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HYDRAULIC CONDUCTIVITY OF SOIL AS AFFECTED BY COMPOSITION OF LEACHING WATER

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The changes in hydraulic conductivity of a normal soil as a function of salt concentration (EC$\leqslant$25dS/m) and sodium adsorption ratio ($\leqslant$40) of Percolating solutions were measured. Each soltion was applied continuously and the volume of percolate measured at constant till a constant rate of flow was observed.

Significant increase occurred in the hydraulic conductivity with increasing electrolyte concentration at a given SAR while it decreased significantly with increasing SAR of leaching water at constant electrolyte concentration. At all the SAR levels, good positive correlations were observed between the electrolyte concentration levels and the hydraulic conductivity of soil.

INTRODUCTION

Surface water is the main source of irrigation in Pakistan and in areas where this source is scarce or unavailable, groundwater is used to irrigate crops. The groundwater is generally marginal to unsuitable for irrigation (high in soluble salts and sodium adsorption ratio). The use of such waters causes deterioration of soil structure and decrease in hydraulic conductivity (HC). According to U S. Salinity Laboratory Staff (1954) if HC of surface soils is as low as 0.1 cm/hour, leaching and irrigation may present serious problems. McNeal and Coleman (1966) observed that soils dominant in montmorillonite and montmorillonite-hydrobiotite showed decrease in HC at exchangeable sodium percentage (ESP) of 25,er over a concentration range of 9-40 me/l. The swelling properties of these soils were found to be correlated with their native HC, whereas kaolinitic soils were independent of ESP and electrolyte concentration. Rhoades and Ingvalson (1969) did not find decrease in HC at ESP values lower than 50 in the absence of mechanical and chemical disaggregation. After disaggregation, HC decreased in the ESP range of 10-40 at the electrolyte concentrations of 5-10 me/l.

Shainberg and Caiserman (1971) found that HC was very sensitive to valency of the ion adsorbed on the montmorillonite clay. The HC of Ca-montmorillonite was 9.30×10^{-9} cm/sec., whereas that of Na-membrance was only 0.65×10^{-9} cm/sec. Felhendler *et al.* (1974) found that HC of silt loam and sandy loam-montmorillonite soils droppedto 42 and 18% of initial values of 10 and 20 and respectively. Shainberg *et al.* (1981) observed that when concentration of soil solution was 3 me/l, the HC and dispersion decreased only if ESP values exceeded 12; conversely when the concentration of soil solution was maintained at about 0.5 me/l, HC decreased at ESP values as low as 1-2%.

MATERIALS AND METHODS

Soil from 0-15 cm depth was collected from the experimental farm of the University of Agriculture Faisalabad. The soil was air dried, ground and passed through a 2 mm sieve. A representative sample was taken to determine physical and chemical characteristics of the soil (Table 1).

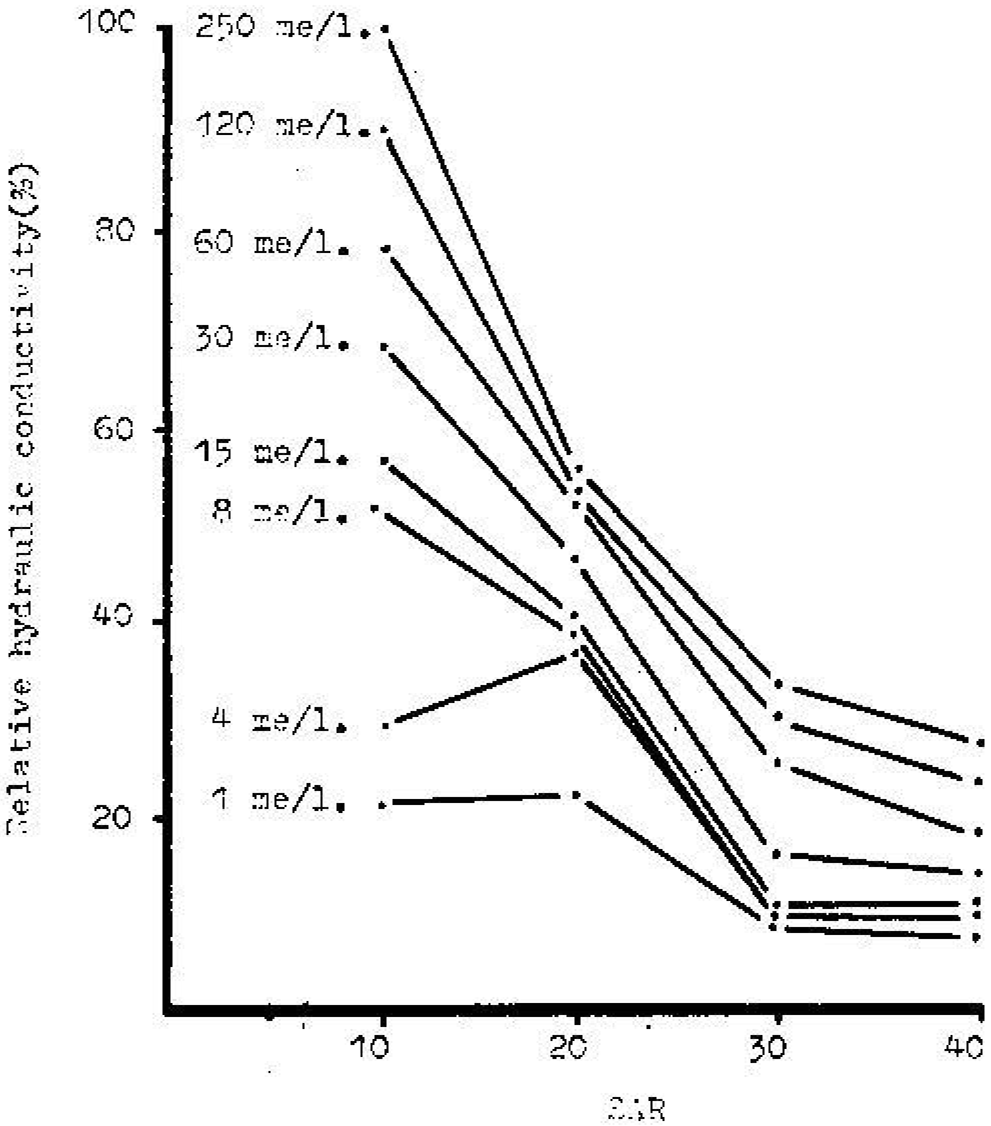
Illite was the dominant clay mineral in this soil followed by vermiculiee and chlorite (Khan, 1979). For leaching purpose, 32 synthetic waters (four SAR levels i. e. 10.20, 30 and 40 at each EC level of 0.1, 0.4, 0.8 1.5, 3.0, 6.0, 12.0 and 25.0 $dS m^{-1}$) were used. The waters were prepared by dissolving calculated amounts of Na_2SO_4, NaCl, $CaCl_2$ and $MgSO_4$ in tap and distilled water get the desired SAR and EC levels.

