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EVALUATION OF LOCAL CALCIC FORMATION RESOURCES IN El-FAYOUM REGION FOR RECLAIMING SALT-AFFECTED SOILS.

BY

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ABSTRACT

This work aims to survey and evaluate the reclamation efficiency of local resources of calcic formations (gypseous and calcareous) amongst El-Fayoum region. Five sample areas comprised 15 sites were studied, and were represented by 27 gypseous and calcareous samples. All of these samples were chemically analysed. Five gypseous and five calcareous samples were subjected to test the release of calcium ions through two experiments: (1) water extraction in ten successive portions for the release of Ca ion. (2) After mixing the calculated gypsum requirements of each sample to saline sodic clay soil in columns and estimate the chemical analysis of 9 successive leachates, beside to achieving the exchangeable cations through two depths (0-10 and 10-20 cm. Sulfur was used at 500 mg/s/kg soil with calcareous samples only.

There are a variation of gypsum and calcareous deposits amongst El-Fayoum region in their purity and so, efficiency in agricultural sector. The solubility of the used gypsum samples had nearly the same trend as the using of only 500 ml water, released more than 90% of their initial Ca content on controversy for calcareous samples the use of 500 ml water released only about 55% of their contents of Ca. The use of such local deposits improved the undesired soil properties but in different rates. ESP values were decreased from 24.08% to less than 6% at using gypsum samples, and 8% with using calcareous samples, either with or without sulfur.

Key words: Calcic formation-gypsum-calcium carbonate- solubility-salt affected soils-leaching.

INTRODUCTION

Calcic formations (i.e., calcareous and gypsic formations) are common deposits in arid and semi- arid regions which precipitated among many geomorphic landscapes, and forms Gypsum is recommended for reclamation and improvement sodic and saline- sodic soils, as a source of calcium ions. In Egypt, gypsum is the mostly used amendment, due to its occurrence as natural deposits and its relatively high dissolution rate. On the other hand, the deteriorated sodic and saline- sodic areas are in increase. Due to inadequate local gypsum deposits in El-Fayoum, attention is to test some alternatives resources of calcium ions, (El-

Shakweer *et al*. 2001). Calcareous formations are focused to meet diminishing amounts of gypsum as calcium sources.

Geological studies of El-Fayoum fringes show that the outcropping rock types are mainly sedimentary of Quaternary and Tertiary ages (Said, 1962) Fig (1). The calcareous formations were recorded in many assemblages and forms, namely, clays, shale and mudstones. It is reported that nearly all limestones are marine originated where sea water is slightly alkaline and favorable for $CaCO_3$ precipitation (Hatch and Rastall, 1975 and Spock, 1962).

Precipitation of gypsum forms and their mechanisms have been discussed by Van Alphin (1971), Charlotte (1975) Devid (1975), Dregene (1976), Robert (1979), FAO (1990) and Norair *et al.* (2001). Gypsic formations are originated mainly due to precipitation and evaporation processes from saturated or sub -saturated waters under shallow subaqueous conditions. The least soluble salts (carbonates) are precipitated first, followed by the more soluble salts (sulfates) and finally the most soluble salts (Chlorides) are precipitated.

The calcic formations are widely spread within the vicinity of the cultivated lands and along the fringes of the depression boundaries. The Egyptian Authority of Geological Survey, E.A.G.S (1980) reported the carbonate rocks in different forms; i.e., limestone, marls and dolomites in upper and middle Eocene ages. While as, the gypsic formations extended in a sheet-like form of Pleistocene age, overlying uncomfortably the older rocks tacking the slope of topographic features. The amorphous gypsum precipitates occupy the upper parts of deposits, (friable to moderately hard) with $CaSO_4.\ 2H_2O$ from 9.26% to 53.01%. The crystalline gypsum type generally occupies the lower parts (cracked, porous and moderately hard) with $CaSO_4\ .2H_2O$ ranges 47.97 to 77.27 %.

The present study aims to identify and evaluate the local resources of calcic formations and their capability as source of Ca ion to reclaim sodic soils.

MATERIALS AND METHODS

On basis of governmental reports (E.A.G.S., 1980) a field work was carried out along El-Fayoum depression and its fringes to examine the locale calcic formations. Five sample areas comprised fifteen sites were examined and twenty- seven samples were collected, Fig (2). Samples were prepared and subjected to the analysis of:

1- Total soluble salts
2- pH
3- Calcium carbonate content
4- Gypsum content

Testing the release of calcium ions were done in two experiments, I .e, using distilled water and under mixing with saline alkali clay soil. Five gypsic and five calcareous samples were selected representing the highest content of component, purity and relative occurrence in the site to test the release of calcium ions.

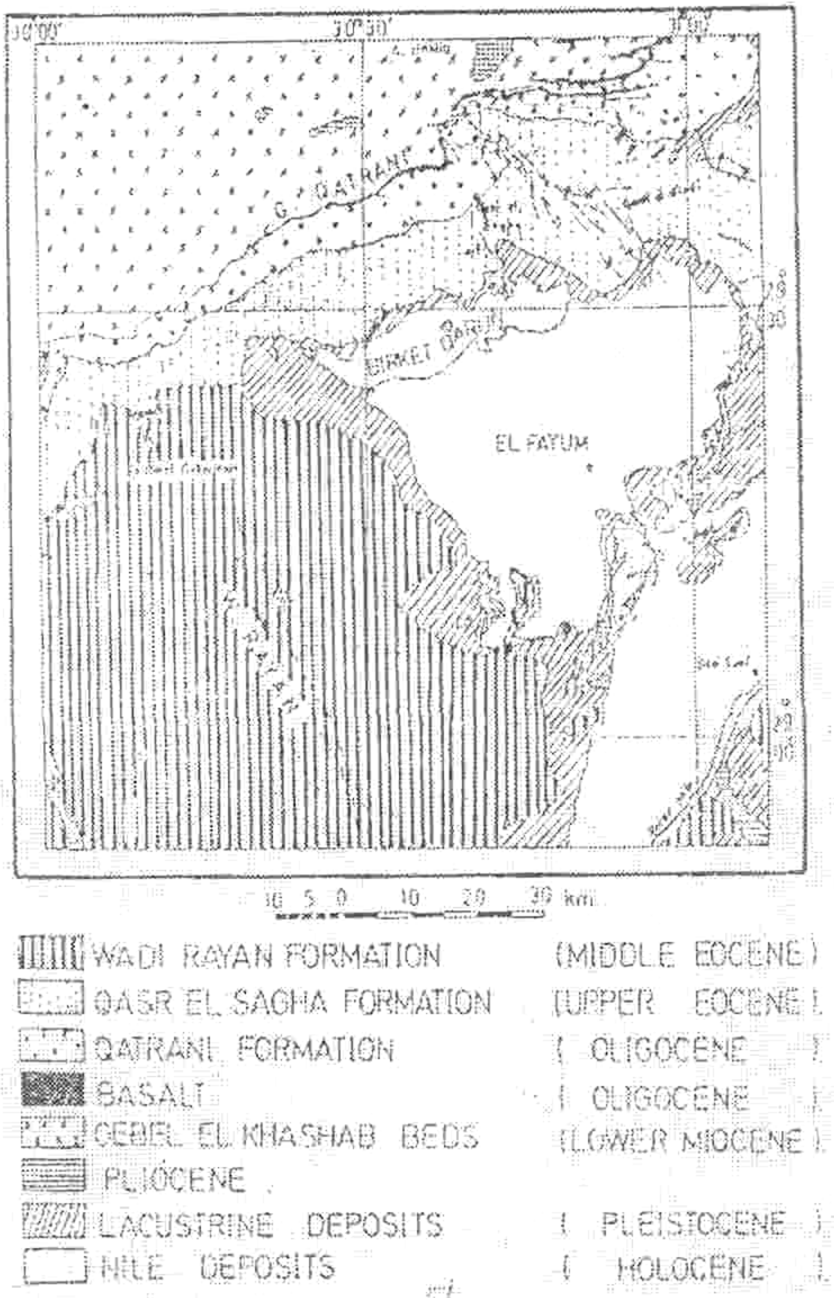

Fig. (1): Geological map of El- Fayoum region (Said, 1962)

