# Final exam. Geoenvironmental Engineering

1. Consider a natural clay liner of waste landfill overlaying an aquifer as shown in the bottom figure. Using the following conditions and assuming that the step function type boundary conditions (Concentration of solute, C =0 at t=0, C at the top of clay layer is fixed C_0) can be reasonably applied in this situation, answer the following questions. (50)

    (*to answer the questions (5) to (9), use the attached charts Fig.1 and Fig.2*)

    ・Leachate height over the clay liner: 0.3m,

    ・Hydraulic head of the aquifer below the liner: 4.3m from the bottom of the clay layer,

    ・Concentration of a hazardous solute in the leachate: C_0=1,000mg/L,

    ・Hydraulic conductivity of clay: K=1x10^{-8}m/s,

    ・Free water diffusion coefficient of the solute: D_0=1x10^{-8}m^2/s,

    ・Effective diffusion coefficient of the solute in the clay: D_m=2x10^{-9}m^2/s,

    ・Porosity of clay: n=0.55; Dry density of clay: ρ_d=1.2g/cm^3,

    ・ Mean diameter of clay particle:D_{50}=3.0x10^{-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) Obtain the concentration profile of the solute at time of 20 years

    (7) Obtain the time at which the concentration of the bottom of the clay liner becomes the allowable limit.

    (8) Obtain the time at which the mass flux at the bottom of the clay liner becomes the allowable limit.
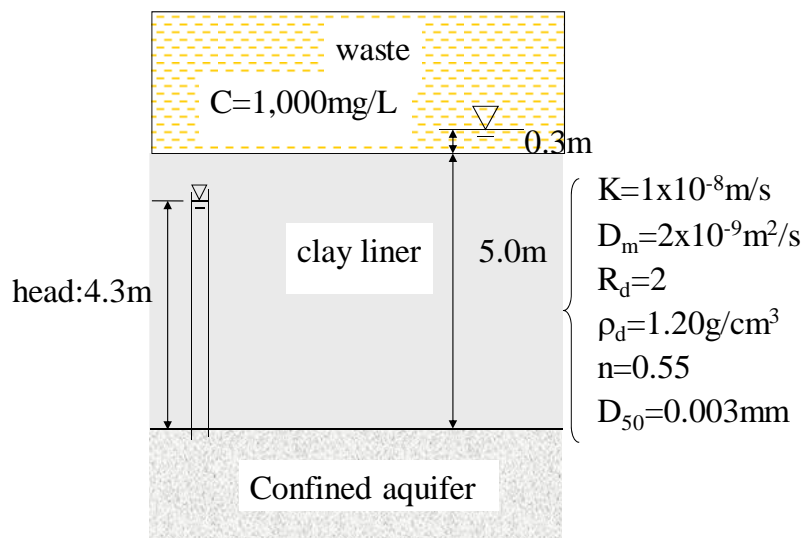
Natural clay liner above natural soil layer

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

(1) Explain the following terms about hydrogeology

   1) artesian aquifer, 2) transmissivity, 3) intrinsic permeability

(2) Draw the structure of the common sanitary landfill with basic components and explain the function of each component.

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

(1) Ex-situ remediation, i.e., excavating and treating contaminated soils, are the most commonly used remediation methods for soil contamination. Explain the reasons why the ex-situ methods are more common than the in-situ methods.

(2) Assuming any conditions of ground or ground water contamination, propose remediation program for the contaminated site.