

Behaviour of salt affected soil

with different electrolyte concentration

Bhargabi Chakraborty¹

ICAR Research Complex North- Eastern Hills Region, Lembucherra (Tripura) 799 210

Irrigation water quality was found to significantly affect soil physical properties. These changes occurred in the presence of high solute concentrations normally associated with maintaining soil aggregate stability and continued throughout the irrigation season. Soil dispersion causes clay particles to plug the soil pores, decrease the mean weight dia and increase bulk densities. Salinity and sodicity affect soil structure, which must be stable for adequate permeability and water infiltration.

Key words: Electrolyte concentration, Salt, Salinity, Sodic soil

SALT affected soil can be defined as the soil that has been adversely affected by the presence of soluble salts, with or without high amount of exchangeable sodium (Na). Salt affected soils occur in all the major physiographic regions of India. Salts released by weathering of silicate (Si) minerals are important original sources and are responsible for enrichment of soils and waters at specific favoured locations. Soil enriched with neutral salts is termed as saline while the one with salts capable of alkaline hydrolysis as alkali or sodic.

Major causes for the formation of salt affected soils

The major causes of formation of salt affected soils are: (i) Excess and unscientific irrigation, (ii) Topographic situation, (iii) Arid climate, (iv) Unlined canal above the ground water, (v) Poor permeability of vertisols, (vi) Use of saline ground water for irrigation, and (vii) Blocking of natural drains.

Extent and distribution of salt affected soils in India

Saline and alkali soils represent one of the most important and widely distributed agricultural

resources that still remains to be developed and utilized effectively. The main problems of these soils are excessive soluble salt content and high exchangeable sodium (Na) percentage. Their reclamation consists in the leaching of excessive salts and exchangeable sodium displacement by amendments to the lower horizons. However, the effectiveness of leaching is markedly reduced by notoriously low hydraulic conductivity of these soils. Infiltrability of arid region soils with 2:1 clays and high exchangeable sodium percentage is sensitive to changes in valence of adsorbed cations and electrolyte concentration of the solution. The reduction in infiltration with monovalent cations and low electrolyte concentration is attributed to swelling or to the dispersion of clay particles and clogging of soil pores. Soil hydraulic conductivity depends on the composition of the exchangeable cations and the composition and concentration of the electrolytes in the soil solution, as well as on soil texture. The hydraulic conductivity decreases with an increase in the ESP and the decrease in the total electrolyte concentration of the soil solution. The permeability of the

soils to irrigate water depends on ESP of soil and electrolytic concentration of the percolating solution.

Development of soil problems under saline sodic condition

Development of soil problems under saline sodic condition by the application of marginal irrigation water with high SAR, which affect the soil. Exchangeable things adversely affect the clay swelling or dispersion by which the physico-chemical properties of the soil, ultimately after the crop production and crop yield used to reduce drastically (Fig 1).

ELECTROLYTE CONCENTRATION

An electrolyte is a compound that ionizes when dissolved in soluble ionizing solvent such as water. This includes most soluble salts, acids and bases.

Electrolyte solutions are normally formed when a salt is placed into a solvent such as water and the individual components dissociate due to the thermodynamic interactions between solvent and molecules, in a process called solvation. For example, when table-salt (sodium chloride,