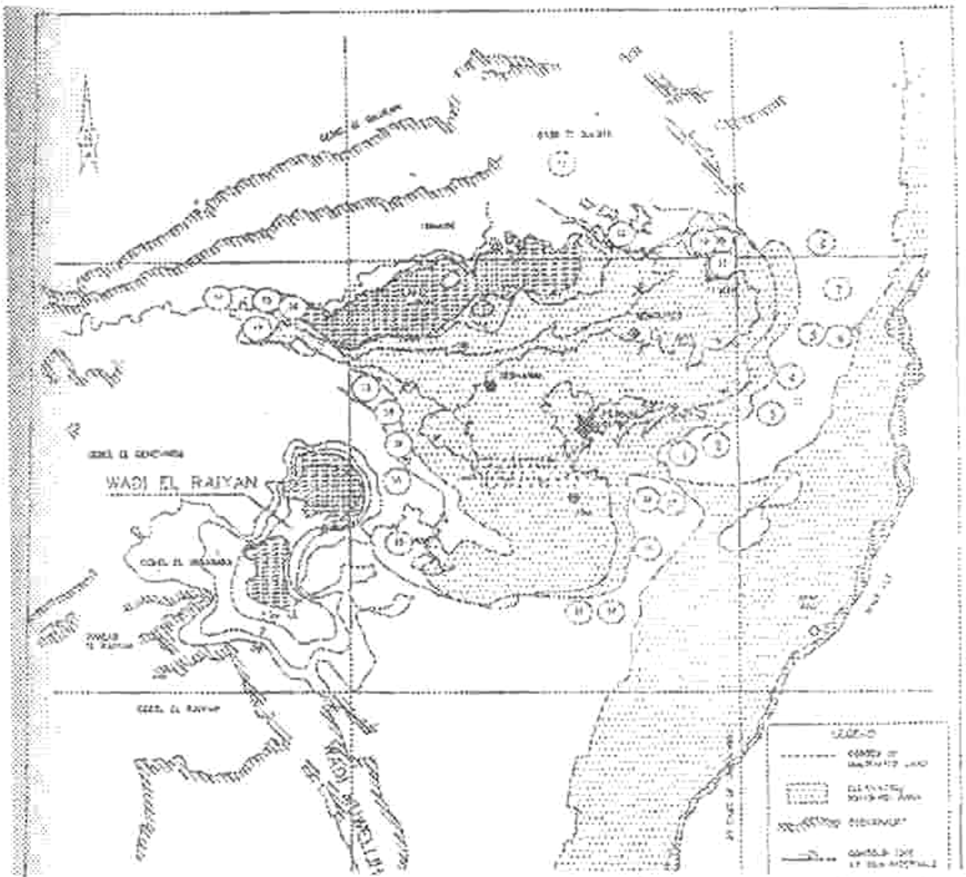

Fig. (2): Location map of the studied samples of gypsic and calcareous formations at El- Fayoum region

a) Release of calcium in distilled water was done on the selected samples. Two grams of each sample were put in a flask and subjected to shacking with portion of 100 ml distilled water for 30 minutes at constant speed and repeted for ten successive portions. The filtered portions were analyzed for calcium ions.
b) Release of calcium through mixing with a saline- sodic clay soil, Table (1a,b,c); the gypsum requirements of the used soil were calculated and converted to proportional weight for each of the gypsic and calcareous selected samples. The treated soil was uniformly packed in plastic column (80 cm height and 10 cm inside diameter) after mixing with aforementioned weights to bulk density of 1.34 g/cm^3 in three replicates. The columns of testing calcareous samples received powder sulfur in constant rate of 500 mg S/Kg soil, which also mixed with the total soil. Moreover, two other treatments were prepared; the first comprised the soil without any amendments and the other contained soil mixed with sulfur.

Table (1 a): Initial properties of the studied soil

Properties	Value
Physical properties	
1- Particle size distribution	
Coarse sand %	6.1
Fine sand %	15.3
Silt %	20.4
Clay %	58.2
Texture class	Clay
Chemical properties	
1- PH (in soil paste)	8.5
2- ECe (in soil paste extract, dS/m)	7.00
3- Soluble cations, m.e./l:	
Ca^{++}	8.48
Mg^{++}	6.20
Na^{+}	54.35
K^{+}	0.97
4- Soluble anions, m.e./l:	
CO_3^{-}	1.20
HCO_3^{-}	2.20
Cl^{-}	45.60
SO_4^{--}	21.00
5- Gypsum %	0
6- $CaCO_3$ %	3.9
7- Gypsum requirements (ton/fed)	5.400
8-CEC (m.e./100g soil)	47.97
9-Exchangeable cations (m.e./100g soil)	
Ca^{++}	19.05
Mg^{++}	11.08
Na^{+}	14.87
K^{+}	2.85
ESP	30.99%
Chemical analysis of compost used	
pH (in 1: 2.5 extract)	7.16
EC, dS/m (in 1:2.5 extract)	6.87
Organic matter, %	47.17
C/N ratio	21.17
Total Nitrogen, %	1.31
Total Phosphorus, %	0.57
Total potassium, %	0.93
Chemical analysis of sewage sludge used	
pH (in 1: 2.5 extract)	7.2
EC, dS/m (in 1: 2.5 extract)	1.8
Total Nitrogen, %	2.7
Organic matter. %	42.35
C/N ratio	9.12
Available Phosphorus,mg/kg	32.60
Available K, mg/kg	545.4

The leaching was carried out using 90 cm head of tap water divided into 9 portions in intermittent leaching. Each portion equal 10 cm head, which nearly maintain the irrigation regime. Balba (1983) stated that 90 cm water head would leach about 80% of salts out to a depth 1.0 m of Nile alluvium soils. The total effluent was collected and analysed for pH, EC and soluble ions. At the end of leaching soil samples at depths of 0 - 10 and 10 - 20 cm for each columns were analyzed for exchangeable cations. Soil analysis for physical and chemical properties were applied using the methods described by Klute (1986) and Page *et al.* (1982). Gypsum requirements were determined according to Schoonover method (Jackson, 1973).

