

Effects of Magnesium on Cation Selectivity and Structural Stability in prominent Vertisols of Karnataka

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Abstract

A study was conducted to evaluate the effects of Mg on ternary (Na-Ca-Mg) exchange and intern structural stability in prominent Vertisols of TBP (Tungabhadra Project) and UKP (Upper Krishna Project) irrigation commands of Karnataka State, India. Surface soil samples representing typical Vertisols derived from granite-gneiss (Gangavati and Kavadimatti), limestone (Devapur and Islampur) and basalt (Kadliwad and Mannapur) were included in the study. These soils were subjected to equilibration with waters of varying sodium adsorption ratio (SAR-5,20,40,60,80 and 100 millimoles per liter^{1/2}) with different Ca/Mg ratio (4:1,2:1,1:1,1:2and 1:4). Exchangeable Na increased as the Mg/Ca ratio increased from 1:4 to 4:1 indicating that Mg charged waters are more detrimental for structural integrity of the soils. Averaged from all SAR treatments, the Mg-Na systems had between 10.5 to 12.1% more exchangeable Na than did the Ca-Na systems. The Mg-induced increase in exchangeable Na was directly related to a preference by the soils for Ca over Mg, which makes Na more competitive against Mg than against Ca. The influence of Mg on soil structural stability was examined by measuring degree of dispersion, capillary raise and moisture diffusivity using Na-Ca-Mg solutions varying with Ca/Mg ratios and SAR values. In order to segregate the specific effect of Mg, separate binary systems (exclusive Ca-Mg solutions with varying concentrations without Na) were used to examine the degree of dispersion. The Mg-Na system developed considerably lower soil moisture diffusivity and higher degree of dispersion as well as capillarity than did the Ca-Na system when equilibrated with solutions having total electrolyte concentration 20 m mol liter¹. Dispersion and water transmission tests confirmed that the effect of Mg was greater than could be explained by the higher exchangeable Na alone in the Mg system or else Mg had a specific effect on clay dispersion. It was obviously proved that Mg does have the effect on clay dispersion in the binary system involving diminishing Ca concentration where Na was completely excluded. Our results suggest that exchangeable Mg is about 1/10th, 1/20th, and 1/30th as dispersive as Na in granite-gneiss, limestone and basalt derived soils, respectively.

Introduction

The role of exchangeable Mg in maintaining soil structural stability is still an unresolved issue. Although the U.S. Salinity Laboratory Staff (1954) grouped Mg and Ca together as having similar beneficial effects on structural stability, it has long been suspected that Mg may be deleterious in some situations. The development of 'Mg solonetz' in Manitoba, Canada, is often cited as an illustration of a situation where Mg has been a factor of structural deterioration [1]. Many laboratory studies have also suggested that Mg may be less effective than Ca in maintaining structural stability. For instance, several studies have demonstrated that mixed Na-Mg soils develop lower hydraulic conductivity than do Na-Ca soils under similar conditions [2,3]. This was attributed to accelerated rupture of soil structure in Na-Mg system compared to Na-Ca system. However, a distinction has been drawn between the direct effect of Mg on soil physical properties (specific effect) and an indirect effect of Mg on sodium accumulation on the exchange sites (Mg-induced sodication). The specific effect is related to the fact that Mg by virtue of its higher hydration number (50%) than Ca ion is triggering the malady [4]. It is expected that the thickness of the Stern's layer in the diffused double layer would be wider for Mg than Ca and thereby leads to structural deterioration. On the contrary, in Mginduced sodication, sodium (Na) will be more competitive against Mg than Ca for exchange sites leading to structural deterioration. The degree of preference for Na in Mg, compared with Ca depends on the nature of the exchange complex [5]. Soils with clay mineralogy dominated by smectite or illite generally have preference for Na in Mg, compared with Ca [6]. On the contrary, the vermiculitic soils may behave differently from other soils in that Na may be less competitive against Mg than with Ca [6]. This is probably due to the fact that vermiculite exhibits a strong preference for Mg relative to that for Ca [7,8]. The question of whether Mg does, in fact, have a specific effect has been a subject of considerable debate in the literature [6,9,10]. From a study with California soils concluded that Mg did not have a specific effect [10]. More clay dispersion when Mg, rather than Ca was the counter ion was attributed to higher levels of exchangeable Na and lower electrolyte concentration in the Mg systems. Through measurements of clay swelling, degree of dispersion and hydraulic conductivity, concluded that Na-Mg montmorillonite as well as montmorillonitic soil behaved identically to their Na-Ca counterparts at the same ESP and TEC indicating no specific effect [6]. On the other hand, an illitic soil and an illitic-montmorilloniticsoil however showed specific effect.

