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UNTRADITIONAL APPROACH FOR RECLAIMING THE EXTREMELY SALT AFFECTED WETLANDS AT THE NORTHERN-EAST NILE DELTA, EGYPT:

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ABSTRACT

The magnitude of the studied salt affected soils has been increased fast due to scale efforts to bring additional areas under the agricultural utilization projects in recent decades. Also, it is necessary to correct their deleterious properties under introduce water management practices that will prevent wasting of fresh water. In addition, executing a suitable technique that has become associated with increasing soil supplying power for nutrients and minimizing the possible adverse effects for adapting land resources to human demand. Therefore, the current work has been undertaken to evaluate the constraints for ameliorating the salt affected soil under the prevailing environmental conditions of the northem-east Nile Delta area. The proposal reclamation technique should be overcome three aspects of related problems, i.e., leaching the excess of salts, lowering the ESP values and developing an adequate soil structure.

The studied soil is commonly found under relatively high ground water table, thus it is surveyed as saline wetland in dry climates and mapped as Aquisalids. The suitability unit of the studied soil was a current not suitable (*N1tws1s4n*), with an identified limitation of wetness that enhances the hazardous effect of excess water that drives the air from the soil pores and leads to lack of oxygen. Also, the relative heavy texture and salinity/alkalinity have direct adverse influences on soil permeability and the available water range. In addition, the shallow saline water table enhances the upward movement and causes salinity/alkalinity conditions under the prevailing hot conditions.

The untraditional approach used for reclaiming the studied soil was started with a continuous leaching technique using the saline drainage water, under an economic land use being from a fish-pond farm, where Tilipia fish cultivated on March 2002 and continued up to the same time of 2003. Then, the soil under study was treated with gypsum requirement and poultry waste as natural soil amendments in individual or combined treatments, thoroughly mixed with a depth of 60 cm using the surface tillage and subsoiling for improving soil physico-chemical and fertility status. The leaching technique was continued under cultivation of the rice crop irrigated with the Nile water and an efficient open drainage ditches at 25 m distance.

Results obtained indicated that the deteriorated soil structure was modified from prismatic or columnar to well define subangular blocky, associated with favourable soil moisture regime cycles and increasing the effective soil depth due to lowering water table level from 85 to more than 140. In addition, disposing the surface salty crust and subsoil olive gray mottles due to improving soil permeability and aeration condition. Also, a pronounced ameliorated conditions were occurred for soil bulk density, soil strength, total porosity, total aggregates, pore size distribution, hydraulic conductivity, available water range, soil pH, ECe and ESP. The optimum values were achieved in the case of combined treatment (4 ton poultry waste/fed + 8 ton gypsum/fed).

The superiority of this treatment is more related to the released active organic acids and soluble Ca^{2+} or SO_4^{2-}, which coagulated the dispersed soil particles, increasing the drainable pores and in turn enhancing soil permeability that encourage the removal of Na-salts and decrease the ESP values. On the other hand, soil organic matter and available nutrient achieved the maximum values at rate of 8 ton poultry waste/fed, due to its enrichment in organic components and essential macro and micronutrients. The studied agro-management practices to the soil under investigation caused a positive effect on the vegetative growth of the grown rice plants, and in turn their yields of straw and grain, with more responded to the combined treatment of (4 ton/fed poultry manure + 8 ton/fed gypsum) for increasing the grain and straw yields with about 73 and 46 %, respectively, over those obtained from the initial state of soil.

Keywords: Fluvio-lacustrine soils, soil limitations, agricultural utilization, improvement practices of salt affected soils.

INTRODUCTION

Recently, sustainability through improving land quality as a natural resource, has become a key concept to describe its successful managements for agriculture purposes to satisfy changing human needs. On the same trend, the agriculture utilization projects of the virgin extremely salt affected wetlands at the northern-east Nile Delta should be executed by using untraditional approach technique in order to sustain their potentialities. This technique depends on the economical aspects of land use during the reclamation steps, declining soil reclaiming period, increasing soil supplying power for plant nutrients, minimizing the possible adverse fears of environmental risks, maximizing profitability and threats to human health.

