Problem 1. Point Spills

A spill of a contaminant into an aquifer has occurred. The spill was short and over a small area. The total mass of the spill is 12kg. You know from a recent study that the Darcy velocity of this aquifer is more or less uniform in one direction and of magnitude 15m/day. The effective porosity of the aquifer 0.35. Define the location where the spill occurs as $(x, y) = (0, 0)$ (in meters), where the flow is in the x direction. There are several individual home drinking wells located at $(5, 5)$, $(40, 10)$,$(100, 10)$ and $(1000, 20)$. Molecular diffusion is 1×10^{-9} m^2/s. The longitudinal dispersivity is 0.02 m. Assume the retardation coefficient is $R = 2$. Calculate concentration arriving at these wells and plot breakthrough curves. Which of residents should be most concerned about the contamination (i.e. which one will experience the highest concentrations)? Try to guess which one before you perform the calculation. Is the actual answer the same as your guess? If so, what made you pick this one and if not, why not?

Finally, imagine the retardation $R = 4$ instead. What changes? Is it the same resident as before who should be most concerned?

Problem 2. Continuous Source

There is a continuous source of BTEX leaching into an aquifer with a mean uniform background flow of Darcy velocity 2m/day. The aquifer porosity is 0.15 and the longitudinal dispersivity is 0.001m. The source aligns perpendicular to the flow and spans a width of 5 meters. Its concentration is 15g/liter. Denote the center of this source as $(x, y) = (0, 0)$

(i) In the absence of any reaction, plot how the concentrations at locations $(x, y) = (10, 0)$, $(x, y) = (10, -2)$ and $(x, y) = (10, 2)$ evolve over time until they reach their steady state value. Estimate how long it takes for them to reach that value and confirm it on your plot (i.e. I know you all hate error functions, but look closely at the erfc term in the solution and see how it behaves so that you can begin to appreciate it a little bit more - practice makes perfect and true love often starts as hate)

(ii) Now, if you needed the concentration at location $(x, y) = (10, 0)$ to be 100 times smaller than the steady state value you calculated in (i) what does the degradation rate have to be? Given this rate, how much smaller are the concentrations at the other two locations $(x, y) = (10, -2)$ and $(x, y) = (10, 2)$.

Problem 3. Creative Project

Provide me with a detailed update of what you have done so far as well as a time line of how you are going to make sure that you complete this project. Set weekly milestones and deliverables, which I then expect you to provide as the semester goes on. I would like everyone's project to be complete prior to the last week of classes so that we can actually have some fun together with them.