Solutions

1/7

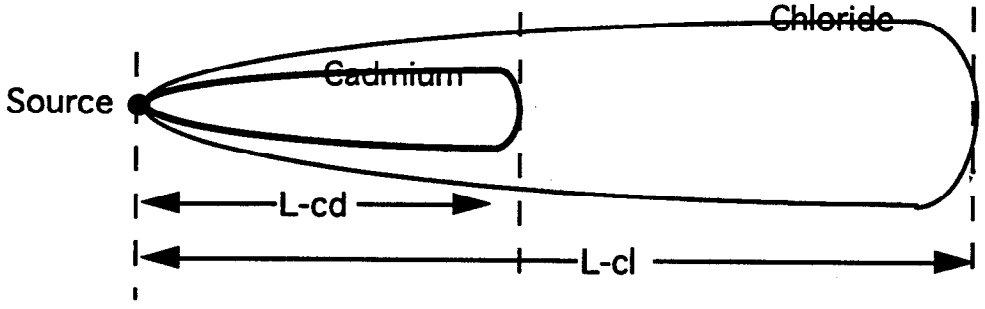
CE6361 Groundwater Hydrology , HW#7, Fall 1993 Due: _____

1) The following equilibrium data were obtained for Rhodamine-6G onto Beaumont Clay. Determine an appropriate isotherm and estimate the constants for the data set.

Rhodamine 6G onto Coastal Center Clay		
1/4/93		
Procedure:	Batch Isotherms, 24 hours	
Analysis:	Fluorometric assay	
Initial C(mg/L	Final C(mg/L)	C*(mg/g)
1	0	0.04
2.5	0	0.1
5	0	0.2
7.5	0	0.3
15	0.001	0.6
25	0.003	1
50	0.006	2
125	0.02	4.9
300	0.053	11.998
500	0.103	19.996
625	0.153	24.994
750	0.229	29.991
1000	0.406	39.984
1250	0.58	49.977
1750	1.138	69.954
2000	5.8	79.768
2500	55.536	97.779

2) What is the retardation coefficient if the solids density of clay is 2.79 g/mL, and the porosity is 53%?

3) In a plan view of a contaminant plume you notice that chloride has moved approximately L-cl meters while cadmium has moved only L-cd meters. Assuming both species were released at the same time, find the distribution coefficient for cadmium if the porosity is n and the solids density is ρ. Assume linear, instantaneous, equilibrium adsorbtion.



4) Use your solution above to determine the numerical value of the distribution coefficient if the chloride plume is 200 meters long, the solids density is 2.65 g/cubic centimeter, and the porosity is 21%.

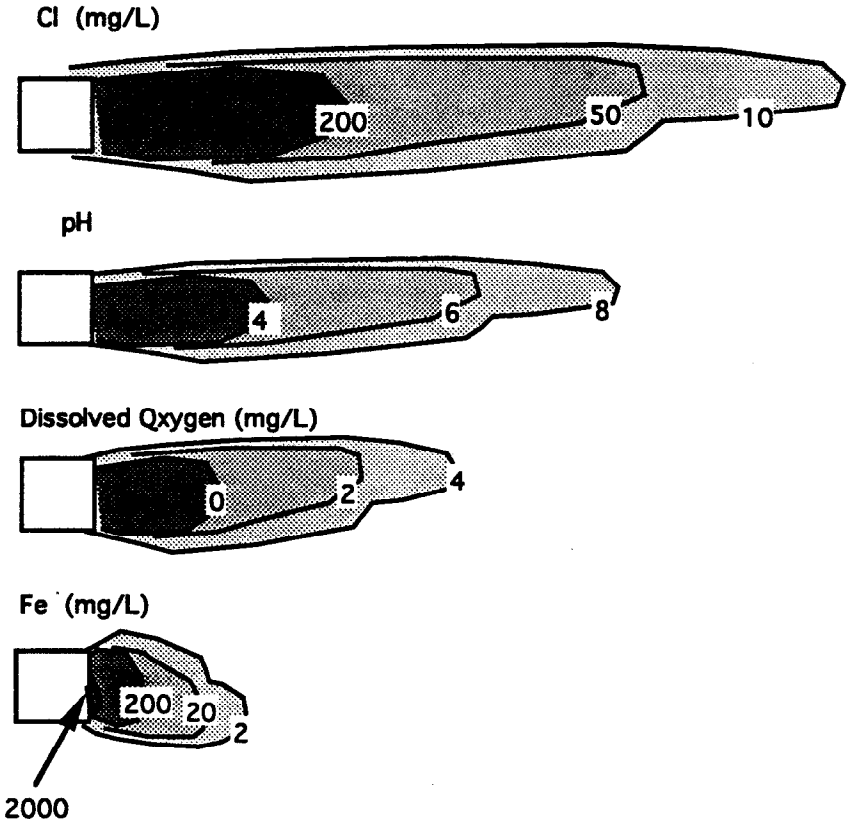
5) The figure below shows a series of plumes from a sanitary landfill. Examine the plumes in detail and answer the following questions (keep your environmental chemistry class in mind).

