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THE COMBINED EFFECT OF LEACHING WATER SALINITY AND SOIL AMENDMENTS ON THE SOIL CHEMICAL PROPERTIES OF EL-TIENA PLAIN

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ABSTRACT*: This study was carried out to evaluate the individual and combined effect of leaching water salinity, gypsum and compost on the soil chemical properties and the content of available macro-nutrients in the salt affected soils of El-Tiena Plain region. Leaching experiment using columns with 60 cm length and 8.5 cm diameter was carried out where the soils of these columns were leached five times with water varied in their salinity. Also, with each level of leaching water salinity was treated with either of gypsum at rates of 0, 100 and 200% of gypsum requirements (GR) or compost at rates of 0, 3 and 6%. Leaching processes were carried out at constant head of leaching water until the EC (dSm^{-1}) values of filtration became constant.*

The results indicated that, soil pH, EC and the content of soluble cations and anions were decreased with the decreasing of salinity level of leaching water. This decrease was increased with the increase rates of either of gypsum or compost. The obtained data showed a wide variations among the obtained values of cation exchange capacity, the content of exchangeable cations and the values of exchangeable sodium percentages according to the studied treatments. Also, the soil amendments played a major role on the available nitrogen, phosphorus and potassium.

Key words*: El-Tiena Plain, Salinity, Sodicity, Amelioration, Leaching, Amendments, Chemical properties, Nutrients availability.*

INTRODUCTION

El-Tiena Plain is situated in the Northwestern part of *Sinai peninsula*. Egypt covers about 50.000 feddans lying between longitudes 32°20 West and 32°40 East and latitudes 30°51 South and 31°15 North. The lands have an elevation varying from 0.0 m to 20 m-above sea level in the areas of the sand dunes. The area extends from the south at the outskirt of the town El-Kantara to the north at the town of Port Foaad for a distance of 44 km attaining a width of 32 km reaches to the border of El-Bardawil Lake at the eastern part. Abdel-Wahab (2008) found that soils of El-Tiena Plain have diverse textures. Clay content in these soils increased in the North East and

decreased downward to the South East of Suez Canal, while sand content followed the opposite direction. The same pattern for both contents were present from the West to the East inside Sinai. Also he found, salinity of these soils and it is extremely high in the North and decreases towards the South. The soils of El-Tiena Plain have a lower content of $CaCO_3$ % which ranged from 0.1 to 4.3%, pH ranges from 7.1 to 8.4 and organic matter content ranged from 0.1 to 2.4%. Concentration of the dissolved cations and anions followed the orders: Na^+ > Mg^{++} > Ca^{++} and Cl^- > $SO_4^=$ > HCO_3^-, cation exchange capacity of the clay soil recorded the higher value; 45.22 – 69.00 meq/100 g soil due to its fine texture and higher organic matter. In contrast, both studied light textured soils; having coarse texture and low organic matter which exhibited lower values. Mahmoud *et al.* (2001) stated that, application of gypsum and sulphur alone or in combination with farm yard manure (FYM) improved some soil properties and fertility status. Ghazy *et al.* (2002) and Salem (2003) indicated that the addition of sulphur amendment decreased soil salinity which reflected on the E.C of soil. The values of E.C were slightly decreased from 5.48 to 4.83 dSm^{-1} and from 20.11 to 12.03 dSm^{-1} in surface and subsurface layers, respectively. Abdel-Wahab (2008) found that, the organic matter of the virgin soils of El-Tiena Plain ranged between 0.1 to 2.4%. The higher values are assigned for the clayey soil. Some investigators explained that the higher value of organic matter in these soils were due to old sedimentations of the Nile. El-Gendy (2005) reported that application of gypsum decreased the bulk density and increased total porosity and hydraulic conductivity in the different soils and found that the application of organic manure decreased soil pH, ESP and EC.

The objectives of the present work were to study the effect of both leaching water salinity as alone or in combination with gypsum as mineral soil amendment or compost as organic soil amendment on some chemical soil properties of El-Tiena Plain.

MATERIALS AND METHODS

1. Soil Samples:

Surface soil samples 0 – 20 cm were taken for this study from Gilbana Village, Ismailiya Governorate, Egypt. The collected samples were air-dried, ground, good mixed, sieved through a 2 mm sieve and kept for chemical and physical analysis. These analysis were carried out according to international methods described by Cottenie *et al.* (1982) and Page *et al.* (1982). The particle size distribution and chemical properties were determined and the obtained data were recorded in Table (1).

Table (1): Main properties of the studied soil.
a) Particle size distribution (%):

Bulk density (g/cm)	Real density (g/cm)	Total porosity (%)	H.C (cm/hr)	Particle size distribution (%)				Textural grade	O.M %
				Clay (%)	Silt (%)	F. sand (%)	C. sand (%)		
1.79	2.60	31.15	0.26	16.30	16.31	3.81	63.58	Sandy loam	1.10

b) Chemical properties:

pH 1 : 2.5 soil suspension	E.C dSm^{-1}	Soluble ions (meq / L)							$CaCO_3$ %	Gypsum %	G.R ton/fed.
		Cations				Anions					
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	Cl^-	$SO_4^=$			
8.65	23.79	83.95	50.58	92.61	10.76	9.48	162.82	65.60	2.66	3.79	6.88

C.E.C	Exchangeable cations (meq / 100 g soil)				E.S.P %	Available macronutrients (mg/kg)		
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}		N	P	K
30.60	8.41	5.10	12.25	4.84	40.03	21.0	2.35	608.40

2. Leaching Water Quality:

In this experiment two sources of irrigation water were used for leaching purposes. The first source was tap water and the other was resemble the sea water and blended with tap water in the laboratory and had ratio of Ca : Mg : Na : Cl : SO_4 at 7 : 36 : 157 : 182 : 18 on equivalent basis according to El-Missiry (2001). Five mixtures of these two water sources were prepared. Data in Table (2) show the chemical composition of these five mixtures.

Table (2): Chemical composition and sodium adsorption ratio (SAR) of the used water sources.

