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COMPETENCY OF SOME SOIL AMENDMENTS USED FOR IMPROVEMENT OF EXTREME SALINITY OF SAHL, EL-TINA SOIL (NORTH-SINAI)

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ABSTRACT

A field experiment was conducted on a clay saline soil of Sahl El-Tina area, North Sinai, Egypt to evaluate the efficiency of some soil amendments *i.e.,* Gypsum (G), Sugar Lime (S.L.), Cement Klin dust By-Pass (B.P.), Mixture (M_1) of (B.P., Vinasse "V" and H_2SO_4 "2:1 A: water") and Mixture (M_2) of (S.L., B.P., Vinasse "V" and H_2SO_4 "conc.") on some characteristics of the studied soil. EC (108 dS m^{-1}), pH (8.60) and ESP (32%) of the surface layer "0-20cm". Intermittent leaching technique was adopted using El-Salam canal water in experiment.

The results showed that the chemical properties of the studied soil were clearly improved due to amendments addition. The common parameters of saline sodic soil *i.e.,* EC, pH and ESP were clearly improved. The superior improvement of these parameters was resulted with M_2 treatment. Leaching is the only effective way to decrease the excessive salts from the root zone. Data showed that EC_e was 108 and 101 dSm^{-1}before leaching and decreased to reach about of (22 and 33 dSm^{-1}) by decreasing rate (80and 67%) at the end of leaching for surface and subsurface layers, respectively. The amendment can be arranged, due to its effect on soil sodicity, in the order of: M_2> M_1>G>S.L.> B.P. The lowest mean values of ESP were recorded under M_2. It was 19.20 and 24.21% with relative decrease was 40and 35% as compared to the initial ESP of soil.

Application of different amendments significantly improved the studied physical properties of the tested soil. Data showed that leaching only (L) led to increase quickly drainable pores (QDP) by (47.34%) while, decrease fine capillary pores (FCP) by (5.57%) compared to initial soil. The application of soil amendments added as alone or in mixtures encouraged the formation of quickly drainable pore and water holding pores. Soil amendments are more effective in surface than subsurface layers. At average basis the QDP, and WHP increased by (50.15%), (21.07%) respectively and fine capillary pores decreased by (14.63%) compared to the (L) treatment. Mixture of amendment M_2 was the superior to all other amendments in reducing FCP in surface layers. All amendments reduced soil B.D and increased Ks. However, M_2 was more pronounced especially in the surface layer. The differences were statistically significant. The best treatment, in the regarded, was also M_2. Thus, application of different amendments in mixtures with intermittent leaching technique may be a good step in the strategy to reclaim the clay soils, suffering from extreme salinity. Whereas, this technique help soils to get rid a huge amount of their salinity.

Keywords: Saline clay soils, Gypsum, Sugar Lime, Cement Klin dust By-Passe, Physical and chemical properties.

INTRODUCTION

The 22000 ha of Sahl El-Tina district is situated in the extreme North Eastern part of the river Nile Delta, with boundaries to the North formed by the Mediterranean Sea and to the West by the Suez Canal. Its elevation is at or just slightly above sea level. The area is hot and dry, with annual open pan evaporation in excess of 2000 mm and annual rainfall in the region of 100 mm. The entire area is devoid of vegetation because of the extremely high salinities, and much of the plain is covered by salt crusts between 50mm and 500mm thick. Soil survey has revealed that heavy clay soils (those with more than 50% clay content) occupy about 20% of the Tina plain (Abdel-Dayem *et al.,* 2000 and Rehman *et al.,* 2002). The maintenance of adequate soil physical and chemical properties in sodic environments may be achieved by leaching, using proper choice of and/or combination of soil ameliorants, good drainage and cultural practices (Grattan and Oster, 2003). Leaching is the only effective way to decrease excessive salts from the root zone of the salt affected soils. This is the process of dissolving and transporting soluble salts by downward movement of water through the soil surface. Its efficiency can be defined as the quantity of soluble salts leached per unit volume of water applied to the soil (Tanji, 1990). Rehman *et al.,* (2002) found that the reclamation of such soil with simple leaching by flooding remains ineffective. (Keren, 1990) showed that intermittent leaching is based on giving a set amount of water to the leaching plot and allowing this set amount to be drained completely to the drains. Sometimes intermittent leaching is combined with mulching to improve its performance. Leaching efficiency increased under intermittent leaching. It allowed more time for the movement of water through pores and improved the leaching efficiency.

Abdalla *et al.* (2010) concluded that tile drainage installation is the most important tool to conserve or reclaim the harmful effect of salty clayey soils to a feasible one. This process must be under taken with gypsum requirements. The most common reclamation amendment for this purpose is gypsum because of its low coast, commercial availability and ease of handling. The application of gypsum enhances leaching by improving soil hydraulic conductivity (Ghafoor *et al*., 2001). The application of gypsum for the reclamation of sodic soils enhanced the removal of soluble Na^+, decreased salinity, ESP and pH and increased soluble and exchangeable calcium and hydraulic conductivity of the reclaimed soil. Beside gypsum, the chemical amendments followed by leaching with canal water can reclaim saline-sodic soils like H_2SO_4, HCl and organic materials are required (Biggar, 1996). Sulfuric acid proved to be more effective in reducing ESP than gypsum. Water penetration into sodic soils was also improved with sulfuric acid treatment (Khalifa *et al*., 1994 and Koriem *et al*., 1994). These amendments either change insoluble soil calcium to calcium form or supply calcium directly, which replace the adsorbed sodium from sodic soils. The chemical amendments, being costly can be replaced successfully by organic manuring which has been found effective in increasing the crop yield and good physical health of soil (Ibrahim et *al*., 2000). Hussain *et al*. (2000) observed that the gypsum in combination with sulfuric acid and FYM decreased soil bulk density but increased the porosity, void ratio, water permeability and hydraulic conductivity more than sole applications of different amendments. Applications of amendments before leaching improved permeability and was found better than leaching before the application of amendments. The use of sugar lime and vinasse, which are final by-product of the sugar industry, is of great interest because of their low coasts and the large quantities that are being produced. Dickson *et al*. (1990) found that sugar lime interest mainly due to the increase in organic matter concentration (about 2%) and, to a lesser extent, by increases in calcium carbonate (more than 30%) and P (four times more). The soil pH was also found to increase slightly (1.4), while the electrical conductivity almost did not change. The properties associated with these pedological qualities therefore had a positive effect by improving nutrient availability. Although the Na^{+} content in sugar lime was high, the relative amount of it with respect to the Ca^{2+} and Mg^{2+} content will not cause a problem with regard to changes in the sodium adsorption ratio (SAR). Mansour (2002) showed that adding sugar lime to saline sodic soils increased total porosity, water holding capacity, quickly drainable and water holding pores, consequently soil hydraulic conductivity increased. On the other hand, soil bulk density and fine capillary pores were decreased by increasing application rate. Reda *et al.* (2006) found that the application of sugar lime with sulpher to saline sodic soil improved soil structure**.**

