated carbon, or air stripping. Unfortunately you don't have the budget to do any preliminary experiments or tests, therefore you need to determine the cost of these methods based only on what you've learned in this course.

Assume that the cost of activated carbon is 10 Fr./g activated carbon, and the cost of air stripping is 0.001 Fr./L air. Which method is more economical? Show all your calculations used to reach your answer. You can approximate the adsorption onto activated carbon by a linear model, and you can assume that activated carbon consists entirely of organic carbon.

4. Inhalation of chloroform

Before distributing surface water as drinking water, it is frequently chlorinated to eliminate pathogens. Thereby several cancerous by-products are formed, for example chloroform. Assume that in treated drinking water, chloroform is present at a concentration of 1 µM. Chloroform is quite volatile at high temperature, therefore it will partition into the air while you bathe. You are interested to find out how much chloroform you inhale during a bath. Unfortunately, the air-water partitioning coefficient of chloroform is not given in Appendix C of your class notes. The only things you know about chloroform are the following:

Molecular weight = 119 g/mol
$\Delta_{vap}H$ = 30 kJ/mol
p^*_L (25 °C)= 0.257 atm
γ_w (25 °C) = 8200



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Based on this information, determine the amount of chloroform you inhale during a 10 minute bath at 35 °C. Assume that you use 100 L of water to bathe, and that the air volume of the bathroom is 20 m^3. Furthermore, you breathe approximately 12 L of air per minute.