Thus, efforts have been directed towards identifying soil productivity limitations, maximizing the efficiency of leaching water use and executing the suitable agro-management practices. Condom et al. (1999) reported that the changes in the geochemical nature of such soils, especially that concerned with the miss agro-management practices, plays an important role for the direction towards land degradation aspects, i.e., alkalinization or sodification that are broadly occurred in like arid and semi-arid climatic zone. These conditions were confirmed by the findings of Dewivedi, et al (1999) and Abd El Kawey (2002) who pointed out that the water-logging and subsequent salinization and/or alkalinization are the major land degradation processes in lands under the arid and semi-arid environmental conditions.

The soil is a dynamic system, however, its conditions are modified by human management practices or by methods of land reclamation or improvement. El Gazzar (1996) reported that the stability of soil aggregates in clay soils was more affected by soil salinity and sodicity. Moreover, a marked reduction in hydraulic conductivity values was occurred, especially in clayey soil that having a relatively high ESP or SAR values (Rao and Parvathappa, 1995). These findings are in agreement with results obtained by Zein El Abedine et al (2004) who reported that soil structure of the clayey soils at the northwestern Nile Delta began to deteriorate at an ECe value of 7.14 dS/m and SARe of 15.40 on an average in the soil paste extract.

Studying the beneficial effects of natural soil amendments used for reclaiming the saline-sodic clayey soils was undertaken by Logan et al. (1996) who found that the applied organic material showed a positive significantly reduce in soil bulk density, while the reverse was true for the total porosity. Also, gypsum application is recommended for ameliorating soil sodicity appearance throughout the leaching process. This effective role could be occurred when its addition to be achieved at the last steps of leaching process (Hassanien, 1996). The response of soil properties to be positively changed is more related to the released ions of Ca^{2+}, which stimulated more displacement of Na by Ca on soil colloidal complexes. Ca-clays enhanced soil particles coagulation. These favourable conditions lead to improve the soil structure and hydraulic conductivity, consequently more salts can be leached out the root zone. In addition, the released SO_4^{2-} encouraging the decrease soil pH, and in turn increasing the nutrients availability (Farrag, 2003).

Ibrahim et al. (2003) studied the beneficial effects of surface and deep tillage practices, i.e., surface ploughing and subsoiling, in combination with organic manure on a compacted clay soils, and found that the values of soil bulk density and strength were tended to decrease as a result of the applied treatments. The reverse was true for both total porosity and hydraulic conductivity, where their values tended to increase and decrease, respectively, coinciding with the applied practices.

So, the main objectives of the current work are to identify effective soil limitations that are controlling the reclamation of salt affected wetlands at the northern-east Nile Delta. In addition, executing a suitable agro-management approach that achieve the economical land use and technical aspects that have become associated with declining soil reclaiming period, increasing soil supplying power for plant nutrients, minimizing the possible adverse fear of both human health and environmental risks.

MATERIALS AND METHODS

In order to find out the most suitable reclamation technique under an economic land use in the studied area, land evaluation system as a guide for economical land use in the agricultural purposes was used for identifying the natural constraints or soil limitations that controlled soil reclamation and its productivity under the prevailing environmental conditions. To fulfill these objectives, the current work was carried out on a virgin extremely salt affected fluvio-lacustrine soil at village of Khaled Ibn El Walid, South El Hosainia plain, northern-east region of the Nile Delta.

The untraditional approach for reclaiming the studied soil was executed under an economical land use being from a field trail on a fish-pond farm, where Tilipia fish cultivated on March 2002 in plots of an area 25 x 90 m^2, and continued up to the same time of 2003. The continuous leaching technique carried out by using the saline drainage water, which was monthly changed. Then, the soil under study was used as an agricultural pilot area by applying agro-management practices for improving soil physico-chemical properties and fertility status. These practices represented by applying the gypsum requirement and poultry waste as natural soil amendments in individual or combined treatments, which thoroughly mixed in a soil depth of 60 cm using surface and subsoiling tillage at a part 1 m between the two sequences runs. Rice as an economic crop was cultivated, and irrigated with the Nile water through an upland irrigation system under an efficient open drainage ditches at 25 m distance.