Vinasse also is a final by-product of the sugar industry. It is produced after removal of the fermentation products from molasses, It can be characterised by high organic carbon (350-830 g O.C kg^{-1}) and nutrient contents (30-53 g N kg^{-1} and 30-95 g K kg^{-1}) in this by-product make it potentially useful as a fertilizer, although with some constraints to its salinity, low C:N ratio and low phosphorus content. Addition of such by-product as amendment to soil lead to improve the physical, chemical and biological properties of soils, as well as the reduction of disposal costs (Parnaudea *et al.,* 2008 and Habib *et al*., 2009). Tejada *el al*. (2007) found that beet vinasse was a positive effect on soil's physical structural stability increased and bulk density decreased with respect to control.

Cement klin dust (CKD)"By-Pass" is a fine grained material generated as a by-product of cement manufacturing. Raw materials are fed into cement Klin and heated to temperatures ranging between 1400 and 1550 °C. The main raw material used to produce cement is lime stone ($CaCO_3$) with approximately ten percent of the raw mix made up of a silica source (*e.g.,* sand or clay), an alumina source and an iron source. (Kosmatka *et al*., 2002). Domy and John (2001) stated that cement dust application treatment did not significantly influence water infiltration rate, bulk density, but substantially improved water-holding capacity and plant-available water. Enhanced water retention capacity, improved the cohesion and handling property of harvested sod. Largest applications of cement dust increased the pH of a suspension of soil in water to 8.0-8.1. The kiln dust was also as effective as coarse lime in adding calcium to the soil.

The broad objective of the current study was to evaluate the efficiency of some soil amendments on the reclamation of Sahl El-Tina saline clay soil**.**

MATERIALS AND METHODS

This current work was conducted on Sahl El-Tina district (North Sinai). It is suffering from salinity stress and represents one of the three regions that will be reclaimed under El-Salam canal project, during the 2010. The study aimed at assessing the efficiency of some by-products materials, that will be used as soil amendments on improvement the properties of the studied soil. The soil would be classified as a highly clay saline sodic soil. Since it's EC of the extract is > 4 dSm^{-1} (108-101 dSm^{-1}) and its exchangeable sodium percent (ESP) is >15 (32-37%). The pH was (8.60-8.80). The relevant chemical and physical properties of the investigated soil are shown in Table 1. The source of irrigation water was from El-Salam canal. The chemical analysis of the used water for irrigation is shown in Table 2.

Table (1): Some physical and chemical properties of the studied soil.

Soil property	Soil depth (cm)	
	0-20	20-40
Physical properties %		
$CaCO_3$	3.16	1.25
OM	1.05	0.43
Coarse sand	10.6	8.90
Fine sand	18.8	19.2
Silt	8.80	11.5
Clay	61.8	60.4
Textural class	Clay	Clay
Chemical properties		
pH (1:2.5 water :soil suspension)	8.60	8.80
EC(dSm^{-1} in saturation extract)	108	101
Soluble ions ($mmol_cL^{-1}$)		
Ca^{2+}	80	68
Mg^{2+}	129	60
Na^+	1025	1022
K^+	23	19
HCO^-_3	9	8
Cl^-	1140	1061
SO^{2-}_4	108	100
CEC ($cmol_c$ kg^{-1})	48	50
ESP	32	37

Table (2): Irrigation water properties

pH	EC ($dS\ m^{-1}$)	Cations $mmol_cL^{-1}$				Anions* $mmol_cL^{-1}$			SAR
		Ca^{2+}	Mg^{2+}	Na^+	K^+	HCO_3^-	Cl^-	SO_4^{2-}	
7.83	1.30	2.06	4.00	6.48	0.31	2.51	7.28	3.06	3.72

***no carbonate was detected**

The experimental design

The experimental design was laid out as a randomized complete block design with 6 treatments and 4 replications. The field experiment was divided into (24) plots; with plot area was 150 m^2. At intervals 10m, a narrow way was installed beside both of drainage ditches (1.25m deep) as shown in Fig 1. These were served to drain the plots and isolate the trial site from the surrounding land. On the other hand, each plot was surrounded by earthen embankment which serving in pounded water of leaching water of leaching was supplied from water canal from EL-Salam canal; with the quantity delivered being measured by in line flow meters.

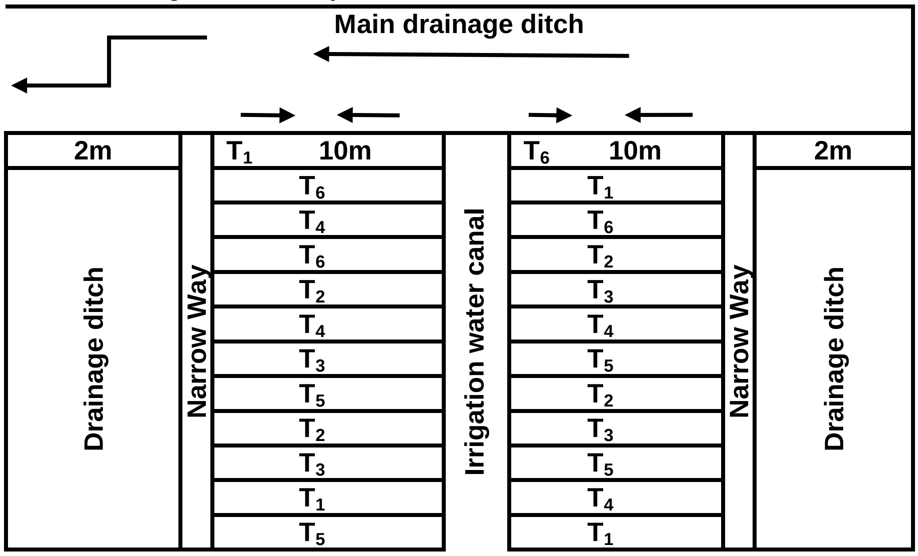

Fig (1): Layout of the experimental plots in a randomized complete block design

The treatments of soil amendment materials were:

- T_1 Leaching only "not amended" compared with initial values as a control) (L).
- T_2 Gypsum (G) at a rate 16.5 Mg f^{-1} according to gypsum requirement for 20 cm. soil depth.
- T_3 Sugar Lime (S.L.), which added at a rate 16.5 Mg f^{-1}.
- T_4 Cement Klin dust By-Passe (B.P), which added at a rate 16.5 Mg f^{-1}.
- T_5 Mixture of (B.P.+ Vinasse "V" + Sulfuric acid "A" (2:1 A:water) denoted as (M_1) at a rate 9.5 Mg f^{-1},
- T_6 Mixture of (S.L. + B.P. + V + A (conc.) denoted as (M_2) at a rate 9.5 Mg f^{-1}.