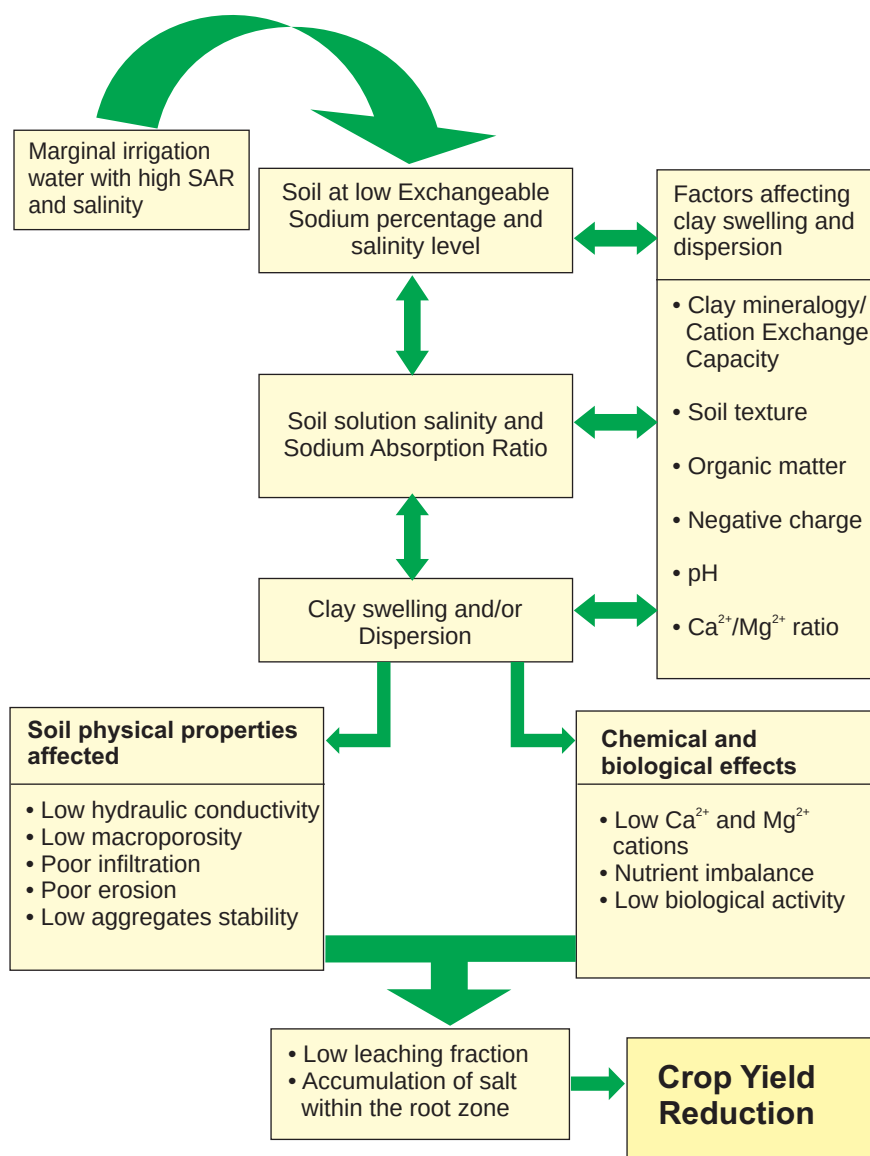


Fig. 1. Development of soil problems under saline sodic conditions.

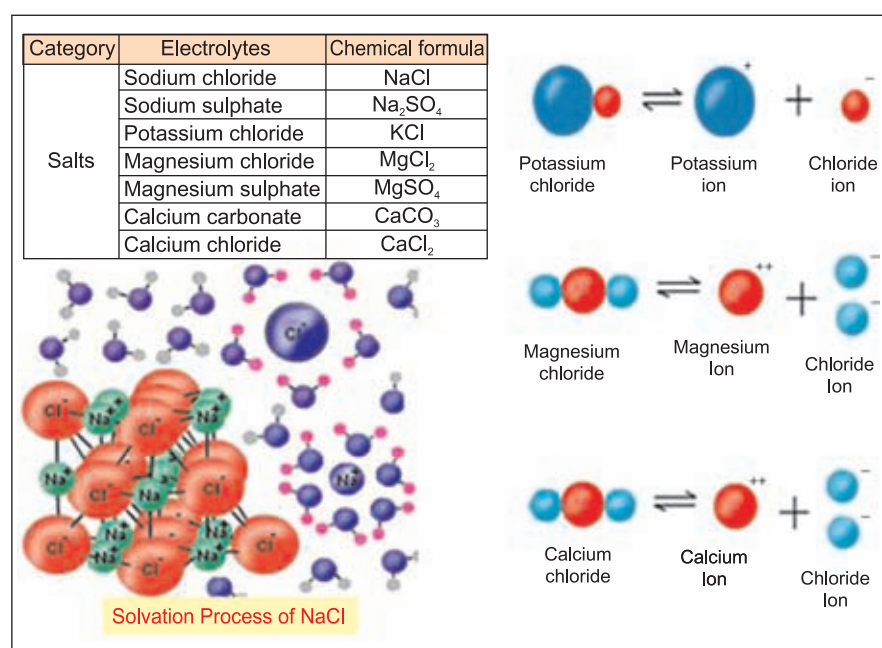
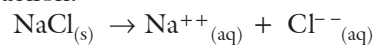


Fig. 2. Some common strong electrolytes are as follows

NaCl) is placed in water, the salt (a solid) dissolves into its component ions, according to the dissociation reaction.



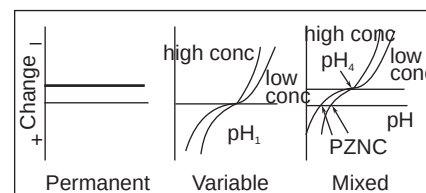
Importance

- Effect of different electrolyte concentration on soil chemical properties is made clear through soil pH:

Table 1. Threshold concentration and pH values for soil.

Salt	Threshold concentration molar
NaCl	2.5×10^{-1}
KCl	2×10^{-2}
MgCl ₂	1×10^{-3}
CaCl ₂	3×10^{-4}

Source: Quirk and Schofield (1955)



Source: Sumner, 1993

The change of pH in soil solution has no effect on the flocculation of permanent charge minerals. Conversely, in case of variable charge minerals, the increase of pH above pH₀ (i.e. the pH value at which there is equal numbers of positive and negative charges on the particle surface) increase negative charges. Whereas below it, positive charges increase and soil water solution oppositely charged surface would interact owing to the soil system to be flocculated.

Threshold electrolyte concentration

Defined as the salt concentration at which the soil permeability starts decreasing for certain sodicity level.

It also can be defined as the electrolyte concentration required flocculating a dispersed suspension of the soil.

