P-ISSN: 2349-8528

E-ISSN: 2321-4902

www.chemijournal.com

IJCS 2020; 8(2): 2023-2027

© 2020 IJCS

Received: 06-01-2020

Accepted: 10-02-2020

TA Shirolkar

Department of Soil Science and
Agricultural Chemistry, Dr.
PDKV, Akola Uttar Pradesh,
India

SM Jadhao

Department of Soil Science and
Agricultural Chemistry, Dr.
PDKV, Akola Uttar Pradesh,
India

DV Agarkar

Department of Soil Science and
Agricultural Chemistry, Dr.
PDKV, Akola Uttar Pradesh,
India

NM Konde

Department of Soil Science and
Agricultural Chemistry, Dr.
PDKV, Akola Uttar Pradesh,
India

DP Deshmukh

Department of Soil Science and
Agricultural Chemistry, Dr.
PDKV, Akola Uttar Pradesh,
India

Corresponding Author:**DP Deshmukh**

Department of Soil Science and
Agricultural Chemistry, Dr.
PDKV, Akola Uttar Pradesh,
India

Effect of varying levels of CA/MG ratios of irrigation water on dispersion and flocculation of soils

TA Shirolkar, SM Jadhao, DV Agarkar, NM Konde and DP Deshmukh

DOI: <https://doi.org/10.22271/chemi.2020.v8.i2ae.9052>

Abstract

The present laboratory investigation was carried out at Department of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola. The bulk soil sample of two different soils i.e. salt affected and normal soil were collected from Ramagarh, Dist.-Amaravati and Department farm of Dr. P. D. K. V. Akola respectively in November 2017. Application of saline water in both studied soils showed decrease in the pH values and increased the EC of the soils leachates. A preferential Ca^{2+} holding in soil profile was only notice in salt affected soil when leaching process was performed with independent saline water. Gradual increase in Mg^{2+} loading in incoming solution holds more Mg^{2+} in soil. Clay of all the soils became more flocculated when leached with concentrated saline water as compared to dilute saline water. It was found that Ca^{2+} ion were more effective than Mg^{2+} ion flocculating in soil clays. A large dispersion percentage in salt affected soil might be due to high exchangeable Na^+ content. Salt affected soil became more dispersed when leached with saline water as compared to normal soil. In this study the 2.5:1 Ca/Mg ratio with 60 $\text{meL}^{-1}\text{TEC}$ and SAR 5 $\text{mm}^{1/2} \text{L}^{1/2}$ was beneficial for clay flocculation and reduce dispersion of clay particles.

Keywords: Salt affected soils, flocculation, dispersion, concentrated saline water, dilute saline water

Introduction

In arid and semi-arid climatic condition, ground water often contains an appreciable amount of salt and is invariably of poor quality. In many cases magnesium concentration dominates calcium and which increases salinity level (Yadav and Girdhar, 1980) ^[1]. Continuous irrigation with such poor quality water containing a high proportion of Mg^{2+} can damage the soil structure (Dontsova and Norton, 1999) ^[3].

Due to detrimental effect of the magnesium ion on soil structure, it is debated whether Mg^{2+} should be grouped with divalent Ca^{2+} or monovalent Na^+ for determining the suitability of irrigation water and management of magnesium rich irrigation water.

Norton and Dontsova (1998) ^[2] illustrated that natural soil with high percentage of magnesium compared to calcium on exchange sites were inferior in soil structure and has greater dispersion. A possible reason for a specific Mg^{2+} effect is the smaller ionic radius of Mg^{2+} compared to Ca^{2+} (0.066nm vs. 0.099nm; Sanyal, Poomia and Baruah, 2009) ^[4] and therefore, its larger hydration shell (Bockris and Reddy, 1970; Dontsova and Norton, 2002) ^[5] results in an increasing particle size of magnesium saturated clay and decrease in interparticle attraction.

In addition, smaller stern layer of Mg-saturated clay is known to result in double layer and decrease in stability of the colloidal system (Overbeek, 1952) ^[7]. Less energy would be required to break the linkages among the aggregates of Mg^{2+} tectoids than the aggregates of Ca^{2+} tectoids as the hydration number of the Mg^{2+} ion is approximately 50 percent greater than that of the Ca^{2+} (Keren, 1991) ^[8]. Yadav and Girdhar (1980) ^[1] reported increased dispersion of clay particles and reduced hydraulic conductivity when the Ca/Mg ratio was decreased at a given SAR and electrolyte concentration of the irrigation water. Negative effects of Mg^{2+} on soil structure are well established for sodic soils and problems of sodicity recognized due to excessive Mg^{2+} content. Most of the findings on flocculation studies are confined to illitic (Heil and Sposito, 1993; Rengasamy, Greene, and Ford, 1986) ^[9, 10] and smectitic (Curtin, Steppuhn, and Selles, 1994) ^[11] clays and

confirm that Mg^{2+} causes dispersion of colloidal system when Present studies are aimed at evaluating the effects of varying Ca/Mg waters on dispersion and flocculation characteristics of two different soils.