Properties of Sugar Lime, Vinasse and Cement Klin dust By-Passe are given in Table 3. Also, Table 4 showed the composition and chemical properties of the mixtures of amendments.

Table (3): Chemical composition of Sugar Lime, Vinasse and Cement klin dust (By-Pass)

Characteristics	Sugar Lime	Vinasse	Cement klin dust (By-pass)
Density (Mg m^{-3})	0.74	1.14	0.63
pH (1:2.5)	8.30	4.50	9.5
EC (dSm^{-1})	25.3	35.0	27.5
SP	70.0	-	209
$CaCO_3$ (%)	25.7	0.12	18.9
Total elements (%)			
Nitrogen	0.94	0.20	0.02
Potassium	0.06	0.71	1.36
Calcium	28.5	0.65	4.51
Phosphorus	0.28	0.21	0.09
Manganese	3.42	0.60	0.35
Iron	0.007	0.0006	0.011
Copper	0.21	0.0073	2.02
Zinc	0.003	0.0024	0.003

Table (4): Composition and chemical properties of the two mixtures of amendments used of the studied soil

Mixtures of amendments	Composition of the two mixtures of amendments* Mg					Chemical properties of the two mixtures of amendments		
	S.L.	B.P.	V	A	Total	pH	EC dS m^{-1}	$CaCO_3$%
M_1	-	0.476	0.095	0.429 (2:1 A: water)	1.0	7.90	11.70	4.50
M_2	0.444	0.222	0.112	0.222 (conc.)	1.0	6.80	12.20	11.0

***S.L=Sugar Lime; B.P. =Cement Klin dust By-Passe; V=Vinasse and A=Sulfuric acid.**

The selection of leaching technique depends on soil type, soil salinity, salinity of leaching water and climate. Application of leaching water was applied as intermittent leaching which is based on giving a set amount of water to the leaching plot and allowing this set amount to be drained completely to the drains. The idea is to give the water table the chance to draw down. (Keren, 1990).

Reclamation procedure

Reclamation was carried out using the intermittent leaching process as follows:

The intermittently leaching basins were irrigated at intervals dictated by the rates of evaporation and infiltration. The intention in this case was to pound water on surface to a depth of 200mm and then allows it to infiltrate and evaporate away until the surface become free or standing water. The soil was then left to dry out for some time before the basins were re-irrigated. So, after broadcasting of amendment and mixed in the soil by tillage. 900m^3 of water/fed. Were added to the soil and left to dry. This dose is the leaching dose which was replicated 8 times. Such cycle from applying water to dry was taken one month. It decreased with increasing leaching cycle. At the end of each two leaching process soil samples were taken for chemical analysis. At the end of experiment disturbed and undisturbed soil samples were collected at depths of (0-20cm) and (20-60cm) representing the investigated soil. The disturbed soil samples air-dried and ground to pass a 2mm screen and kept for chemical analysis. Soil pH, salinity, organic matter and total calcium carbonate were determined according to Page *et al*. (1982). Particle size distribution was carried out by pipette method by Gee and Bauder (1986). The undisturbed soil samples were used to determine some physical properties. Soil moisture characteristics were determined according to Stakman (1966). The values of moisture content on volume basis were used for calculating the percentage of quickly drainable pores (QDP), slowly drainable pores (SDP), water holding pores (WHP) pores and fine capillary pores (FCP) which have the diameter >28.84, 28.84-8.62, 8.62-0.19, <0.19µ according to De-Leenher and De-Boodt (1965). Soil bulk density (B.D) was determined using the core method technique according to Black (1982). Saturated hydraulic conductivity (Ks) was determined using the falling head method as described by Black (1982). Analysis of Variance was statistically analyzed according to Snedecor and Cochroan (1976) using SAS program (SAS institute, 1982).

RESULTS AND DISCUSSION

Soil chemical indices

Some soil properties of the experimental soil are given in Table 1. The soil had an average pH value of (8.60-8.80), EC (108-101dSm^{-1}) and organic matter content (1.05-0.43%), exchangeable sodium percentage was (32-37%) for surface and subsurface soil layers, respectively.

Reclamation and soil improvement

Effect on soil pH

The data presented in Table 5 show the effect of leaching and applied amendments on soil pH. In general, the soil pH before leaching *i.e.,* initial was (8.60-8.80) for surface and subsurface layers, respectively; after leaching without amendments (L) it reduced to be about (8.43 and 8.62) for surface and subsurface layers respectively. Where the soil was amended showed mean values of (7.50 and 7.88) "M_2", (7.70 and 8.13)"M_1", (8.03 and 8.24) "G", (8.50 and 8.69)"S.L" and (8.52 and 8.71) "B.P" in the surface and subsurface layers, respectively.

The soil pH values increased with soil depth and tended to be higher in the un-amended soil (L). Statistical analysis indicated that there are significant differences among forms of the used amendment. Using soil amendments reduced the pH values. This constructive effect was more obviously with M_2 treatment. Gypsum amendment was relatively more effective in reducing the pH values than (S.L.) and (B.P.) application under leaching of the tested soil. This may be due to the effective solubility of gypsum, which increased considerably because the exchanger phase serves as a sink for the dissolved Ca-ions; the high salinity level and released sodium enhances its solubility often five fold or more (Oster, 1982). Also, as the soil water concentration is decreased with leaching, the replacement of Na^+ by Ca^{2+} is enhanced because the affinity of the exchanger phase for Ca^{2+} adsorption increases with dilution, in accordance with the “valence dilution” principle (Gupta and Abrol, 1990). M_2 and M_1 were the most efficient over the other amendments in lowering soil pH. This trend may be due to sulfuric acid was the most efficient in both treatments as indicated by the fastest reductions Na^+ consequently soil pH, this action was attributed by Mace *et al*. (1999) These findings indicate that all amendments will be beneficial in correcting sodocity problems of the study soils.