The current experiment was designed on four treatments, i.e., untreated soil (initial state, control treatment), gypsum requirement (16 ton/fed that achieved ESP of about 10 %), poultry waste (8 ton/fed) and the combined one (4 ton/fed poultry waste + 8 ton/fed gypsum). Soil properties under investigation were determined at three periods, i.e., a) at the initial soil state (virgin soil), b) at end of the fish-pond farm and c) after the harvest of rice on the selected soil depths of 0-25, 25-60 and 60-100 cm. The main characteristics of the used natural soil amendments (poultry waste and gypsum) are given in Table (1).

In a randomized complete block design with three replicates, rice grains (Sakha 102) were sown in plots of an area 6 x 7 m^2 for each treatment on last April 2003. The recommended doses of the mineral fertilizers, i.e., superphosphate (15 % P_2O_5) was added to soil at a rate of 100 kg/fed and thoroughly mixed with soil before planting, as well as, ammonium sulphate (20.5 % N) was applied at a rate of 200 kg/fed, added in three equal doses starting after planting with 25, 40 and 55 days.

Table (1): Some characteristics of the used farmyard manure and gypsum (dry weight basis).

Poultry waste		Gypsum	
pH (1:10 water suspension)	7.08	pH (1:2.5 water suspension)	6.27
EC (dS/m, 1:10 water extract)	3.36	Soluble salts %	4.56
Organic carbon %	36.95	$CaCO_3$ %	7.91
Total N %	2.74	$CaSO_4.2H_2O$%	87.45
C/N ratio	13.49	Organic matter %	0.08

Total contents of some nutrients in the poultry waste						
Macronutrients %			Micronutrients (mg/kg)			
N	P	K	Fe	Mn	Zn	Cu
2.74	1.97	2.13	1403	379	153	86

The other normal agricultural practices were performed according to the recommendations of Ministry of Agriculture. Soil samples were collected from each plot before planting of rice crop and at harvest (i. e., last April and October 2003, respectively). Soil analytical data of the studied treatments were listed as an average value for the three replicates, to determine the changes in the various studied soil parameters. Also, the rice yield (grain and straw) was estimated for each of the applied treatments.

The representative soil profiles of the three periods for reclamation technique were described morphologically (FAO, 1990), and the selected soil samples were air dried, crushed to pass a 2 mm sieve and analyzed for the investigated soil physical and chemical properties as well as soil fertility status. Soil physical and chemical properties of the collected soil samples were determined by using the standard methods of Black (1965) and Page et al. (1982). Soil strength was estimated using the Penetrometer (EISELKAMP–Giesbeek, Equipment, Netherland, Model 2-81-154-2) as described by Klute (1986). Available N, P and K were extracted by 1 % potassium sulphate, 0.5 M solution bicarbonate and 1 N ammonium acetate, respectively (Sultanpour and Schwab, 1977), and determined according to Jackson (1973). Also, available micronutrients (Fe, Mn, Zn, and Cu) were extracted using ammonium bicarbonate DTPA extract according to Lindsay and Norvell (1978), and measured by using the Atomic Absorption Spectrophotometer. Data obtained were used for land suitability evaluation as well as soil limitations, which were obtained by using the parametric systems of Sys and Verheye (1978).

RESULTS AND DISCUSSION

In order to reclaim salt affected soils, it is necessary to correct the deleterious conditions of salinity or sodicity under introduce water management practices that will prevent wasting of fresh water through leaching technique. In most cases, salt removal process is becoming an increasingly serious problem as water of less desirable quality is exploited for leaching and as greater intensity of water use leads to soil degradation. That means the reclamation technique should be overcome three faces of related problems, i.e., a) leaching the excess of salts, b) lowering the exchangeable Na % and c) developing or adequate soil structure. Solving the latter problems leads to obtain a hydraulic conductivity high enough as to accomplish the reclamation process. Such introduction may be helpful to arrange the discussion items for the obtained results.

I- Irrigation water sources:

According to the water salinity and sodicity classes undertaken by Ayers and Westcot (1985), data in Table (2) indicated that the used irrigation water resources, i.e., mixed Nile water lies in the first class of C1S1, where the values obtained for ECiw and SAR were < 0.75 dS/m and < 6.0, respectively. On the other hand, the saline drainage water lies within the second category of C2S2, where ECiw and SAR values lay within the range of 0.75-3.00 dS/m and > 6.0, respectively.