Rahman and Rowell suggested that the presence of Mg should be taken into classification of irrigation waters [6]. Moreover, the ground waters of TBP and UKP commands used for irrigation have relatively high Mg concentration next only to Na. The use of such Mg charged waters may result both in increases in exchangeable Mg and in higher exchangeable Na levels than would be the case with low-Mg waters. The

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Received February 04, 2015; Accepted February 10, 2015; Published February 17, 2015

Citation: Suguru PM (2015) Effects of Magnesium on Cation Selectivity and Structural Stability in prominent Vertisols of Karnataka. Fungal Genom Biol 5: 121. doi:10.4172/2165-8056.1000121

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presence of Mg thus could increase the sodicity hazard of irrigation water besides directly affecting on the deterioration of soil structure. In the light of the above contentious issues, the present study was conducted to elucidate the Mg-induced sodication as well asexchangeable Mg per se (specific effect of Mg)in soils derived from granite-gneiss, limestone and basalt of TBP and UKP irrigation commands with the objective to explain the effect of waters of varying sodium adsorption ratio (SAR) and Ca/Mg ratio.

Materials and Methods

Six surface soils (Ap horizon) representing granite-gneiss, limestone and basalt were used in the equilibration studies with waters of varying SAR (5, 20, 40, 60, 80 & 100 m mol $l^{-1/2}$) and Ca/Mg ratio (4:1, 2:1, 1:1, 1:2 & 1:4) with total electrolyte concentration being restricted to 20 meq L⁻¹. The initial properties of all the soils are made available in Table 1. Batch equilibration studies on ternary exchange (Na, Ca and Mg) were carried out on pretreated soils (CaCO₃ free) and homoionic (Na-soil) soil system. The adsorbed Na, Ca and Mg were accounted by the difference in the concentration in the equilibration solution and the exchangeable Na as well as Gapon's selectivity coefficients was worked out.

The degree of dispersion was measured as water dispersible clay being expressed as the percentage of the total clay present in the soil [11]. The effect of varying SAR (25, 50 and 100 m. mol.L^{-1/2}) and Ca:Mg ratio (1:4, 1:1 and 4:1) on capillarity was measured. For this soils passed through 2 mm sieve was packed to a known bulk density (1.25 Mg m⁻³) in a glass tube (10 mm diameter) and placed in such a way that water touches the bottom of the tube. The capillary rise of water as a function of time was thus expressed in terms of cm/hr. The soil moisture diffusivity coefficients were computed by the method suggested by Bruce and Klute [12].

