A Study On Dispersion, Pore Water Velocity And Moisture Content Relationship In The Porous Medium

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1. INTRODUCTION:

The role of the unsaturated zone in solute transport has attracted the attention of the many researchers in recent years. This is due to the fact that most often the solute reaches the ground water after first moving through the unsaturated zone. Miscible displacement experiments in the glass beads column were carried out to study the dispersion phenomena of the solute in the porous medium. Electrical conductivity was monitored using electrical probes to detect the change in concentration with respect to time and space inside the column.

2. THEORY:

One-dimensional steady state flow of non reacting solute through the porous medium with constant moisture content is, usually, described by ,

$$\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial z^2} - v\frac{\partial C}{\partial z} \qquad (1)$$

where C^* is concentration of solute (g/cm^3), D is the dispersion coefficient, (cm^2/sec), $v = q/\theta$, the pore water velocity, q is Darcy flux (cm/sec), θ is the moisture content (cm^3/cm^3), t is time (sec) and z is the space coordinate (cm). With dimensionless variables and relative concentration (at exit point) as define respectively,

$$Z = z/L,\ T = vt/L,\ B = vL/D \qquad (2a)$$

$$C_e = (C-C_i)/(C_0-C_i) \qquad (2b)$$

The solution of the above equation (1) with appropriate boundary and initial conditions is

$$C_e = 1-\frac{1}{2}[\mathrm{erfc}\{\frac{\sqrt{B}}{2\sqrt{T}}(1-T)\} + \exp(B)\mathrm{erfc}\{\frac{\sqrt{B}}{2\sqrt{T}}(1+T)\}] \qquad (3)$$

where erfc is complementary error function

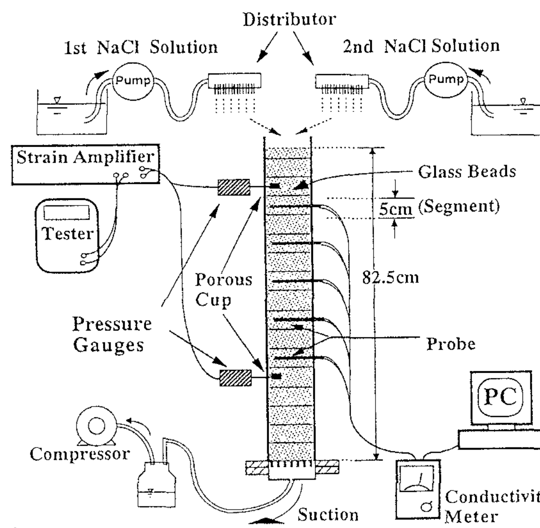

Fig. 1: Experimental Setup

3. EXPERIMENTAL METHODS:

Glass beads were mixed thoroughly with a solution having certain electrical conductivity. Probes were stacked and filled with this glass beads one by one. The solution with the same conductivity was applied over the media (with distributors connected to solution container via the pump) and suction was applied at the bottom of the media to keep the moisture content inside the column uniform (Fig. 1). To establish the steady state condition, a constant flow was used until the rainfall rate was equal to that of discharge from the bottom. When the steady state condition was reached, another solution with higher conductivity was applied at the same rate as a displacing solution. Electrical conductivities with respect to time were measured by using probes connected to the conductivity meters . At the end of the experiment, each 5cm column was cut and the inside beads and solution was used to determine the moisture content by gravimetric method. This was done to check homogeneity of the moisture content inside the column.

4. ANALYSIS; RESULTS AND DISCUSSION:

Fig. 2 shows the break through curves (BTCs) as an example of one of the experiment. Pore water velocity, the mean travel time taken by the solution to reach a certain location, was determined from the BTC of each probe. For each experiment, from the known value of Darcy flux and pore water velocity, mobile water content was determined. It was found almost equal to the total moisture content determined by grvimetric method. It means there was almost no immobile water, which is usual for a non- aggregated case as ours. Dispersion coefficient was estimated using the minimum value of the sum of the square of the

*Electrical conductivity ($\mu S/cm$) was used in our analysis insted of concentration, as they are linearly related.

difference between observed and estimated values (using equation. 3) of the solution conductivities for all the probes. In Fig. 2 estimated BTCs are shown by solid lines. Good fittings were obtained.