Table (5): Mean values of soil pH as affected by treatment and depth after improvement soil by using amendments and leaching

Treatment (T)	Depth "D" (cm)		Mean (T)
	0-20	20-40	
L	8.43	8.62	8.53
G	8.03	8.24	8.14
S.L.	8.50	8.69	8.60
B.P.	8.52	8.71	8.62
M_1	7.70	8.13	7.92
M_2	7.50	7.88	7.69
Mean (D)	8.11	8.38	
LSD at 0.05	T=0.24	D=0.14	TD=ns

Notes: L= Leaching only "not amended"; G=Gypsum; S.L=Sugar Lime; B.P.=Cement Klin dust By-Passe; M_1= Mixture1; M2= Mixture2

Effect on soil salinity (EC_e)

The changes in soil salinity parameters expressed as electrical conductivity (EC_e) due to leaching process and application of some soil amendments are shown in Table 6. Statistical analysis indicated that there are significant differences among forms of the used amendment. The data revealed that EC_e decreased to between (62.67 and 76.83 dSm^{-1}) for surface and subsurface layers respectively, where the soil was leaching and not amended (L).

The EC_e before reclaiming soils was high; it was 108 and 101 dSm^{-1} for surface and subsurface layers. After leaching the soil without amendments application decreased to reach about of (62.67 and 76.83 dSm^{-1}) for surface and subsurface layers. But by added amendment and leaching, the soil showed the lowest EC_e (dSm^{-1}) mean values with (21.67 and 32.80)"M_2", (23.67 and 37.03)"M_1"and (27.67 and 38.73)"G" for surface and subsurface layers respectively.

Also, data showed that there were differences in EC_e under treated soils among depths and active desalinization was observed in all the treatments. The sharp decrease in ECe in all treatments was observed with M_2 treatment which was found most effective treatment. The treatments were more efficient in the upper (0-20cm) layers than the lower depth. The EC_e was decreased being about (21.67 and 32.80 dSm^{-1}) for M_2 treatment in both surface and subsurface layers, respectively. Hence, EC_e was significantly decreased due to application of amendments in the order of M_2 **>** M_1 > G > S.L. > B.P. This effect is hold true for surface and subsurface layers with more decreasing in EC_e mean values of surface layers than subsurface layers.

Table (6): Mean values of EC_e as affected by treatment and depth after improvement soil by using amendments and leaching

Treatment (T)	**Depth "D"(cm)**		**Mean (T)**
	0-20	**20-40**	
L	62.67	76.83	69.75
G	27.67	38.73	33.20
S.L.	40.00	47.87	43.93
B.P.	42.00	53.27	47.63
M_1	23.67	37.03	30.35
M_2	21.67	32.80	27.23
Mean (D)	36.28	47.76	42.02
LSD at 0.05	T=1.99	D=1.15	TD=ns

Leaching is only the effective way to decrease excessive salt from the root zone of the salt affected soils. Data presented in Table 7A&B showed that the EC_e before leaching was high (108 and 101 dSm^{-1}), after leaching for the first time, it clearly decreased and then continuous in decreasing by increasing leaching process to reach the highest decreasing in compare with (L) treatment at the end of leaching times. The relative decrease of EC_e at the end of leaching time for (L) treatment which leaching only and not amended were (42 and 24%) for surface and subsurface layers respectively.

Data also, showed, irrespective of source amendments, that application of any amendment to soils causes a clear decline in the EC_e values compared to EC_e of initial soil. The results suggest that the combined amendments were superior to either any alone treatment in their effect to decrease EC_e. It is worthy to mention that application of M_2 decreased EC_e by about (35, 26%) at the beginning of leaching to reach (80 and 67%) at the end of leaching for surface and subsurface layers respectively. The forms of amendment can be arranged due to its effect on decreasing EC_e as follows:

M_2 > M_1> G > S.L > B.P > L "not amended"

Table (7A): Average salinities of soil after leaching (EC_e) in soil saturation extracts for surface layers (EC_e of initial soil =108 dSm^{-1})

Treatments (T)	A.R* $Mg f^{-1}$	pH	Leaching (1)		Leaching (2)		Leaching (3)		Leaching (4)	
			EC $dS m^{-1}$	R.D %	EC $dS m^{-1}$	R.D %	EC dSm^{-1}	R.D %	EC dSm^{-1}	R.D %
L	-	8.43	98	9	86	20	66	39	63	42
G	16.5	8.03	73	32	52	52	34	69	28	74
S.L.	16.5	8.50	84	22	71	34	52	52	40	63
B.P.	16.5	8.52	81	25	69	36	48	56	42	61
M_1	9.50	7.70	71	34	49	55	30	72	24	78
M_2	9.50	7.50	70	35	45	58	28	74	22	80

R=Application rate of amendments; R.D=Relative decrease.

Table (7B): Average salinities of soil after leaching (EC_e) in soil saturation extracts for subsurface layers (EC_e of initial soil = 101 dSm^{-1})

Treatments (T)	A.R Mgf^{-1}	pH	Leaching (1)		Leaching (2)		Leaching (3)		Leaching (4)	
			EC dSm^{-1}	R.D %	EC dSm^{-1}	R.D %	EC dSm^{-1}	R.D %	EC dSm^{-1}	R.D %
L	-	8.62	99	2	92	9	85	16	77	24
G	16.5	8.24	78	23	69	32	55	46	39	61
S.L.	16.5	8.69	86	15	76	25	64	37	48	53
B.P.	16.5	8.71	85	16	74	27	61	40	53	48
M_1	9.50	8.13	77	24	66	35	58	43	37	63
M_2	9.50	7.88	75	26	64	37	56	45	33	67

Effect on Exchangeable Sodium Percentage (ESP)

Data presented in Table 8 showed that exchangeable sodium percentage (ESP) values before leaching increased with soil depth and tend to be higher in the soil; being 32 and 37% for surface and subsurface layers, respectively. While, after leaching only where the soil was not amended (*i.e*. L) they decreased to reach about of 29.27% and 30.22% with relative decrease (9 and 18%) for surface and subsurface layers, respectively. Also, the data showed that the using of different forms of soil amendments reduced significantly the ESP values. M_2 amendment was the most effective in reducing the ESP values than other amendments. At average basis, the ESP value decreased by (40 and 35%), (37and 32%), (31 and 29%), (24 and 24%) and (22 and 24%) for surface and subsurface layers of soil treated by M_2, M_1, G, S.L and B.P treatments, respectively compared the ESP of initial soil.

