UNIT III

TRANSPORT OF CONTAMINANTS

3.1 Contaminant transport in sub surface

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Advection in contaminant transport

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Advection, Diffusion, Dispersion – Governing equations

TRANSPORT OF CONTAMINANTS

3.1 Contaminant transport – Advection, Diffusion, Dispersion

Introduction to contamination transport

Contamination of subsurface soils and ground water formations is a pervasive environmental problem that has proven to be extremely difficult to remediate. Cleanup of contaminated subsurface environments is complicated both by the physical nature of the formation and the behavior of contaminants introduced to the formation.

The myriad of materials that have been introduced to the subsurface environment have resulted in excessive levels of heavy metals, organic and inorganic chemicals and bacteriological agents. The contaminant materials can exist in the subsurface in different phases; attached to the soil solids, dissolved in the ground water, or occupying the pore spaces as a separate gaseous or liquid phase. Properties of the phase(s) in which contaminant materials exist in the subsurface influence the potential mobility of the contaminants.

What is the contamination transport?

Once a chemical enters the subsurface several transport mechanisms occur that aid in the spreading of the contamination. These mechanisms include diffusion, advection, mechanical dispersion, and hydrodynamic dispersion.

What is diffusion in contaminant transport?

Diffusion is the process by which a contaminant in water will move from an area of greater concentration toward an area where it is less concentrated.

What is advection in contaminant transport?

Advection refers to the transport of contaminants at the same speed as the average linear velocity of groundwater.

What is dispersion in contaminant transport?

Dispersion is the spreading in longitudinal and transversal direction due to the complex movement of particles through tortuous pores with varying microscopic velocities.

Advection, Diffusion, Dispersion – Governing equations

The advection equation is the partial differential equation that governs the motion of a conserved scalar field as it is advected by a known velocity vector field. It is derived using the scalar field's conservation law, together with Gauss's theorem, and taking the infinitesimal limit.

The advection equation

$$D\frac{\partial^2 c}{\partial x^2} - v\frac{\partial c}{\partial x} = R\frac{\partial c}{\partial t}$$

Advection term

$$v = -\frac{K}{n_e}\frac{dh}{dx}$$

n_e – effective porosity

- Advection causes translation of the solute field by moving the solute with the flow velocity
- In 1-d all is does is shift the plume in time by a distance $v\Delta t$. It does not change the shape at all

Dispersion Equation

$$D\frac{\partial^2 c}{\partial x^2} - v\frac{\partial c}{\partial x} = R\frac{\partial c}{\partial t}$$

Dispersion term

$$D = D_{mol} + D_{mech}$$

- Dispersion causes 'spreading' of the solute plume
- It is composed of both molecular and mechanical dispersion (that can not be distinguished on the Darcy scale)

Diffusion Equation

- **Diffusion** describes the spread of particles through **random** motion from regions of higher concentration to regions of lower concentration.
- Fick's Law - diffusive flux $F_D = D_{mol} \frac{dC}{dx}$
- The diffusion coefficient depends on the materials, temperature, electrical fields, etc.
- Measured in the Lab
- Typically not as large as mechanical dispersion (but this is context specific)