II- A general view on the initial state of soil:

a) Soil morphology:

It is worthy to mention that the soil site under consideration is mainly encompassing the interference zone between the Nile alluvium and lacustrine deposits as sources of soil parent materials, and it is developed under climatic conditions of a long hot rainless summer and short mild winter, with scare amounts of rainfall. Due to the prevailing waterlogged condition, it is surveyed as saline wet soil in dry climates. Such wet soil, in general, is not prevalent in dry and seasonally dry climates, but its morphology and characteristics are considerably different from those in more humid climates. This soil is commonly found at general ground-water discharge sites such as lacustine plains or playas.

Table (2): Water characteristics of the used irrigation sources.

Irrigation water characteristics	Irrigation water sources	
	Mixed Nile water	Drainage water
Chemical characteristics		
PH	7.15	7.36
EC (dS/m)	0.62	2.35
Total dissolved salts (mg/l)	396.80	1504.00
Soluble ions (me/l):		
Ca^{++}	1.81	5.45
Mg^{++}	2.04	3.28
Na^{+}	2.45	15.00
K^{+}	0.20	0.97
CO_3^{--}	0.00	0.00
HCO_3^{-}	1.96	5.62
Cl^{-}	2.85	16.70
SO_4^{--}	1.69	2.38
Sodium adsorption ratio (SAR)	1.27	7.18
Residual sodium carbonate (RSC)	0.00	0.00
Irrigation water suitability degree	C1S1	C2S2
Some available nutrients (mg/l)		
N	2.07	6.58
P	1.13	3.75
K	5.23	9.04
Fe	0.430	0.702
Mn	0.036	0.084
Zn	0.058	0.109
Cu	0.032	0.067

Boettinger (1997) summarized the geographic distribution, parent material, landform and vegetation of saline and wet soils mapped as Aquisalids (formally Salorthids). Soil morphological features (Table, 3), showed that the initial state of the studied soil site was characterized by mineral wetland, surface salty crust and mostly shallow effective soil depth due to the relatively high water table (85 cm) and water-logging conditions.

Soil structure was angular blocky in topsoil and massive in the subsoil layers, which also characterized by mottling phenomena (reddish brown patches in the upper oxidized zone alternative with olive gray spots in the reduction phase) due to water table fluctuation and the occurrence of gleyzation phenomenon that confirmed by very sticky and very plastic conditions. The latter features could be taken into account to minimize soil drainage or aeration conditions and the nutritional problems, which are more related to size, healthy and vertical distribution of roots. These features could be continued up to the second stage of soil reclamation (before soil amendments application), with modifying the deteriorated soil structure from massive to bad types of prismatic and columnar ones in the subsoil layers, which reflected the signs of soil deterioration.

Table (3): The main field morphological features of the initial soil state.

Parent material	Land-use	Depth (cm)	Soil colour			Texture class	Soil structure	Soil consistence			Lower boundary
			Hue	Dry	Moist			Dry	Moist	Wet	
Fluvio-lacustrine	Barren	0-25	10YR	4/3	3/3	c	anb	ha	fir	stpl	--
		25-60	10YR	4/2	3/2	c	mas	vha	vfi	vstpl	gs
		60-85	10YR	4/1	3/2	c	mas	vha	vfi	vstpl	ds

Soil texture: C=clay
Soil structure: anb=angular blocky mas=massive
Soil consistence: Dry: ha=hard
Moist: fi=firm vfi=very firm
Wet: stpl=sticky & plastic vstpl=very sticky & very plastic
Boundary: gs=gradual smooth ds= diffuse smooth

b) Soil physico-chemical properties:

The obtained results in Table (4) revealed that soil texture tended to be heavy clay grade, where the clay content was more than 60 %. This is mainly attributed to the depositional regime during the accumulated or coagulated of the Nile suspended matter under the aqueous saline depositional media. Data showed also the negative effects of the progressive increment of Na-salts on the investigated soil properties, i.e., an increase in soil bulk density, soil strength and fine capillary pores vs a decrease in each of total porosity, stable aggregates, available water range, drainable and water holding pores.

