SALINE WATER MOVEMENT BY EVAPORATION AND ITS EFFECT ON EXCHANGEABLE CATION STATUS

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INTRODUCTION

This study focuses on basic processes of water and salt transport under evaporation in the unsaturated zone capillary action is often the mechanism leading to salination in an evaporative environment.The objective of this study is to verify theoretical assumptions by experiments. This study emphasized the movement of salt and solutes due to capillary rise and subsequent evaporation.

MATERIALS AND METHODS

The soil used for this experiment was analyzed and determined (Table1) according to the limits. After air-drying, the soil was passed through a 2-mm screen, throroughly mixed, and packed in 5-cm diameter PVC cylinders which were segmented (5cm) each into 8 equally sliced parts to keep a total height of the column at 40 cm. The bottom of each column was placed in a tank filled with NaCl (170 m eq/l) solution so that the lower 2 cm of the column was permanently submerged. The surface of the tank was insulated in such a way that only the soil surface was exposed for evaporation (Fig.1). A set of 8 such columns was prepared for the experiments.The evaporation rate was measured by means of an electronic weighing device and an average temperature of 25° C was kept during the experiment.

Soil type KAOLINITE

$Al_2 Si_2 O_5 (OH)_4$

Table 1 : Soil analysis.

Ca++: 3.72 C mol (+)/kg	Mean diameter: 0.292mm
Mg++: 0.67 "	Porosity: 0.32
Na+ : 0.15 "	Hydraulic conductivity:
K+ : 0.12 "	$K=1.4x10^{-4}$cm/s
C E C : 4.66 m eq/100g soil	Dispersivity·
pH : 5.3 in water	0. 00058 cm2/s

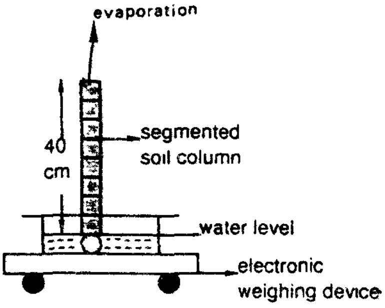

FIG. 1 experimental set-up

The soil in one 40 cm column was analyzed after a day of evaporation and other columns were analyzed with an interval of 2 days . Each segment of 40 cm columns was analyzed for moisture content and the solute was extracted by fractional distillation under vacuum. Exchangeable cations in soil as well as cation concentration in the soil solution were determined by Atomic absorption method with1N NH_4OAc extraction. The chloride concentration was determined by summing up the total cation concentration in the soil solution.

RESULTS AND DISCUSSION

Salinization in soils and sub-soils is a result of the imbalance in transported solutes through the soil zone. The results obtained from the analysis shows (Fig. 3)that chloride has been transported from the bottom in the first to the top of the end segment.Thus, the experiment show the chloride transport in time.In clay soils cation exchange is the dominant process during the solute transport. The ion-exchange process can be conceptulized as the preferential adsorption of selective ions with concomitant loss of other ions. The general ordering of cation exchangeability for common ions in groundwater is

$$Na+ > K+ > Mg++ > Ca++$$

The divalent ions are more strongly bonded and tend to replace monovalent ions. However, it is a reversible reaction and, at high concentrations, the monovalent ions can replace divalent ions(Fig.4).This is the concept behind the process in this experiment where high concentration of Na Cl solution was used as groundwater. Mainly cation exchange took place between Na+ and Ca++, though to a minor extent also afraction of the Na+ was exchanged with Mg++ and to some extent with with K+.Soluble species recovered during the washing procedure have inferred their concentrations are fairly constant withrespect to depth and were systematically greater than those in the aquifer water, suggesting that the composition of the

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solution was not in equilibrium with the aquifer.Almost all the concentrations increased in the upper segments of the columns, suggesting the evaporation zone is in upper 5 cm depth.

The speed and direction of ion-exchange processes in the water-soil system are determined by many factors, the main one is the adsorption capacity of ions and their concentration in solution and the adsorption complex of the soil.

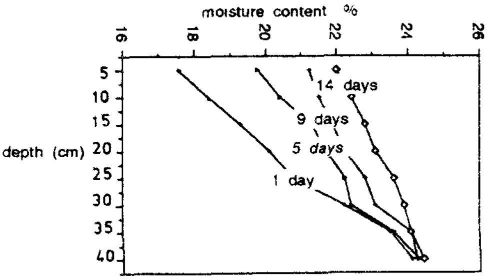

Fig 2

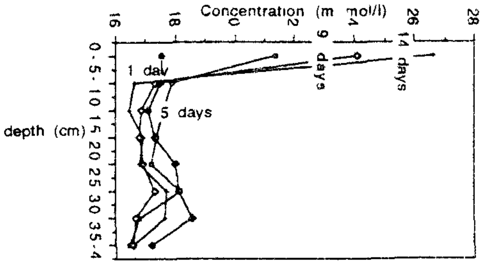

Fig 3 Chloride concentration

The concentration of major cations (Ca, Mg, Na and K) was determined for each segment of all columns. They did not change significantly with to depth, except for the top segment of all columns where those ions were strongly concentrated as a result of water removal from evaporation. To quantify the accumulation process, a simple mass balance calculation (Table 2) was made using the following equation.

$$\text{Total cationic mass} = \sum_i Z_i * q_i = 2\times qCa + 2\times qMg + qNa + qK$$

Where Z is the valence of the cation, q is the concentration of cation.

Table 2. Total Cationic mass

depth (cm)	day			
	1	5	9	14
0-5	76.18	92.11	113.7	129.6
5-10	77.31	90.7	98.1	101.8
10-15	83.47	90.14	94.9	100
15-20	85.13	90.62	90	101 5
20-25	82.16	89.7	90.04	86
25-30	97.3	91.4	89.1	85.51
30-35	97.2	91.8	89.2	85.6
35-40	92.16	89.8	87 3	85.02

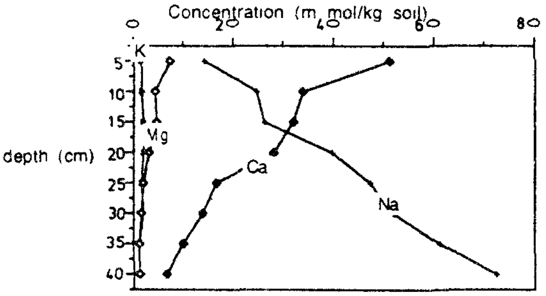

Fig. 4 Cation adsorption through exchange

CONCLUSIONS:

The experiment lead to the following conclusions:

1. The solution moved by capillary action from the water supply towards the soil surface where soluble salts accumulated. Soluble species were supplied by the aquifer water, but may also by the lower levels that had been leached by the migrating solution.Evaporation rate, proved to be very high with shallow groundwater levels.
2. Although the rate of evaporation is moderate to low, considerable chloride concentration accumulated at the surface of the soil in two weeks period and the zone of evaporation and the salt accumulation zone found in the upper 5 cm soil column.
3. The cation exchange phenomena was observed at a fast rate even in the column of one day evaporation and progressed with time and evaporation.

REFERENCES

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