Saline solution number	Mixed ratio (%)		Mixed ratio (%)		E.C (dSm^{-1})	Soluble ions (meq/L)					SAR
	Tap water	Sea water	Tap water	Sea water		Ca^{++}	Mg^{++}	Na^{+}	Cl^-	$SO_4^=$	
1	100.00	0.000	100	0	0.50	1.50	2.20	1.30	3.55	1.45	0.96
2	25.000	75.000	1	3	37.80	37.93	78.46	261.61	320.85	57.15	34.29
3	6.250	93.750	1	15	47.29	47.45	98.00	327.37	401.47	71.35	38.39
4	1.563	98.437	1	63	49.60	49.60	103.00	343.25	421.30	74.55	39.30
5	0.000	100.00	0	100	50.45	50.65	104.65	349.20	428.35	76.15	39.63

3. Soil Amelioration Experiment:

Some chemical properties of the used compost were listed in Table (3). So, 90 columns of polyetheleine with 60 cm height and 8.5 cm diameter. Each column fillted by fine and leached gravel into 5 cm depth in the column bottom. Then the columns were filled by the tested soil at height of 40 cm. The columns were divided into two main groups (45 columns for each main group). The columns of each main group were divided into three subgroups (15 columns / sub group). The columns of each sub group of the first main group were treated with one rate of gypsum which were 0, 100 and 200% of gypsum requirements (GR). Also, the columns of each sub group of the second main group were treated with

compost which the rates were 0, 3 and 6%.

The columns of each sub group were divided into five sub sub groups (3 columns for each sub-sub-group). Three columns of each sub-sub-group were treated or leached with one of the tested water sources. The E.C (dSm^{-1}) of each leachate was measured every day. Leaching process was conducted up to the values of E.C (dSm^{-1}) became constant. Then, the columns left for drying. The soil of each column was separated to two equal layers (20 cm /layer). The soil of each layer was air-dried, ground, sieved through a 2 mm sieve and kept in dry and clean glass bottles and used in the studied determination. The soils were analyzed for soil pH, total soluble salts, and soluble cations and anions, CEC and exchangeable cations. Also, available N, P and K of these soils were determined. These determination were carried out according to Cottenie *et al.* (1982), Page *et al.* (1982) and Jackson (1973).

Table (3): Some chemical properties of the used compost.

Properties	Value	Properties	Value
pH (1 : 10) composting : water	7.65	O.M %	57.00
E.C (1:10) compost: water extract (dS/m)	4.30	O.C %	35.15
Soluble cations (meq L^{-1}):		Total N (%)	1.87
Ca^{++}	5.97	C/N	18.79
Mg^{++}	3.85	Total P (%)	0.97
K^{+}	4.75	Total K (%)	1.85
Na^{+}	9.18		
Soluble anions (meq L^{-1}):		Available nutrients (%)	
$CO_3^{=}$	0.0	N	0.29
HCO_3^{-}	3.16	P	0.05
Cl^{-}	10.85	K	0.79
$SO_4^{=}$	9.80		

RESULTS AND DISCUSSION

1. Soil Chemical Properties:

1.1. Soil pH:

The presented data in Tables (4 and 5) show that the soil pH slightly decreased as a result to leaching with different salinity water levels. These values were increased with the increasing of salinity levels of leaching water. Also, soil pH was decreased with soil depth. This may be resulted from the high leaching rates of sodic or alkaline ions (especially Na^{+}) with the decrease of salinity level of irrigation water especially from the soil surface layer. In addition the leaching process may be associated with the decrease of soil content of stable organic compounds. These results are in agreement with those obtained by Shaban (2005) and Abou Hussien and Shaban (2008).

Also, data in Tables (4 and 5) show that, the application of gypsum at different rates results in a clear decrease of soil pH. The decrease in soil pH values with the surface layers relatively was higher than those of subsurface one. This decrease may be resulted from the increase of leaching soluble and exchangeable Na^{+} followed by Ca^{2+} released from gypsum hydrolysis and

also from sulphate salts (especially Na_2SO_4) formed by the reaction between sodium carbonate (Na_2CO_3) and SO_4^{2-} ions as products of gypsum reactions (El-Gendy, 2005, El-Sanat, 2003 and 2008 and Mohamed, 2009).

Table (4): Combined effect of both leaching water salinity and gypsum application rates on soil, pH, EC and the content of soluble ions.

Application of gypsum %	Ratio of blended water	Soil depth cm	pH 1 : 2.5	EC dSm^{-1}	Soluble ions (meq / L)							
					Cations				Anions			
					Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
0	Tap water	0-20	8.00	10.74	78.39	20.25	5.64	3.36	0	3.26	2.05	102.33
		20-40	8.00	11.70	84.60	22.50	6.30	3.45	0	3.50	2.20	111.15
	1 : 3	0-20	8.20	13.20	94.89	27.36	6.63	3.54	0	3.50	2.31	126.19
		20-40	8.20	13.50	95.94	28.41	7.56	3.96	0	3.55	2.64	128.81
	1 : 15	0-20	8.40	13.44	95.10	28.29	7.29	3.75	0	3.60	2.64	128.16
		20-40	8.40	13.80	97.40	29.89	8.07	4.17	0	6.69	2.76	128.55
	1 : 63	0-20	8.40	17.46	121.71	39.57	9.24	4.11	0	5.10	4.80	164.70
		20-40	8.40	18.00	125.01	40.77	9.84	4.50	0	6.60	5.85	167.55
	Sea water	0-20	8.50	18.15	125.50	40.90	10.10	4.50	0	6.85	6.10	168.55
		20-40	8.50	18.50	127.15	41.55	11.45	4.85	0	7.30	7.45	170.25
100	Tap water	0-20	7.85	4.92	35.30	9.84	1.86	2.20	0	2.91	1.52	44.77
		20-40	7.85	6.27	44.65	12.75	3.10	2.20	0	3.25	1.58	57.87
	1 : 3	0-20	8.05	7.47	47.86	19.14	5.00	2.70	0	3.25	2.11	69.34
		20-40	8.05	7.86	51.10	19.44	5.24	2.82	0	3.30	2.30	73.00
	1 : 15	0-20	8.20	7.95	51.66	19.74	5.24	2.86	0	3.50	2.60	73.40
		20-40	8.20	8.10	52.91	19.85	5.24	3..00	0	3.59	2.50	74.91
	1 : 63	0-20	8.25	8.07	52.18	19.92	5.42	3.18	0	3.70	2.75	74.25
		20-40	8.25	8.25	53.23	20.10	5.72	3.45	0	4.20	3.10	75.20
	Sea water	0-20	8.30	10.35	69.10	23.80	6.85	3.75	0	5.75	3.25	94.50
		20-40	8.30	10.50	69.78	24.12	7.20	3.90	0	6.25	3.50	95.25
200	Tap water	0-20	7.82	4.80	34.70	9.55	1.80	1.95	0	2.60	1.45	43.95
		20-40	7.83	6.00	44.00	11.25	2.75	2.00	0	2.85	1.52	55.63
	1 : 3	0-20	8.00	6.75	45.23	15.12	4.65	2.50	0	2.96	2.00	62.54
		20-40	8.00	7.20	48.09	16.32	4.85	2.74	0	3.05	2.15	66.80
	1 : 15	0-20	8.10	7.08	47.45	15.72	4.98	2.65	0	3.20	2.30	64.58
		20-40	8.10	7.35	48.98	16.62	5.00	2.90	0	3.30	2.40	67.80
	1 : 63	0-20	8.10	7.80	53.39	16.41	5.20	3.00	0	3.50	2.56	71.94
		20-40	8.15	7.92	53.48	17.20	5.27	3.25	0	3.75	2.84	72.61
	Sea water	0-20	8.20	9.50	63.85	21.50	6.15	3.50	0	4.65	3.00	87.35
		20-40	8.21	9.75	65.40	21.95	6.45	3.70	0	4.80	3.20	89.50