Soils were packed in soil containers according to method 34 B for determining the hydraulic conductivity of disturbed soil (U.S. Salinity Laboratary Staff, 1954). Each water was applied to the soils packed in soil containers in duplicate. The volumes of percolates were measured at constant intervals till a constant ratet of flow was observed. The hydraulic conductivity was measured by constan water head method using brass tubes (U.S. Salinity Laboratory Staff, 1954).

RESULTS AND DISCUSSION

Results achieved on the hydraulic conductivity of soil as affected by total electrolyte concentration and SAR of leaching waters are presented in Table 2 and Fig. 1. There was a highly significant increase in HC with increasing salt concentration at a given SAR while it decreased significantly with increasing SAR of leaching water at constant EC. Since increase in ESP causes swelling and dispersion of soil particles, therefore, increased SAR of leaching water resul-

Fig.1. Relative hydraulic conductivity(%) of soil as a function of solution concentration and composition.



ted in decreased HC. At all SAR levels good correlations were observed between the electrolyte concentrations and HC values (Table 3). These results agree with those of NcNeal and Coleman (1966), who observed appreciable reduction in HC of soil dominant in 2 : 1 layer silicate clays, when salt concentration decreased from 600 to 55 me/l at a SAR of 40. The results are similar in respect of ESP to those of Rhoades and Ingvalson (1969).

Table 1. *Physical and chemical characteristics of the investigated soil.*

Determinations	Units	Values
pH_s	—	7 8
EC_e at 25°C	(dSm^{-1})	1.1
SAR	$(mmoles/l)^{\frac{1}{2}}$	2.2
CEC	(me/100g)	5.3
Saturation extract		
HCO_3	me/l	1.8
Cl	,,	3 8
SO_4	,,	5.4
Ca + Mg	,,	6.1
Na	,,	3 8
K	,,	0.9
Exchangeable cations		
Na	(me/100g)	0.05
Ca + Mg	,,	4.97
ESP	—	0.87
Saturation percentage		34.3
Soil texture, loam (18% clay)		

Many workers have given critical values of electrolyte concentration and sodicity levels of leaching water. Doneen (1961) abserved 15% reduction in permeability of montmorillonitic Yolo soils when electrolyte concentrations were less than 3.5, 6.5, and 10.0 me/l at ESP values of 0.6, 3.4, and 8.0 respecitively.

Shainberg *et al.* (1981) suggested that an ESP of 6 was determinental to physical properties of soil with poor quality water. However, when waters of higher salinity (more than 3 me/l) are used, an ESP of 15 is required to damage the physical properties of soil.

Soil HC generally decreased with increasing SAR and decreasing electrolte concentration (Fig.1). Dispersion and swelling of clays are interrelated and either of these can reduce the soil HC. Dispersion can occur at lower ESP (10 to 20) if electrolyte level is less than 10 me/l (Felhendler *et al.*, 1974). But swelling is not generally appreciable unless the ESP exceeds about 25 or 30 (Shainberg and Gaiserman, 1971.

Table 2. *Hydraulic conductivity (cm / hour) of soil as function of SAR and electrolyte concentration of applied water.*

EC	SAR				
dSm^{-1}	10	20	30	40	Average
0.1	0.111	0.117	0.045	0.044	0.079
0.4	0.152	0.193	0.050	0.051	0.112
0.8	0.262	0.200	0.050	0.051	0.141
1.5	0.291	0.211	0.055	0.058	0.154
3.0	0.353	0.242	0.085	0.074	0.188
6.0	0.406	0.266	0.131	0.096	0.225
12.0	0.470	0.270	0.167	0.121	0.255
25.0	0.520	0.285	0.172	0.141	0.380
Average	0.321	0.223	0.093	0.080	—

L. S. D. at	5%	1%
SAR	0.023	0.030
EC	0.033	0.044
SAR x EC	0.654	0.087

Table 3. *Correlations and regression equations between EC and salinity levels.*

x = Salinity		Y = HC
At SAR 10 r = 0.824*	and	Y = 0.236 + 0.014 x
At SAR 20 r = 0.715*	and	Y = 0.195 + 0.0046 x
At SAR 30 r = 0.892**	and	Y = 0.0697 + 0.005 x
At SAR 40 r = 0.939**	and	Y = 0,055 + 0.0039 x

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