Results and Discussion

Effect of Mg on sodication

An increase in SAR resulted in higher ESP in all the soils irrespective of parent materials from which they were derived (Table 2). However, the increase in ESP was more conspicuous in limestone weathered soils (Devapur and Islampur) compared to those of basalt (Kadliwad and Mannapur) and granite-gneiss (Gangavathi and Kavadimatti). Among the granite-gneiss derived soils, the ESP in Gangavathi increased from 5.1 to 17.9 percent owing to increase in SAR from 5 to 100 m mol 1-1/2 The corresponding in ESP was from 5.3 to 16.3 per cent in Kavadimatti soils. The effect of Mg-induced sodication was more pertinent in these soils where the mean ESP of Gangavathi soils (Mean over all the SAR) increased from 10.3 to 13.3 when the Mg charged water was introduced (Ca/Mg ratio was altered from 4:1 to 1:4) at similar SAR values. On the contrary, the other member of this group Kavadimatti soils exhibited lower magnitude of sodication (10.0 to 11.3%) when similar Mg charged waters were treated with identical SAR. There was about 12.1 per cent increase in ESP among the granite-gneiss derived soils with an increase in Mg (Ca:Mg ratio from 4:1 to 1:4) at similar SAR levels. The mean selectivity coefficients of Ca→Na remained higher compared to the respective Mg→Na at all the SAR values. This clearly illustrates that Mg is less competent against Na for occupying the exchange sites compared to that of Ca. In case of Devapur (representing limestone), the ESP increased from 7.4 to 17.9 percent when SAR was increased from 5 to 100 m mol l^{-1/2}. But the increase in ESP was slightly higher in Islampur (8.3 to 18.6%) when similar alteration in SAR was introduced. The Mg-induced sodication was higher (11.5 to 13.1%) in Devapur when compared to its compatriot Islampur (12.6 to 14.0%) when the Mg charged water was used in the equilibration (Ca/Mg ratio was increased from 4:1 to 1:4). Similarly, there was an increment in ESP (11.4%) amongst the limestone derived soils when Mg charged waters were introduced in the equilibration. The mean selectivity coefficients of Ca→Na remained higher compared to the respective Mg→Na at all the SAR values; however these values were lower in magnitude when compared to the soils derived from granite-gneiss.Basalt derived Kadliwad appeared to be least affected by increasing SAR (5 to 100 m mol l^{-1/2}) as the ESP was altered in a lower (4.7 to 13.0%) magnitude compared to rest of the soils. However, Mannapur soil was more susceptible (6.7 to 18.7% ESP)SAR was increased. Similarly, the Mginduced sodication was higher (17.9 to 19.4%) in Mannapur compared to Kadliwad (7.8 to 8.8%) when Mg charged water was introduced at similar SAR values. There was about 10.5 per cent increase in ESP among the basalt derived soils with an increase in Mg (Ca: Mg ratio from 4:1 to 1:4) at similar SAR levels.

In general, cations with higher charge are preferred and when charges are equal, cations of higher atomic mass are adsorbed. In this study, Ca was preferred at the expense of Mg. Further, in ternary exchange (Na-Ca-Mg), Na became less competitive compared to other divalents, based on the consideration of its charge and higher degree of hydration. On the contrary, Ca was preferred over Mg as well as Na by virtue of its lower hydration number and mean effective diameter. Thus Ca might have adsorbed on the Stern layer with a minimum energy as compared to Mg. Based on the hydration number (50%) higher) Mg was least preferred against Ca [13]. These explanations partially describe why selectivity coefficients of Mg \rightarrow Na were lower compared to that of Ca \Rightarrow Na. However, owing to the difference in the nature of exchanger, higher CEC, charge density and the chances of precipitation of Mg as magnesium hydroxide might have altered the degree of sodication in the soils [14-18].

Effect of Mg on clay dispersion

The degree of clay dispersion as influenced by Mg in Na-Mg system in comparison with Ca-Na is depicted in Table 3. In general Mg induced sodication and intern degree of dispersion was more in granite-gneiss derived soils followed by those of limestone and basalt. The relationship between ESP and dispersion tends to be sigmoidal, with a distinct ESP above which dispersion occurs. The presence of Mg lowered the threshold ESP required for dispersion. In granite-gneiss derived soils, dispersion (14%) was conspicuously triggered at an ESP of 5.5 per cent

Parent material	Location	pH-water (1:2.5)	pH-KCI (1:2.5)	EC	CEC	ESP	RSC
Granite-gneiss	Gangavathi	8.7	8.0	13.0	44.5	7.4	-13
	Kavadimatti	9.4	7.7	0.4	44.6	21.9	1.0
Limestone	Devapur	9.1	7.8	1.4	36.5	25.5	0.5
	Islampur	8.0	7.1	6.0	37.0	18.2	1.8
Basalt	Kadliwad	9.4	8.1	1.6	54.8	17.1	-1.2
	Mannapur	10.2	7.7	1.2	35.5	9.8	-1.8

 Table 1: Initial physico-chemical properties of selected soils.