The process of leaching was effective in presence as well as in absence of amendments. Reclamation by leaching only caused a reduction in ESP. This perhaps due to Salam irrigation water seems adequate for reclamation, and reducing ESP. This is most probably due to it's rather contain adequate contents of Ca^{2+} and Mg^{2+} ions (Table 2). However ESP decrease by leaching without using amendments was not considerable and the soil remained sodic with highly ESP values. However, the final ESP obtained after leaching with amendments gave in the majority the highest decreasing *i.e.*, highest R.D% in the values of ESP. The use of the M_2, M_1 proved to be more effective than G, S.L. and B.P. treatments. This could be attributed to its constituents (*i.e.* S.L., B.P., sulfuric acid and vinasse). Vinasse and S.L. can be characterised by high organic carbon (Habib *et al*., 2009). Cement klin dust (CKD) has high content of $CaCO_3$ and can be used as a source of Ca^{2+}. Sulfuric acid may increase quantities of exchangeable hydrogen on clay surface and therefore have an acidic reaction. Also, release of organic acids and CO_2 ions during the decomposition process of organic materials *i.e.*, Vinasse and S.L. and thus decreased precipitation of Ca^{2+} and CO_3 ions which should lead to decrease ESP. This effect is more pronounced in the surface layer. Surface applied water would pass through the surface applied amendment and infiltrate the top layers allowing exchange process between Ca^{2+} and Na^+ (El-Sharawy *et al*., 2008).

Table (8): Mean values of soil ESP as affected by treatments and depth after improvement soil by using and leaching (ESP of initial soil =32 for surface and 37 for subsurface.

Treatment (T)	Depth "D" (cm)				Mean (T)
	0-20	R.D%	20-40	R.D%	
L	29.27	9	30.22	18	29.75
G	22.20	31	26.21	29	24.21
S.L.	24.27	24	28.22	24	26.24
B.P.	25.10	22	28.05	24	26.58
M_1	20.03	37	25.21	32	22.62
M_2	19.20	40	24.21	35	21.70
Mean (D)	23.34	-	27.02	-	
LSD at 0.05	*T=0.14*		*D=0.08*		*TD=0.19*

Soil physical properties

Soil physical properties are a fundamental part of soil quality assessment, as they often cannot be easily improved. Of special important, is porosity and pore size distribution. Thereby it affects the water retention and soil hydraulic conductivity. Soil bulk density is a major product of the changes in the soil and field conditions. It is affected by the variations in soil texture, soluble salts, and exchangeable sodium percentages, all of which govern the structural status. The variation in soil bulk density (BD) is accompanied with porosity and pore size distribution.

Changes in pore size distribution

In general, Pore size distribution depends mainly on the way in which soil particles are arranged because soil structure has a great influence on this parameter. Pore size distribution also delimits the air/ water balance of soils *(*El-Samnoudi *et al*., 1991). It is known that large pores serve for aeration and water infiltration, while medium size pores a serve for water conduction, and small pores serve for available water.

Data presented in Table (9A and 9B) show that leaching of the soil even without amendments (L) increased (QDP) and (WHP) by 47.34% and 61.80%, respectively and decreased (FCP) by 5.57% compared to initial soil. This may be due to the influence of salt concentration enhanced the coagulation of particles and create a renewed false aggregates that was accompanied by large pores (Gupta and Abrol, 1990). Data also showed that the effect of soil amendments application on pore size distribution of the studied soil. The application of soil amendments alone or in mixtures encouraged the formation of drainable pores and water holding pores on the account of fine capillary pores. The data indicate that there is an increase in values of the quickly drainable pores, which played a fundamental role during the salt leaching process, in all ameliorated soils comparing with (L). At the same time, aeration pores value decreased due to the increase of the fast drainage pores and to the effect of the decrease of the medium and small pores. At average basis (QDP) and (WHP) were increased in (M_2) treatment by 50.15% and 21.07% while the fine capillary pores were decreased by14.63% compared to (L) treatment. Its worth to mention that, the most efficient treatment here was (M_2). The most inferior treatment was solo application of S.L, even which was better than (L). The treatment of gypsum proved superior to (S.L.) and (B.P.) treatments but inferior to various combinations namely (M_1) and (M_2). Soil amendments are more effective in surface than subsurface layers. This is due to the use of the calcium sources of easily released Ca^{2+} ions (*i.e.,* gypsum) proved to be more effective than either, S.L. or B.P which have slow release of Ca^{2+} ions in comparison with gypsum.

Table (9A): Mean values of soil pore size distribution as affected by treatments and depth after improvement soil by using amendments and leaching

Treatment (T)	**QDP**			**SDP**			**WHP**		
	Depth "D" (cm)		**Mean (T)**	**Depth "D" (cm)**		**Mean (T)**	**Depth "D" (cm)**		**Mean (T)**
	0-20	**20-40**		**0-20**	**20-40**		**0-20**	**20-40**	
Initial	**5.01**	**4.02**	**4.52**	**10.90**	**13.51**	**12.21**	**15.48**	**10.29**	**12.88**
L	6.60	6.72	6.66	7.68	7.60	7.64	21.46	20.21	20.84
G	10.13	6.50	8.32	10.08	9.03	9.56	27.36	23.16	25.26
S.L.	7.64	6.32	6.98	8.51	8.69	8.60	23.47	22.61	23.04
B.P.	7.65	6.71	7.18	9.13	8.52	8.83	23.49	21.87	22.68
M_1	12.63	6.39	9.51	11.52	8.85	10.19	26.17	22.21	24.19
M_2	13.82	6.19	10.00	10.11	8.91	9.51	28.27	22.19	25.23
Mean (D)	9.75	6.47		9.51	8.60		25.04	22.04	
LSD at 0.05	T=0.17 D=0.10 TD=0.24			T=0.08 D=0.04 TD=0.11			T=0.30 D=0.16 TD=0.40		

Table (9B): Mean values of soil pore size distribution as affected by treatments and depth after improvement soil by using amendments and leaching