Concerning the studied soil chemical properties, data illustrated in Table (4) indicated that soil organic matter, $CaCO_3$ and gypsum contents are relatively low, may be ascribed to the mineral nature of soil deposits and the prevailing hot and arid climatic conditions. The obtained data showed that there was a gradual decrease in soil organic matter content vs an increase in $CaCO_3$ towards profile bottom, may be due to the occurrence of an accumulation for bio-shell fragments. In general, the relatively high values of soil ECe, pH and ESP (i.e., > 49 dS/m, > 8.5 and >19, respectively) led to the studied soil was classified as extremely saline and alkaline. This is mainly due to the absence of adequate soil drainage system, shallow water table and continuous lateral seepage from the adjacent saline water bodies.

c) Soil taxonomy and evaluation:

According to soil morphological features and analytical data obtained as well as on the basis and guidelines of Taxonomic system undertaken by Soil Survey Staff (1999), the soil under consideration could be classified as Halic Haplotorrerts, very fine clayey, smectitic, thermic. In addition, parametric system undertaken by Sys and Verheye (1978), which could be considered a favourable system under the conditions prevailing in the soils of Egypt (Moussa, 1991), was applied to identify soil limitations and their intensity as well as suitability category for the studied soil.

Table (4): Soil physical and chemical characteristics of the initial soil state.

Soil characteristics	Soil depth (cm)		
	0-25	25-60	60-85
Soil physical properties			
Particle size distribution %			
Sand	11.15	9.17	6.38
Silt	27.28	26.75	29.97
Clay	61.57	64.08	63.65
Texture class	Clay	Clay	Clay
Bulk density (g/cm^3)	1.29	1.36	1.41
Total porosity %	49.86	51.07	53.50
Total stable aggregates %	20.09	12.73	10.48
Soil strength (kg/cm^2)	7.01	9.16	9.97
Pore size distribution %:			
Drainable pores	16.42	10.65	9.05
Water holding pores	32.80	21.84	18.12
Fine capillary pores	50.78	67.51	72.83
Hydraulic conductivity (cm/h)	1.65	1.14	0.82
Available water %	17.53	14.69	12.03
Soil chemical properties			
Total $CaCO_3$ %	5.76	7.05	9.02
Gypsum %	0.94	0.67	0.52
Organic matter %	0.86	0.59	0.43
CEC ($cmol_c/kg$ soil)	49.52	47.60	46.76
ESP	19.75	25.01	28.14
pH (1:2.5 soil water suspension)	8.54	8.63	8.69
ECe (dS/m)	82.48	67.03	49.50
Soluble ions (me/l):			
Ca^{++}	136.80	109.54	83.35
Mg^{++}	243.31	198.46	151.65
Na^{+}	498.00	410.00	303.00
K^{+}	2.65	2.15	1.70
CO_3^{--}	0.00	0.00	0.00
HCO_3^{-}	2.45	2.85	3.20
Cl^{-}	661.50	540.84	405.48
SO_4^{--}	216.83	176.46	131.02

Applying the parametric evaluation system undertaken by Sys and Verheye (1987), data illustrated in Table (5) showed that the studied soil had no limitations for their soil depth (s2) and $CaCO_3$ content (s3). Topography (t, landscape of almost) and gypsum (s4) exhibited a moderate and slight intensity, respectively. On the other hand, it is cleared that wetness (w), soil texture (s1) and salinity/alkalinity (n) are represented the most effective limitations concerned soil productivity, where their degree for all the identified soil productivity limitations lies in the intensity range of very severe (rating < 50) and severe (rating 50-60).

Table (5): Soil limitations and evaluation of the initial soil state.

Topography (t)	Wetness (w)	Soil texture (s1)	Soil depth (s2)	$CaCO_3$ (s3)	Gypsum (s4)	Salinity/ alkalinity (n)	Rating (CI)	Suitability class	Soil productivity limitation
80	35	50	100	100	90	50	6.30	N1	N1tws1s4n

It is worthy to mention that the identified limitations of wetness, soil texture and salinity/alkalinity are enhanced the hazardous effect of excess water that drives the air from the soil pores and leads to lack of oxygen. Also, the relative heavy texture has a direct adverse influence on soil permeability and the available water range. In addition, the shallow soil depth enhances the upward movement of saline water and causes salinity/alkalinity conditions under the prevailing arid and hot conditions of the studied area. The suitability unit of the studied soil was *N1tws1s4n*, which was considered as a current not suitable (N1), with a suitability index of rating 6.30.