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				Ca:Mg Ratio		Mean	Mean		
Location	SAR	4:1	2:1	1:1	1:2	1:4	Mean ESP	K _c (Ca→Na)	K _c (Mg→Na)
Gangavathi	05	3.8	5.1	5.1	5.1	6.3	5.1	13.8	11.0
	20	5.6	6.6	7.1	7.1	7.6	6.8	38.6	30.7
	40	7.6	8.4	9.1	9.9	10.6	9.1	56.6	42.5
	60	12.6	13.4	14.4	15.2	16.4	14.4	55.6	39.5
	80	15.2	15.9	17.2	17.7	19.0	17.0	58.9	42.6
	100	17.0	17.2	17.7	18.7	19.7	17.9	69.8	48.8
	Mean	10.3	11.1	11.8	12.3	13.3			
	05	4.7	4.7	5.4	5.6	6.1	5.3	13.9	9.8
	20	5.4	5.6	5.9	5.9	6.3	5.8	44.9	33.0
	40	6.1	6.3	6.3	6.8	6.8	6.5	81.6	56.8
Kavadimatti	60	12.9	13.4	13.8	14.3	14.6	13.8	60.6	43.8
	80	15.3	15.7	16.0	16.4	16.7	16.0	66.1	46.6
	100	15.5	16.0	16.2	16.9	17.1	16.0	79.0	55.6
	Mean	10.0	10.3	10.6	11.0	11.3			
Parent mate	rial Mean	10.2	10.7	11.2	11.7	12.3			
	05	6.9	6.9	7.3	7.7	8.2	7.4	9.0	6.7
Devapur	20	7.7	7.7	8.2	8.6	9.0	8.2	30.3	21.8
	40	9.9	10.3	11.0	11.4	11.6	10.8	45.3	32.2
	60	11.4	11.8	12.0	12.5	12.9	12.5	64.3	45.8
	80	16.1	16.6	17.2	17.8	18.3	17.2	55.8	40.0
	100	17.2	17.6	17.8	18.3	18.5	17.9	66.6	45.7
	Mean	11.5	11.8	12.2	12.7	13.1			
	05	7.7	8.1	8.3	8.7	9.2	8.4	8.1	5.2
	20	9.2	9.4	9.8	10.0	10.9	9.9	25.6	16.7
	40	9.8	10.0	10.6	11.3	12.2	10.8	47.6	27.8
	60	13.2	13.6	13.8	14.2	15.2	11.0	55.6	33.3
Islampur	80	17.7	18.1	18.3	18.5	19.4	18.4	52.6	32.3
	100	17.7	18.1	18.7	19.1	20.1	18.7	62.5	38.5
	Mean	12.6	12.9	13.2	13.6	14.5			
Parent mate	rial Mean	12.0	12.4	12.7	13.2	13.8			
	05	4.4	4.7	4.7	4.7	5.1	4.7	11.0	10.8
	20	4.7	4.7	4.7	4.9	5.1	4.8	40.0	38.2
	40	4.7	4.9	5.3	5.3	5.5	5.1	71.4	73.3
Kadliwad	60	9.1	9.5	9.8	10.2	10.6	9.8	62.5	61.0
	80	11.9	11.9	12.2	12.6	13.0	12.3	58.8	58.4
	100	11.9	12.2	12.6	13.0	13.2	12.6	71.4	71.6
	Mean	7.8	8.0	8.2	8.4	8.8			
	05	6.2	6.5	6.8	6.8	7.0	6.7	12.0	8.5
	20	7.3	7.6	7.9	8.4	8.4	7.9	38.2	26.5
Mannapur	40	9.8	10.1	11.0	11.5	11.3	10.7	55.1	36.2
	60	14.1	14.4	14.9	14.9	15.5	14.8	62.7	41.0
	80	16.3	16.9	17.7	17.7	18.3	17.4	67.7	42.9

Table 2: Effect of SAR and Ca/Mg ratio on ESP and Gapon's selectivity coefficients.