Material and Methods

The present laboratory investigation entitled “Effect of varying levels of Ca /Mg ratios of irrigation water on dispersion and flocculation of soils” was carried out during 2017-18 in Purna valley of Vidarbha region of Maharashtra state and Department farm of Soil Science and Agriculture Chemistry, Dr. PDKV, Akola. Geographically the location of Purna Valley is from 20° 40' to 21° 22' N

latitude and 76° 15' to 77° 45' E longitude and the elevation varies from 250 to 450 meters above the mean sea level. The soils have Typic Tropustic moisture regime and isohyperthermic temperature regime. The soil samples were collected from village Ramagarh, District Amaravati, District having Latitude 20° 55' 19.452" N and Longitude 77° 19' 36.40" E and Department farm of Soil Science and Agricultural chemistry, Akola having Latitude: 20° 58' .513 " N and Longitude: 77° 58' .076 " E. The bulk soil samples of two different soils were collected from Purna valley of Vidarbha and Department farm of Dr. P. D.K. V. Akola. Out of these two soils, one was salt affected and another was normal used for this investigation

Fig 1: Map of Purna valley tract

15 cm height and 15 cm diameter PVC pipe were used which was filled with soil and the soil columns were slowly wetted from the bottom by capillary rise with deionized water for 24 h or until the water reached the soil surface. The columns were drained overnight, on the next day, saturation and drainage processes were repeated once again. separate column leaching experiments were conducted with 60 and 120 me L^{-1} solutions using chloride salts of Ca and Mg at a fixed SAR of 5.0 mmol $1/2$ $L^{-1/2}$ and Ca/Mg ratios of 2:1, 1:1, 1:2 and 2.5:1. Five pore volumes (1720 cm^3) of each of the four

solutions (deionized water, 60 me L^{-1} and 120 me L^{-1}) were passed and subsequently leachate was collected at the end of each pore volume. The leachates were filtered through a whatman no. 40 filter paper and frozen for subsequent laboratory analyses. The pH, EC, and concentrations of Ca^{2+} , Mg^{2+} , Na^+ , SO_4^{4-} and Cl^- of filtrate were determined by standard methods. By following the same procedure, separate column leaching experiments were conducted with 60 and 120 me L^{-1} solutions using

Fig 2: Leaching of soil column with different electrolytic concentration

After completion of the leaching, the soil columns were allowed to drain. Then the soil in the column was air dried and passed through a 2-mm sieve. 50 g of 2 mm equilibrated soil was placed in a 1 L cylinder and volume was made to 1 L mark with distilled water. Forty normal strokes with a long plunger were applied to the soil suspension. The percentages of silt and clay-sized particles were determined by the international pipette method (Gee and Bauder 2006) and termed as water-dispersible silt + clay. Similarly, 50 g of the same equilibrated soil was taken in a 1 L beaker, and 30 mL of 30 percent H_2O_2 will be added in two instalments of 15 mL. The content was allowed to react for 6 h. After complete oxidation of organic matter, 15 mL of 0.1N HCl will be added and allowed to react for 1 h. 200 mL of 5 percent sodium hexa-meta-phosphate solution will be added in the organic matter and CaCO_3 -free soil, and the soil suspension were allowed to deflocculated for 12 h. The suspension was stirred by an electrical stirrer (at 4000 revolutions per minutes) for 3 min and transferred to a 1 L cylinder. The suspension volume was made to 1 L by adding distilled water. Using a long plunger, forty gentle strokes were applied to the suspension and total dispersible 'silt + clay' was determined Using the International pipette method. Dispersion was expressed as dispersion index (DI) as described by Chaudhari (2001).

$$\text{DI \%} = [\text{water dispersible (silt + clay)}/\text{Total (silt + clay)}] \times 100$$

Flocculation studies were performed to investigate the effect of different Ca/Mg ratios of solutions on soil clay flocculation. The clay fraction of soil ($<2.0 \mu\text{m}$) was separated using a standard method (Dontsova and Norton 1999) ^[3], where organic matter was not destroyed and a chemical dispersing agent was not used. The needed fraction of the soil was dispersed with deionized (DW) water and sedimented. The clay was washed and dialyzed until no Cl^- was detected with the AgNO_3 test, then freeze dried and stored for further use. A 0.25 g clay sample per 40.0 mL test tube was taken to obtain a suspension concentration of 6.25 g L⁻¹. Samples were manually dispersed, shaken, and kept overnight to settle for 24 h. After 24 h, transmittance of the suspension at 3.5 cm deep was measured by spectrophotometer at 420 nm wavelengths (Dontsova and Norton 1999) ^[3]. Transmittance of deionized water was set at 100 percent.

