1.061 / 1.61 Transport Processes in the Environment
Fall 2008

Transport in Porous Media

Objective: Use a tracer study to estimate the dispersion coefficient, pore velocity and porosity of a sediment column.

Background:
Material carried by a fluid flowing through a porous medium is dispersed by several processes; e.g. a) molecular diffusion, b) mechanical dispersion, c) stagnation in pore spaces, and e) spatial variation in hydraulic conductivity. In this lab you will observe dispersion in a porous media by observing its effect on a slug of tracer, M, released into a column of soil. The concentration of tracer at the end of the column is given by the 1-D advection-dispersion equation. The tracer travels at the mean pore velocity, $\bar{v}$ such that the arrival time of the peak is $L/\bar{v}$. In this lab you will use conductivity as a surrogate for concentration, and assume that there is a linear relationship between the concentration and conductivity, here *C*. Then, correcting for the background conductivity, C_B, the observed conductivity, C_O, should be,

$$C_O - C_B = [C_{max} - C_B] \exp\left[-\frac{\left(L - \bar{v}t\right)^2}{4Dt}\right]$$

Here, C_{max} is the maximum observed conductivity, D is the dispersion coefficient, and L is the length of the column between the injection port and the measurement position.

Pre-Laboratory Activity:
Prepare an EXCEL spread sheet that plots $C_O(t)$ based on the above equation. Allow the variables C_{max}, L, $\bar{v}$, and D to be adjusted with ease to produce new $C_O(t)$ curves. Using the following test values plot $C_O(t)$ versus t for t = 1 to 20 seconds at 0.5 second intervals. Show that the peak arrival time and the duration of the peak are correctly reproduced on the graph. [See Chapter 3, Instantaneous Point Source in web notes].
You will hand in a copy of this graph at the beginning of class.

Test Values: $D = 0.1\ cm^2s^{-1}$, $L = 10$ cm, $C_B = 5$, $C_{max} = 40$ and $\bar{v} = 1\ cms^{-1}$.

Outline for Lab Report
1. Record the experimental set-up and procedure in sufficient detail that you could recreate the experiment ten years hence.
2. Describe the analyses used to estimate the dispersion coefficient, D, the mean pore velocity, $\bar{v}$, and the effective porosity, n_e.
3. Table of observed conductivity and a plot comparing observations to 'best fit'
4. Clearly state your estimates for D, $\bar{v}$, and n_e, with uncertainty.
5. Discussion points:
   5.1 How do you know that turbulent diffusion is not contributing?
   5.2 Describe the processes that determine the observed spread of tracer.

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