			Granite-gneiss		Limestone		Basalt	
Na	Ca/Mg	SAR	Na-Ca	Na-Mg	Na-Ca	Na-Mg	Na-Ca	Na-Mg
2	18	0.7	0.8 (0.4)	1.25 (1.4)	1.45 (1.4)	1.65 (6.0)	1.0 (0.7)	1.2 (5.1)
4	16	1.4	1.65 (0.55)	2.65 (1.65)	2.9 (2.9)	2.9 (10.6)	2.05 (1.25)	2.4 (11.3)
6	14	2.3	2.65 (0.80)	4.15 (12.1)	4.9 (11.8)	5.45 (25.5)	3.3 (4.5)	3.95 (12.0)
8	12	3.3	3.8 (1.30)	5.9 (20.1)	6.9 (17.5)	7.8 (38.9)	4.75 (8.35)	5.65 (17.2)
10	10	4.5	5.2 (2.5)	7.95 (27.5)	9.4 (27.1)	10.65 (41.45)	6.5 (14.45)	7.75 (21.9)
12	8	6.0	5.5 (13.95)	8.2 (42.5)	9.65 (36.75)	10.96 (46.0)	6.7 (15.65)	7.9 (28.0)
14	6	8.1	6.0 (16.0)	8.6 (65.5)	10.0 (39.65)	11.4 (52.35)	7.0 (17.6)	8.15 (23.8)
16	4	11.3	6.7 (20.5)	9.2 (70.3)	10.55 (44.05)	12.1 (54.35)	7.5 (20.8)	8.5 (24.4)
18	2	18.0	8.15 (24.25)	10.45 (71.95)	11.65 (45.7)	22.0 (59.50)	8.0 (21.15)	9.2 (25.65)

Table 3: Sodium saturation and consequent dispersion in presence of Ca and Mg.

an EMP attained (over

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in Na-Ca system. On the other hand, in Na-Mg system it was initiated at still lower (4.1%) exchangeable sodium. At highest SAR (18 m mol Γ^1), the Mg-Na system resulted in higher (72%) dispersion compared to Ca-Na system which recorded lower (24.2%) dispersion. Although the difference between the ESP attained between the two systems was low but still the dispersion was more in Na-Mg system compared to Na-Ca system. In limestone derived soils, the perceptible dispersion was initiated at lower ESP in Na-Mg system (2.9%) compared to Ca-Na system (4.9%) the respective dispersion values being 10.6 and 11.8 per cent which remained comparable. At the highest SAR level, the Na-Ca system attained an ESP of 8.2 percent resulting in 45.7 per cent dispersion. On the contrary, the Mg-Na system attained slightly higher (11.6%) ESP but resulted in significantly higher (59.5%) clay dispersion.

The basalt derived soils were least affected by the Mg-induced sodication and intern related clay dispersion. The threshold ESP required to induce perceptible dispersion was higher in both Ca-Na (6.5%) and Mg-Na (2.4%) systems. At the higher end SAR the ESP attained was 8.0 per cent in Ca-Na system which resulted in 21.2 per cent clay dispersion. Similarly, the Mg-Na system developed still higher (9.2%) ESP, which consequently resulted in higher (25.6%) dispersion.

The specific effect of Mg on dispersion is presented in Table 4, where the prime ion (Na) responsible for causing dispersion is totally eliminated and varied Ca/Mg waters were introduced to elucidate the degree of dispersion which as a result of exclusive magnesium. The degree of dispersion increased as the Mg saturation (EMP) increased on the exchange complex. The specific effect of Mg in causing clay dispersion was more evident in granite-gneiss derived soils followed by those of limestone and basalt. The mean EMP attained (over different Ca/Mg ratios) was 37.5 percent with a dispersion of 11.6% in granite gneiss. Although the mean dispersion remained identical (4.0%) in both limestone as well as basalt derived soils, the EMP attained in the former was lower (32.4%) compared to the latter (42.8%). The threshold EMP required to initiate noticeable dispersion was lower (31.0%) in granite-gneiss derived soils compared to those of limestone (78.0%) and basalt (85.5%).