Table (5): Relative change (RC, %) of the studied soil, EC and soluble ions as affected by gypsum application.

Ratio of blended water	Added application of gypsum	Soil depth cm	EC dSm^{-1}	Soluble ions (meq / L)						
				Cations				Anions		
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	$SO_4^{=}$
Tap water	100%	0-20	-54.19	-54.97	-51.41	-67.03	-34.52	-34.20	-3.00	-56.15
		20-40	-46.42	-47.23	-43.34	-50.79	-36.23	-28.18	-7.14	-46.76
1 : 3		0-20	-43.41	-49.56	-30.04	-24.59	-23.73	-9.72	-9.72	-45.01
		20-40	-41.78	-46.74	-31.57	-30.69	-28.79	-12.88	-9.84	-43.28
1 : 15		0-20	-40.85	-45.68	-30.22	-28.12	-23.73	-1.51	-2.78	-42.73
		20-40	-41.30	-45.68	-33.59	-35.07	-28.05	-9.42	-2.71	-44.05
1 : 63		0-20	-53.78	-57.13	-49.66	-41.34	-22.63	-42.71	-27.45	-54.91
		20-40	-54.17	-57.42	-50.70	-41.87	-23.33	-47.01	-36.36	-55.12
Sea water		0-20	-42.97	-44.94	-41.81	-32.18	-16.67	-46.72	-16.06	-43.77
		20-40	-43.24	-45.12	-41.95	-37.12	-19.59	-53.02	-14.38	-44.05
Tap water	200%	0-20	-55.31	-55.73	-52.84	-68.08	-41.96	-37.23	-13.33	-56.95
		20-40	-48.72	-47.99	-50.00	-56.35	-42.03	-30.91	-18.57	-48.82
1 : 3		0-20	-48.86	-52.33	-44.74	-29.86	-29.38	-13.42	-17.78	-50.40
		20-40	-46.67	-49.87	-42.56	-35.85	-30.81	-18.56	-16.67	-48.10
1 : 15		0-20	-47.32	-50.11	-44.43	-31.69	-29.33	-12.88	-11.11	-49.60
		20-40	-46.74	-49.71	-44.40	-38.04	-30.46	-13.04	-10.57	-48.47
1 : 63		0-20	-55.33	-56.13	-58.53	-43.72	-27.01	-46.67	-31.37	-56.32
		20-40	-56.00	-57.22	-57.81	-46.44	-27.78	-51.45	-43.18	-56.67
Sea water		0-20	-47.66	-49.12	-47.43	-39.11	-22.22	-50.82	-32.12	-48.02
		20-40	-47.30	-48.56	-47.17	-43.69	-23.71	-57.05	-34.25	-47.43

Soil pH was also negatively affected by compost application (Tables 4 and 5), where this decrease was increased with the increasing the application rate of compost. In this respect, the obtained decrease in soil pH was resulted from the acidic effect of some organic acids and other organic compounds produced during compost decomposition. In this connection, Mohamed (2009) and Ayad (2010) obtained similar results.

2. Total Soluble Salts (EC) and Soluble Ions:

Data in Tables (4 and 5) show that, soil EC values were clearly decreased with the decreasing of leaching water salinity levels. The high decrease of soil EC was found in the surface layer especially with the leaching with tap water. Confirmed results were prementioned by Shaban (2005) and Abou Hussien and Shaban (2008) on some salt affected soils of Egypt leached by different water qualities. The calculated values of RC (%) of soil EC with different water salinity levels were negative as shown in Tables (5 and 7), where the lowest negative values were associated with the leaching by sea water. These results were in agreement with those obtained by Zein *et al.* (2002) and El-Sheikh (2003).

Data in Tables (4 and 5) show that, the content of soluble ions decreased with the decreasing salinity levels of leaching water where the highest decrease was found with leaching by tap water. Also data show that the decrease of salinity in the surface layer was higher than that of subsurface layer. The calculated values of RC (%) declared that the previous decrease of the content of soluble ions associated with the leaching. Also, data show that, the highest decrease was found with Na^+ followed by Mg^{++} for soluble cations and Cl^- followed by HCO^-_3 for soluble anions. The negative values of RC were increased with the decreasing salinity levels of leaching water. Also, the negative values of RC for leaching soluble ions from surface layer were higher than those of subsurface one. These results are in agreement with the results obtained by El-Sheikh (2003) and Shaban (2005).

