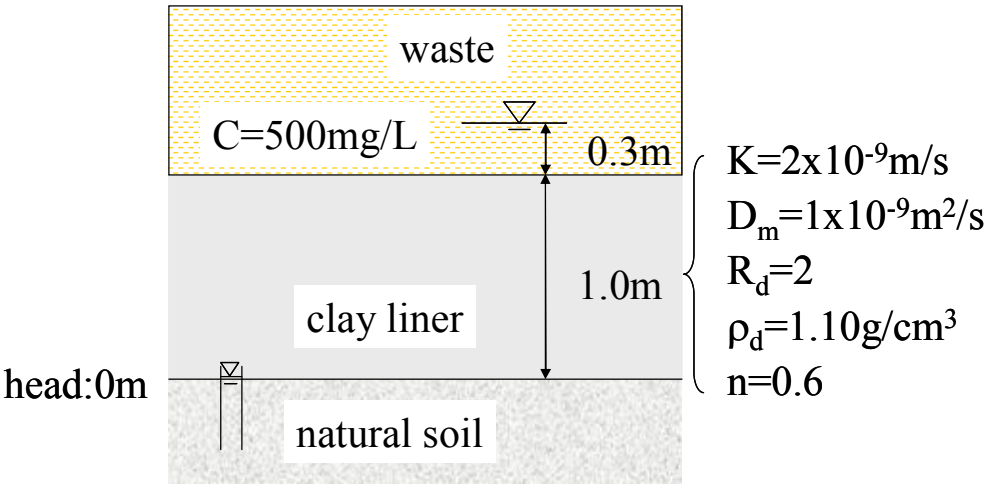
Final exam. Geoenvironmental Engineering

1. Consider a clay liner of waste landfill overlaying a natural soil as shown in the bottom figure. Using the following conditions and assuming that the step function type boundary conditions can be reasonably applied in this situation, answer the following questions. (50)

(*to answer the questions (6) to (8), use the attached charts Fig.1 and Fig.2*)

- Thickness of clay liner: L=1m
- Leachate height over the clay liner: 0.3m
- Hydraulic head of natural soil below the liner: 0m from the surface of the natural soil
- Concentration of hazardous solute in the leachate: C_0=500mg/L
- Hydraulic conductivity of clay: $K=2\times10^{-9}$m/s
- Free water diffusion coefficient of the solute: $D_0=1\times10^{-8}$m^2/s
- Effective diffusion coefficient of the solute in the clay: $D_m=1\times10^{-9}$m^2/s
- Porosity of clay: n=0.6; Dry density of clay: ρ_d=1.1g/cm^3,
- Mean diameter of clay particle:$D_{50}=2.0\times10^{-6}$m
- Coefficient of retardation of the solute in clay: R_d=2
- Allowable concentration of the solute at the bottom of liner: less than 50mg/L
- Allowable mass flux of the solute at the bottom of line: less than 3g/(m^2·year)
- Life span of the landfill: t_d= 30 year

(1) How much are the density of soil grain (ρ_s), and saturated density (ρ_{sat}), the void ratio (e) and water content (w) of the clay?
(2) How much is the apparent tortuosity factor (τ_a) of the clay?
(3) How much is the partitioning coefficient (K_d) of the solute on the clay?
(4) Calculate the time for the solute to reach the bottom of liner with no dispersion condition, i.e., D_m=0.
(5) Estimate the micro scale Peclet number and explain why the mechanical dispersion can be negligible in the process of contaminant transport in clay.
(6) Calculate an approximate time when the concentration at the bottom of the liner reaches the allowable limit.
(7) Obtain an approximate thickness of clay liner for which the concentration at the bottom of the liner reaches the allowable limit at the time of the life span of the landfill (t_d).
(8) Examine whether the mass flux at the bottom of the clay liner obtained above satisfies the allowable value at t_d.



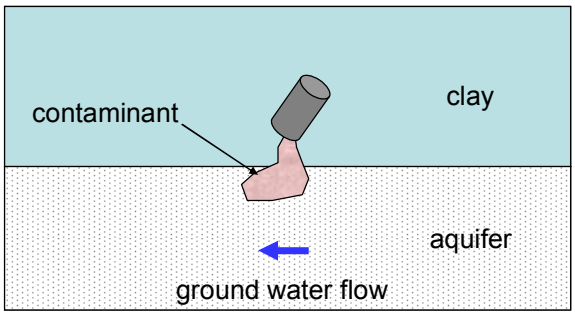
Clay liner above natural soil layer

2. Choose one question from the following two and answer it. (25)

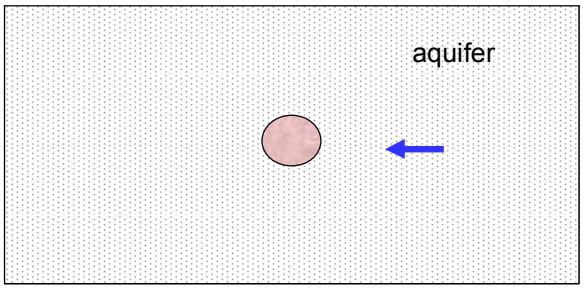
(1) Explain the following terms in hydrogeology and geoenvironment engineering
(1)confined aquifer, (2) transmissivity, (3) intrinsic permeability, (4) composite liner

(2) From the principle on miscible contaminant transport mechanisms, derive the one-dimensional advection-dispersion equation for the case with neither sorption nor bio-chemical reaction.

3. Due to a leakage of contaminant from a container buried in a clay layer, an aquifer below the clay is in danger of pollution. Discuss the possible remediation work on this site. You can assume the conditions which are required in the planning and execution of the remediation. (25)



Cross section



Plan