Effect of Varying Quality Leaching Waters Having Different Mg : Ca Ratios on Moisture Retention Characteristics of Soils

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Proper water management requires a thorough understanding of the moisture retention characteristics of soils which govern the availability of stored water to the growing plants. Besides texture, organic matter and other factors, the nature and relative proportion of different cations in the exchange complex also play significant role in influencing the water retention properties of the soil. THOMAS and MOODY [8] and KUTILEK [6] reported that the amount of water held at 1/3 atm. pressure was closely related to the clay type and cation saturation, Na-montmorillonite clays retaining much more water than other clays. Recently VÁRALLYAY [10] and VÁRALLYAY and SZABOLCS [11] have observed an increase in water retention at a given suction with increasing ESP-level. Further, the effect of Na_2CO_3 salt on water retention was found to be more marked than that of NaCl dominated salt. However, very little information is available with regard to the effect of Mg on moisture retention characteristics of the soils.

The ground waters in most arid and semi-arid areas as well as in the coastal region of the tropical countries, especially in India, are of poor quality. In addition to the total concentration of the dissolved salts, the relative proportion of Mg also varies considerably in these waters, often exceeding the concentration of Ca and it generally increases with an increase in the salinity level of the water. The use of such waters for irrigation affects the release and adsorption pattern of different cations which in turn exert a great influence on the water retention properties of the soil.

In view of the above, a laboratory investigation was carried out to examine the effect of different Mg : Ca ratios of leaching water having varying SAR and electrolyte concentration on the moisture retention characteristics of soils.

Materials and methods

Leaching trials were conducted in a specially designed permeameter to evaluate the effect of water having different Mg : Ca ratios, SAR values and electrolyte concentrations on the water retention characteristics of four soils, representing two alluvial soils (*A* and *B*) dominated by illite clay mineral and

Table 1

Initial physical and chemical properties of soils used in the studies

Soil properties	Alluvial soil		Black clay soil	
	(A)	(B)	(C)	(D)
Mechanical composition				
Sand (%)	57.9	14.1	44.4	21.8
Silt (%)	22.4	51.6	26.8	21.2
Clay (%)	20.0	33.5	24.8	54.0
Mineral composition in order of abundance	Illite Chlorite Kaolinite	Illite Montmorillo-nite, Kaolinite	Montmorillo-nite, Illite, Chlorite	Montmorillo-nite, Illite
pH (1 : 2)	8.0	7.9	8.0	7.6
EC (1 : 2) mmhos/cm	0.2	8.0	0.9	0.2
Exchangeable cations (me/100 g)				
Ca^{2+}	6.6	—	19.9	42.9
Mg^{2+}	2.5	—	5.3	12.6
Na^{+}	0.4	5.8	1.5	0.6
K^{+}	0.7	0.9	0.8	0.6
CEC (me/100 g)	10.0	13.5	27.0	56.0
Organic matter (%)	1.1	0.8	2.1	0.9
Calcium carbonate (%)	0.7	Nil	1.9	2.1

two black soils (*C* and *D*) dominated by montmorillonite clay mineral collected from four different places in India. Two hundred g of each soil at 10 per cent moisture was packed to a uniform bulk density in the plastic permeameter (diam. 6.28 cm, height 9.2 cm). Each soil was then leached respectively with the solutions having four Mg : Ca ratios (2, 4, 8 and 16), three SAR values (10, 25 and 50) and two electrolyte concentrations (20 and 80 me/l). Toluene (0.5%) was added in the leaching solution in order to guard against any fungal development. For achieving continuous leaching through the soil column, a constant head of 2 cm $\pm$ 0.2 cm was maintained over the soil surface by inverting a 250 ml corning flask filled with the appropriate leaching solution. The leachate was collected in 500 ml capacity conical flask through a glass funnel (Fig. 1.). The steady state in leachate composition was obtained. Since the maximum volume of leaching solution required to attain such steady state condition came to 3000 ml, all these soils were leached with 3000 ml of the solution.

The chloride salts of Ca, Mg and Na were used for preparing the leaching waters of desired quality using deionized water. In calculating SAR of irrigation water, Mg was grouped with Ca as is widely done. The soil samples were analysed for various properties, employing the standard procedures outlined by Piper [7] and Richards [9]. The initial physical and chemical properties of the four soils used in the studies are presented in Table 1.