RESULTS AND DISCUSSION

1- Field work and sampling description:

Five sample areas were checked and sampled on basis of E.A.G.S (1980) along El-Fayoum region, Fig (1). These areas and the included sites are presented in Table (2). The detailed morphological description of sample areas, different sampling sites and the collected samples were described else where, Abdel-Hafeez (2004).

Table (2): Locations of samples areas, sampling sites and collected samples along El-Fayoum region.

Sample area	Site	Sample No.
Northern eastern parts (Gable El-Roose)	Demo	1 and 2
	El-Nassaria	3
	El-Roose	4,5,6,7 and 8
Northern parts(Koom Oshem)	Ezbt Ali Abd El-Moniem	9,10 and 11
	Koom Oshem	12
	Qasr El Sagha	13
North-Western parts (Qasr Qarun)	Quta	14
	Qasr Qarun	15,16 and 17
Western parts (Wady El-Rayan)	El-Khawagat	18
	Hanna Habib	19
	El Hamole	20
	El Hosienia	21
	Ezbt El Brince	22
South-eastern parts (Kalamshah)	Kalamshah	23 and 24
	Shakalufa	25
	Demshkeen	26 and 27

2- Chemical properties of the studied samples:

The collected samples mostly represent the outcropping rocks of El-Fayoum depression fringes which belong to Quaternary and Tertiary ages, (Geological map, Fig (1). These vast formations form the basement rock and bed rock of the depression soils and its surrounding fringes.

The pre-chemical analysis, table (3), declares that fourteen samples (1, 6, 9, 11, 13, 14, 15 16, 20, 21, 22, 24, 25 and 27) represent calcareous sediments, nine samples (3, 4, 7, 8, 12, 18, 19, 23, and 26) represent gypsferious sediments and four samples (2, 5, 7 and 10) represent calcareous- gypsferious nature.

The pH values measured in 1: 2.5 show slightly to highly alkaline nature, as their values varied from 7.45 in highly calcareous sediment (sample No. 20) to 8.33 in moderate calcareous ungypsic one (sample No. 15). El-Gabaly (1973) reported that calcareous soils have pH greater than 8 and may reach 8.6. While as, it seams that the pH values came to be greater coinciding with soluble salts and become closer to 7.8 with gypsum accumulations. These findings are in agreement with that of Wiklander (1984).

The total soluble salts varied between 0.15 to 7.32% clarifying a highly saline nature for most of these sediments. These precipitates were accumulated through geological humid periods, so their proportional distribution depends upon the nature of primary sediment and local elevation of the fissures and cracks of the hosted rocks.

With respect to calcium carbonate content, their values varied from 1.18 to 95.9%. The studied sediments imply to Quaternary and Tertiary outcropping rocks of the old shoreline of Qarun lake comprised of limestone and marl formations. (Samples 1, 5, 9, 10, 11, 24, 25 and 27). On the other hand, the calcareous deposits of samples 13, 15, 16, 20, 21 and 22 are Nummulitic limestone formations.

Regarding the gypsic content, their values varied from zero to 73.62% The amorphous form gypsum of is chiefly near the uppermost band of the deposit, in pure nature or mixed with salt crystals (Samples 2, 3, 4, 7 and 12). While, the crystalline form gypsum of occupies the deepest bands of the deposits intercalating with shale of clay deposits (Sample 8, 17, 19, 23 and 26), Abdel-Hafeez (2004).

3 - Release of calcium ions from the studied samples.

Through further studies, five gypsic samples (4,7,8,19 and 23) and other calcareous samples (9, 11, 22, 24, and 25) were selected to represent different forms of precipitates components that are more spreaded through the sites. The release of calcium ions was examined in two stages, i.e, in free distilled water and after mixing with saline-sodic soils.

a) In free distilled water:

Two grams of each dry selected samples was shaken with repeated successive ten portions of distilled water each of them 100 ml. Electrical conductivity and calcium ions (m.e./l) of the leachates were measured and were counted as cumulative calcium and as percent of total calcium released.

Table (3): Chemical analysis of the representative samples of calcic formations selected from different fringes of El- Fayoum depression.

Location	Sample No.	pH*	EC, dSm^{-1}	T.S.S. %	Ca CO_3, %	Gypsum %
Gabl El-Roos	1	7.80	13.44	2.15	24.20	-
	2	7.99	18.56	2.97	7.84	17.29
	3	8.21	24.31	3.89	2.35	37.84
	4	8.00	4.44	0.71	1.80	36.46
	5	8.04	2.40	0.98	21.70	33.54
	6	8.14	4.88	0.78	32.00	7.01
	7	7.80	8.13	1.30	1.18	73.62
	8	8.26	11.81	1.89	3.11	44.40
Koom Oshim	9	7.67	3.75	0.60	36.23	-
	10	7.87	5.13	0.82	28.09	13.60
	11	7.80	9.13	1.46	73.50	-
	12	8.13	9.75	1.56	2.63	26.00
	13	7.96	7.00	1.12	46.00	5.60
Kasr Qarun	14	8.24	21.44	3.43	28.23	-
	15	8.33	5.56	0.89	21.71	-
	16	8.23	30.00	4.80	18.40	2.70
	17	7.83	9.88	1.58	7.85	19.40
Wadi El-Rayan	18	7.80	21.25	3.40	8.00	27.17
	19	8.00	20.00	3.20	1.79	39.90
	20	7.45	45.75	7.32	36.75	-
	21	7.94	31.44	5.03	95.90	-
	22	7.83	3.88	0.62	70.88	-
Kalamshah	23	8.25	7.65	1.22	1.31	37.47
	24	8.31	1.94	0.15	67.38	-
	25	8.10	5.44	0.87	62.65	-
	26	7.49	12.75	2.04	2.11	17.40
	27	8.20	17.56	2.81	27.00	4.90

pH and EC were measured in 1: 2.5 solid-water

Data of gypsum samples (4, 7, 8, 19 and 23) are presented in Table (4) and Fig. (3). The gypsum dissociation rate could be recognized from EC_l values and calcium release. For sample 4, the rate had nearly the same value through the first four portions. On the other hand, more than 91 % of dissolved -Ca was dispelled with the addition of prior 600 ml water. The sharp decrease in EC_l values after frist portion accompanied with steady relatively high Ca release while the gradually denotes the relatively high content of primary soluble salts (samples 8, 19 and 23). The gradual decrease in EC_l values coincided with decrease in Ca-release which denotes dissolution of the majority of gypsum content. The addition of the first 500 ml distilled water pulled out 8.71, 13.07, 10, 8.71 and 9.27) m.e Ca^{++} which coupled with their gypsum percent of samples 4 (36.46%), 7 (73.62%), 8 (46.40%), 19 (39.9%) and 23 (37.47%), respectively. This point varied from sample to other according to purity and to some extent sample hardness. The crystalline gypsum samples (8, 19 and 23) were more easily dissociated, as more than 90% of their calcium was released by application of first 500 - 600 ml water. About 90 % of dissolved Ca^{++} were released after application of 600-700 ml water for the amorphous form of gypsum samples (4 and 7). These results are nearly in agreement with Balba (1983) who reported that 25 to 26 m.e. of pure $CaSO_4.H_2O$ dissolved in distilled boiled water and Lagerweff *et al.*, (1965) who reported that 2.65 g of pure gypsum were dissolved in a liter of water.