Turbidity concentration

Defined as the salt concentration at which clay fractions appear in the percolated water. Turbidity concentration indicates that soil microstructure is becoming unstable and increasingly so as the amount of turbidity increases as ESP increases.

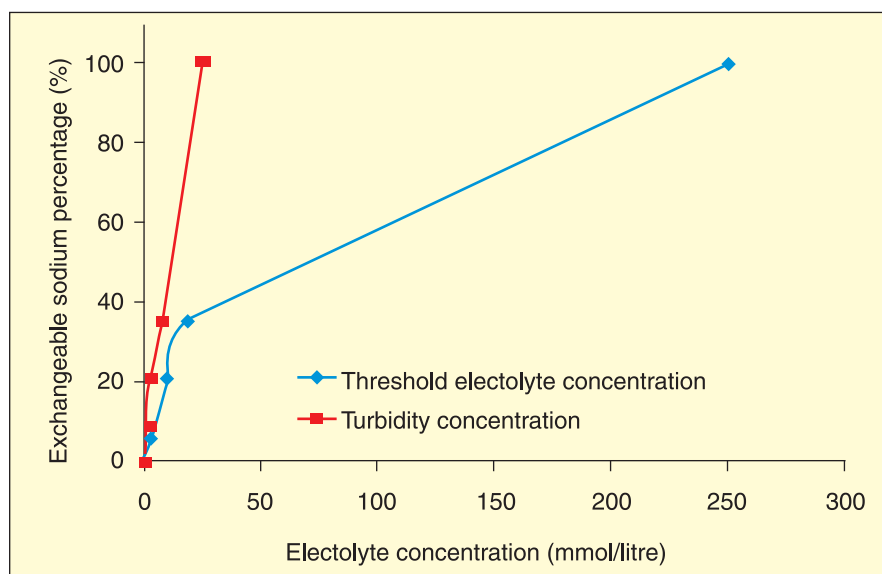


Fig. 3. Electrolyte concentration on maintaining permeability
Source: Quirk and Schofield (1955)

Permeability of single ion system

The concentration of salt which causes 10 to 15% decrease in soil permeability is defined as the

threshold concentration. That is the concentration where factors which can cause drastic reduction in permeability are becoming operative.

In case of sodium saturated soil the decrease in permeability for the sodium saturated soil is thought to be due to swelling and deflocculation. Swelling would be expected to precede deflocculation which was first observed at 2.5×10^{-1} M NaCl.

For potassium (K) saturated soil similar results were obtained. The decrease in soil permeability was observed at lower salt concentration, which first observed at 2×10^{-1} M KCl concentration.

Magnesium (Mg) saturated soil was saturated with magnesium by using a 3.16×10^{-1} M $MgCl_2$. Decreases in permeability are obtained at a concentration below 3.16×10^{-3} M.

Calcium (Ca) saturated soil was saturated with calcium by 1×10^{-2} M $CaCl_2$ solution. Small decreases in permeability were obtained when the calcium ion concentration was 3.16×10^{-4} .