Treatment (T)	FCP			TP		
	Depth "D" (cm)		Mean (T)	Depth "D" (cm)		Mean (T)
	0-20	20-40		0-20	20-40	
Initial	**38.37**	**39.11**	**38.74**	**69.76**	**66.93**	**68.34**
L	37.68	35.49	36.58	73.42	70.19	71.80
G	28.54	34.61	31.57	76.11	73.30	74.70
S.L.	33.79	34.10	33.94	73.65	71.83	72.74
B.P.	34.47	35.08	34.78	74.81	72.11	73.46
M_1	27.44	37.22	32.33	77.76	74.67	75.93
M_2	26.26	36.19	31.23	78.46	73.48	76.72
Mean (D)	31.36	35.45		75.70	72.60	
LSD at 0.05	T=2.64	D=1.52	TD=3.73	T=0.24 D=0.14 TD=0.34		

Statistical analysis of data presented in Table (9A&B) showed also, that, the addition of gypsum, M_1 and M_2 significantly increased the values of quickly drainable pores (QDP), Water holding pores (WHP). The data in Table 9B indicate that in soil leaching only and not amended (L) the fine capillary pores FCP represent the largest portion of the total pores volume. On the other hand, FCP values were significantly and progressively decreased with the application of G, B.P., M_1 and M_2. The Mixture of amendments (M_2) was superior to all other amendments in reducing FCP. The effect of amendments in reducing FCP is more pronounced in surface layers. A significant effect of interaction between the forms of amendments and soil depth was attained on QDP, SDP and FCP. These results agree with Mansour (2002) who reported that the positive effect of sugar lime could be that such material serve as cementing agents. As the microbial decay of organic materials produces polymers (such as (Polysccharides and polynuorides) capable for binding soil aggregates and may a contribution on increasing soil porosity.

Soil bulk density(B.D)

Soil bulk density is a function of different factors, *i.e*., particle size distribution, specific ions, total salts, soil compaction, total porosity and moisture content. The data presented in Table 10 indicated that the process of leaching was effective in presence as well as in absence of amendments. Where, it is noticed that the values of soil bulk density were reduced under leaching only (L) treatment compare with initial soil. The bulk density improved as a result of amended soil with all the treatments. Application of different soil amendments decreased the soil bulk density compared with the (L) treatment and they could be arranged as follows M_2 > M_1 > G > B.P > S.L. This trend is hold true for surface and subsurface layers, respectively. The solo application of amendments was, although affect positively but the inferiority was to the combinations of (M_1 and M_2). The bulk density value was decreased by (12% and 7%) and (14% and 8%) for (M_1) and (M_2) for surface and subsurface layers, respectively compared to (L) treatment. These amendments either change insoluble soil calcium to calcium form or supply calcium directly, which replace the adsorbed sodium from sodic soils. A decrease in dispersion ratio may by the reason for improvement in soil bulk density (Ibrahim *et al.,* 2000). This finding can be also attributed to the low specific gravity of organic materials (*i.e*.,Vinasse and S.L.) and their decomposition material which increase apparent soil volume and decrease soil bulk density. The data also showed that the effect of the two mixtures of different amendments material is more pronounced in the surface than subsurface soil. This is because the materials were incorporated in the top surface soils. Statistical analysis indicated that there are significant differences among the different forms of amendments and soil depth. A significant effect of interaction between the forms of (T) and (D) was attained on B.D.

Table (10): Mean values of soil bulk density and saturated hydraulic conductivity as affected by treatments and depth after improvement soil by using amendments and leaching

Treatment (T)	**B.D ($Mg\ m^{-3}$)**			**Ks ($cm\ h^{-1}$)**		
	Depth "D" (cm)		**Mean (T)**	**Depth "D" (cm)**		**Mean (T)**
	0-20	**20-40**		**0-20**	**20-40**	
Initial	**1.44**	**1.45**	**1.44**	**0.45**	**0.24**	**0.35**
L	1.42	1.44	1.43	0.85	0.63	0.74
G	1.29	1.37	1.33	2.61	1.10	1.86
S.L.	1.35	1.40	1.37	1.57	0.92	1.25
B.P.	1.33	1.40	1.36	2.05	0.98	1.51
M_1	1.25	1.34	1.30	3.09	1.22	2.15
M_2	1.22	1.33	1.27	3.27	1.25	2.26
Mean (D)	1.31	1.38		2.24	1.02	
LSD at 0.05	T=0.01 D=0.01 TD=0.02			T=0.18 D=0.11 TD=0.25		

Soil hydraulic conductivity (Ks)

The distinguishing characteristics of slowly permeable saline sodic and sodic soils are due to high contents of exchangeable sodium and low hydraulic conductivity. The hydraulic conductivity measurement provides an indication of relative water transmission rate of the soil and depends on many factors, especially the volume of drainable pores. Data in Table 10 showed that the values of hydraulic conductivity in initial soil were decreased as a result of increasing soil salinity and alkalinity which, decreases the volume of drainable pores. This behavior may be due to the dispersion of soil particles created by sodium ions that occupy a pronounced area of the exchangeable sites. Also, it might be attributed to the internal swelling that would narrow the pores and allow for more entrapment of slaked and dispersed particles; internal swelling reduces the number of large free drainable pores, which are responsible for saturated water movement (Abdel-Mawgoud, 2005). Data also showed the effect of different amendments on soil hydraulic conductivity. The data revealed that the leaching processes did help in increasing the hydraulic conductivity compared to initial soil. It was maximized when sugar lime, by- passe, vinasse and sulfuric acid were combined together in (M_2) treatment for both surface and subsurface layer, respectively. Single application of amendments gypsum, sugar lime and by- Passe, also increased this parameter and the numerical values were higher than (L) but lower than (M_1 and M_2) treatments. As regard the reclamation efficiency in terms of improving hydraulic conductivity, various amendments proved useful but the Mixture of some of them may be regarded the best. This finding is agree with Hussain *et al*., (2000) who found that application of amendment in lesser quantities in combination may be a good strategy to reclaim the sodic soils.

Data in Table 10 showed the mean values of hydraulic conductivity (Ks) are response to the application of different soil amendments. The data showed that the values of Ks were significantly increased under application of all amendments. The superiority of the treatment M_2 in improving soil hydraulic conductivity is quite clears that it significantly increased Ks compared to (L) or other treatments. This could be attributed to the production of high amounts of calcium and organic matter from M_2, consequently improving physical soil properties and the dynamic soil water movement. (El-Sharawy *el al*., 2008). Statistical analysis indicated that there are significant differences among the different forms of amendments and soil depth. A significant effect of interaction between (T) and (D) was attained on soil B.D.