Table (4): Electrical conductivity (EC, dS/m) and cumulative values of Ca^{++} released (as m.e.Ca^{++}/L and % of total Ca^{++} released(by successive extraction gypsic material samples

Portion No.	EC dS/m	*Calcium released, with each portion*		
			Cumulative values	
		m.e.Ca $^{+}$/ L	m.e. Ca^{++}/ L	% of total Ca^{++} released
1- Sample No. 4 (gypsum formations) of 36.46 % gypsum				
1	1.78	1.57	1.57	16.60
2	1.66	1.57	3.14	33.09
3	1.66	1.57	4.71	49.59
4	1.66	1.52	6.23	65.64
5	1.27	1.20	7.43	78.37
6	1.27	1.17	8.60	91.09
7	0.76	0.51	9.11	96.45
8	0.36	0.23	9.34	98.74
9	0.05	0.06	9.40	99.56
10	0.01	0.05	9.45	100.00
2- Sample No. 7 (gypsum formations) of 73.62 % gypsum				
1	1.66	2.79	2.79	15.23
2	1.53	2.64	5.43	29.63
3	1.53	2.61	8.04	43.88
4	1.53	2.58	10.62	57.79
5	1.40	2.45	13.07	71.34
6	1.40	2.05	15.09	82.39
7	1.02	1.61	16.70	91.17
8	0.76	1.19	17.89	97.12
9	0.41	0.32	18.21	99.45
10	0.10	0.11	18.32	100.00
3- Sample No. 8 (gypsum formations) of 44.4 % gypsum				
1	1.91	2.24	2.24	18.90
2	1.53	2.19	4.43	37.38
3	1.15	2.16	6.59	55.63
4	1.15	2.12	8.71	73.49
5	0.76	1.29	10.00	84.42
6	0.64	1.06	11.06	93.38
7	0.38	0.43	11.49	97.01
8	0.18	0.20	11.69	98.66
9	0.06	0.12	11.81	99.68
10	0.03	0.04	11.85	100.00

Table (4): cont.

Portion No.	EC dS/m	Calcium released, with each portion		
			Cumulative values	
		m.e.Ca $^{+}$/ L	m.e. Ca^{++}/ L	% of total Ca^{++} released
4- Sample No. 19 (gypsum formations) of 39.90 % gypsum				
1	2.80	1.96	1.96	18.01
2	2.53	1.87	3.83	35027
3	1.53	1.83	5.66	52.08
4	1.40	1.81	7.47	68.78
5	1.02	1.24	8.71	80.21
6	0.89	1.23	9.94	91.53
7	0.71	0.70	10.64	96.79
8	0.29	0.12	10.76	99.08
9	0.06	0.08	10.84	99.77
10	0.03	0.03	10.87	100.00
5- Sample No. 23 (gypsum formations) of 37.47 % gypsum				
1	1.78	2.27	2.27	22.31
2	1.40	2.26	4.53	44.46
3	1.15	2.18	6.71	65.79
4	1.02	1.74	8.45	82.78
5	0.51	0.82	9.27	90.86
6	0.45	0.45	9.72	95.21
7	0.18	0.19	9.91	97.08
8	0.10	0.11	10.02	98.20
9	0.06	0.10	10.12	99.17
10	0.05	0.09	10.21	100.00

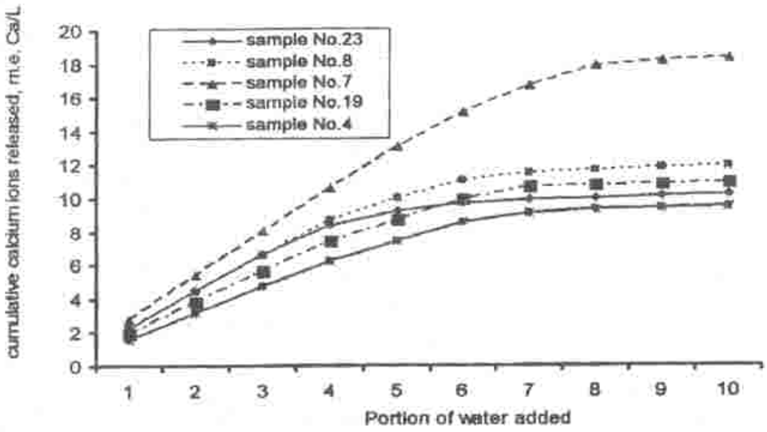

Figure (3) : Effect of portions of water added on cumulative calcium ions released from gypseous samples as m.e./L.

The chosen calcareous samples (9, 11, 22, 24 and 25) have nearly the same trend of dissolution (Table 5 and Fig. 4). This rate varied in narrow range from 0.08 to 0.17 m.e. for all samples, except for the first portion which ranged from 0.12 to 0.33 m.e./L. The high values of first portion may be rendered to the primary salinity as it coincided with relatively high EC values of leachates. Also, the total cumulative amounts of Ca- released were in low range (1.02 to 1.32 m.e.) for the tested 2 g of the studied samples. Extraction with free distilled water under the atmospheric CO_2 pressure pulled out 45 to 70% of the total counted Ca-content of the studied samples (1.45 - 2.94 m.e.Ca^{++} /2g) as the total $CaCO_3$ % of the studied samples varied between 36.23, 73.5%.

The dissociation rate of carbonates may be enhanced with a rising pressure of CO_2 (FAO, 1990), or increasing H^+ ion donors (Doner and Lynn, 1977). Nettelton *et al.*, (1982) found that both mobility of dissolved Ca^{++}, temperature and presence of gypsum and other salts affect the solubility of carbonates.

b) After mixing with saline-sodic clay soil

The previous selected five gypsic samples (4,7,8,19 and 23) and the five calcareous ones (9,11,22,24 and 25) were used in column experiment. The calculated Ca-requirements from the gypsic and calcareous samples were mixed with the saline-sodic clay soil (Table, 1). Distilled water was used in intermittent leaching in nine stages, each of them about 10 cm head. The leachates of each stage were analyzed for different ions. As well as, soil exchangeable cations of soil after completion of leaching were determined in two depths (0 - 10 and 10-20 cm).

Table (5): Electrical conductivity (EC, dSm^{-1}) and Cumulative values of Ca^{++} released (as m.e.Ca^{++}/ L and % of total Ca^{++} (by successive extraction of calcareous material samples.

Portion No.	EC, dSm^{-1}	*Calcium released, with each portion*		
			Cumulative values	
		m.e. Ca^{++}/ L	m.e. Ca^{++}/ L	% of total Ca^{++} released
6- Sample No. 9 (calcareous formations) of 36.23 % $CaCO_3$				
1	1.23	0.29	0.29	21.97
2	0.18	0.15	0.44	33.33
3	0.09	0.15	0.59	44.70
4	0.09	0.12	0.71	53.79
5	0.08	0.12	0.83	62.88
6	0.08	0.11	0.94	71.21
7	0.08	0.11	1.05	79.55
8	0.08	0.08	1.13	85.61
9	0.09	0.08	1.21	91.67
10	0.08	0.11	1.32	100.00

Table (5): cont.

