RESIT Solute Transport Assessed Exercise

The Ogata-Banks solution to the advection-dispersion equation is a valuable tool for quickly and efficiently estimating solute travel distances and times in groundwater. It is often used as a range-finding method to bound the spatial and temporal extents of solute transport problems.

Scenario:

Your organization has received a report concerning a site where a leaking underground storage tank (UST) at a decommissioned fuel station has resulted in the release of petroleum hydrocarbons into the subsurface. Groundwater sampling confirms the presence of dissolved-phase BTEX compounds—specifically benzene, toluene, and xylene—originating from the tank. The tank has no secondary containment, and contamination has infiltrated the water table.

The concentrations of these contaminants in the pore water at the source zone are assumed to be at their full aqueous solubility limits, based on recent laboratory characterisation:

Compound	Aqueous Concentration (mg/L)
Benzene	1,780
Toluene	526
Ethylbenzene	152
Xylenes	198

The site is characterized by loamy, organic soil with a dry bulk density of 1.45 g/cm^3, which is assumed to be homogeneous and isotropic in its hydraulic properties. Additional site data provided includes:

- **Hydraulic conductivity**: 2.65 x 10^{-5} m/s
- **Effective porosity**: 0.38
- **Hydrodynamic dispersion coefficient**: 7.2 x 10^{-2} m^2/day
- **Hydraulic gradient**: -0.042

Sorption data for TCE is also provided in a spreadsheet to calculate the retardation factor (R) for the contaminant in the soil.

As the newly appointed contaminant hydrogeologist on the team, your task is to conduct a preliminary transport assessment for the BTEX compounds released from the leaking underground storage tank. A sensitive receptor located 40 m downgradient in the direction of groundwater flow. Your supervisor has requested a concise, technically clear memo that evaluates the predicted spatial extent of each dissolved-phase BTEX contaminants at this distance at two time points. This information will support the early-stage risk assessment and help determine whether remedial action is required.

A batch equilibrium test has been conducted, though not yet validated. Your supervisor has asked that you perform both a one-dimensional conservative solute transport analysis (without sorption) and a second analysis incorporating sorption kinetics. Both results should be reported to provide a range of possible solutions.

ENVI 1195 Contaminant Hydrogeology and Groundwater Remediation Assessed Exercise
RELEASE DATE: DUE DATE:

Using the Ogata & Banks (1961) solution, create a memo that clearly and professionally communicates the answer the following questions:

1. *What is the estimated R factor (R) for TCE in the soil at the site for each of the components (Benzene, Toluene, Ethylbenzene and Xylene)?*
2. *From the results of your stochastic model, plot absolute concentration profiles downgradient for each component at 60 days, 120 days and 180 days, to be attached to your memo as an appendix.*
3. *Interpret the transport behaviour of each compound. Comment on potential legal, health and environmental implications at downgradient receptors.*
4. *Recommend appropriate next steps for site investigation or mitigation, including suggested time frames for intervention, based on your hydrogeological interpretation*

Include, as an appendix, a calculation spreadsheet, authored by you and clearly notated as supporting evidence for your engineering advice.

Your written memo should be no longer than one page (single-spaced). Introduce the problem, describe the scenario, and present the relevant data. Address points 1 through 4, ensuring that all necessary information is provided for your employer. You may include plots as additional pages and upload your spreadsheet containing your stochastic mode , as this will demonstrate your procedure and may help identify any calculation errors.

DUE DATE:

Tips:

- ***Pay attention to units!***
- ***Breaking the Ogata-Banks solution into terms can minimize calculation errors in the spreadsheet.***

Ogata-Banks (1961)

$$C = \frac{C_o}{2}\left[erfc\left(\frac{x - \left(v/_R \right) t}{2\sqrt{Dt/_R}} \right) + \exp\left(\frac{vx}{D} \right) erfc\left(\frac{x + \left(v/_R \right) t}{2\sqrt{Dt/_R}} \right) \right]$$

$$\operatorname{erfc}(x) = \frac{2}{\sqrt{\pi}} \int_x^{\infty} e^{-t^2}\, dt$$

Batch Sorption Test Results

Benzene		Toluene		Ethylbenzene		Xylene	
Csolution	C*	Csolution	C*	Csolution	C*	Csolution	C*
mg/L	ug/g	mg/L	ug/g	mg/L	ug/g	mg/L	ug/g
60	1.72	60	2.7	60	3.68	60	4.66
60	2.36	60	3.71	60	5.06	60	6.4
60	1.18	60	1.85	60	2.52	60	3.2
40	1.4	40	2.2	40	2.99	40	3.79
40	1.12	40	1.76	40	2.4	40	3.03
25	0.8	25	1.25	25	1.71	25	2.16
25	0.84	25	1.31	25	1.79	25	2.27
25	0.8	25	1.25	25	1.71	25	2.16
15	0.55	15	0.87	15	1.19	15	1.51
15	0.43	15	0.68	15	0.93	15	1.18
15	0.53	15	0.84	15	1.14	15	1.45
8	0.26	8	0.4	8	0.55	8	0.7
8	0.22	8	0.35	8	0.47	8	0.6
8	0.18	8	0.28	8	0.38	8	0.48
5	0.17	5	0.27	5	0.36	5	0.46
5	0.21	5	0.34	5	0.46	5	0.58
3	0.14	3	0.22	3	0.3	3	0.37
3	0.015	3	0.24	3	0.32	3	0.41
3	0.11	3	0.17	3	0.24	3	0.3
1	0.03	1	0.05	1	0.06	1	0.08