

**CE 473/573 Groundwater
Fall 2009**

Homework 7
Due Friday December 11

38. Salt, which has a molecular diffusivity of about $1 \times 10^{-9} \text{ m}^2/\text{s}$, is injected into an aquifer with a hydraulic conductivity of $5 \times 10^{-5} \text{ m/s}$, an effective porosity of 0.15, and a hydraulic gradient of zero. At what time is the concentration 1 m away from the injection point equal to 50% of the concentration at the injection point? (In class we estimated the time. Here you can calculate a specific number.)
- *39. Suppose in problem 38 the hydraulic gradient is 0.01.
- a. For a flow length of 10 m, compute the fraction of hydrodynamic dispersion caused by mechanical dispersion and molecular diffusion.
 - b. Which is more important—advection or dispersion?
40. Do exercise 3 on page 440 of Fetter's book.
41. Do exercise 5 on page 440 of Fetter's book.
42. Leaking gasoline tanks are a source of the BTEX compounds: benzene, toluene, ethylbenzene, and xylene. Rank them in order of increasing solute velocity if all experience the same average linear velocity of groundwater flow.
- *43. Approximate half-lives for the benzene, toluene, ethylbenzene, and xylene are 300, 20, 120, and 190 days, respectively. The EPA maximum contaminant levels for these compounds are 5, 3, 700, and 10,000 $\mu\text{g/L}$, respectively. Suppose the concentrations of all four in a leaking tank is 30 mg/L. Which has the largest plume length?

*44. (Old exam problem) A manufacturing plant has been leaking 1,1-dichloroethane into a confined aquifer of thickness 13 m since the 1960s. The aquifer has hydraulic conductivity 5 m/d, effective porosity 21%, soil organic carbon content 0.4%, bulk density 2.4 g/cm³, and hydraulic gradient with a magnitude of 0.01. Studies nearby show the dispersivity to be about 5 m. The contaminant 1,1-dichloroethane has a solubility of 5500 ppm, a half-life of about 110 days, a value of K_{oc} of 45 mL/g, and a maximum contaminant level (MCL) of 7 μg/L.

- a. If the concentration of 1,1-dichloroethane at the source of the leak is 25 mg/L, how long is the plume—that is, how far downgradient is the concentration above the MCL?
- b. A well is to be installed so that the contaminated water can be pumped and treated. However, it cannot be placed downgradient of the source because of a parking lot. If it is placed 50 m upgradient of the source, what flowrate would you recommend using?
- c. Would the required flowrate from part b increase or decrease if the following parameters increase? Briefly explain why.
 - i. Half-life
 - ii. Soil-water partition coefficient K_{oc}
 - iii. Hydraulic gradient
 - iv. Aquifer thickness
 - v. Source concentration