III- Soil properties as affected by the agro-management practices:

a) Soil morphology:

Concerning the beneficial effects of the applied different soil agro-management practices, such as an efficient open drainage systems, gypsum or poultry application and leaching process, morphological data obtained reflected the signs of soil ameliorated, i.e., modifying the deteriorated soil structure from bad types of prismatic and columnar structures to well defined angular or subangular blocky. Also, it was noticed that the clay skins or films coated soil aggregates and the occurrence of natural bio-channel in the subsoil layers, which are mainly due to the bio-activity of warms and soil fauna. These positive changes are also related to the effect of soil moisture regime cycles as a result of perennial irrigation and bio-fertilization. It is quite to note that the effective soil depth increased owing to lowering water table levels from 85 cm to more than 140 cm as well as disposing the olive gray coloured spots, which represent the common features of gleyic condition in the reduced subsoil layers due to improving the soil moisture regime cycles.

b) Soil physico-chemical properties:

The response of soil characteristics to the positively changes as a result of land management practices was more related to the uppermost layer (root zone of a depth of 0-60 cm) as well as it depends on both soil nature and prevailing environmental conditions.

Table (6): Soil properties as affected by the applied poultry waste (P) and gypsum requirement (G) to the leached soil (L).

Soil properties	Soil depth in cm							
	0-25				25-60			
	L*	P	G	P+G	L*	P	G	P+G
Physical properties								
Bulk density (g/cm^3)	1.34	1.23	1.18	1.10	1.41	1.36	1.31	1.28
Total porosity %	48.5	54.6	57.9	63.4	50.3	55.2	56.9	59.6
Total stable aggregates%	16.9	38.5	49.2	60.7	10.8	33.7	47.1	53.7
Soil strength (kg/cm^2)	7.86	5.94	4.67	3.81	9.83	7.25	5.27	4.34
Pore size distribution %:								
Drainable pores	13.6	23.2	27.9	32.1	9.3	19.5	24.3	30.7
Water holding pores	28.5	31.6	37.6	39.7	17.6	24.8	32.9	33.9
Capillary pores	57.9	45.2	34.8	28.2	73.1	55.7	42.8	35.4
Hydr. Conductivity (cm/h)	0.84	3.72	4.53	2.65	0.72	6.32	6.71	5.69
Available water %	13.3	16.7	15.3	17.4	9.8	12.4	11.9	13.2
Chemical properties								
Organic matter %	2.18	2.76	2.25	2.40	1.23	1.56	1.32	1.45
pH (1:2.5 soil water susp.)	8.79	8.53	8.26	7.94	9.14	8.67	8.40	8.21
ECe (dS/m)	8.36	5.34	4.39	3.76	10.5	7.51	4.93	4.07
Soluble ions (mg/l): Ca^{2+}	7.9	9.1	13.7	11.3	9.8	15.6	14.7	12.2
Mg^{2+}	22.3	10.4	10.3	9.2	29.5	20.5	10.9	8.9
Na^{+}	54.6	34.0	20.0	17.1	73.2	39.2	23.8	19.6
K^{+}	0.92	0.60	0.45	0.35	1.40	0.85	0.55	0.45
CO_3^{2-}	1.46	0.90	0.00	0.00	0.65	0.30	0.00	0.00
HCO_3^{-}	5.09	4.10	2.45	2.15	4.75	3.95	2.55	2.75
Cl^{-}	48.2	30.5	23.4	21.0	60.4	48.0	28.0	20.8
SO_4^{2-}	30.7	18.6	18.6	14.8	48.1	23.9	19.4	17.6
ESP	26.5	17.8	10.6	9.4	34.2	21.5	11.7	10.3

l* refers to leached soil after fish-pond farm drainable (3000-9µ), water holding (9-0.2µ) and capillary pores (< 0.2 µ)

The obtained results in Tables (4 and 6) showed that cultivated fish-pond farm caused pronounced increases in soil bulk density, soil strength, fine capillary pores, pH values and ESP vs parallel decreases in total porosity, stable aggregates, available water range, drainable, water holding pores and ECe ones. The aforementioned trend could be attributed to the negative effects of the progressive increment of Na-salts and exchangeable Na on dispersion of soil aggregates. Moreover, this distinct pattern was confirmed by the reduction in the values of hydraulic conductivity, especially in the compacted subsoil layers and lack of drainage system. The reverse was true for soil organic content, which exhibited a pronounced increased more related to the residual organic compounds that directly nourish the fish after different biochemical and chemical changes. It is worthy to mention that the beneficial effects of this step of reclamation technique included a progressive removal for soluble salts, reached 801.79 and 785.52 % in soil depths of 0-25 and 25-60 cm, respectively, under an economic land use (fish-pond farm).

