

# Hydrogeology - HWR/GEOS 431/531 - Fall 2020

## Homework 5

*Posted 21 October 2020*

*Due 26 October 2020 (Monday)*

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### Transport

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Read about diffusive transport processes (section 3.4 and 9.2 of Freeze & Cherry; see lecture notes “Part 9: Scans”).

**Problem 17. [10 points; 5 points each]**

- (a) Read about the error function (erf) and complementary error function (erfc) - erfc is the solution of diffusion-type equations.

How is erf defined? (Exact functional form that is not analytical.)

How is it computed? (Approximate form that is analytical.)

What is the relationship between erf and erfc? What is  $\text{erfc}(x)$  and  $\text{erfc}(-x)$ ?

Calculate and plot  $\text{erfc}(x)$  for  $x$  between -3 and +3.

- (b) Diffusion coefficient  $D$  of a chemical species in pure liquid is  $2\text{E-}9 \text{ m}^2/\text{s}$  and tortuosity  $\omega$  in a porous medium is 0.5. If the initial concentration  $C_0$  at the source is 122 ppm, calculate the concentration  $C$  in the aquifer water at a distance of 6 m from the source after 60 years of diffusion. Use the analytical solution to the diffusion equation in porous media.

**Problem 18. [10 points; 5 points each]**

- (a) Read about the Peclet number. How is it defined? What is its use?

How do we determine whether transport of a contaminant in an aquifer is dominated by advection-dispersion or molecular diffusion?

- (b) [Problem 4 on page 458 of Freeze & Cherry.]

A contaminant zone is migrating through an aquifer composed of medium grained sand. The average hydraulic gradient is 0.01. A representative values of the hydraulic conductivity of the sand is  $10^{-5} \text{ m/s}$ . Is the movement of non-reactive contaminants influenced primarily by advection and mechanical (hydrodynamic) dispersion or by molecular diffusion? Why?

**Problem 19. [20 points; 5 points each]**

Read about dispersivity and dispersion coefficient. On one page or less answer the following questions.

- (a) What is dispersivity? What are its units? What does it depend on? What are typical/example values for common porous materials (sand, loam, silt, etc)?
- (b) Find ten published values of dispersivity for different porous media. Is there a correlation with the medium type - sand, loam etc?
- (c) What is scale dependence of dispersivity?
- (d) How is dispersivity related to dispersion coefficient? Why is the coefficient of longitudinal dispersion greater than that of transverse dispersion?

**Problem 20. [10 points]**

Laboratory experiments with two sorbing chemicals resulted in linear distribution coefficients,  $K_d$  (mL/g), to be 0.1 and 1, respectively. If these two chemicals are released from the same source, which will be detected first at the same point of measurement? What is their travel time relative to travel time of an ideal tracer (one that travels by advection with water velocity)? Assume bulk density of aquifer material of 2.0 g/cm<sup>3</sup> and porosity of 0.2.