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1.061 / 1.61 Transport Processes in the Environment
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Problem 6.1

A small stream was found to be contaminated with Lindane, a pesticide known to cause convulsions and liver damage. Groundwater wells in the same region have also been found to contain Lindane, and so you suspect that river contamination is due to groundwater inflow. To test your theory you conduct a dye study. Based on the information given below, estimate the ground water volume flux, Q_{GW} , and the concentration of Lindane, $C_{L_{GW}}$, in the groundwater.

Station 1: A 50-mg/l solution of tracer is injected at the rate of $Q_i = 100\text{cm}^3/\text{s}$.

Station 2: Located 100-m downstream of Station 1.
Dye concentration, $C_{\text{dye}} = 10\ \mu\text{g/l}$
Lindane concentration, $C_{L2} = 0.5\ \mu\text{g/l}$

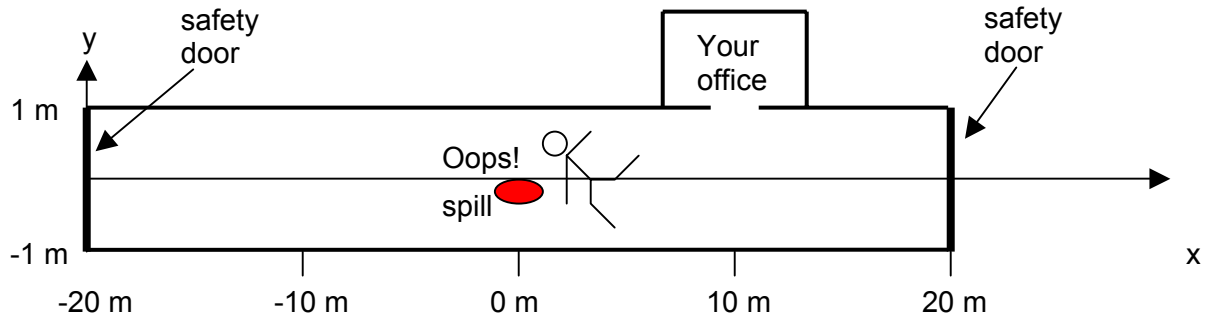
Station 3: Located 200-m downstream of Station 1.
Dye concentration, $C_{\text{dye}} = 8\ \mu\text{g/l}$
Lindane concentration, $C_{L3} = 0.9\ \mu\text{g/l}$

Problem 6.2

A clumsy professor trips and spills 1 g of chemical 10 m down the hall from your door. The hallway is 2 m wide and 2 m high. The chemical evaporates in 25 seconds. Assume isotropic turbulent diffusion $D = 0.05\ \text{m}^2/\text{s}$.

Case 1. The safety doors are closed so that there is no air current in the hall. Write an expression for the concentration at your door, justifying all assumptions. Plot the exposure concentration at your door versus time, indicating the maximum and final concentration.

Case 2. The safety doors have been propped open (bad, bad, bad), so that there is a 4 m/s breeze blowing down the hall from the spill towards your door. Calculate the magnitude and duration of the maximum concentration at your door. Sketch the concentration, $c(t)$, clearly indicating the maximum and final concentration.



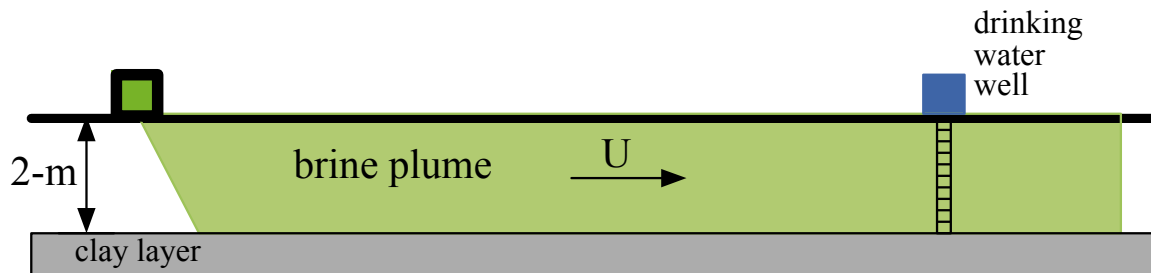
Problem 6.3

Indeck Corporation has proposed to construct a new 350 MW gas-fired power plant in Smithfield, Rhode Island. Environmental reports submitted for the plant indicate it would discharge 150 metric tons per year of carbon monoxide from a 57.9-m high stack. Your house is located 1-km downwind of the proposed stack, so you are very interested in the potential carbon monoxide exposure. Assume a steady wind of $U = 2 \text{ m/s}$, a vertical turbulent diffusion coefficient of $D_z = 1 \text{ m}^2/\text{s}$, and a horizontal turbulent diffusion coefficient of $D_x = D_y = 2 \text{ m}^2/\text{s}$.

- a. Write the equation for the carbon monoxide concentration downwind of the stack.
- b. Plot the vertical profile of concentration, $C(z)$, at your house. If your house is 10 m high, what is the maximum concentration you might experience?

Problem 6.4

Pickles are made in large wooden vats filled with brine of 10 g L^{-1} salt concentration. The base of each vat is square, 5-m to a side. At the Dill Pickle factory one of the vats begins leaking brine directly into a shallow aquifer at a rate of $0.1 \text{ m}^3 \text{ week}^{-1}$. The leaking is distributed evenly over the vat's base area. The aquifer is 2-m deep and sits atop an impermeable clay layer. The density of the brine allows it to quickly disperse over the depth of the aquifer. The Pickle Company is not concerned about losing this small amount of brine, but the community using the aquifer for drinking water is concerned. The community well is located 500-m from the vats in the direction of groundwater flow. Assess the possible impact on drinking water quality by estimating the maximum salt concentration at the well. How long after the leak begins will this concentration be reached? The transport velocity (pore velocity) in the aquifer is 10^{-6} m/s . The molecular diffusion of brine is $10^{-9} \text{ m}^2 \text{ s}^{-1}$. The longitudinal dispersion coefficient is $10^{-5} \text{ m}^2 \text{ s}^{-1}$. The lateral dispersion coefficient is $10^{-6} \text{ m}^2 \text{ s}^{-1}$.



Side View of Plume - Not to scale

Problem 6.5

Tracer is released at 10mg s^{-1} at the sidewall of a rectangular irrigation channel. The concentration is measured mid-channel at three downstream locations, $x = 20\text{m}$, 40m , and 60m . The injection starts at $t = 0$. Estimate the flow in the channel, the mean cross-sectional area, and the coefficient of longitudinal dispersion.