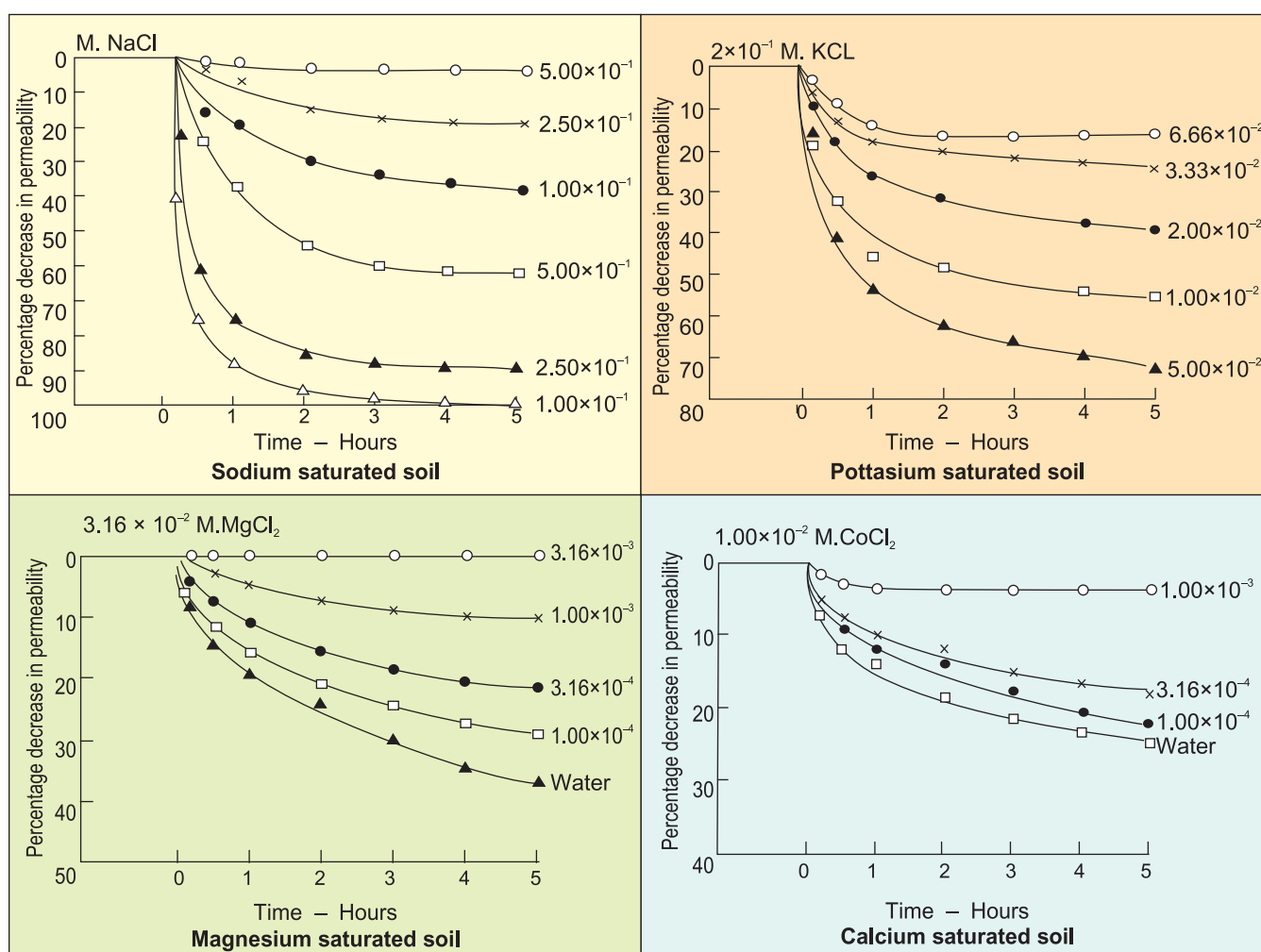


Fig. 4. Permeability of single ion system

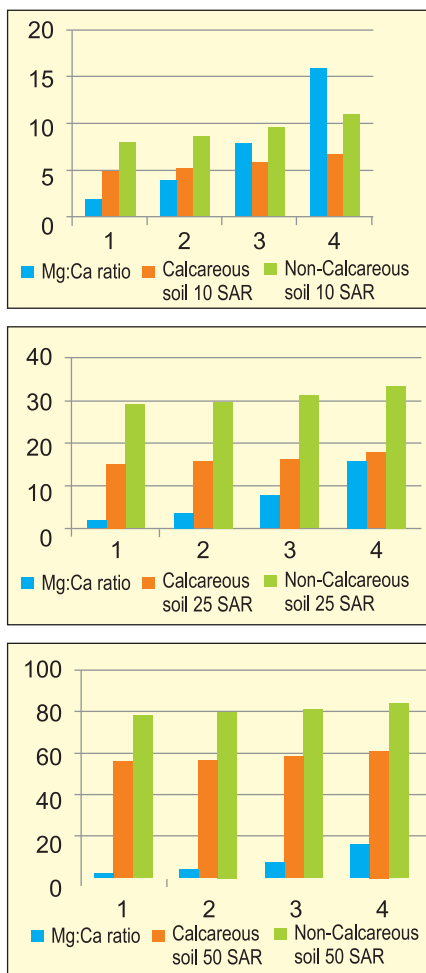


Fig. 5. Effect of different Mg : Ca ratio and SAR on degree dispersion

Effect of electrolyte on dispersible clay

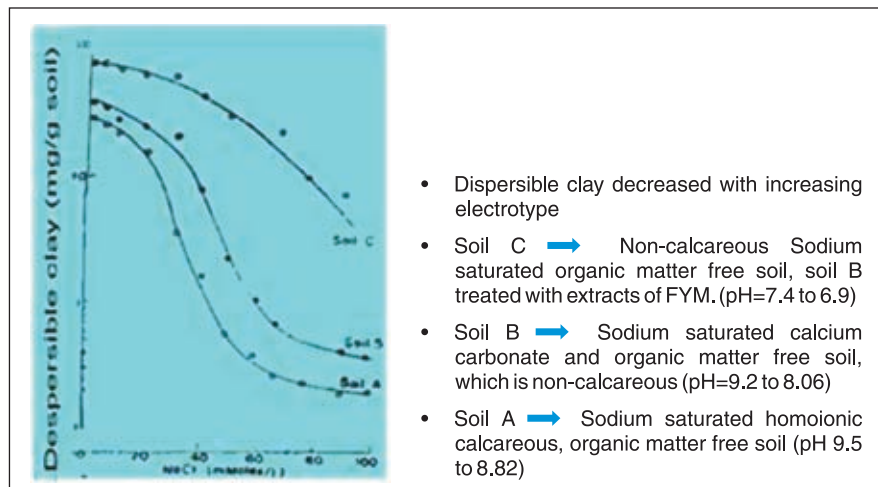


Fig. 6. Dispersible clay in soil suspension at various added level NaCL concentration
Source: CSSRI (1982) by Gupta and Abrol

Table 2. The increase in ESP showed fractional change in HC.