Data in Tables (4 and 5) show that, gypsum application at different rates resulted in a clear decrease of soil EC (dSm^{-1}) and its content of soluble cations and anions (meq / L). Data also show that, the decrease of EC increased with the increase the rate of added gypsum. The obtained decrease associated with gypsum application was resulted from some chemical reactions of gypsum and its products which formed other compounds characterized by more solubility and ability to leaching. These results were become clearly and supported by the high negative values of RC (%) for these treatments. Similar results were found by El-Masry (2001).

The individual compost applications (Tables 6 and 7) or in combination with saline water resulted in a decrease of soil EC and the contents of soluble ions, where the compost treatments may be increased the solubility of some soil compounds. The high decrease of these parameters was associated with the treatments of high rate of added compost with TW and water have low salinity levels. This decrease also was more clear in the surface layer. Also, the calculated values of RC (%) of soluble ions were varied from ion to another. The highest negative values of RC as affected by compost treatments were recorded with Na^+ followed by K^+ for soluble cations and with Cl^- and SO_4^{2-} for soluble anions. Recently, Ayad (2010) obtained similar results with different sources of compost on sandy and alluvial soils.

3.Cation Exchange Capacity (CEC), Exchangeable Cations and ESP:

Data in Tables (8 and 9) show that, a little increases of soil CEC and exchangeable cations with leaching by TW and other sources of leaching water especially those characterized by low salinity levels, and these values were decreased with the increasing of leaching water salinity levels. This may be attributed to dispersion effect of TW and waters having low salinity levels on soil particles which leads to the increase of specific surface area of soil particles compared with that resulted from high salinity levels of leaching water. The previous data were supported by the calculated values of RC (%)

of CEC with different treatments under study. These results of CEC were in agreement with those obtained by El-Masry (2001).

Table (6): Combined effect of both leaching water salinity and compost application rates on soil, pH, EC and the content of soluble ions.

Application of compost %	Ratio of blended water	Soil depth cm	pH 1 : 2.5	EC dSm^{-1}	Soluble ions (meq / L)							
					Cations				Anions			
					Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
0	Tap water	0-20	8.00	10.74	78.39	20.25	5.64	3.36	0	3.00	2.31	102.09
		20-40	8.00	11.70	84.60	22.50	6.30	3.45	0	3.50	2.20	111.30
	1 : 3	0-20	8.20	13.20	94.89	27.36	6.63	3.54	0	3.50	2.31	126.19
		20-40	8.20	13.5	95.94	28.41	7.56	3.96	0	3.55	2.64	128.81
	1 : 15	0-20	8.40	13.44	95.10	28.29	7.29	3.75	0	3.60	2.64	128.16
		20-40	8.40	13.80	97.40	29.89	8.07	4.17	0	6.69	2.76	128.55
	1 : 63	0-20	8.40	17.46	121.71	39.57	9.24	4.11	0	5.10	4.80	164.70
		20-40	8.40	18.00	125.01	40.77	9.84	4.50	0	6.60	5.85	167.55
	Sea water	0-20	8.50	18.15	125.50	40.90	10.10	4.50	0	6.85	6.10	168.55
		20-40	8.50	18.50	127.15	41.55	11.45	4.85	0	7.30	7.45	170.25
3	Tap water	0-20	7.90	6.75	47.40	13.05	4.05	3.00	0	2.70	2.04	62.76
		20-40	7.90	6.96	48.10	13.35	4.95	3.20	0	2.85	2.10	64.65
	1 : 3	0-20	8.10	7.29	50.03	13.95	5.57	3.35	0	2.90	2.20	67.80
		20-40	8.10	7.98	55.70	14.85	5.75	3.50	0	3.00	2.40	74.40
	1 : 15	0-20	8.25	8.40	56.30	17.25	6.85	3.60	0	3.20	2.50	78.30
		20-40	8.25	9.81	64.54	21.75	7.95	3.85	0	3.35	2.57	92.18
	1 : 63	0-20	8.30	9.15	60.21	18.78	8.51	4.00	0	4.85	4.65	82.00
		20-40	8.30	11.25	73.85	25.05	9.35	4.25	0	6.30	5.35	100.85
	Sea water	0-20	8.35	11.65	74.70	25.85	9.55	4.40	0	6.75	5.95	103.80
		20-40	8.35	11.80	75.36	26.25	10.84	4.55	0	7.00	6.80	104.20
6	Tap water	0-20	7.84	6.00	41.22	12.28	3.85	2.65	0	2.50	1.95	55.55
		20-40	7.85	6.36	43.77	12.73	4.20	2.90	0	2.65	2.00	58.95
	1 : 3	0-20	8.10	7.08	48.69	13.05	5.24	3.10	0	2.70	2.10	66.00
		20-40	8.10	7.41	52.07	13.21	5.57	3.25	0	2.85	2.20	69.05
	1 : 15	0-20	8.20	7.71	53.95	13.95	5.85	3.35	0	3.00	2.30	71.80
		20-40	8.20	8.46	55.25	19.05	6.80	3.50	0	3.15	2.45	79.00
	1 : 63	0-20	8.28	8.76	58.45	17.55	7.65	3.95	0	4.65	4.40	78.55
		20-40	8.28	9.87	63.15	22.95	8.55	4.05	0	6.00	5.00	87.70
	Sea water	0-20	8.32	10.70	67.23	25.35	10.27	4.15	0	6.35	5.70	94.95
		20-40	8.32	10.95	68.90	25.85	10.45	4.30	0	6.70	6.50	96.30

Table (7): Relative change (RC, %) of the studied soil, EC and soluble ions as affected by compost application.