Portion No.	EC, dSm^{-1}	*Calcium released, with each portion*		
			Cumulative values	
		m.e. Ca^{++}/ L	m.e. Ca^{++}/ L	% of total Ca^{++} released
7- Sample No. 11 (calcareous formations) of 73.50 % $CaCO_3$				
1	1.82	0.17	0.17	16.19
2	0.32	0.12	0.29	27.62
3	0.08	0.08	0.37	35.24
4	0.09	0.11	0.48	45.71
5	0.08	0.11	0.59	56.19
6	0.09	0.11	0.70	66.66
7	0.09	0.08	0.78	74.29
8	0.08	0.11	0.89	84.76
9	0.08	0.08	0.97	92.38
10	0.07	0.08	1.05	100.00
8- Sample No. 22 (calcareous formations) of 70.88 % $CaCO_3$				
1	1.65	0.25	0.25	19.08
2	0.34	0.17	0.42	32.06
3	0.19	0.12	0.54	41.22
4	0.08	0.11	0.65	49.62
5	0.10	0.11	0.76	58.02
6	0.10	0.11	0.87	66.41
7	0.09	0.11	0.98	74.81
8	0.09	0.11	1.09	83.21
9	0.08	0.11	1.20	91.60
10	0.08	0.11	1.31	100.00
9- Sample No. 24 (calcareous formations) of 67.38 % $CaCO_3$				
1	1.91	0.33	0.33	25.38
2	0.22	0.15	0.48	36.92
3	0.13	0.12	0.60	46.15
4	0.08	0.12	0.72	55.38
5	0.09	0.12	0.84	64.62
6	0.09	0.11	0.95	73.08
7	0.08	0.11	1.06	81.54
8	0.08	0.08	1.14	87.69
9	0.06	0.08	1.22	93.85
10	0.06	0.08	1.30	100.00
10- Sample No. 25 (calcareous formations) of 62.65 % $CaCO_3$				
1	1.02	0.12	0.12	11.76
2	0.22	0.11	0.23	22.55
3	0.11	0.11	0.34	33.33
4	0.09	0.11	0.45	44.12
5	0.09	0.11	0.56	54.90
6	0.09	0.11	0.67	65.69
7	0.08	0.11	0.78	76.47
8	0.08	0.08	0.86	84.31
9	0.08	0.08	0.94	92.16
10	0.06	0.08	1.02	100.00

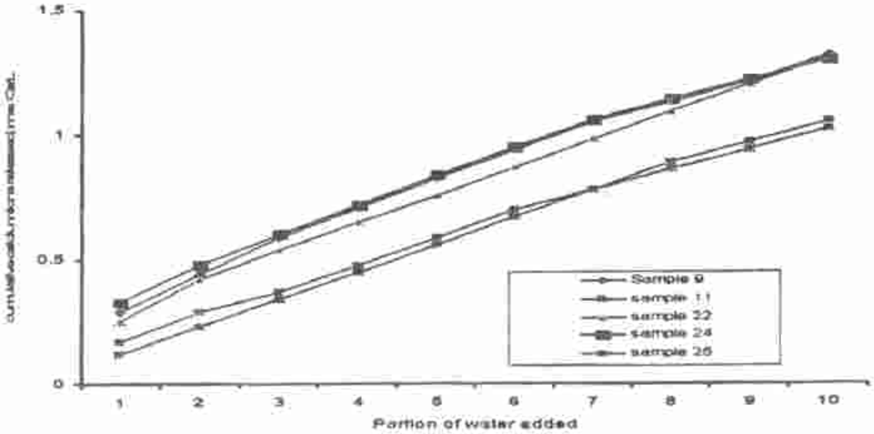

Figure (4) :Effect of portions of water added on cumulative calcium ions released from calcareous samples as m.e./L.

Table (6). Leachates- pH values were alkaline a long all stages of leaching reflecting the nature of the removal ions from soil column. The gradual increase in leachate- pH values at the beginning of leaching processes crop to lechcate 4 or 5 reflects the primary salinity. The increase of pH values could be attributed to the hydrolysis of the Na-clay in water, replaced by another cation, especially divalent cations. If divalent cations were not equivalent, hydrogen ions mostly retained in place of sodium. Consequently, sodium ions were leached as $NaHCO_3$ or Na_2CO_3 in the presence of CO_2 of water. While, the decrease of lecheate- pH values from lechcate 5 or 6 may be rendered to a dissolution of gypsum. The amount of released Ca^{++} can rive and replace adsorbed Na^+. The released Na-ions leached as neutral salts, which depressed the leachate pH-values. The stage at which the dual between increase and decrease must explain the dissolution rate of non-soluble salts, i.e., initial $CaCO_3$ for control treatment and gypseous for other treatments.

With respect to soluble salts of leachates, Table (6), indicates a gradual decrease in EC_l values with successive stages of leaching. However, the values for control treatment remained higher along all stages of leaching. The rate of salt removal was accelerated with gypseous treatments as EC_l of 9th stage for control (4.01) was rather similar to that of 5th stage for other treatments. Thereby, significant amounts of soluble salts were removed during the first stages of leaching. Consequently, the dissolution of less soluble substances (initial $CaCO_3$ and added gypseous) increased gradually. The highest rate of salt removal was coincided with the addition of sample No. 7 which contain the highest content of gypsum (73.62).

The proportion distribution of individual ions denotes the liability of faster monovalent ions as found by Balba and El-Liethy, (1968) and so, comprised high concentrations of leachates. Values of SAR were high in the beginning of leaching reflecting aconsiderable monovalent ions (Na+) liberation. The values of SAR were slightly decreased for control treatments till the last stage of leaching (22.37). They showed a sharp decrease in the presence of gypseous samples. So, the leaching processes could be set out after the 5th stage which coincides with about 4 dS/m and 10 SAR in leachates.

The values of CEC, of the subsurface layer were higher than that of surface layer for all treatments Table (7). This may be explained as the leaching processes with 90 cm head enhanced the migration of fine particles and the exchange complex. By leaching soluble salts, Na- clay may be replaced by other properties cations, especially divalent cations. The changes in the chemical were accompanied with the improvement of soil physical properties. Gypsum, caused desirable declines in exchangeable sodium, which appear as ESP values, (Table 7). The recovery of Ca ions in gypsum treatments were done via the solubility of gypsum. While, the leaching of sodium ions, (Table 6) reduced its rivaly on the exchange sites.

Table (6): Effect of using gypsic samples to the tested saline- sodic soil on the chemical composition of 9 successive leachates.