Data presented in Table (6) showed also the beneficial effects in soil physical and chemical properties as a result of applying the individual or combined treatments of organic and inorganic soil amendments (poultry waste and gypsum) to the studied soil. Also, it was noticed that the beneficial effects resulted from the combined treatment of ½ (poultry manure + gypsum requirement) were surpassed those obtained from the individual ones. This superiority is more related to effective role of the combination magnitude between the active organic colloids and inorganic soluble Ca^{2+} or SO_4^{2-} that derived from the applied poultry manure and gypsum and caused a coagulated process for soil particles and a pronounced acidity in soil. The positive changes in the studied soil properties were represented by a parallel decrease in each of soil bulk density, soil strength, fine capillary pores, ECe, Na^+, Cl^-, pH, and ESP vs an increase in soil total aggregates, total porosity, storage pores, available water range and hydraulic conductivity. Moreover, the individual treatment of poultry manure left its positive effect on the relative high content of organic compounds in soil.

So here, it obvious that the produces of active organic acids could be chelate Ca^{2+} derived from the applied gypsum as a divalent cation and led to improve the soil structure through their enhancing the coagulated clay particles and forming soil domains, which involved with them and forming relative coarse soil aggregates. The latter condition leads to improve soil moisture regime through increasing the drainable pores (conductive pores) and in turn hydraulic conductivity that resulting in more salts could be leached out the root zone, as well as, to an increase for both storage pores that increment the available water range. It is worthy to mention that the beneficial changes occurred in the subsurface layers behaved almost similar trend to those of topsoil, mainly due to the extended positive effect of subsoiling technique up to a depth of 60 cm. The sequence of the superiority for the applied soil amendments under the condition of the conducted experiment could be arranged into the descending order of (4 ton poultry waste/fed + 8 ton gypsum/fed) > 16 ton gypsum/fed > 8 ton poultry waste/fed, except for soil organic matter that recorded the maximum values at the treatment of 8 ton poultry waste/fed.

c) Soil taxonomy and evaluation:

Based on soil morphological features and analytical data obtained after executing the aforementioned improvement practices and aid by the guidelines of Taxonomic system undertaken by Soil Survey Staff (1999), the ameliorated soil could be classified as Typic Haplotorrerts, very fine clayey, smectitic, thermic. In addition, by using the parametric evaluation system after Sys and Verheye (1978), the suitability unit of the treated soil was S3*s1s4*, which was considered as a marginal suitable (S3), with a suitability index of rating 45.0 and controlled by severe and slight intensity limitations of soil texture and gypsum content, respectively.

IV- Soil fertility status:

a) Initial state of the studied soil:

It is accepted that knowledge of the nutrient status and factors controlling their uptake by plants may be considered as the cornerstone in soils and crop productivity. In spite of the studied fluvio-lacustrine soil is distinctly rich in some nutrient-bearing minerals, the prevailing unsuitable condition of salinization or sodification cause an adverse aspect for nutrients availability to the sufficient levels for plant nutrients, as shown in Table (7).

b) Soil fertility status as affected by agro-management practices:

It is evident from data presented in Table (7), that a pronounced increase in soil content of nutrients after fish-pond farm at the studied site, which was more related to the residual organic compounds that directly nourish the fish after different biochemical and chemical changes that led to increase the available nutrients. Results showed also a progressive increase in the amounts of available nutrients was achieved upon treating the soil with the poultry manure followed by the combined treatment (4 ton poultry manure /fed + 8 ton gypsum/fed) and individual gypsum as compared to the initial state of studied soil.

The superiority of poultry treatment is mainly attributed to it attains a relatively high content of essential macro and micronutrients, beside it causes indirect positive effects on soil properties that are more related to soil fertility and could be achieved through lowering soil pH and maintaining a suitable air-moisture regime, as discussed previously. The latter condition can be caused also a pronounced positive effect on biological activity in soil. That means supplying essential elements through the bio-fertilization is undoubtedly of a great importance to maximize the content of nutrients in soil, especially for micronutrient deficient.