Ratio of blended water	Added application of compost %	Soil depth cm	EC dSm^{-1}	Soluble ions (meq / L)						
				Cations				Anions		
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	$SO_4^{=}$
Tap water	3	0-20	-37.15	-39.53	-35.55	-28.19	-10.71	-11.68	-10.00	-38.52
		20-40	-40.51	-43.14	-41.11	-21.42	-7.24	-4.54	-18.57	-41.92
1 : 3		0-20	-44.77	-47.27	-49.01	-15.98	-5.36	-4.76	-19.44	-46.27
		20-40	-40.88	-41.94	-47.72	-23.94	-11.61	-9.09	-18.03	-42.19
1 : 15		0-20	-37.50	-40.79	-39.02	6.03	-4.00	-5.30	-11.11	-38.90
		20-40	-28.91	-33.73	-27.23	-1.48	-7.67	-6.88	-11.92	-28.29
1 : 63		0-20	-47.59	-50.52	-52.53	-7.90	-2.67	-3.12	-4.90	-50.21
		20-40	-37.50	-40.92	-38.55	-4.97	-5.55	-8.54	-4.54	-39.80
Sea water		0-20	-35.81	-40.47	-36.79	-5.44	-2.22	-2.45	-1.45	-38.41
		20-40	-36.21	-40.73	-36.82	-8.29	-6.18	-8.72	-4.10	-38.79
Tap water	6	0-20	-44.13	-47.41	-39.35	-31.73	-21.13	-15.58	-16.66	-45.58
		20-40	-45.64	-48.26	-43.42	-33.33	-15.94	-9.09	-24.28	-45.76
1 : 3		0-20	-46.36	-48.68	-52.30	-20.96	-12.42	-4.54	-25.00	-47.65
		20-40	-45.11	-45.72	-53.50	-26.32	-17.92	-16.66	-22.13	-46.39
1 : 15		0-20	-42.63	-43.27	-50.68	-19.75	-10.66	-12.87	-19.44	-43.97
		20-40	-38.69	-43.27	-36.26	-15.73	-16.06	-11.23	-14.63	-40.30
1 : 63		0-20	-49.82	-51.19	-55.64	-17.20	-3.89	-8.33	-8.82	-52.30
		20-40	-45.16	-49.48	-43.70	-13.10	-10.00	-14.52	-9.09	-47.65
Sea water		0-20	-41.04	-46.43	-38.01	-3.46	-7.77	-6.55	-7.29	-43.66
		20-40	-40.81	-45.81	-37.78	-8.73	-10.41	-12.75	-8.21	-43.43

The determined exchangeable cations i.e., Ca, Mg, Na and K were greatly affected by salinity levels of leaching water, where the trend and the rate of this effects were varied among these cations and also related with soil depth. All values of RC (%) for the exchangeable cations were positive except Ca under leaching by tap water and its values varied from cations to another. The highest values of RC were recorded with Na followed by K. The highest values of RC for Na and K resulted from the easily desorption of these monovalent cations and released by high valenet cations (Shaban, 2005). All values of RC for exchangeable cations were decreased with the increasing salinity levels of leaching water, but it varied according to soil depth. These results concluded that the ability of these water in the leaching of El-Tiena Plain saline soils. These results are in agreement with these obtained by Abdel-Wahab (2008).

Soil ESP (%) and its RC (%) are presented in Tables (8 and 9). Data show that the soil ESP greatly affected by salinity levels of leaching water, where the values of ESP were decreased with the decreasing salinity levels of leaching water. In general, the values of ESP for surface layer were higher than those of subsurface layer. The obtained values of ESP show that this soil classified as alkali soil, where its values were greater than 15% (Richard's, 1954).

Table (8): Combined effect of leaching water and gypsum application on CEC, exchangeable cations and ESP.

Ratio of blended water	Added application of gypsum %	Soil depth cm	CEC (meq/100 g)	Exchangeable cations (meq/100 g)				ESP (%)
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	
Tap water	0	0-20	30.87	8.41	5.10	11.82	5.54	38.28
		20-40	30.80	8.40	5.10	11.50	5.80	37.33
1 : 3		0-20	30.70	8.42	5.10	11.98	5.20	39.02
		20-40	30.60	8.45	5.00	11.82	5.33	38.62
1 : 15		0-20	30.60	8.50	5.15	12.22	4.73	39.93
		20-40	30.45	8.58	5.20	12.13	4.54	39.90
1 : 63		0-20	30.32	8.63	5.28	12.55	3.86	41.39
		20-40	30.15	8.71	5.42	12.70	3.32	42.12
Sea water		0-20	30.10	8.70	5.40	12.92	3.10	42.92
		20-40	29.90	8.80	5.50	12.98	2.62	43.41
Tap water	100	0-20	30.10	12.20	5.33	5.50	7.07	18.27
		20-40	30.10	15.62	6.05	2.25	6.18	7.47
1 : 3		0-20	30.60	13.10	5.35	5.80	6.35	18.95
		20-40	29.60	15.93	6.15	2.50	5.02	8.44
1 : 15		0-20	30.20	12.95	5.50	6.15	5.60	20.36
		20-40	28.95	16.10	6.25	2.60	4.00	8.98
1 : 63		0-20	29.25	12.80	5.50	6.41	4.54	21.91
		20-40	28.50	16.25	6.35	2.70	3.20	9.47
Sea water		0-20	28.90	13.11	5.58	6.50	3.71	22.49
		20-40	28.05	16.40	6.45	2.80	2.40	9.98
Tap water	200	0-20	30.10	13.00	5.50	5.10	6.50	16.94
		20-40	29.80	16.50	6.25	1.65	5.40	5.53
1 : 3		0-20	29.80	14.05	5.50	5.40	4.85	18.12
		20-40	29.10	17.05	6.30	1.97	3.78	6.76
1 : 15		0-20	29.50	14.20	5.72	5.78	3.80	17.55
		20-40	28.40	17.45	6.60	2.15	2.20	7.57
1 : 63		0-20	28.60	14.65	5.80	6.05	2.10	21.15
		20-40	27.80	17.80	6.68	2.42	0.78	8.70
Sea water		0-20	28.45	15.20	5.85	6.28	1.12	22.07
		20-40	27.50	18.00	6.75	2.60	0.15	9.45

Table (9): Relative change (RC, %) of the studied soil, CEC, ESP and the content of the exchangeable catinos as affected by gypsum application.