Leachates No.	pH	EC, dS/m	Soluble cations, m.e. /L				Soluble anions, m.e./L				SAR
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	
1- Contol (saline-sodic soil only).											
1	9.27	17.41	9.50	8.60	153.5	1.42	4.74	15.65	102.06	50.59	50.99
2	9.46	10.48	6.27	5.29	92.51	0.70	23.08	34.78	22.90	24.01	38.48
3	9.48	6.49	1.83	5.00	57.51	0.48	15.33	18.83	5.51	25.15	31.12
4	9.69	7.24	0.70	3.52	67.67	0.42	29.31	26.02	0.59	16.39	46.59
5	10.03	7.18	1.33	2.67	67.29	0.47	27.28	39.50	0.64	4.34	47.72
6	9.58	6.35	1.55	1.00	60.34	0.53	25.05	30.22	0.85	7.32	53.44
7	9.63	4.87	1.33	1.12	45.63	0.55	18.81	25.22	1.88	2.72	41.23
8	9.65	4.25	0.60	3.93	35.40	0.47	18.50	14.25	1.95	7.70	24.85
9	9.16	4.04	0.57	3.73	33.63	0.45	17.58	13.54	1.85	7.22	22.37
2- saline-sodic soil + sample No. 4 (of 36.46 % gypsum)											
1	8.22	15.63	15.07	35.83	103.70	1.61	2.67	18.50	102.70	32.34	20.56
2	8.39	11.66	11.13	20.40	84.09	0.94	2.33	14.00	81.82	18.41	21.18
3	8.79	11.46	9.47	22.80	81.38	0.87	1.33	15.39	3.77	94.03	20.26
4	8.69	6.98	8.00	17.93	43.12	0.67	2.40	16.28	3.48	47.56	11.98
5	9.00	4.85	4.50	13.20	30.25	0.52	2.07	17.65	2.61	26.14	10.17
6	8.35	5.59	4.30	11.17	20.06	0.15	2.00	4.00	2.61	27.63	7.17
7	8.46	4.00	5.33	12.45	21.33	0.81	2.96	4.82	0.35	31.79	7.15
8	8.78	4.50	4.00	13.00	27.07	0.90	1.97	5.68	0.38	36.94	9.27
9	8.46	2.57	4.93	14.80	5.19	0.73	1.66	3.00	1.38	19.61	1.65
3- saline-sodic soil + sample No. 7 (of 73.62 % gypsum)											
1	8.05	20.03	17.10	35.27	136.35	1.51	5.50	20.25	125.01	39.47	26.68
2	8.40	15.23	16.98	34.16	102.87	0.92	3.50	18.50	122.53	10.40	20.37
3	8.79	7.40	5.50	17.60	50.08	0.72	3.40	18.06	2.90	49.54	14.74
4	9.12	4.32	0.90	6.33	35.47	0.40	8.88	19.90	3.48	10.84	18.65
5	8.80	4.08	2.17	9.00	29.09	0.45	3.67	5.83	2.61	28.60	12.31
6	8.24	4.99	4.45	16.22	28.15	0.99	4.44	4.33	0.81	40.23	8.76
7	8.69	3.44	2.11	10.89	20.58	0.80	2.96	7.65	0.48	23.29	8.07
8	9.25	2.73	1.40	4.70	20.87	0.27	7.10	11.80	2.90	5.44	11.95
9	8.33	2.21	2.40	13.60	5.36	0.72	2.33	4.66	2.25	12.84	1.90

Table (6): cont.

Leachates No.	pH	EC, dS/m	Soluble cations, m.e. /L.				Soluble anions, m.e/L.				SAR
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$	
4- saline-sodic soil + sample No.8 (of 44.40 % gypsum)											
1	8.07	19.31	17.20	37.54	136.69	1.64	3.00	18.33	132.35	39.39	26.13
2	8.26	11.88	10.57	23.04	84.09	1.06	1.33	16.83	84.22	16.38	20.51
3	8.73	1035	9.33	23.67	69.55	0.89	5.33	14.80	2.91	84.40	17.12
4	8.68	7.36	10.33	20.20	42.43	0.63	2.07	14.36	4.06	49.84	10.86
5	9.06	5.58	6.60	15.27	33.39	0.51	1.00	8.40	2.90	42.40	10.10
6	8.34	3.80	4.17	15.70	18.06	0.51	1.00	4.30	2.61	30.00	5.81
7	8.28	4.01	6.78	17.22	15.24	0.82	2.22	4.44	0.37	33.03	4.40
8	8.76	3.56	2.78	14.44	17.48	0.83	1.97	5.18	0.33	28.88	5.97
9	8.07	2.18	2.67	15.40	3.02	0.67	1.00	3.17	1.18	16.41	1.00
5- saline-sodic soil + sample No. 19 (of 39.90 % gypsum)											
1	8.08	21.38	14.57	43.16	154.38	1.60	2.33	21.67	152.38	37.33	28.73
2	8.29	11.66	10.57	20.55	84.47	0.98	2.00	17.67	82.34	14.56	21.44
3	8.70	10.20	9.13	22.67	69.21	0.91	1.63	18.79	3.77	77.73	17.35
4	8.62	6.16	7.27	17.60	36.17	0.55	2.11	17.31	3.48	38.69	10.26
5	8.85	4.46	6.33	13.27	24.69	0.43	1.78	16.87	2.61	23.46	7.88
6	8.31	3.56	5.33	12.83	17.05	0.51	1.00	4.50	2.61	27.61	5.66
7	8.31	3.59	5.22	13.44	15.45	0.78	2.22	4.44	0.37	28.86	4.93
8	8.74	3.25	3.33	12.22	16.07	0.81	2.96	4.93	0.33	24.21	5.76
9	8.05	2.07	3.27	13.53	3.81	0.67	1.00	4.00	1.18	14.47	1.10
6- saline-sodic soil + sample No.23 (of 37.47 % gypsum)											
1	8.23	21.17	19.63	37.19	154.14	1.91	6.15	16.50	150.34	39.88	28.91
2	8.57	16.15	17.20	35.25	107.53	1.45	4.00	16.50	106.43	36.50	20.99
3	8.83	9.31	6.53	19.40	66.43	0.71	2.37	17.25	2.90	70.55	18.44
4	8.94	4.68	1.87	10.33	34.08	0.44	6.22	13.54	3.48	23.48	13.80
5	8.97	3.10	2.00	9.33	18.75	0.82	2.96	8.64	0.35	18.95	11.00
6	9.36	2.74	1.13	5.40	20.52	0.26	6.51	16.54	2.61	1.65	11.35
7	8.90	2.70	1.50	6.00	19.06	0.36	3.67	3.83	2.61	14.81	9.84
8	8.80	2.81	1.68	8.55	17.24	0.63	5.18	6.19	0.33	16.40	7.62
9	8.83	1.23	1.07	6.13	4.53	0.50	3.33	5.50	1.23	2.17	2.39

The superiority of used gypseous samples can be arranged as 7> 23> 8 >4 and 19. This may be due to the fineness of particles and the crystallization forms.

Regarding treatments which received calcareous materials are shown data of leachate analysis in Table (8). Sulfure was used in rate of 500 mg/kg soil to maintain biological acidity. This acidic nature is proposed to enhance dissolution of $CaCO_3$ according the following reactions (Starky, 1966).

$2S + 3O_2 \rightarrow 2SO_3$ (biologically)

$2SO_3 + H2O \rightarrow H2SO_4$

$H_2SO_4 + CaCO_3 \rightarrow CaSO_4 + H_2O + CO_2$

$CaSO_4 + Na_2\text{-clay} \rightarrow Ca\text{-clay} + Na_2SO_4$

With respect to pH of leachates, Table (8) values show a gradual increase with leaching stages, either in presence of sulfur or without. This alkaline reaction may be assumed to dissolution of initial $CaCO_3$ either for the control or the treatments to produce Na_2CO_3; Gupta et al. (1981) showed that in sodic soils containing CaCO3, soil sodicity and pH values were closely related to Na+ ions which was easily dissociated from adsorption complex and salts. The slight decrease in pH values through the last stages of leaching may be rendered to liberation of salts from soil column, beside to the possibility of neutral reactions and biological anaerobic conditions forming NaHCO3 and H2S,(Kovda, 1958).