Economic evaluation

Capital coasts of these materials (Sugar Lime and By-Passe) equal transported coasts from factory to the location. The data in Table 11 show that the use of any of mixture1 or mixture 2 decreased from period of reclaiming soil comparing to other treatments. The absolute profit took the following order:

$$M_1 = M_2 > G > S.L > L$$

Table (11): Economic evaluation of used amendment

Treatments (T)	Application rate Mg f^{-1}	Cost for Mg (L.E.)	Total cost (L.E.)	Time of reclamation (Month)	Order
L	-	-	-	18	5
G	16.5	300	4950	10	2
S.L.	16.5	100	1650	12	3
B.P.	16.5	100	1650	14	4
M_1	9.50	525	4987	6	1
M_2	9.50	582	5529	6	1

Conclusion

Based on the aforementioned discussion, it could be concluded that the usage of any amendment (Gypsum, Sugar Lime, By-Passe, Mixture1 and Mixture2) could be positively affect on about reclamation of saline clay soil in Sahl El-Tina district. Efficiency of two mixtures (1 and 2) was more pronounced than the other treatments. Furthermore, leaching depend on the existence of a drainage system. Current indications are that the drains should be open ditches, about 1.25m deep, Spaced at intervals of 10m. On the other hand, intermittent bonding should be adopted for leaching, in order to encourage greater uniformity of percolation, also to provide some opportunity to develop soil structure as the soil dries out between irrigation. Water for leaching was supplied from water canal off from El- Salam Canal; with the quantity delivered being by in line flow meters.

REFERENCES

Abdalla M.A.M.; S.F. Mansour; Abdel Razek and M.K. Mona (2010). Effect of applying gypsum on some physio-chemical and hydrological properties of saline sodic soil provided with tile drainage system. Fayaum J. Agric. Res. and development, 24(2):89-103.

Abdel-Dayem S.; D.W. Rycroft; F. Ramadan; I. Barudy and A.Tahoun (2000) Reclamation of saline clay soils in Taina plain,Egypt ICID rournal,49(1)22-32

Abdel-Mawgoud, A.S.A. (2005). Water quality appraisal for soil-water behavior in irrigated clay soil, Egypt. 9^{th} Int. Water Technology Conf., IWTC9 2005, Sharm El-Sheikh, Egypt.(3): 1245-1256

Biggar, J.W.(1996). Regional salinity, sodicity issues in Punjab-Pakistan. Consultancy report IIMI, Lahore Pakistan, 1-26.

Black, C. A. (1982). “Methods of Soil Analysis”. Soil Sci. Soc. Amer., Inc. Pub. Madison, Wisconsin, USA

De-Leenheer, L. and M. De-Boodt (1965). "Soil Physics". International Training Center for Post gradual Soil Scientist Ghent, Belgium

Dickson, P.H.; A. Groenevelt and V. Rasiah(1990) Evaluation of two selected industrial wastes for disposal on cropland. Soil Technology 3(2): 167-172

Domy C.A. and T. John (2001). Influence of fly ash on soil physical properties and Turfgrass Establishment Journal of Environmental Quality. 30 (2): 596-601

El-Samnoudi, I.M., S.A. Mohamed and H.F. Danial (1991). Relationships between soil aggregation, pore size distribution and hudraulic conductivity in sandy clay loam soils. The 2nd African Soil Sci. Soc. Conf. of soil and water management for sustainable productivity. Cairo, Egypt, November 4-10, 1991. p 209-217.

El-Sharawy, M.A.O., M.M. El-Bordiny and S.A. Abdel-Wahed (2008). Improvement of a salt affected soil on Bahr El-Bakar area using certain industrial by-products: 1. Effect on physical and chemical characteristics. J. of Appl. Sci. Res., 4(7):839-854.

Gee, G.W. and J.W. Bauder (1986).“Particle size analysis ” .In methods of soils analysis ,Part I .Klute ,A . ed. , Agronomy No.9 .

Ghafoor, A.; M.A. Gill; A. Hassan; G. Murtaza and M. Qadir. (2001). Gypsum: An economical amendment for amelioration of saline-sodic waters and soils for improving crop yields. Int. J. Agri. Biol., 3: 266-275.

Grattan, S.R. and J.D. Oster (2003). Use and reuse of saline-sodic water for irrigation of crops. In: S.S. Goyal, S.K. Shara and D.W. Rains (Eds), crop production in saline environments: Global and integrative perspectives. Haworth Press, New York, 131-162.

Gupta, R.K. and I.P. Abrol (1990). Salt-affected soils: their reclamation and management for crop production. Adv. Soil Sci. 11, 223.

Habib, F. M.; A.H. Abd El-Hameed; M.S. Awaad and T.H.M.A. Deshesh (2009). Effect of some organic conditioners on some chemical and physical properties of newly reclaimed soils in Egypt. J. Soil Sci. and Agric.Eng. Mansoura Univ., 34 (12): 1537-1547.

Hussain,N.; B.H.Niazi; M. Salim; A. Ali and G. Hassan (2000). Effect of split application of gypsum on wheat yield and properties of saline sodic soil irrigated with brackish water. Int. J. Agri. Biol., 3:2346.

Ibrahim, M.; M. Rashid; M.Y. Nadeem and K. Mahmood (2000). Integrated use of green manuring, FYM, wheat straw and inorganic nutrients in rice-wheat crop rotation. Proc. Symp. IPNS., NFDC, Islamabad, Pakistan, pp. 186-195.

Keren, R. (1990). Reclamation of saline, sodic and boron affected soils. Drainage for salinity control, agriculture salinity assessment and management, ASCE Manuals and Reports on Engineering Practice No.71, Scientific Publishers, Jodhpur, India pp410-431.

Khalifa,M.R.; M.A. Koriem; M.M. Ibrahim; and E. Hammad (1994). Reclamation of saline sodic soils by leaching with drainage water gypsum application. Monofiya Agric. Res. 19,685.

Koriem, M.A.; M.R. Khalifa; M.M. Ibrahim; and E. Hammad (1994). Reuse of drainage water and application of gypsum mixed with lime in reclamation of saline sodic magnesic soils. Monofiya J. Agric.Res.,19,699.

Kosmatka, S.H.; B. Kerkhoff; W.I. Panarese; N.F. Macleod and R.J. McGrath (2002). Design and control of concrete mixtures. 1st Edition Ottawa,Ontario; Cement Association of Canada.