a) Evaluate in a qualitative manner the extent to which advection and dispersion are important in controlling contaminant spread at the site.

b) Given the type of source and the resulting plume shapes, what can be said about the type of source loading?

c) Suggest what processes are operating to cause the pH to increase away from the source.

d) Metals are relatively abundant in landfill leachates - however Fe^{2+} is often strongly attenuated relative to a mobile species like Cl^-. Explain why iron behaves this way at the site.



1) see attached spreadsheet

appropriate isotherm - Longmuir

(Freundlich or Tóo!)

NOT LINEAR

$$\text{Slope} = \frac{0.011 - 0.004}{0.6} = 0.0116 = \frac{1}{\beta}$$

$$\beta = 85.7$$

$$\text{Intercept} \approx 0.004 = \frac{1}{\alpha\beta}$$

$$\beta\alpha = 250 \qquad \alpha = \frac{250}{85.7} = 2.9171$$

2) $$R = 1 + \frac{1-n}{n} \rho_s \left(\frac{\alpha\beta}{(1+\alpha C)^2} \right)$$

$$R(C) = 1 + \left(\frac{1-0.53}{0.53}\right)(2.79)\frac{250}{(1+2.9171C)^2}$$

$$= 1 + \frac{618.53}{(1+2.9171C)^2}$$

Assume some "limiting" C, say 5 mg/L

$$\Rightarrow R_5 = \frac{3.546}{1.909} \qquad R_{10} = \frac{1.739}{1.679} \qquad R = 41.31$$

High concentrations less retarded than low concentration

3) $R = 1 + \frac{1-n}{n} \rho_s K_d$

let L_{Cl} = distance Cl moved

L_{Cd} = distance Cd moved

Chloride is conservative tracer $\Rightarrow R_{Cl} = 1$

$$R_{Cd} = \frac{V_{Cl}}{V_{Cd}}$$

$$L_{Cl} = V_{Cl} \cdot t \qquad L_{Cd} = V_{Cd} \cdot t \longrightarrow \frac{L_{Cl}}{L_{Cd}} = R_{Cd}$$

So: $R_{Cd} = 1 + \frac{1-n}{n} \rho_s K_d$

$$\frac{(R_{Cd} - 1)\frac{n}{1-n}}{\rho_s} = K_d$$

$$\Rightarrow \left(\frac{\frac{L-Cl}{L-Cd} - 1}{\rho_s}\right)\left(\frac{n}{1-n}\right) = K_d$$

4) Assume drawing to scale

$$\left(\frac{\left(\frac{110}{51}\right) - 1}{2.65}\right)\left(\frac{.21}{1-(1.21)}\right) = 0.116$$

5 a) Advection carries plume from landfill, conc. gradient of shallow slope along axis of plume suggests significant longitudinal dispersion

Plume spreads laterally very little, negligible transverse dispersion

b) Source loading is continuous since there is no point in the plume that decreases in direction of the source

Cl^-, pH, and DO depletion plumes suggest uniform source within landfill.

Fe plume appears to come from a point source within the landfill

c) Organic material in landfill uses oxygen and produces organic acids. The low pH facilitates Fe dissolution as does the low oxygen (reducing environment).