Table (7): Exchangeable cations, C.E.C and ESP of saline-sodic soil mixed with gypsic material samples after 9 stage of leaching with tap water.

Sample No.	Depth, cm	Exchangeable Cations, m.e./100g soil				ESP %	C.E.C. m.e./100 g soil	improving efficiency in ESP,%
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}			
Control	0 - 10	19.76	24.97	11.86	2.67	24.97	47.48	-
	10 - 20	20.10	24.08	12.72	2.80	24.08	48.86	-
4	0 - 10	27.90	8.17	3.85	2.51	8.17	47.10	67.28
	10 -2 0	28.82	8.60	4.19	2.90	8.60	48.72	64.29
7	0 - 10	28.59	4.60	2.18	2.63	4.60	47.30	81.58
	10 - 20	28.95	4.73	2.29	2.88	4.73	48.41	80.36
8	0 - 10	28.07	8.13	3.85	2.81	8.13	47.35	67.44
	10 - 20	29.66	8.01	3.89	2.87	8.01	48.60	66.74
19	0 - 10	28.64	6.46	3.05	2.87	6.46	47.21	74.13
	10 - 20	28.64	5.53	2.67	2.87	5.53	48.26	77.03
23	0 - 10	27.67	7.14	3.38	2.64	7.14	47.28	71.41
	10 - 20	28.98	7.24	3.52	2.80	7.24	48.56	69.93

The successive leaching accelerated the removal of soluble salts, which settled at less than 4.0 dS/m. The settlement of leachate EC values coincided with last stages of leaching for control treatments while it accompaind the mid stages of leaching with other treatments.

Carbonates and bicarbonates show high values throughout the different stages of leaching in the control treatment which accompanied high alkalinity values. The other treatments, which have Ca-resource revealed a decline in the free carbonate which reflected in lower pH in the leachates. It could be stated that soil amendments led to liberation of chlorides from soil which leached more rapidly than other anions. The gradual increase of SAR values, Table (8), in the control treatment was coupled with a pronounced decrease for the calcareous amended treatments, especially in the last stages of leaching. This may be due to leaching of dissolved Na out and renewed source of Ca ions from dissociation of Ca-bearing material ($CaCO_3$). The gradual increase in Ca^{++} ions in the stages of leaching could be attributed to the formation of sulfuric acid biologically which would affect the added calcareous samples forming gypsum, (Oster and Frenkel 1980).

Table (8): Effect of using calcareous material samples enriched with sulfur to the tested saline-sodic soil on the chemical composition of 9 successive leachates.

Leachate No.	pH	EC dS/m	Soluble cations, me/L				Soluble anions, me/L				SAR
			Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	
1- Control (saline-sodic soil only).											
1	9.27	17.41	9.51	18.62	143.82	1.43	4.76	15.65	102.22	50.59	39.09
2	9.46	10.48	6.17	5.29	92.51	0.70	8.08	14.78	72.9	34.01	38.48
3	9.48	9.42	3.53	3.00	57.51	0.48	5.32	15.83	25.51	15.15	31.17
4	9.69	7.24	3.71	3.57	63.67	0.37	9.31	16.02	20.59	16.37	33.21
5	10.03	7.13	[illegible]	3.67	65.29	0.47	7.26	9.30	35.64	14.54	37.75
6	9.53	6.35	20.5	3.00	58.24	0.53	5.03	16.22	31.76	17.32	26.92
7	9.63	4.62	1.5	2.12	66.63	1.35	8.81	10.81	19.72	9.02	31.87
8	9.65	4.25	1.69	2.93	35.4	0.47	6.50	11.25	19.98	8.70	25.61
9	9.16	4.64	1.37	1.53	[illegible]	3.45	5.85	11.54	16.72	7.37	26.75
1a – Control-S (saline-sodic soil) + enriched with sulfur											
1	[illegible]	11.59	8.32	18.11	24.67	1.43	9.16	4.14	115.44	47.15	44.02
2	9.29	11.36	4.36	[illegible]	[illegible]	1.72	3.27	27.72	62.71	30.02	34.05
3	9.1	9.17	4.47	3.83	75.95	0.89	8.19	32.10	43.29	20.21	29.56
4	9.76	[illegible]	[illegible]	3.25	70.05	6.66	7.75	36.69	39.28	17.40	27.72
5	8.6	7.23	1.29	3.74	73.26	1.60	8.82	30.20	21.85	15.22	27.27
6	9.59	7.51	3.22	3.11	57.42	0.52	5.02	6.57	46.80	16.17	38.74
7	9.46	6.55	2.13	2.27	59.18	0.42	5.11	[illegible]	42.76	14.22	40.05
8	9.90	7.02	2.07	0.97	4.52	[illegible]	2.92	1.92	32.15	13.01	31.25
9	9.40	3.77	2.05	1.52	34.93	0.36	[illegible]	3.0	30.40	2.75	22.65
2- saline-sodic soil + sample No. 9 (of 36.23 % calcium carbonates) + Sulfur											
1	8.34	18.91	9.82	19.01	157.71	1.46	3.22	9.75	126.21	68.13	40.02
2	9.21	12.56	7.51	12.27	104.35	1.32	4.17	10.21	86.06	25.94	33.28
3	9.36	8.60	3.16	9.10	69.61	1.10	5.24	17.01	47.38	14.13	29.07
4	9.71	5.76	2.09	5.09	57.24	0.29	3.02	15.56	31.55	10.51	27.38
5	9.30	6.51	2.32	5.44	54.54	0.99	5.11	15.81	27.62	9.27	25.51
6	9.79	5.55	1.94	4.25	48.95	0.85	6.22	16.72	34.00	11.07	27.97
7	8.13	3.03	1.63	2.58	27.91	0.60	5.23	8.34	16.56	9.37	19.11
8	8.17	4.42	2.24	2.91	36.65	0.70	3.16	7.14	20.77	5.93	18.53
9	8.21	3.94	2.32	2.86	27.11	0.60	3.62	6.91	18.21	4.15	16.40
3- saline-sodic soil + sample No. 11 (of 73.56 % calcium carbonates) + Sulfur											
1	8.27	18.06	9.51	8.66	155.2	1.42	4.74	16.35	102.15	50.59	60.99
2	9.59	11.47	5.09	7.12	99.29	1.30	5.03	14.31	70.72	24.01	38.33
3	10.05	10.10	5.92	8.62	35.90	1.14	6.12	10.21	63.62	21.05	31.63
4	9.53	7.23	2.17	3.22	60.53	1.08	5.54	8.39	45.71	9.46	32.31
5	9.40	5.09	2.89	3.69	53.75	1.80	3.25	9.17	40.72	[illegible]	20.50
6	9.22	5.20	2.17	3.33	40.61	0.70	4.65	8.60	31.61	8.62	19.98
7	8.39	4.63	1.82	2.01	36.75	0.62	2.92	8.17	22.16	6.95	26.40
8	7.99	4.56	2.61	2.66	38.44	0.83	2.07	6.92	26.26	7.27	23.72
9	8.21	3.17	2.50	2.17	28.61	0.62	1.85	6.67	21.27	4.72	18.62
4- saline-sodic soil + sample No 22 (of 70.81 % calcium carbonates) + Sulfur 0.5 t/fed											
1	8.34	18.75	7.77	9.72	150.38	1.61	5.17	17.72	110.21	48.90	52.22
2	9.22	12.78	5.19	3.02	110.57	1.27	4.75	13.22	77.71	37.39	41.37
3	9.73	9.26	3.82	7.01	76.59	1.06	4.65	13.74	40.98	20.36	30.51
4	9.75	7.68	4.72	7.14	63.22	0.92	3.75	10.82	42.17	21.26	26.01
5	9.15	6.02	3.22	3.22	45.70	0.48	3.22	9.15	28.89	18.71	21.36
6	8.97	5.40	3.16	6.17	42.87	0.40	2.76	6.24	24.67	20.93	20.31
7	9.44	4.91	3.02	4.32	41.14	0.60	2.27	5.96	22.54	18.45	21.45
8	9.22	4.66	3.23	3.76	36.57	0.44	3.72	5.47	13.27	16.99	18.94
9	8.72	4.14	3.27	3.15	37.21	0.47	2.06	3.52	18.13	13.29	18.09