Results and discussion

Effect of Mg : Ca ratios on water retention

Data on the effect of different Mg : Ca ratios (2, 4, 8 and 16) of leaching water of 20 me/l electrolyte concentration having three SAR levels (10, 25 and 50) on moisture retention at 0.33 and 15 bar suction of four soils are illustrated in Fig. 2. Water retention at 15 bar suction in case of Mg : Ca ratio of 2 and 16 in leaching water of SAR 10 came to 7.85 and 11.00 percent in Soil *A*, 10.30 and 13.80 percent in Soil *B*, 17.00 and 19.48 percent in Soil *C* and 25.35 and 27.85 percent in Soil *D*, respectively. The values of moisture retention at Mg : Ca ratios of 4 and 8 remained in between those observed at the extreme Mg : Ca ratios. From these data it can be seen that water retention at 15 bar suction increased with an increase in Mg : Ca ratio in leaching water of SAR 10. It can be ascribed to the fact that the soil dominated by Mg ion has more swelling and dispersing characteristics (BAKKER, et al. [2], DARAB and REMÉNYI [4], GIRDHAR and YADAV [5], YADAV and GIRDHAR [12]). An almost similar trend was observed at SAR 25 and 50, but the effect of increasing Mg saturation on water retention was more pronounced at SAR 50 as compared to that of 10. Further the magnitude of the effect of these increasing Mg : Ca ratios on the moisture retention at 0.33 bar was less than at 15 bar suction (Fig. 2.).

It is also interesting to note that water retention due to increasing degree of Mg adsorption was greater in Soil *C* and Soil *D* as compared to Soil *A* and Soil *B*, mainly because of the dominance of highly expandable montmoril-

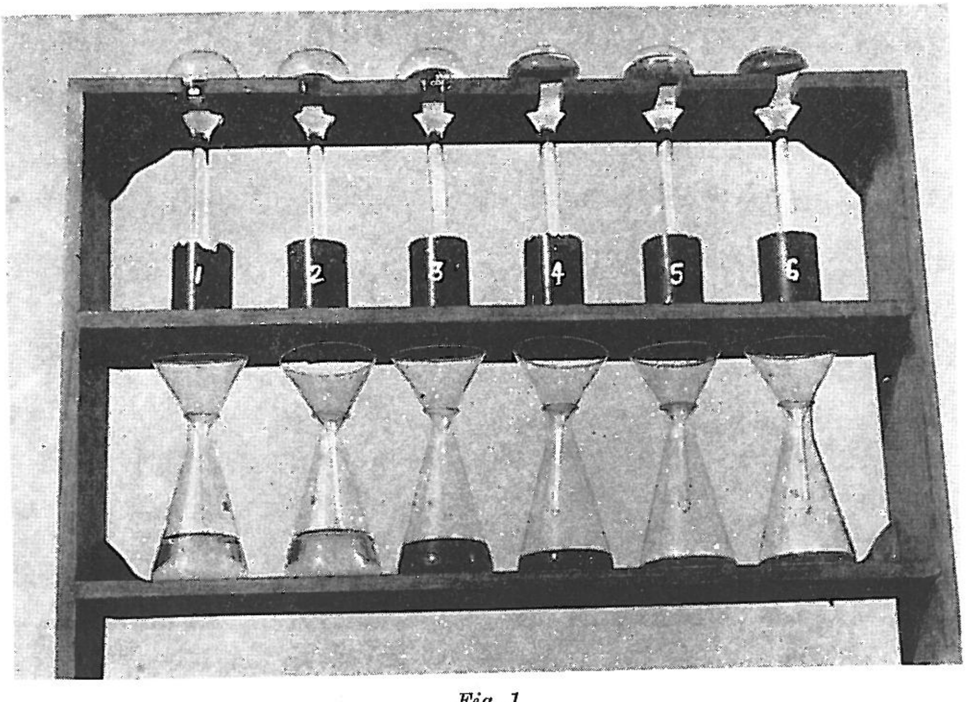

Fig. 1
A setup of six permeameters used in leaching trial

lonite type of clay mineral in the former two soil. The effect of Mg : Ca ratios on the water retention also varies with the electrolyte concentration. It was found that an increase in moisture retention with an increase in Mg : Ca ratio is more at 20 me/l electrolyte concentration than in case of 80 me/l electrolyte concentration (Fig. 3.) at both 0.33 and 15 bar suction, but the magnitude of reduction due to the effect of these treatments was greater at 15 bar suction than at 0.33 bar suction.