ESP	Bundelkhand T.111B (Clay) soil	Mirzapur T.11A (Clay loam) soil	Kanpur T.1(Silty clay loam soil	Banaras T.111A (Silty loam) soil	Bhabar Soil (Loam) soil	Dehradun (Sandy soil)	Mean
1.36	2.06	3.06	2.68	2.64	2.53	3.76	2.79
5.01	1.85	2.81	2.10	2.16	2.08	3.22	2.37
10.13	1.42	2.24	1.84	1.78	1.76	2.74	1.96
14.43	1.02	1.68	1.38	1.31	1.30	2.13	1.47
19.90	0.52	1.32	1.03	1.01	0.97	1.90	1.12
24.50	0.21	0.68	0.45	0.40	0.32	1.50	0.59
29.88	0.07	0.21	0.13	0.10	0.09	0.45	0.16

S Ed. = ± 0.440

CD.(5%)=0.898

Source: Dixit and Lal (1972)

Effect of Electrolytes and SAR on dispersible clay

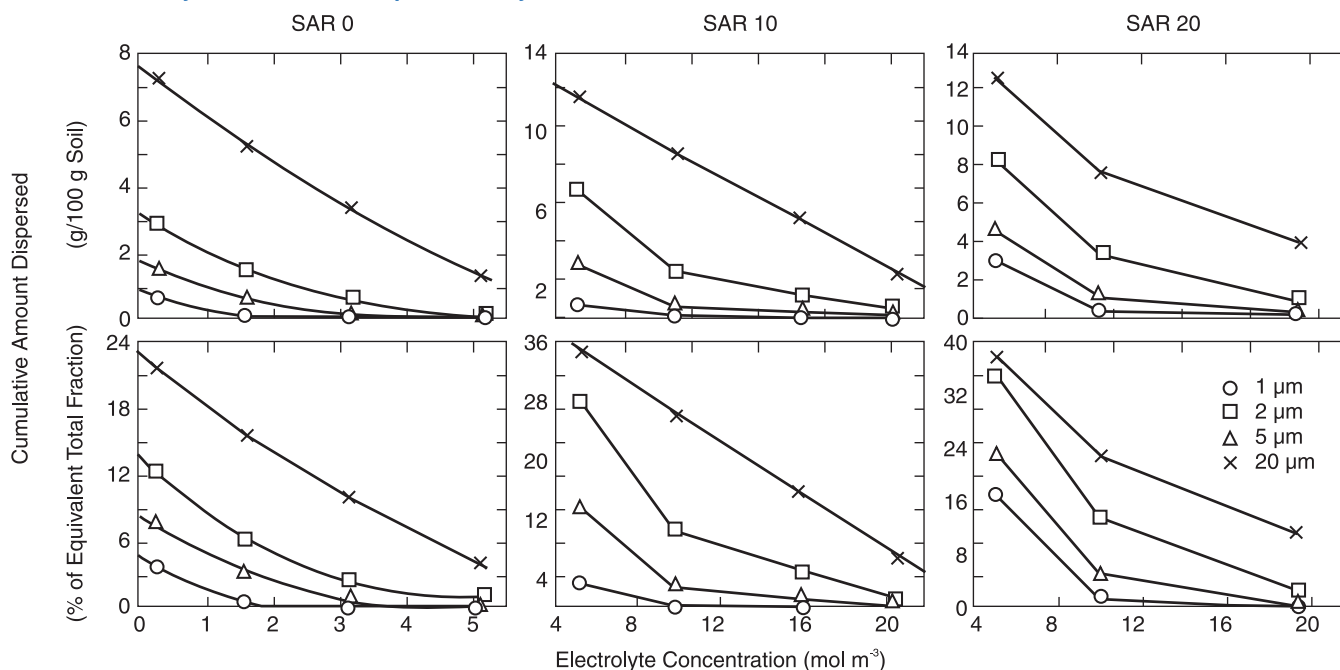


Fig. 7. Effect of electrolyte concentration and SAR combinations of applied water on the ratio of dispersed to aggregated clay.

- Abu-Sharar and associates (1987) studied the percentage of clay material with in soil dispersed when subject to different EC and SAR combination.
- With the increase of SAR level the amount of dispersible clay also increase.

Source: Abu-Sharar *et al.*, 1987

Effect of different Mg: Ca ratio and SAR on degree of dispersion

With increasing SAR, higher salt concentration are required to maintain a relatively constant degree

of swelling and dispersion (Table 3).

Effect of different electrolyte concentration on soil physical properties

These are based on Degree of

Dispersion, Hydraulic Conductivity, Water Retention Capacity, MWD of soil, and Bulk density of soil.

Effect of different Mg: Ca ratio and SAR on hydraulic conductivity

A greater reduction in Hydraulic conductivity (HC) with an increase in Mg:Ca ratio at a particular SAR was observed in the non-calcareous soil then in the calcareous soil. The percentage of decrease in HC with an increase in the Mg: Ca ratio from 2 to 16 in leaching water of SAR 10 was 14.4 in the calcareous soil and 20.5 in the non-calcareous soil. The corresponding percentage of decrease in the HC at SAR 50 was 20.4 in the calcareous and 36.5 in the non-calcareous soil.