Table (8): cont.

Leachate No.	pH	EC, dS/m	Soluble cations, m.e. /L				Soluble anions, m.e./L				SAR
			Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	
5- saline-sodic soil + sample No. 24 (of 67.38 % calcium carbonates) + Sulfur											
1	8.18	19.21	9.73	18.27	161.54	1.46	4.27	11.92	130.12	44.64	45.63
2	9.16	12.71	8.07	11.36	105.14	1.38	5.83	12.37	76.69	31.11	33.82
3	9.53	8.08	5.18	5.09	67.51	1.22	6.19	13.41	34.82	24.58	29.87
4	9.24	6.71	4.61	6.63	56.75	1.01	6.08	12.92	30.69	17.21	25.67
5	9.68	7.55	5.28	5.92	62.72	0.80	7.82	13.07	34.17	19.71	26.51
6	8.13	5.94	3.66	6.31	48.23	0.80	5.37	14.22	26.32	10.90	24.23
7	8.44	4.01	2.82	2.62	32.92	0.64	3.28	9.47	17.56	8.67	20.27
8	8.94	3.65	2.39	2.76	28.37	0.48	2.17	6.53	18.64	7.66	17.73
9	8.03	3.05	2.02	2.17	24.41	0.40	1.02	4.92	16.33	6.73	16.95
6- saline-sodic soil + sample No. 25 (of 62.65 % calcium carbonates) + Sulfur											
1	8.49	19.50	9.11	14.31	168.94	1.64	4.37	16.22	126.19	47.22	49.39
2	9.28	12.59	8.22	10.36	106.18	1.24	6.19	14.27	72.19	31.35	34.26
3	9.60	8.83	6.33	6.76	73.65	1.26	7.02	11.98	48.78	20.24	28.84
4	9.50	6.46	4.24	4.84	52.75	1.17	6.92	10.33	30.81	14.94	24.76
5	9.94	5.83	3.17	3.92	49.99	1.02	7.11	9.23	28.14	12.52	26.53
6	8.30	4.61	3.89	2.63	37.62	0.86	5.02	7.18	22.37	10.43	20.90
7	8.26	5.01	3.27	3.42	41.65	0.76	4.28	7.06	23.16	14.60	22.87
8	8.37	4.86	2.59	3.77	39.74	0.40	2.27	4.35	20.87	19.01	22.32
9	8.46	3.70	2.67	2.23	28.20	0.40	1.07	4.67	20.22	7.54	18.07

Data of exchangeable cations, (Table 8), indicates fluctuation of the individual cations in concomitant coincidence with soluble ions, during leaching process, (Table 8). This is in agreement with Oster, (1982). Exchangeable calcium values increased on the expense of sodium, a decrease in this is may be rendered to H^+ ims in solution by leaching and the renewed source for calcium. This criterion was emphasized by ESP values which reflect explicit desirable declines by using sulfur only or after mixing with calcareous materials.

The efficiency of using the calcareous materials in retaining sodic soils could be examined through their effects on ESP. Thereby, the higher efficient treatment was that of adding the calcareous material No 11 with sulfur which restricted ESP values to 6.8 and 6.11 % for the successive two soil layers, respectively.

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تقييم التكوينات الكالسية (الجبس- الكربونات) في منطقة الفيوم لإصلاح الأراضي المتأثرة بالأملاح

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يهدف البحث إلي حصر وتقييم الموارد المحلية من الرسوبيات الكالسية (جبس وكربونات) خلال منخفض الفيوم والحواف المتاخمة. وتركزت الدراسة علي إمكانية استخدام هذه الرسوبيات في إصلاح وتحسين الأراضي الملحية الصودية. إختيرت خمسة مناطق ممثلة تشتمل علي ١٥ موقع عينات والتي تم تمثيلها بأخذ ٢٧ عينة جبسية وجيرية والتي تم تحليل جميعها كميائيا. إختيرت خمسة عينات جبسية وآخري جيرية لإستبيان الكالسيوم المنفرد خلال تجربتين:

الاولي: استخدام المياه المقطرة لاذابة ٢جم من العينة في لتر ماء علي ١٠ دفعات، وتحليل الراشح وحساب التجميعي التراكمي من الكالسيوم المنفرد.

الثانية: خلط ما يعادل الاحتياجات الجبسية من كل عينة مع تربة طينية ملحية صودية في عمود غسيل والغسيل المتقطع المتكرر باستخدام عمود ماء ٩٠ سم علي ٩ فترات. وتحليل المترشح كميائيا ثم تقدير الكاتيونات المتبادلة في عمود التربة لعمقين (صفر-١٠ و ١٠-٢٠ سم) مع استخدام الكبريت بمعدل ½ طن/فدان مع العينات الجيرية فقط.

تشير النتائج إلي تباين الرسوبيات المحلية في محتواها من الجبس والكربونات وكذلك مدي نقاوتها وبالتالي صلاحيتها للاستخدام الزراعي. تتقارب معدلات ذوبان عينات الجبس المختارة، حيث أن استخدام ٥٠٠ مل ماء أدي إلي انفراد اكثر من ٩٠% من محتواها من الكالسيوم. علي عكس العينات الجيرية ذات معدل الانفراد البطيء حيث استخدام ٥٠٠ مل أدي إلي انفراد حوالي ٥٥% فقط من محتواها من الكالسيوم. أدي استخدام الرسوبيات إلي تحسين خواص التربة المستخدمة ولكن بمعدلات متفاوتة فكان المعدل افضل مع عينات الجبس حيث انخفضت قيمة النسبة المئوية للصوديوم المتبادل من ٢٤,٠٨% إلي ٦% بينما استمرت اعلي من ٨% مع العينات الجيرية في وجود الكبريت.