Effect of SAR and electrolyte concentration on water retention in different soils

Water retention in soils at 0.33 bar suction in case of leaching water having SAR 10, 25 and 50 at 20 me/l electrolyte concentration and Mg : Ca ratio of 2 worked out to 17.95, 18.79, and 19.76 percent in Soil *A*; 25.76, 26.59 and 28.00 percent in Soil *B*; 28.80, 30.33 and 31.78 percent in Soil *C* and 39.20, 40.90 and 42.30 percent in Soil *D*, respectively (Table 2.). The corresponding values of water retention at 80 me/l electrolyte concentration of leaching water were 16.65, 18.00 and 18.55 percent in Soil *A*; 23.56, 25.17 and 27.43 percent in Soil *B*; 26.10, 28.00 and 29.90 percent in Soil *C* and 37.50, 38.73 and 39.85 percent in Soil *D*, respectively. Almost a similar trend was noticed at Mg : Ca ratios of 4, 8 and 16 of leaching water, but the magnitude of differences varied as discussed above. It is inferred from the above data that water retention increased

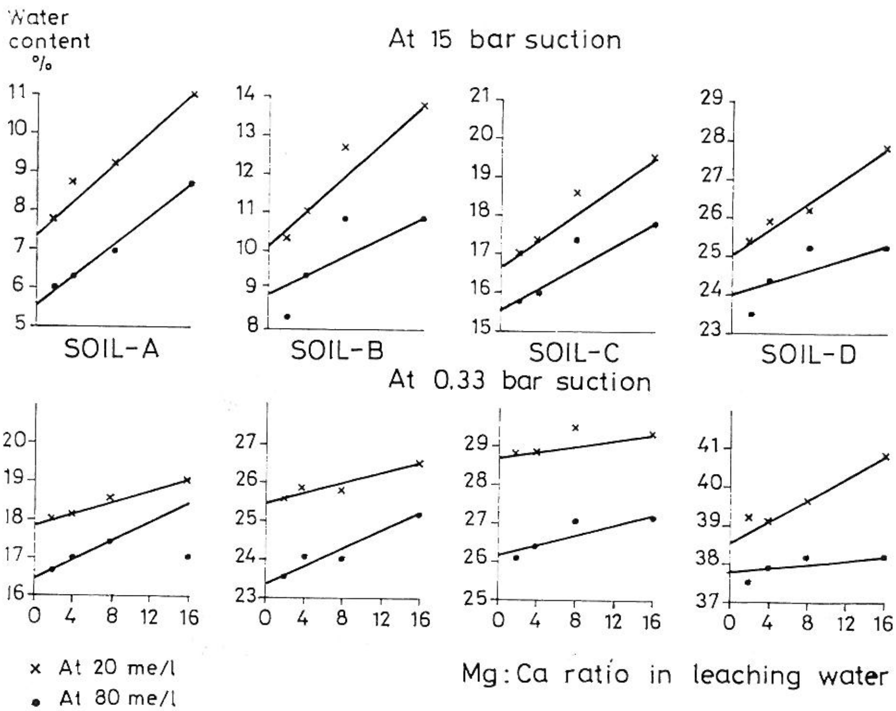

Fig. 2
Effect of different Mg : Ca ratios and SAR values of leaching water at 20 me/l electrolyte concentration on moisture retention characteristics of soils

Table 2

Moisture retention characteristics of soils as affected by varying quality leaching waters (Mg : Ca = 2) at two suction levels

Leaching water		Moisture retention							
		at 0.33 bar suction				at 15 bar suction			
SAR value	Electrolyte conc. me/l	Alluvial soil		Black clay soil		Alluvial soil		Black clay soil	
		A	*B*	*A*	*B*	*A*	*B*	*A*	*B*
		Water content, %							
10	20	17.95	25.76	28.80	39.20	7.85	10.30	17.00	25.35
25		18.79	26.59	30.33	40.90	8.75	12.54	18.36	28.10
50		19.76	28.00	31.78	42.30	10.95	13.00	20.67	29.12
10	80	16.65	23.56	26.10	37.50	6.00	8.30	15.79	23.51
25		18.00	25.17	28.00	38.73	8.00	11.10	16.90	26.45
50		18.55	27.43	29.90	39.85	9.59	12.57	18.79	27.00

with an increase in SAR and with a decrease in electrolyte concentration at a given Mg : Ca ratio of the leaching water at both suctions, but the effect in this case also was more marked at 15 bar than at 0.33 bar tension (Table 2.).