Ratio of blended water	Added application of gypsum %	Soil depth cm	CEC (meq/100 g)	Exchangeable cations (meq / 100 g)				ESP (%)
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	
Tap water	100	0-20	-2.50	45.06	4.50	-53.46	27.61	-52.27
		20-40	-2.27	85.95	18.62	-80.43	6.55	-79.98
1 : 3		0-20	-0.32	55.58	4.90	-51.58	22.11	-51.43
		20-40	-3.26	88.52	23.00	-78.84	-5.81	-78.14
1 : 15		0-20	-1.30	52.35	6.79	-49.67	18.39	-49.01
		20-40	-4.92	87.64	20.19	-78.56	-11.89	-77.49
1 : 63		0-20	-3.52	48.31	4.16	-48.92	17.61	-47.06
		20-40	-5.47	86.56	17.15	-78.74	-3.61	-77.51
Sea water		0-20	-3.98	50.68	3.33	-49.69	19.67	-47.60
		20-40	-6.18	86.36	17.27	-78.42	-8.39	-77.00
Tap water	200	0-20	-2.50	54.57	7.84	-56.85	17.32	-55.74
		20-40	-3.24	96.42	22.54	-85.65	-6.89	-85.18
1 : 3		0-20	-2.93	66.86	7.84	-54.92	-6.73	-53.56
		20-40	-4.90	101.77	26.00	-83.33	-29.00	-82.49
1 : 15		0-20	-3.59	67.05	11.06	-52.70	-19.66	-56.04
		20-40	-6.73	103.37	26.92	-82.27	-51.54	-81.02
1 : 63		0-20	-5.67	69.75	9.84	-51.79	-45.59	-48.90
		20-40	-7.79	104.36	23.24	-80.94	-76.50	-79.34
Sea water		0-20	-5.48	74.71	8.33	-51.39	-63.87	-48.57
		20-40	-8.02	104.54	22.72	-79.96	-94.27	-78.23

Cation exchange capacity (CEC) and exchangeable cations (meq/100 g) of El-Tiena Plain soils are presented in Tables (8 and 9). Data revealed that, CEC value slightly decreased with the increase the rates of added gypsum. Also, this decrease in CEC in the subsurface layers was more than that of surface one. This negative effect was cleared by RC (%) values of CEC for the two studied layers. Mohamed (2009) obtained similar results. The decrease of soil CEC after treating soils by gypsum may be resulted from aggregation state of the studied soils which reduced the specific surface area of soil particles.

In spite of the little decrease of exchangeable cations (except Ca) associated with the application of gypsum, the rate of RC of these cations was varied from cation to another. The greater negative values of RC were recorded with Na, where its values were positive with Ca which produced from gypsum hydrolysis. Studies by El-Sanat (2008) and Faiyad *et al.* (2010) recorded similar results.

On the other side, the soils treated by compost appeared increase of soil CEC and the content of exchangeable cations as meq / 100 g (Tables 10 and 11). The obtained increase resulted from added compost (Mohamed, 2009 and Ayad, 2010). The calculated values of RC (%) of the determined exchangeable cations due to the effect of added compost on the content of these cations, where all values of RC were positive, except that of Na and K which appeared negative values. These results showed the importance of compost application as a soil amendment. These results are in agreement with those obtained by Abd Allah (1990) and Faiyad *et al.* (2010).

Data presented in Tables (10 and 11) show that, with different the values of ESP (%) were clearly decreased as a result to application of different rates of soil amendments. The rate of this decrease was varied depending on types and application rate of soil amendment and also on soil depth. Increasing rate of added amendment resulted in a more decrease of ESP. The highest decrease of ESP was found with the application of gypsum. The efficiency of the evaluated amendments on the reduction of soil ESP was increased with the decrease salinity levels of leaching water. These data and its discussion may be supported by the calculated values of RC (%) of ESP as affected by different treatments of soil amendments under different salinity levels of leaching water, where with all treatments of the tested soil amendments, all values of RC (%) of ESP were negative. El-Gendy (2005), El-Sanat (2008), Mohamed (2009) and Ayad (2010) were obtained the similar results.

Table (10): Combined effect of leaching water salinity and compost application on CEC, exchangeable cations and ESP.

Ratio of blended water	Added application of compost %	Soil depth cm	CEC (meq / 100 g)	Exchangeable cations (meq / 100 g)				ESP (%)
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	
Tap water	0	0-20	30.87	8.41	5.10	11.82	5.54	38.28
		20-40	30.80	8.40	5.10	11.50	5.80	37.33
1 : 3		0-20	30.70	8.42	5.10	11.98	5.20	39.02
		20-40	30.60	8.45	5.00	11.82	5.33	38.62
1 : 15		0-20	30.60	8.50	5.15	12.22	4.73	39.93
		20-40	30.45	8.58	5.20	12.13	4.54	39.90
1 : 63		0-20	30.32	8.63	5.28	12.55	3.86	41.39
		20-40	30.15	8.71	5.42	12.70	3.32	42.12
Sea water		0-20	30.10	8.70	5.40	12.92	3.10	42.92
		20-40	29.90	8.80	5.50	12.98	2.62	43.41
Tap water	3	0-20	31.60	12.90	5.20	9.75	3.41	30.85
		20-40	36.10	13.10	5.50	7.15	10.35	19.80
1 : 3		0-20	31.40	13.15	5.20	9.95	3.10	31.68
		20-40	35.80	13.30	5.50	7.32	9.98	20.44
1 : 15		0-20	31.10	13.45	5.35	10.10	2.20	32.47
		20-40	35.20	13.75	5.70	7.70	8.05	21.87
1 : 63		0-20	31.00	13.50	5.35	10.35	1.80	32.85
		20-40	34.50	13.80	5.99	8.10	6.91	23.47
Sea water		0-20	30.80	13.75	5.40	10.82	0.83	29.40
		20-40	33.10	14.05	5.95	9.00	10.30	28.93
Tap water	6	0-20	32.50	12.95	5.30	9.43	4.82	29.01
		20-40	39.50	14.32	5.65	6.50	13.03	16.45
1 : 3		0-20	32.15	13.25	5.30	9.60	4.00	29.86
		20-40	38.10	14.60	5.70	6.90	10.90	18.11
1 : 15		0-20	32.10	14.74	5.30	9.85	2.12	30.68
		20-40	37.65	15.05	5.70	7.15	9.75	18.99
1 : 63		0-20	31.60	14.92	5.41	10.00	1.27	31.64
		20-40	36.10	15.32	5.82	7.62	2.84	21.10
Sea water		0-20	31.25	15.15	5.50	10.25	0.35	32.80
		20-40	35.50	15.85	6.20	7.95	5.50	22.39

Table (11): Relative change (RC, %) of the studied soil, CEC, ESP and the content of the exchangeable cations as affected by compost application.