With increasing degree of dispersion hydraulic conductivity decreased. A greater reduction in hydraulic conductivity with an increase in Mg: Ca ratio at particular SAR was noted in the non-calcareous soil than in the calcareous soil.

Effect of electrolytes on dispersible clay

Dispersible clay decreased with increasing electrolyte, whereas calcareous soil A showed the minimum dispersion, non-calcareous soil B had intermediate dispersion and farmyard manure extract treated non-calcareous soil C had the maximum dispersion at all electrolyte concentration. Dispersion due to repulsion mechanism in low salt solutions is apparently associated with increase in double layer thickness.

The percentage of clay material with in soil dispersed when subject to different EC and SAR combination was reported and on the basis of that it was concluded that as SAR increase, higher salt concentration are required to maintain a relatively constants degree of swelling and dispersion. With the increase of SAR level the amount of dispersible clay also increase.

Effect of ESP and Electrolyte Concentration on the Dispersion Index of different soil

It was observed that with increasing electrolyte concentration and with increasing ESP hydraulic conductivity used to decreased. When

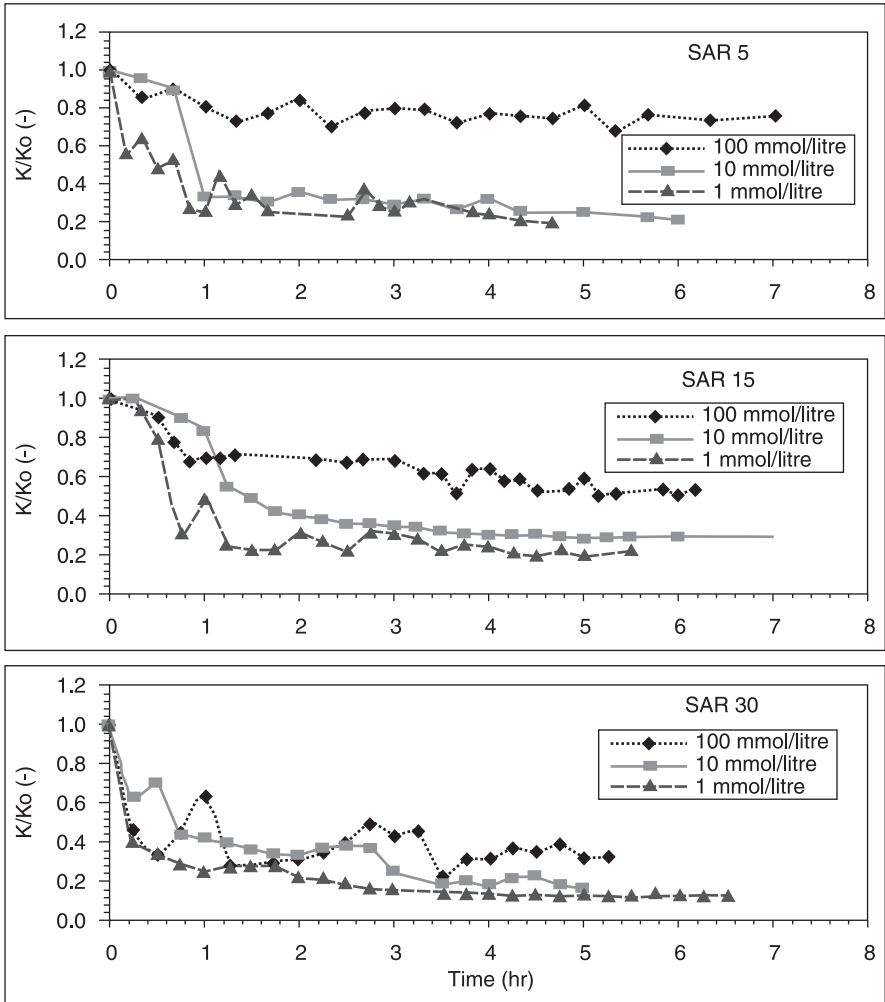


Fig. 8. Electrolyte concentration following leaching of soil columns solution of SAR 5, SAR 15 and SAR 30

Table 3. The percentage of increase in soil dispersion with an increase in SAR from 10 to 50 at the Mg: Ca ratio of 16 was only 54 in calcareous soil as against 74 in the non-calcareous soil.