In Fig. 3, dispersion coefficients obtained from a series of experiments (by changing the applied rainfall rate and suction) are plotted against the pore water velocities and moisture contents. Dispersion coefficients were found increasing with pore water velocity as well as with moisture content under unsaturated condition. Dispersion coefficients were, however, found smaller for saturated than that of unsaturated case for the same pore water velocity.

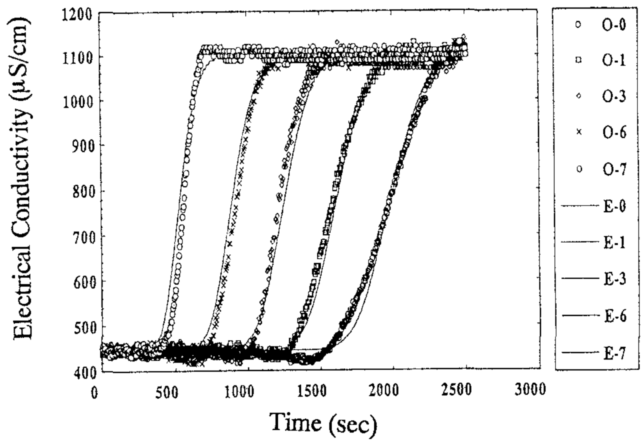

Fig. 2 : Electrical Conductivity vs Time Under Unsaturated Condition

Previous investigators (e.g.[1]) found higher dispersivity in unsaturated condition than saturated condition. They assumed it was due to the presence of mobile and immobile water phases and solute transfer between the solution and soil particles. Glass beads are non-reactive and even without immobile water, the dispersion coefficient was found higher. It means dispersion coefficient is not only the function of pore water velocity (e.g. [2]) or moisture content (e.g. [3]) but also depends on some other factors. In unsaturated condition some pores are completely filled with water and some are partially filled while others are empty. The flow can take different paths under this condition while under

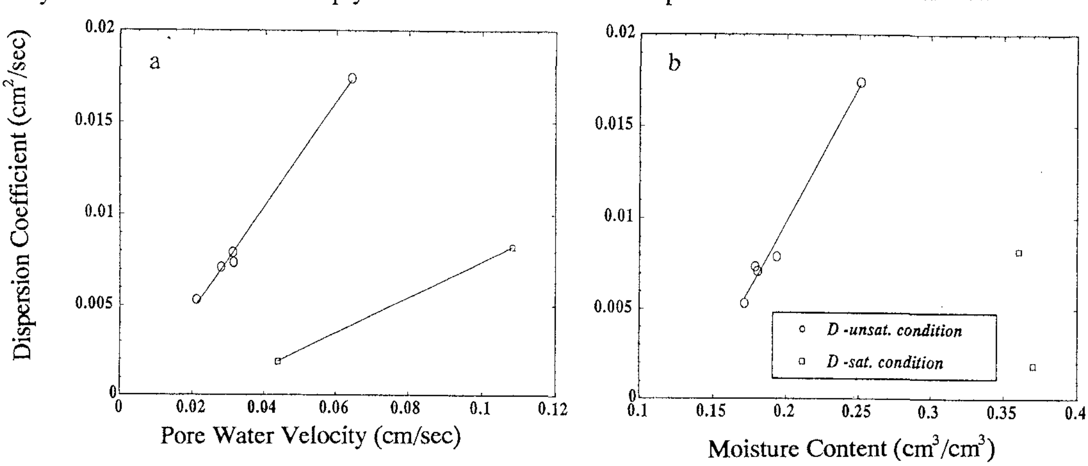

Fig. 3 : Dispersion Coefficient vs Pore Water Velocity and Moisture Content

saturated condition flow paths are more or less well defined. One possible factor may, thus, be the flow pattern which in turn depends on degree of saturation. It should be discussed in order to link the dispersion phenomena under saturated and unsaturated conditions.

5. CONCLUSIONS:

The main conclusions are:

1. No immobile water was found in glass beads medium.
2. Dispersion coefficient was found increasing with increasing pore water velocity.
3. Dispersion coefficients was found smaller in saturated cases than unsaturated cases.

6. REFERENCES:

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