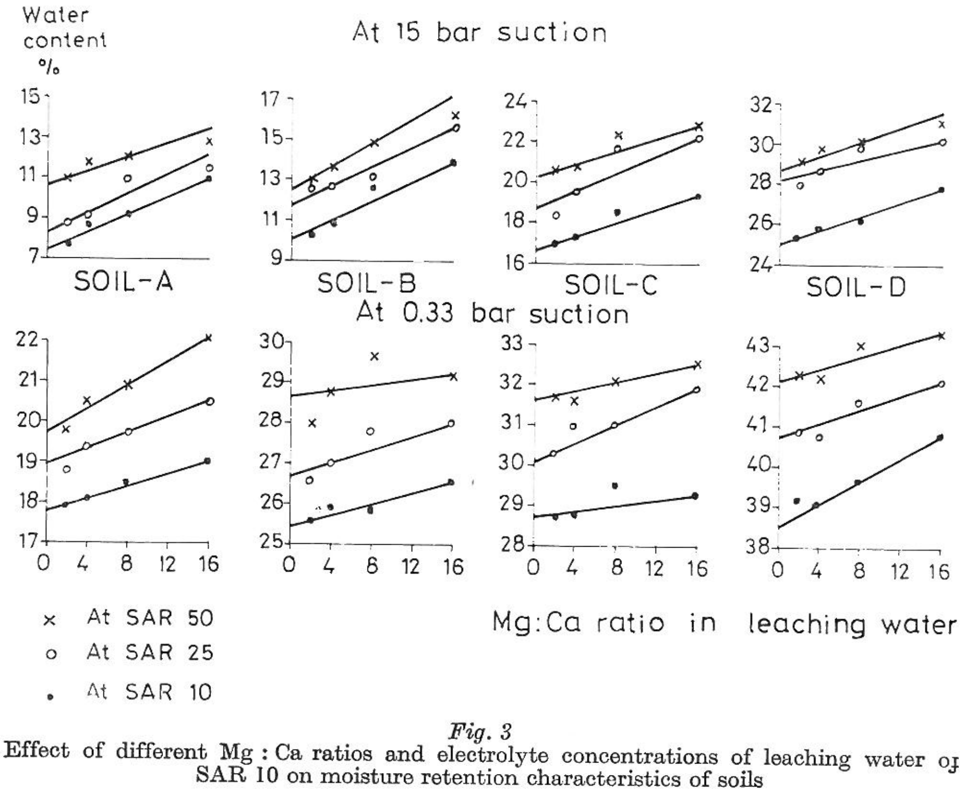

Fig. 3
Effect of different Mg : Ca ratios and electrolyte concentrations of leaching water of SAR 10 on moisture retention characteristics of soils

The increase in water retention with an increase in SAR was mainly due to an increase in exchangeable sodium, which altered the pore size distribution through its dispersive action on the soil colloids. Relatively greater reduction in the number of larger pores and total porosity and the corresponding increase in the proportion of smaller size pores as a result of soil dispersion at high ESP values, were responsible for the observed differences in the moisture retention. CHANG and DREGNE [3] had also found that the moisture retention at 0.33 bar and 15 bar tensions increased with increasing ESP of the soil. Recently VÁRALLYAY [10] and ABROL et al. [1] have also obtained similar results.

Further, the effect of high SAR on moisture retention of soils was found to decrease on leaching with water of high electrolyte concentration (Table 2.) mainly because of the flocculating effect. The moisture retention was found to be greater in Soil *C* and Soil *D* as compared to Soil *A* and Soil *B* under different treatments chiefly owing to the dominance of montmorillonite clay mineral in the former soils. These results are in agreement with the findings of THOMAS and MOODY [8] and KUTILEK [6].

In conclusion, it can be mentioned that the continuous use of Mg-rich water of given SAR and electrolyte concentration increased water retention in different soils at both 0.33 bar and 15 bar suctions, but the effect was more pronounced at higher suction. The effect of increasing adsorption of Mg on water retention further increased with increasing SAR and decreasing electrolyte cocentration of leaching water. The influence of these treatments was more marked in the heavier textured soils dominated by montmorillonitic clay mineral. Hence, the effect of Mg on the moisture retention characteristics of the soils needs to be examined separately and not together with that of calcium.

Summary

A laboratory experiment was conducted in a specially designed permeameter to study the effect of varying quality leaching waters, having four Mg: Ca ratios (2, 4, 8 and 16), three SAR values (10, 25 and 50) and two electrolyte concentrations (20 and 80 me/l) on the moisture retention characteristics of four soils of varying texture and clay mineralogy.

It was found that the moisture retention at 0.33 and 15 bar suction increased with an increase in Mg : Ca ratio in leaching water at a given SAR and electrolyte concentration, but relatively the increase in moisture retention at 0.33 bar suction was of much smaller magnitude. The effect of increasing Mg : Ca ratio on water retention further increased with an increasing SAR and decreasing electrolyte concentration of leaching water. The moisture retention was found to be greater in Soil *C* and Soil *D* as compared to Soil *A* and Soil *B* under different treatments, chiefly owing to the dominance of montmorillonite clay mineral in the former soils.

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