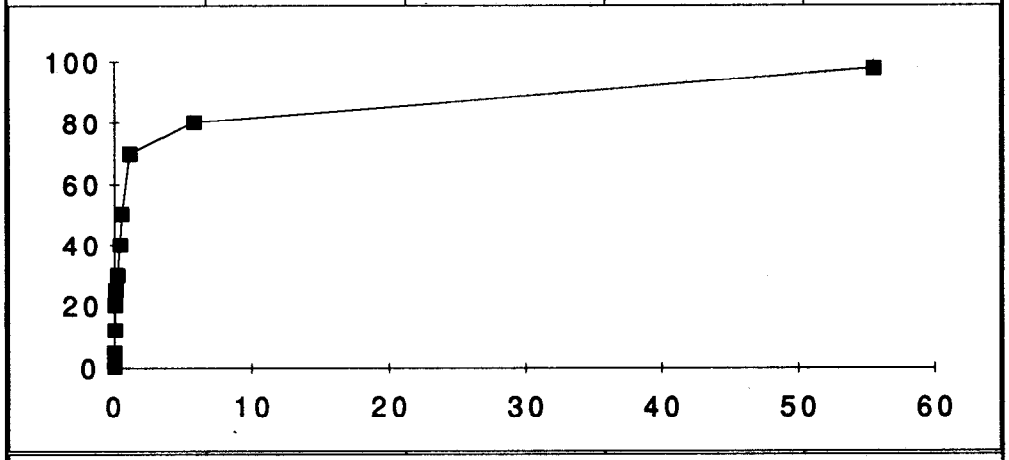
d) In low DO conditions Fe^{2+} is dominant Fe form, soluble and mobile.

As DO ↑, Fe^{2+} oxidized to Fe^{3+}, less soluble and precipitates onto solids.

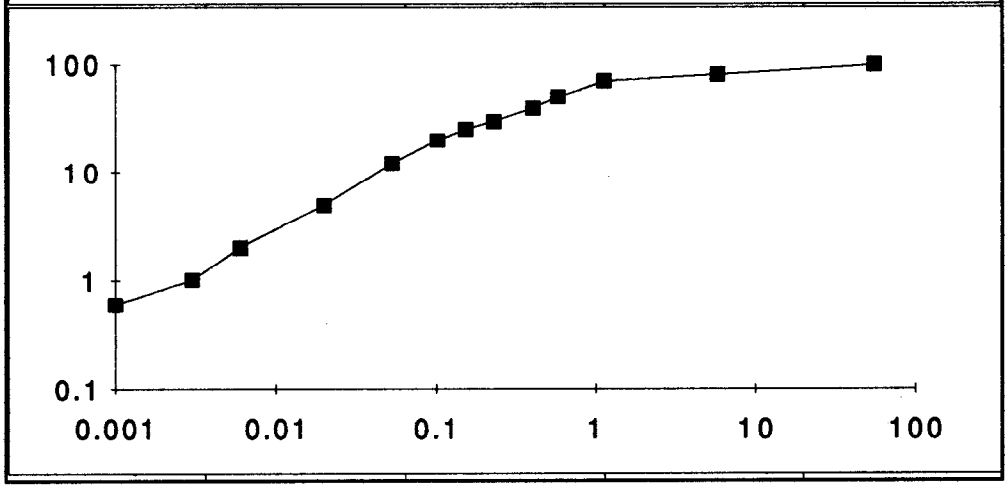
Plume is total Fe — The oxidation potential of water controls the mobility of this plume.

6/7

HW7#1				
C(mg/L)	C*(mg/g)	C/C*		
0	0.04	0		
0	0.1	0		
0	0.2	0		
0	0.3	0		
0.001	0.6	0.00166667		
0.003	1	0.003		
0.006	2	0.003		
0.02	4.9	0.00408163		
0.053	11.998	0.0044174		
0.103	19.996	0.00515103		
0.153	24.998	0.00612049		
0.229	29.991	0.00763562		
0.406	39.984	0.01015406		
0.58	49.977	0.01160534		
1.138	69.954	0.01626783		
5.8	79.968	0.07252901		
55.536	97.779	0.56797472		