Ratio of blended water	Added application of compost %	Soil depth cm	CEC (meq / 100 g)	Exchangeable cations (meq / 100 g)				ESP (%)
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	
Tap water	3	0-20	2.29	53.38	1.96	-17.51	-38.44	-19.40
		20-40	17.20	55.95	7.84	-37.82	78.44	-46.95
1 : 3		0-20	2.28	56.17	1.96	-16.94	-40.38	-18.81
		20-40	16.99	57.39	10.00	-38.07	-87.24	-47.07
1 : 15		0-20	1.63	58.23	3.88	-17.34	-53.48	-18.68
		20-40	15.59	58.41	9.61	-36.52	77.31	-45.18
1 : 63		0-20	2.24	56.43	1.32	-17.52	-53.36	-19.35
		20-40	14.42	58.43	10.51	-36.22	108.13	-44.27
Sea water		0-20	2.25	58.04	0.00	-16.25	-73.22	-31.50
		20-40	10.70	59.65	8.18	-30.66	293.31	-33.35
Tap water	6	0-20	5.28	53.98	3.92	-20.21	-12.99	-24.21
		20-40	28.24	70.47	10.78	-43.47	124.65	-55.93
1 : 3		0-20	4.72	57.36	3.92	-19.86	-23.07	-23.47
		20-40	24.50	72.78	14.00	-41.62	104.50	-53.10
1 : 15		0-20	4.90	73.41	2.91	-19.39	-55.17	-23.16
		20-40	23.64	73.38	9.61	-41.10	114.75	-52.40
1 : 63		0-20	4.22	72.88	2.46	-20.31	-67.09	-23.55
		20-40	19.73	75.88	7.32	-40.00	-14.45	-49.90
Sea water		0-20	3.82	74.13	1.85	-20.66	-88.70	-23.57
		20-40	18.72	80.11	12.72	-38.75	109.92	-48.42

4. Macronutrients Availability:

Data in Tables (12 and 13) show that, salinity levels of leaching water have a wide effect on the content of N, P and K (mg/kg). This effect was negative on the available N, while it was positive on P. On the other hand, this effect was negative on K with water have low salinity levels and TW since it was positive with leaching water characterized by high salinity levels. These variation resulted from the effect of salinity levels on the stability and solubility of the different nutrients (Basak, 2006). The changes of these nutrients content were related with soil depth. In this respect this effect was resulted from the effect of the evaluated leaching saline water on soil properties. The calculated values of RC (%) of content of available N, P and K as affected by salinity level of leaching water and recorded in Tables (12 and 13) show also that, these values varied from layer to another. Fayed (2009), Hamad (2009) and Abou Hussien *et al.* (2010) obtained similar results.

The recorded data in Tables (12 and 13) show that the content of the available N, P and K (mg/kg) in soil was clearly increased as a result of soil amendments applications, where these values increased with the increase of

added rate and the highest values were found in the surface layer. This increase may be attributed to the effect of evaluated amendments on improvement of soil physical and chemical properties and its reaction effect on the solubility and transfer nitrogen compounds in the soil.

Table (12): Combined effect of leaching water salinity and gypsum application on El-Tiena Plain saline soils content on available N, P and K and its relative change (R.C %).

Ratio of blended water	Added application of gypsum %	Soil depth cm	N		P		K	
			mg/kg	R.C %	mg/kg	R.C %	mg/kg	R.C %
Tap water	0	0-20	51.00	142.85	3.40	44.68	347.10	-42.94
		20-40	47.55	126.42	3.10	31.91	360.70	-40.70
1 : 3		0-20	43.13	-15.43	3.95	-16.17	330.33	-43.97
		20-40	40.35	-15.14	3.55	-14.51	362.31	-40.44
1 : 15		0-20	35.15	-31.07	5.00	-47.05	330.72	-45.64
		20-40	32.35	-31.96	4.68	-50.96	339.69	-44.16
1 : 63		0-20	29.08	-42.29	6.00	-76.47	310.83	-48.91
		20-40	25.65	-46.05	5.76	-85.80	304.98	-49.87
Sea water		0-20	25.15	-50.68	6.50	-91.17	296.40	-51.28
		20-40	23.65	-50.26	5.80	-87.09	291.33	-52.11
Tap water	100	0-20	55.63	9.07	3.78	11.17	283.53	-18.31
		20-40	53.33	12.15	3.59	15.80	326.82	-9.40
1 : 3		0-20	50.45	16.97	4.50	13.92	352.95	3.54
		20-40	45.35	12.39	4.00	12.67	305.76	-15.60
1 : 15		0-20	45.53	29.53	5.30	6.00	329.94	-2.35
		20-40	42.23	30.54	4.80	2.56	273.00	19.63
1 : 63		0-20	37.30	28.26	6.65	10.83	301.08	3.13
		20-40	33.18	29.35	5.86	1.73	259.35	-14.96
Sea water		0-20	30.46	21.11	7.98	22.76	290.94	-1.84
		20-40	28.18	19.15	6.25	7.75	245.70	-15.66
Tap water	200	0-20	65.35	28.13	5.61	65.00	329.55	-5.05
		20-40	61.58	29.50	5.25	69.35	288.60	-20.00
1 : 3		0-20	60.27	39.74	6.20	56.96	286.65	-15.90
		20-40	56.65	40.39	5.75	61.97	254.28	-29.81
1 : 15		0-20	55.00	56.47	8.37	67.40	251.55	-23.93
		20-40	51.44	59.01	7.50	60.25	198.90	-41.44
1 : 63		0-20	41.43	42.46	10.58	70.00	198.90	-36.01
		20-40	38.14	48.69	10.20	77.08	157.17	-48.46
Sea water		0-20	33.38	32.72	10.78	65.84	180.18	-39.21
		20-40	31.29	32.30	10.50	81.03	150.15	-48.46

Table (13): Combined effect of leaching water salinity and compost application on El-Tiena Plain saline soils content on available N, P and K and its relative change (R.C %).