Mg:Ca ratio	Calcareous soil			Non-Calcareous soil		
	10 SAR	25 SAR	50 SAR	10 SAR	25 SAR	50 SAR
2	5.0	15.5	56.0	8.1	29.4	79.0
4	5.3	16.0	57.0	8.7	30.2	80.4
8	5.9	16.7	58.5	9.6	31.4	81.6
16	6.7	18.0	61.1	11.0	33.7	85.3

Source: Giridhar and Yadav (1981)

Table 4. Effect of ESP and Electrolyte Concentration on the Dispersion index of different soil

Belvatagi (Black Soil)		Siruguppa (Black Soil)		Manoli (Red soil)	
ESP	DI	ESP	DI	ESP	DI
9.8	8.1	13.6	5.2	7.1	12.77
13.1	9.5	22.3	6.3	11.2	15.32
16.6	18.7	28.2	12.1	17.6	18.45
19.8	26.3	35.4	41.6	22.1	26
21.4	31.1	38	42.3	26.3	46.5
28.5	44.4	42	48.1	42	68

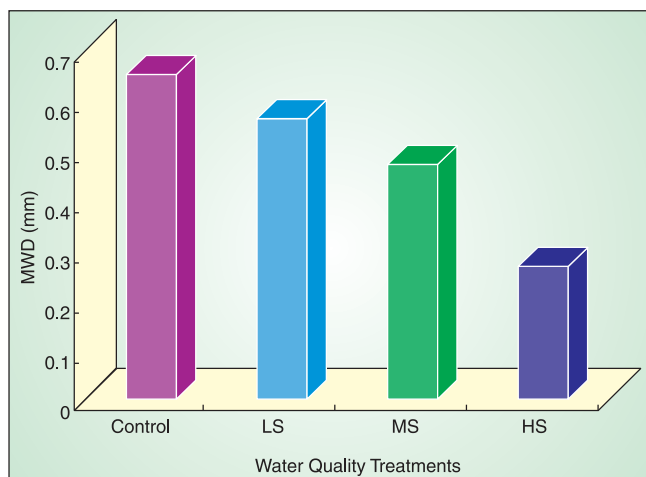


Fig. 9. LS, low EC-SAR (EC=0.6 dSm⁻¹ and SAR = 0.9); MS, moderate EC-SAR (EC=2.0 dSm⁻¹ and SAR = 10); and HS, high EC-SAR (EC=6 dSm⁻¹ and SAR = 30)
Source: M. R. Emded (2006)

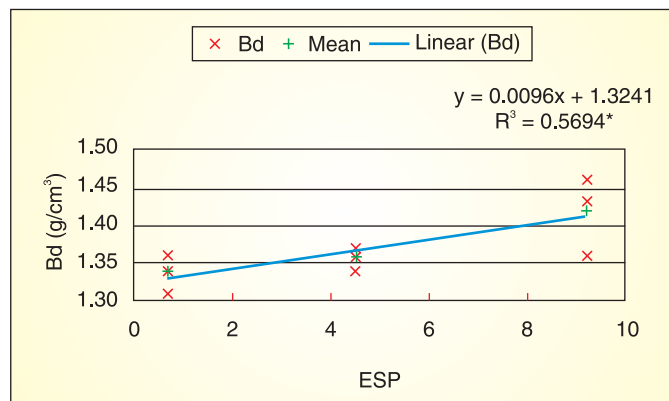


Fig. 10. Relationship between ESP and sub-surface bulk density of soil.
Source: M. R. Emded (2006)

Table 5. Effect of leaching with waters having different Mg:Ca ratio, SAR value and electrolyte concentration on the hydraulic conductivity of different soils

Leaching Water		Hydraulic Conductivity mm/ha							
		Karnal Soil		Canning Soil		Kota Soil		Indore Soil	
SAR	Mg:Ca ratio	20	80	20	80	20	80	20	80
(m mol ^{1/2} litre ^{-1/2})									
10	2	6.5	8.3	1.55	2.1	14.3	17.6	34	39
	4	6.1	7.7	1.5	2	14.1	17.2	33.6	38
	8	5.9	7.4	1.46	1.93	13.5	16.7	32.7	36.8
	16	5.6	7.1	1.4	1.84	13.1	16	32	36.1
25	2	5.1	6.7	1.1	1.6	11.4	14.7	29	35
	4	4.7	6.1	1.05	1.51	11.1	14	28.1	33.7
	8	4.5	5.8	0.98	1.38	10.5	13.3	26.7	32
	16	4.2	5.3	0.93	1.32	10	12.6	26.2	31
50	2	4.4	5.8	0.8	1.3	9.7	12.8	26	32
	4	4	5.3	0.76	1.22	8.5	12	25.3	30.5
	8	3.8	4.9	0.71	1.1	8.2	11.4	24	29.1
	16	3.3	4.5	0.65	1.03	7.8	10.5	23.4	28.3

20 and 80 denote electrolyte concentration of leaching water in me/l

Source: Girdhar and Yadav, CSSRI, Karnal (1980)

the micelle electronegativity is at a maximum. Highly hydrated movement ions, such as Na⁺⁺, which are not very tightly hold, cannot reduce the electronegativity of the micelle. Permitting the individual micelles to repel each other and to stay in dispersion.

Dispersion index of all soils increasing ESP and decreasing electrolyte concentration. The soils dispersed more in distilled water (0 ml/l) than in 20 and 40 ml/l salt solution. The higher dispersion in distilled water could be attributed to the increased hydration of absorbed ions especially sodium which resulted in greater thickness of electrical double layer.