Statistical analysis data will be tabulated and analyzed by applying completely randomized design with three replications.

Result and Discussion

Effect of Ca/Mg ratio water on Dispersion

The dispersion indexes (DI) of salt affected and normal Vertisols were 30.9, 23.45% respectively before leaching. A large dispersion percentage (Table 1) in salt affected soil might be associated with high exchangeable Na^+ content). (Fig. 1)

The effect of Ca/Mg ratios on dispersion index showed that the increase in dispersion index was more with magnesium saturated water in both salt affected and normal soil and the large dispersion was noted with 1:2 Ca/Mg ratio in both 60 and 120 meL^{-1} TEC water treated soils and the increase was 18.43 and 14.11% in salt affected soil with 60 and 120 meL^{-1} TEC respectively and 41.66 and 6.31% with 60 and 120 meL^{-1} TEC respectively in normal soil.

Equal/lower magnesium concentration behaves like calcium if magnesium more than calcium it behaves like sodium resulting dispersion and decrease infiltration rate (Bohn *et al.*, 1985) ^[13].

Table 1: Dispersion index of soils as a function of water quality

Total electrolyte concentration meL ⁻¹	Ca/Mg ratio	Dispersion index (%)	
		Salt affected soil	Normal soil
Initial value		30.9	23.45
60	2:1	34.17	29.54
	1:1	35.83	33.09
	1:2	36.57	33.22
	2.5:1	31.5	27.97
	Mean	34.51	31.01
SE(m)+		1.32	2.22
CD@5%		4.33	7.21
120	2:1	33.12	22.29
	1:1	34.41	25.56
	1:2	35.26	26.47
	2.5:1	28.72	24.93
	Mean	32.85	26.31
SE(m)+		2.04	2.11
CD@5%		6.66	6.91

The 2.5:1 Ca/Mg ratio at 120 meL^{-1} TEC found better to minimize the dispersion of soils. Dispersion index was more noted in lower (60 meL^{-1} TEC) total electrolyte concentration than higher (120 meL^{-1} TEC). Same results were reported by Van (1977) ^[14] who coined that the decrease in the degree of dispersion with increase in total electrolyte concentration. He also observed that in a stable clay suspension, dispersed particles colloid frequently because of their Brownian movement but separate again because of diffuse double layer repulsion forces when salt is added to the clay suspension, the particles stick together upon collision, forming flocks which settle down

Fig 3: Dispersion index of soils as a function of water quality

Normal Vertisols remained more dispersed when leached with both the TEC levels compared to original condition. This finding is supported by Chaudhari (2001), who reported sodic solutions (regardless of varying SAR level 2.5 to 30 mmol/1/2 $L^{-1/2}$ with low TEC 10.0 me L^{-1}) enhanced dispersion of soils in three texturally different soils.

Smectitic clays are more dispersible than kaolinitic clays (Goldberg and Glaubig, 1987) ^[15] as well as illitic and kaolinitic soils, which contain small amounts of smectite that may be dispersible and as susceptible to sealing as smectitic soils.

Effect of Ca/Mg ratio water on Soil Clay Flocculation

The data in respect of effect Ca/Mg ratio on flocculation of two different soils placed in Table 2 and depicted in Fig. 2 which shows that, leached effluents of saline solution with 60 and 120 me L^{-1} TEC which having four Ca/Mg ratios influenced on both soils. The clay flocculation was decreased in both studied soil after leaching. The clay of both soils became more flocculated when leached with 120 me L^{-1} TEC as compared to 60 me L^{-1} TEC.

A decreased in flocculation might have caused by the expansion of the double layer, decreasing electrolyte concentration. The highest value observed in 5:1 Ca/Mg ratio, followed by 2:1, 1:2, 1:1 ratio in both the soils. It might be due to these ratio contain more calcium which influence the flocculating effect.