Ratio of blended water	Added application of H_2SO_4%	Soil depth cm	N		P		K	
			mg/kg	R.C %	mg/kg	R.C %	mg/kg	R.C %
Tap water	0	0-20	51.00	142.85	3.40	44.68	347.10	-42.94
		20-40	47.55	126.42	3.10	31.91	360.70	-40.70
1 : 3		0-20	43.13	-15.43	3.95	-16.17	330.33	-43.97
		20-40	40.35	-15.14	3.55	-14.51	362.31	-40.44
1 : 15		0-20	35.15	-31.07	5.00	-47.05	330.72	-45.64
		20-40	32.35	-31.96	4.68	-50.96	339.69	-44.16
1 : 63		0-20	29.08	-42.29	6.00	-76.47	310.83	-48.91
		20-40	25.65	-46.05	5.76	-85.80	304.98	-49.87
Sea water		0-20	25.15	-50.68	6.50	-91.17	296.40	-51.28
		20-40	23.65	-50.26	5.80	-87.09	291.33	-52.11
Tap water	3	0-20	58.00	13.72	4.25	25.00	249.99	-27.97
		20-40	55.28	16.25	4.10	32.25	528.45	46.48
1 : 3		0-20	53.00	22.88	4.48	13.41	251.55	-22.19
		20-40	51.25	27.01	4.27	20.28	525.72	45.10
1 : 15		0-20	49.00	39.40	6.25	25.00	226.20	-31.60
		20-40	45.35	40.18	5.79	23.71	464.10	36.62
1 : 63		0-20	44.25	52.16	7.28	21.33	226.20	-26.76
		20-40	41.13	60.35	6.65	15.45	435.24	42.71
Sea water		0-20	39.12	55.54	7.50	15.38	203.97	-31.18
		20-40	35.27	49.13	6.94	19.65	579.15	98.79
Tap water	6	0-20	74.35	45.78	4.82	41.76	291.33	-16.06
		20-40	70.85	49.00	4.55	46.77	621.27	72.21
1 : 3		0-20	71.18	65.03	5.28	33.67	276.90	-14.35
		20-40	68.20	69.02	5.00	40.84	551.85	52.31
1 : 15		0-20	65.20	85.49	7.50	50.00	213.33	-35.49
		20-40	61.32	89.55	6.95	48.50	516.75	52.12
1 : 63		0-20	48.55	66.95	9.10	51.66	203.58	-34.09
		20-40	46.13	79.84	8.65	50.17	268.71	-11.89
Sea water		0-20	42.30	68.19	9.25	42.30	173.55	-41.44
		20-40	38.27	61.81	9.05	56.03	382.20	31.19

In addition used gypsum and compost have a positive effect on the activity of soil macro- and micro-organisms (Mengel and Kirkby, 1987 and Basak, 2006). The increase of soil content of available N associated with the application of compost which was higher than resulted from gypsum treatments for N and P. On the other hand, gypsum treatments have a greater increase effect on soil content of available K compared with the application of compost. This order was supported and become more clear by the calculated and recorded values of RC (%) of available N, P and K content in the soils. The highest values of RC were recorded with compost treatments especially at higher application rates. The superior effect of compost compared with other two amendments may be attributed to the release of nitrogen from compost materials (El-Sanat, 2003 and 2008; Mohamed, 2009 and Ayad, 2010). From the above-mentioned results it could be concluded that such this soil may be leached by water have a low concentration of salinity especially with treatments of organic and inorganic soil amendments.

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التأثير المشترك لملوحة ماء الغسيل ومحسنات التربة على الخواص الكيميائية وحالة المغذيات فى أراضى سهل الطينة

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الملخص العربى

أجريت هذه الدراسة لتقييم التأثير الفردى والمشترك لملوحة ماء الغسيل بدون و مع أى من الجبس أو الكمبوست على الخواص الكيميائية ومحتوى التربة من المغذيات الكبرى الميسرة فى الأراضى المتأثرة بالأملاح فى منطقة سهل الطينة . ولقد أجريت تجربة غسيل باستخدام أعمدة بأطوال ٦٠ سم وقطر ٨.٥ سم حيث تم غسيل الأرض خمسة مرات بمياه غسيل مختلفة المحتوى من الملوحة وعند كل مستوى ملوحة لمياه الغسيل عوملت الأرض إما بالجبس بمعدلات إضافة ٠ أو ١٠٠ أو ٢٠٠% من الاحتياجات الجبسية أو بالكمبوست بمعدلات إضافة ٠ أو ٣ أو ٦% . ولقد أجريت عمليات الغسيل عند عمق ثابت لماء الغسيل واستمرت عملية الغسيل حتى ثبات قيمة التوصيل الكهربائى للراشح . وتُشير نتائج انخفاض كل من رقم حموضة الأرض والأملاح الكلية الذائبة وكذلك المحتوى من الكاتيونات والأنيونات الذائبة ولقد ازداد هذا الإنخفاض بزيادة معدلات الإضافة لكلٍ من الجبس أو الكمبوست .

ولقد أوضحت النتائج المتحصل عليها تبايناً واسعاً فى القيم المتحصل عليها لكلٍ من السعة التبادلية الكاتيونية والمحتوى من الكاتيونات المتبادلة وكذلك قيمة النسبة المئوية للصوديوم المتبادل طبقاً لعوامل الدراسة . ولقد لعبت ملوحة ماء الغسيل وكذلك محسنات الأرض تحت التقييم دوراً هاماً فى تجديد محتوى الأرض من النيتروجين والفوسفور والبوتاسيوم الميسر .