At near equivalent ESP and

electrolyte concentration, red soils dispersed more than black soils. The lower values of DI in black soils even at relatively higher ESP values might be due to the presence of CaCO₃, a binding agent. On the other hand, relatively higher dispersion in red soils could be attributed to their higher sand content. The critical ESP for dispersion varied from soil to soil. The critical values were 13.1, 22.3, 17.2 for Belavatagi, Sirguppa, Arabhavi black soil (Table 4) and 11.2, 11.8 and 16.3 for Manoli, Sirigeri and Kallogi red soil.

Permeability as function of electrolyte concentration for various SAR and time

The relation permeability (k/ko), (where ko and k is the initial and

actual measured permeability respectively), measured as function of electrolyte concentration, following leaching of the soil columns with solutions of SAR 5, 15 and 30 (Fig 8). Generally k/ko decreased with time, with increasing SAR and with decreasing electrolyte concentration.

But in case of SAR level of 30 with the increasing electrolyte concentration from 1 mmol/litre to 100 mmol/L the HC was low because at the high SAR level the electrolyte concentration was not strong enough to suppress the effect of high strong enough to suppress the effect of high SAR level.

Fractional change in HC can be observed by the increased of ESP from 1.36 to 5.01, the HC of Buhdelkhand type III B, Kanpur, Bhabar and Dehradun decreased by 10, 21, 18 and 14% respectively (Table 2). Corresponding decrease for the above soil was 50, 44, 49 and 43% at 14.42 ESP and 95, 96, 97 and 87% 29.88 ESP.

As with the increase of SAR value from 10 to 15 m mol^{1/2} L^{-1/2} HC decrease, but with the increase in electrolyte concentration from 20 to 80 meq/litre the hydraulic conductivity increase. With the increase of Mg:Ca ratio the hydraulic conductivity decreases.

It can be concluded that per cent decrease in the hydraulic conductivity increased with the increasing SAR and decreasing electrolyte concentration of leaching irrigation

water. The magnitude of the present decrease in hydraulic conductivity due to increase in SAR in leaching water. Karnal and Canning soil the decrease in HC was high than the Indore and Kota soil. Indore and Kota soils highly calcareous in nature and dominated by exchange Ca, the hazardous effect of high SAR was much less.

Behaviour of different water quality with mean weight diameter

In this experiment the values of mean weight diameter using different water qualities are grouped in different classes (level of significance <0.01). These results show that with increasing SAR values in irrigation water, mean weight diameter was decreased rapidly.

Sodium (Na) has opposite effect on soils that salinity does. The primary physical process associated with high sodium (Na) concentrations is soil dispersion. Soil dispersion results from the breakdown of soil aggregates in water, leaving clay particles to disperse and settle into pore spaces between soil (aggregate breakdown and increase bulk density).

Relation between ESP and subsurface bulk density

Bulk density increased linearly with increase in exchangeable sodium percentage.

SUMMARY

A major concern in irrigated agriculture is the maintenance of

sufficiently high soil permeability for salinity control. It is well known that the concentration and composition of the percolating solution has a great influence on the stability of soil structure and hydraulic conductivity with decreasing electrolyte concentration and increasing SAR of the percolating solution. A satisfactory permeability could be maintained even at higher levels of ESP by maintaining the electrolyte concentration of the percolating water.

¹Block Technology Manager (BTM), C/o The S A Hazamara, Hazamara Agriculture Sub-Division, Corresponding authors' e mail: bhargabi07@gmail.com

Attracting and Retaining Youth in Agriculture (ARYA)

Realizing the importance of rural youth in agricultural development especially from the point of view of food security of the country, ICAR has initiated a program on "Attracting and Retaining Youth in Agriculture."

The objectives of ARYA project are:

- (i) To attract and empower the youth in rural areas to take various agriculture, allied and service sector enterprises for sustainable income and gainful employment in selected district;
- (ii) To enable the farm youth to establish net work groups to take up resource and capital intensive activities like processing, value addition and marketing; and
- (iii) To demonstrate functional linkage with different institutions and stakeholders for convergence of opportunities available under various schemes/program for sustainable of youth.

ARYA project will be implemented in 25 states through KVKs, one district, 200-300 rural youth will be identified for their skill development in entrepreneurial activities and establishment of related micro-enterprise units in the area of Apiary, Mushroom, Seed processing, Soil testing, Poultry, Dairy, Goatry, Carp-hatchery, Vermi-compost etc. KVKs will involve the Agricultural Universities and ICAR Institutes as technology partners. At KVKs also one or two enterprise units will be established so that they serve as entrepreneurial training units for farmers. The purpose is to establish economic models for youth in the villages so that youths get attracted in agriculture and overall rural situation is improved.

The trained youth groups will function as role model for other youths and will demonstrate the potentiality of the agri-based enterprises which will help in improving their confidence levels and encourage them to pursue farming as profession, generate additional employment opportunities to absorb under employed and unemployed rural in secondary agriculture and service related activities in rural areas.

Pradhan Mantri Krishi Sinchai Yojana

This Yojana brings

- Per Drop More Crop.
- Inputs from MoWR and DOLR received.
- Increase in agricultural production and productivity and enhance farm income.