지하수및토양오염

Physical transport of chemicals

♠ Mass balance expression

o Change in storage of mass

= mass transported IN - mass transported OUT

+ mass PRODUCED by sources - mass ELIMINATED by sinks

o Rate of change in storage of mass

= mass transport rate in - mass transport rate out

+ mass production rate by sources - mass elimination rate by sinks

(* rate = mass per time [M/T])

☞ *If storage does not change with time the left-hand sides are zero*

---> steady state

♠ Types of mass transport

1) Advection

- mainly resulting from bulk, large scale movement of a medium
  (e.g.) wind blows, water flows,....
- so, transported at the same velocity as the fluid
  macroscale view; center of mass of chemical moves by advection
  microscale view; Fickian transport occurs at the same time
- *convection*; often vertical advection (but, considered almost a similar term)
- flux density (J); mass of chemical transported across an imaginary surface of unit area per unit of time

$$J = CV$$

J [M/L^2T]
C [M/L^3]; chemical concentration
V [L/T]; fluid velocity

- in ground water, V is the Darcy flux of water

$$J = C(nv_p)$$

n; porosity
v_p; seepage (pore) velocity

2) Fickian transport

o Turbulent diffusion ("eddy diffusion")

- resulting from random mixing of air or water by eddies
- carries mass in the direction of decreasing chemical concentration
  (e.g.) dye blob injected into a river
- important in surface water and air (not considered in the subsurface)
- use Fick's first law to describe

$$J = -D(dC/dx)$$

J [M/L^2T]
D; turbulent diffusion coefficient
C [M/L^3]; chemical concentration
x [L]; distance over which a concentration change is considered

o (Mechanical) Dispersion

- fluctuations in the velocity field at scales smaller than advection
- ground water flow;
  - no eddies present due to its low velocity
  - but still random detours exist, causing mixing chemicals
- transport of a chemical from regions of higher to lower concentration
- use Fick's first law to describe

$J = -D_{mechanical}(dC/dx)$

J [M/L^2T]

D; mechanical dispersion coefficient

C [M/L^3]; chemical concentration

x [L]; distance over which a concentration change is considered

o Molecular diffusion

- random movement of chemical due to local concentration gradient
- lower flux density compared to other Fickian transport processes
- use Fick's first law to describe

$J = -D_{molecular}(dC/dx)$

J [M/L^2T]

D; molecular diffusion coefficient

C [M/L^3]; chemical concentration

x [L]; distance over which a concentration change is considered

- not related to turbulence (eddies) or obstructions (particles) but dependent on molecular properties (primarily, size) and temperature

※ For the subsurface transport of chemical, advection, dispersion, and molecular diffusion are considered. In addition, POROSITY should be included.

$J = J_{adv} + J_{dis}$

where $J_{adv} = C(nv_p)$

$J_{dis} = \{-nD(dC/dx)\}$ (n; porosity)

$D = D_{mechanical} + D_{molecular}$

※ So far, one-dimensional situation is considered. But, in most cases, flow is anisotrophic;

(e.g.) flow direction vs. perpendicular to flow,
homogeneous medium vs. heterogeneous medium,
time