Effect of Mg on moisture diffusivity and capillarity

The results of soil moisture diffusivity and capillarity as influenced by varying SAR and Ca/Mg ratio are made available in Table 5. In general the soil moisture diffusivity reduced with increasing SAR of the waters and also with the increase in Mg concentration. The reduction in moisture diffusivity with increase in Mg was more in granite-gneiss derived soils followed by those of limestone and basalt. On the other hand, the capillarity increased with the increase in SAR and Mg concentration in the waters. These results are consistent with the earlier observations where the infiltration rates of soils exposed to simulated rainfall was lower when they were saturated with Mg than when saturated with Ca [19,20]. The Mg soil was more susceptible for surface sealing, caused by aggregate disintegration and clay dispersion, than was the Ca soil. Emerson and Chi related the effect of Mg in comparison with Ca to the fact that the hydrated Mg ion is slightly greater than that of Ca (0.47 against 0.42 nm) [21]. This means that the electrostatic force with which Mg ion is held to the soil surface is less than that of Ca, so that greater proportion of ions can dissociate from the exchange sites in

Solution composition (me I ⁻¹)		Granite-gneiss		Lime	stone	Basalt	
Са	Mg	EMP	DD%	EMP	DD%	EMP	DD%
2	18	85.5	25.5	78.0	10.8	85.5	10.6
4	16	72.0	22.3	64.5	8.4	75.0	8.6
6	14	59.0	16.2	51.5	7.4	63.0	7.0
8	12	40.5	13.2	42.0	2.0	51.5	5.4
10	10	31.0	9.6	28.0	1.8	40.0	1.0
12	8	20.5	8.0	18.5	1.6	29.5	1.0
14	6	14.0	6.8	8.5	1.5	20.5	0.8
16	4	10.2	2.4	3.5	1.3	13.5	0.6
18	2	5.4	0.3	1.5	1.2	7.0	0.7
Mean		37.5	11.6	32.4	4.0	42.8	4.0

Table 4: Specific Effect of Mg on dispersion.

	CAD	Ca/Mg ratio								
	JAR	4	4:1		1:1	1:4				
		Diffusivity	Capillary rise	Diffusivity	Capillary rise	Diffusivity	Capillary rise			
Granite-gnoise	25	0.97	28.75 (0.40)	0.82	27.0 (0.37)	0.72	25.0 (0.34)			
Granite-grieiss	50	0.83	26.25 (0.36)	0.70	24.85 (0.34)	0.58	22.5 (0.31)			
	100	0.64	24.05 (0.33)	0.53	22.55 (0.31)	0.50	20.75 (0.28)			
Mean		0.81	26.25 (0.36)	0.68	24.8 (0.34)	0.60	22.75 (0.31)			
	25	0.86	27.95 (0.39)	0.75	27.3 (0.38)	0.71	26.5 (0.37)			
Limestone	50	0.59	24.4 (0.34)	0.57	24.0 (0.33)	0.53	23.3 (0.32)			
	100	0.49	21.7 (0.30)	0.46	21.2 (0.29)	0.38	20.75 (0.29)			
Mean		0.65	24.68 (0.34)	0.59	24.17 (0.33)	0.54	23.52 (0.33)			
	25	0.18	16.4 (0.22)	0.15	15.7 (0.22)	0.13	14.5 (0.20)			
Basalt	50	0.14	14.4 (0.20)	0.12	14.1 (0.19)	0.11	13.55 (0.18)			
	100	0.12	12.2 (0.17)	0.11	11.75 (0.16)	0.10	10.9 (0.15)			
Mean		0.15	14.3 (0.20)	0.13	13.85 (0.19)	0.11	12.98 (0.18)			

Table 5: Moisture transmission characters as influenced by varying SAR and Ca/Mg ratio.

the Mg system. Repulsive forces, which are responsible for dispersion, are thus somewhat greater in the Mg system.

Summary and Conclusion

The soils examined had a stronger tendency to accumulate exchangeable Na when Mg, rather than Ca, was the complimentary ion. This was directly related to a preference by the exchange sites for Ca over Mg, which makes Na more competitive against Mg than against Ca. Assessment of the effect of Mg on structural stability revealed that the degree of clay dispersion increased and consequently the soil moisture diffusivity reduced in Mg-Na system compared to that of Ca-Na system. Exchangeable Mg appears to be about 1/10th, 1/20th and 1/30th as dispersive as Na in granite-gneiss, limestone and basalt derived soils, respectively. Outcome of the present experiment suggest that the effect of Mg on the sodicity hazard of irrigation waters is likely to be large for granite-gneiss derived soils. The use of Mg charged waters would probably result in soils having higher exchangeable Na levels than with low Mg waters. The specific effect occasioned by a higher exchangeable Mg content will further increase the sodicity hazard of Mg rich waters. Lumping Mg together with Ca to characterize irrigation water quality may be in vogue for practical purpose but specific allowance for Mg, as suggested by is probably necessary for granite-gneiss derived soils [6].