Mace, J.E.; C. Amrhein and J.D. Oster (1999). Comparison of gypsum and sulfuric acid for sodic soil reclamation. Arid Soil Res. Rehabil. 13:171-188.

Mansour, S.F.(2002). Improvement of soil structure in some soils of Egypt. Ph.D. Thesis Fac. Of Agric. Cairo Univ., Egypt.

Oster, J.D. (1982). Gypsum usage in irrigated land. Review Fertilizer Res. 3, 73.

Page A.L.; R.H. Miller and D.R. Jkeeney (1982). "Methods of soil analyses part 2. Chemical and Microbiological properties." Second Edition. Agronomy monograph, No.9, Madison Wisconsin. part 2, A.L.Page Ed, Agronomy Nomograph No.9, Madison, Wisconsin P: 181-197

Parnaudea V.; N. Condom; R. Oliver; P. Cazevieille and S. Recous (2008). Vinasse organic matter quality and mineralization potential, as influenced by raw material, fermentation and concentration processes. Bioresource Technology, 99, 1553-1562.

Reda,M.M.A; F.M. Mouhamed; S.F. Mansour and M.Y.Abou-Zaid (2006). Interaction between sugar lime, sulphur and applied Bio-Inorganic N.fertilization on saline Sodic soil properties and wheat production. Egypt. J. of Apply. Sci. 21(6): 150-162

Rehman, M.Z.; A. Ghafoor; G. Murtaza and M.I. Manzoor (2002). Management of brackish water for reclamation of a saline-sodic soil and rice wheat production. Pak. J. Soil Sci., 21(4): 89-94.

SAS Institute, (1982). SAS User's guide: Statistics. SAS Institute, Inc., Raleigh, NC, PP.84.

Snedecor, G.W. and W.G., Cochroan (1976). Statistical Methods 6th ed., Lowa State Univ.Press. Lowa, USA.

Stakman, W.P. (1966). Determination of soil water retention curves I. Sand-box method .II. Pressure membrane methods. ICW, Wageningen, the Netherlands.

Tanji, K.K. (1990). Salinity assessment and management. Manual and reports on engineering practices 71, American Society of Civil Eng., New York, U.S.A.

Tejada M.; J.L. Moreno; M.T. Hernandez and C. Garcia (2007). Application of two beet vinasse forms in soil restoration: effects on soil properties in an arid environment in southern Spain, Agriculture Ecosystems and Environment, 119, 289-298.

كفاءه بعض محسنات التربة المستخدمة لتحسين الملوحة الشديدة لارضي سهل الطينة (شمال سيناء)

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أجريت تجربة حقلية بمنطقة سهل الطينة شمال سيناء- جمهورية مصر العربية - لتقييم كفاءة إضافة بعض المحسنات الأرضية مثل الجبس ,جير السكر,وتراب الأسمنت (الباى- باس) ,خليطين يتكونا من جير السكر,وتراب الأسمنت (الباى- باس),الفيناس وحامض الكبرتيك بنسب مختلفة على بعض خواص الأراضى الملحية ذات القوام الطيني ولها EC_e=108ديسيمنز/م, pH =8¸60 وESP=32% للطبقة السطحية (0-20 سم) وأستخدمت مياه ترعة السلام فى غسيل هذه الأراضى بنظام الغسيل المتقطع.
أوضحت النتائج أن هناك تحسن واضح فى الخواص الكيميائية للأراضى تحت الدراسة نتيجة لإضافة محسنات التربة.حيث كان هناك تحسن واضح فى كل من خواص التربة التالية EC_e , pH, ESP. كانت المعاملة M_2 هى أفضل المعاملات فى انخفاض قيم هذه الخواص. ولما كان الغسيل هو الوسيلة الفعالة لخفض ملوحة منطقة إنتشار الجذور, أوضحت النتائج أن قيمة الـ EC_e كانت 108 ديسيمنز/م قبل عملية الغسيل وأنخفضت خلال عملية الغسيل لتصل إلى (33,22 ديسيمنز/م) وبمعدل نقص (80 ،67%) فى كلا من الطبقة السطحية والتحت سطحية على التوالى. ويمكن ترتيب المحسنات من حيث درجة تأثيرها على قيم الـESP كالأتى :

.M_2> M_1>G>S.L> B.P

وكان أقل متوسط لقيم الـESP تحت المعاملة M_2 حيث كانت (19,20 و 21¸24%) وبمعدل نقص (40، 35%) مقارنة بقبل عملية الغسيل وذلك لكل من الطبقة السطحية وتحت سطحية على التوالى.
أدت إضافة محسنات التربة إلى تحسن جوهرى وملحوظ لخواصها الطبيعية. وأوضحت النتائج أن إجراء عملية الغسيل فقط بدون إضافة للمحسنات ادت الى زيادة نسبة مسام الصرف الواسعة بحوالى (47.34) بينما قلت نسبة المسام الشعرية الضيقة بحوالى (5.57%) مقارنة بالأراضى الغير معاملة (بدون غسيل أواضافة للمحسنات). وأدت إضافة المحسنات بصوره مفردة أو فى خليط مع عملية الغسيل الى زيادة نسبة مسام الصرف الواسعة وكذلك المسام الحاملة للماء حيث زادت كل من نسبة مسام الصرف الواسعة و المسام الحاملة للماء بحوالى (50.15 %) و(21.07%)على التوالى وقلت نسبة المسام الشعرية الضيقة بحوالي 14.63 % مقارنة بمعاملة الغسيل فقط . وتعتبر المعاملة M_2 هى أفضل المعاملات مقارنة بباقى المحسنات الأخرى فى انخفاض المسام الشعرية الضيقة وخاصة فى الطبقة السطحي. كما إنخفضت قيم الكثافة الظاهرية وزاد معامل التوصيل الهيدروليكى وذلك مقارنة بمعاملة الغسيل فقط . وتعتبر المعاملة M_2 هى أفضل المعاملات.
لذي توصي الدراسة بإستخدام خليط من بعض محسنات التربة مع إجراء عملية الغسيل المتقطع وذلك يعتبرمن أفضل الاساليب في استصلاح الاراضي الملحية الطينية والتي تعاني من الاجهاد الملحي. كما تعتبر خطوة جيدة في استراتيجية الاستصلاح ، حيث يساعد هذا الاسلوب في التخلص من كميات كبيرة من أملاح هذه الاراضي.

قام بتحكيم البحث

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