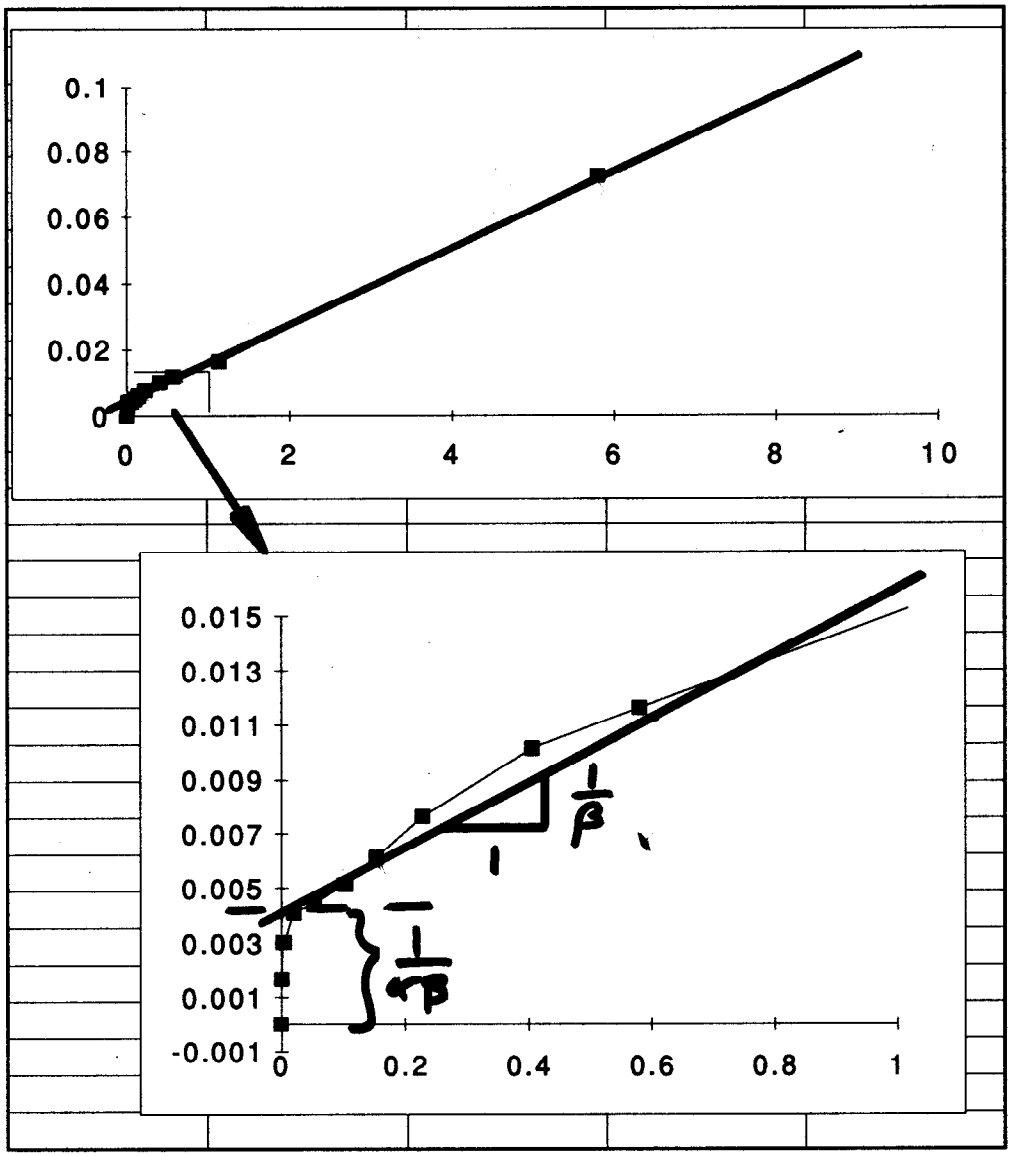


LEA



Freundlich

7/7


0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
0.015
0.013
0.011
0.009
0.007
0.005
0.003
0.001
-0.001
0
0.2
0.4
0.6
0.8
1
1
1/β
1/qβ

Langmuir