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An Investigation of Solute Transport through Unsaturated Soil Exposed to Evaporation

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1. INTRODUCTION

Evaporation of water from the soil surface creates an upward soil water potential gradient; in response to this gradient, water is transported from deeper in the profile toward the soil surface where it evaporates and species dissolved in it concentrate or precipitate (Zawislanski et al 1992). This study presents a new method for predicting upward solute movement in unsaturated soil due to evaporation. For the purpose, ventilated box method was used for describing precisely the evaporation rate. Applicability of chemical analytic techniques were studied. Also, velocity profile of groundwater in vadoze zone was estimated.

2.MEASURING APPARATUS

Figures 1 and 2 schematically show the measuring equipment. It mainly consists of three units: ***A***. a ventilated chamber ***B***. a soil box, and ***C***. an evaporation rate measuring equipment developed by Mohamed et al. (1998). The main idea of the equipment is, if some part of the ground surface is covered by a box made of transparent sheet and the air is injected one side and exhausted from the other side, the absolute humidity of the air increased when the vapor is coming out from the ground surface by evaporation or transpiration.

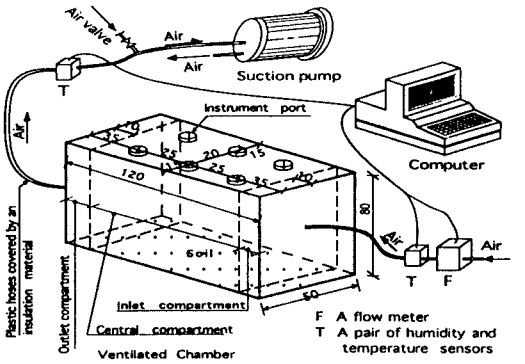

Fig. (1) Schematic view of the evaporation measuring equipment.

3. EXPERIMENTAL WORK

Laboratory test was carried out on fine sand (Toyoura standard sand) lasting 14.25 days. Sodium chloride solution of 45 g/l was supplied through the groundwater supply tank. A groundwater table was provided at 38 cm depth from the soil surface, the volumetric flow rate of air in the ventilated chamber was constant at 15.0 l/s, and the air temperature was stabilized at 23 °c. At the end of the experiment, two adjacent soil samples were taken at several depths over the height of the soil to estimate the water content and NaCl concentration, one sample for each.

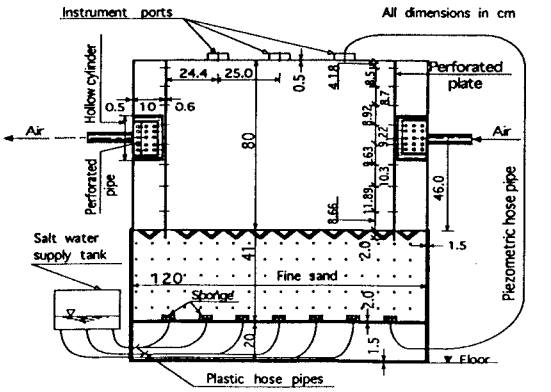

Fig. (2) Longitudinal section through chamber over the soil box.

4. RESULTS AND ANALYSIS

From the measured relative humidity and temperature of air before and after leaving the ventilated chamber, the volumetric flow rate of the air, and the area covered with the chamber, we could estimate the evaporation rate as shown in Fig. 3 and its average value was 3.13 mm/d. The moisture profiles were estimated as in Fig. 4 and it showed an excellent agreement with experimental data. Using the numerical

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technique (F.E.M.), the pore-water velocity distribution as in Fig. 5 was estimated, the solute (NaCl) concentration was estimated over the depth, both of the measured and calculated values were plotted verses height above the groundwater table for comparison as in Fig. 6. The figure shows a good agreement between the measured and the fitted data.

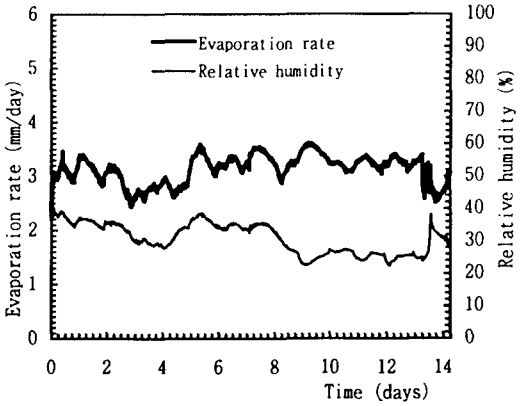

Fig. (3) Evaporation rate and relative air humidity during experiment.

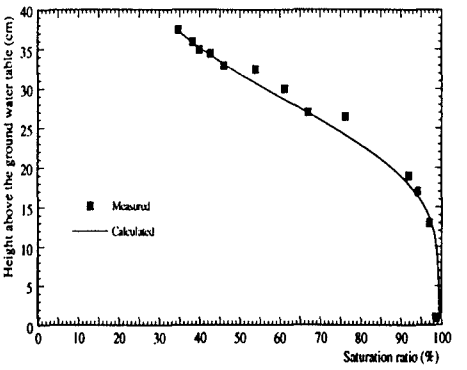

Fig. (4) Measured and the calculated moisture profiles at the end of experiment.

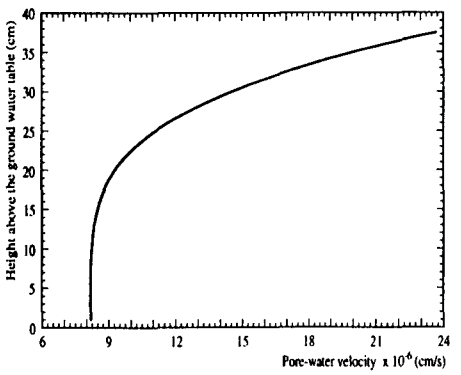

Fig. (5) Upward pore-water velocity profile during experiment.

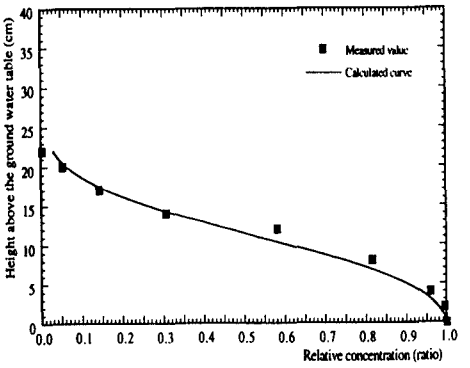

Fig. (6) Measured and calculated concentration profiles at the end of the experiment

5. CONCLUSIONS

The evaporation rate could be accurately measured during the time of the experiment using a new ventilated chamber system. The excellent description of the data indicates the possibility to apply the classical convection-dispersion equation to transport in the unsaturated homogeneous column. Also, an accurate estimation of the arrival times of the solute that moving upward in the vadose zone was predicted.

6. REFERENCES

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