Dontsova and Norton (1999) ^[3] reported that the percentage of calcium in the solution had significant influence on the flocculation of the clay fraction; Kadir Yilmaz (2005) reported that, an increase in clay does not always result in

increased stability. While the clay mineral content is an important factor in aggregation, its influence is modified by the stability of high-clay soils, which depends on the physical-chemical properties of the clay.

Clay of all the soils became more flocculated when leached with concentrated saline water as compared to dilute saline water. On sequentially lower electrostatic force with which a hydrated Mg^{2+} ion is held at the clay surface (Dontsova and Norton 2002) ^[6] compared to normal Vertisols and salt affected.

Table 2: Percentage transmittance of clay suspension at 420 nm of two soils

Total electrolyte concentration meL ⁻¹	Ca/Mg ratio	Flocculation	
		Salt affected soil	Normal soil
Initial value		66.3	35.4
60	2:1	50.57	32.87
	1:1	49.40	32.33
	1:2	49.33	31.77
	2.5:1	63.37	36.50
	Mean	59.36	33.34
SE(m)+		6.13	3.34
CD@5%		19.99	10.9
120	2:1	61.37	35.83
	1:1	56.07	34.50
	1:2	52.83	31.17
	2.5:1	62.17	37.57
	Mean	53.16	34.51
SE(m)+		1.73	2.20
CD@5%		5.66	7.20

Fig 4: Percentage transmittance of clay suspension at 420 nm of two soils

Conclusion

From these result it is concluded that the 2.5:1 Ca/Mg ratio with 60 meL⁻¹ TEC of synthetic water has found to be beneficial for calcium holding in soil, less dispersion of clay particle and influence clay flocculation.

References

1. Giridhar IK, Yadav JSP. Effect of different Mg/Ca ratios and SAR values and electrolyte concentration in the leaching water on the dispersion and hydraulic conductivity of soil s. int. Symp. Salt affected Soils, Karnal, 1980, 210-218.
2. Norton LD, Dontsova. Use of soil amendments to prevent soil surface sealing and control erosion. Advance in Geo Ecology. 1998; 31:581-87.
3. Dontsova KM, Norton LD. Effect of exchangeable Ca:Mg ratio on soil clay flocculation, infiltration, and erosion. In Tenth International Soil Congress Organization, 1999, 580-85.
4. Sanyal SK, Poonia SR, Baruah TC. Soil colloids and ion exchange in soil. In Fundamentals of soil science, ed. N. N. Goswami. New Delhi, India: Indian Society Soil Science, 2009, 269-314.
5. Bockris JO, Reddy AKN. Modern electrochemistry, vol. 1. New York: Plenum, 1970.
6. Dontsova KM, Norton LD. Clay dispersion, infiltration, and erosion as influenced by exchangeable Ca and Mg. Soil Science. 2002; 167(3):184-93.
7. Overbeek JTG. Stability of hydrophobic colloids and emulsions. In Colloid science, vol. I: Irreversible systems, ed. Kruyt HR, Amsterdam, the Netherlands: Elsevier, 1952, 302-41.
8. Keren R. Specific effect of magnesium on soil erosion and water infiltration. Soil Science Society of America Journal. 1991; 55:783-87.
9. Heil D, Sposito G. Organic matter role in illitic soil colloids flocculation, I: Counter ions and pH. Soil Science Society of America J. 1993; 57:1241-46.
10. Rengasamy P, Greene RSB, Ford GW. Influence of magnesium on aggregate stability in sodic red-brown earths. Australian Journal of Soil Research. 1986; 24:229-37.
11. Curtin DH, Steppuhn, Selles F. Effects of magnesium on cation selectivity and structural stability of sodic soils. Soil Science Society of America Journal. 1994; 58:730-37.
12. Gee GW, Bauder JW. Particle size-analysis. In Methods of soil analysis, part I, 2nd ed. Klute A. Madison, WI: ASA and SSSA, 2006, 383-409.
13. Bohn HL, McNeal BL, Connor GAO. Soil Chemistry. John Wiley and sons Inc. New York, 1985.
14. Van OH. An introduction to clay colloid chemistry 2nd Ed. New York, John Willey and Sons, 1977.
15. Goldberg S, Glaubig RA. Effect of saturation cation, pH, and aluminum and iron oxide on the flocculation of kaolinite and montmorillonite. Clays Clay Min. 1987; 35:220-227.
16. Yilmaz K. Clay Minerals, Ca/Mg Ratio and Fe-Al-Oxides in Relation to Structural Stability, Hydraulic Conductivity and Soil Erosion in Southeastern Turkey. Turk J Agric For. 2005; 29(2005):29-37.