References

- Ellis, J.H and Caldwell, O.G 1935 Magnesium Clay solonetz, Transactions 3rd International Congress of Soil Science 3: 348-350
- McNeal, B.L., Layfield, D.A., Norvell, W.A., and Rhodes, J.D 1968. Factors influencing hydraulic conductivity of soils in the presence of mixed salt solutions. Soil Science Society of America Proceedings 32:187-190
- Levy, G.J., Van Derwatt, H.V.H., and Duplissis, H.M. 1988 Effect of sodiummagnesium and sodium-calcium systems on soil hydraulic conductivity and infiltration. Soil Science, 146: 303-310
- Bockris, J. O. M. and Reddy, A.K.N. 1970 Modern electrochemistry, Volume I Plenum Press New York
- 5. Haghnia, G.H. and Pratt, P.F 1988 Effect of exchangeable magnesium in soils. Soil Science, 145: 432-436
- Rahman, W.A., and D.L. Rowell. 1979. The influence of magnesium in salineand sodic soils: A specific effect or a problem of cation exchange? Journal of Soil Science, 30: 535-546

- Wild, A and J. Keay 1964. Cation exchange equilibria with vermiculite. Journal of Soil Science, 15: 135-144
- Peterson, F.F., J. Rhoades, M. Arca and N.T. Coleman.1965. Selective adsorption of magnesium ions by vermiculite. Soil Science Society of America Proceedings 29: 327-328
- Alperovitch, N, Shaiberg, I. and Keren, R. 1981 Specific effect of magnesium on the soil hydraulic conductivity of sodic soils. Journal of Soil Science, 32: 543-554
- Yousaf, M., O.M. Ali, and J.D. Rhoades. 1987. Dispersion of clay from some salt affected, arid land soil aggregates. Soil Science Society of America Journal 51:920-924
- 11. Hamid, X.S. and Mustafa, M.A. 1975 Dispersion as an index of relative hydraulic conductivity in salt affected soils of Sudan. Geoderma 14: 107-114
- Bruce, R. R. and Klute, A. 1956 Measurement of soil moisture diffusivity, Soil Science Society of America Proceedings 20; 458-462
- 13. Baver, L D., Gakdner, W. H., and Gardner, W. R.1972, Soil Physics (4th Edition) Wiley New York
- Robbins, C W and Carter D.L.1983 Selectivity coefficients for Calciummagnesium-sodium-potassium exchange in eight soils, Irrigation Science, 4:95-102
- Lippman, L.P 1973 Studies on saline sodic soils and magnesium precipitation on sodication. Soil Science Society of America Journal 37:150-154
- Levy, R., Whittig, L.D and Tanji K.K 1982 Ionic activity products and crystal forms of calcium and magnesium carbonates precipitated from calcium and magnesium bentonites, Soil Science Society of America Journal 46:125-137
- Levy, R., Tanji K.K and Whittig, L.D 1983 Effect of precipitation of alkaline earth carbonates and magnesium hydroxides on Na-Ca-Mg exchange in Wyoming bentonite, Soil Science Society of America Journal 47: 906-912
- Hunsaker, V. E. and Pratt P.E. 1970 Calcium-Magnesium exchangeequilibria in soils. Soil Science Society of America Proceedings 35:151-152
- Keren, R. 1991 Specific effect of magnesium on soil erosion and water infiltration. Soil Science Society of America Journal, 55: 783-787
- Curtin, D., Steppuhn, H., and Selles, F.1994 Effects of magnesium on cation selectivity and structural stability of sodic soils. Soil Science Society of America Journal, 58:730-737
- Emerson, W. W. and Chi, C. L. 1977 Exchangeable calcium, magnesium and sodium and the dispersion of illite in water II dispersion of illite in water Australian Journal of Soil Research 15: 255-262