Table (7): Available macro and micronutrients in both the initial (I) and treated soils by poultry waste (P) or gypsum (G).

Treatment	Depth (cm)	Available plant nutrients in the treated soil (mg/kg)						
		N	P	K	Fe	Mn	Zn	Cu
I*	0-25	21.68	5.74	586.53	4.86	0.95	0.81	0.73
L**		87.93	9.15	645.48	6.97	1.35	1.06	0.96
I*	25-60	18.79	3.95	412.82	5.02	0.83	0.70	0.61
L**		52.50	5.86	573.78	7.95	1.15	0.96	0.83
P	0-25	171.26	22.57	798.04	13.45	7.20	5.35	4.68
	25-60	116.25	13.94	754.36	11.23	5.18	4.35	3.72
G	0-25	132.51	13.65	690.89	9.92	4.01	3.96	2.75
	25-60	83.91	8.27	618.57	8.96	3.10	2.84	2.16
P+G	0-25	155.72	16.74	736.24	11.83	5.97	4.51	3.64
	25-60	97.62	10.28	695.37	10.56	4.29	3.61	2.97

*Critical limits of nutrients in mg/kg****

Limits	N	P	K	Fe	Mn	Zn	Cu
Low	< 40.0	< 5.0	< 85.0	< 4.0	< 2.0	< 1.0	< 0.5
Medium	40.0-80.0	5.0-10.0	85.0-170.0	4.0-6.0	2.0-5.0	1.0-2.0	0.5-1.0
High	> 80.0	> 10.0	> 170	> 6.0	> 5.0	> 2.0	> 1.0

I* refers to initial state of soil
L** refer to leached soil after fish-pond farm
*** critical levels of nutrients after Lindsay and Norvell (1978) and Page et al. (1982)

The aforementioned findings are confirmed by the results undertaken after Tester (1990) and Sarker *et al.* (1992) who found that, the organic manure provided a substantial modification of physical properties such as bulk density and aeration, which affected solubility, adsorption and availability of nutrients.

V) Rice straw and grain yields as affected by the agro-management practices:

Data presented in Table (8) indicated that application of the studied agro-management practices to soil under investigation resulted in a positive effect on the vegetative growth of the grown rice plants, and in turn their yields of grain and straw. The obtained results showed the superiority was more responded to the combined treatment of (4 ton/fed poultry manure + 8 ton/fed gypsum) for increasing the rice yield of both grain and straw with about 73 and 46 %, respectively, over those obtained from the initial state of soil.

Table (8): Grain and straw yields of rice grown on the initial (I) and treated soils by poultry waste (P) or gypsum (G).

Treatments	Rice yield (kg/fed)		Relative increase %	
	Grain	Straw	Grain	Straw
I*	1846.89	3270.52	--	--
P	2205.75	3862.78	19.43	18.11
G	2984.63	4634.63	61.60	41.71
P+G	3197.92	4784.91	73.15	46.30

I* refers to leached soil after fish-pond farm

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إتجاه غير تقليدى فى مجال إصلاح الأراضى الغدقة الشديدة التأثر بالأملاح فى منطقة شمال شرق دلتا نهر النيل - مصر

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توضح هذه الدراسة أن هناك إتجاه متزايد إلى إصلاح الأراضى المتأثرة بالأملاح فى ظل الجهود المبذولة لزيادة الرقعة الداخلة فى مشاريع التنمية الزراعية فى السنوات الأخيرة، ولذا أصبح من الضرورى تحسين صفات تلك الأراضى المتدهورة باتباع اسلوب خدمة مائية تحد من الإسراف أو فقد المياه العذبة، بالإضافة إلى إجراء طرق خدمة زراعية تزيد من قدرة التربة الإمدادية بالمغذيات النباتية، وكذا تحد من التأثيرات المحتملة والمعاكسة لتأهيل المصادر الأرضية لمتطلبات الإنسان، لذا فان هذه الدراسة وضعت لتقييم المعوقات التى تتحكم فىتحسين صفات الأراضى المتأثرة بالأملاح وزيادة إنتاجيتها تحت الظروف البيئية السائدة لمنطقة شمال شرق دلتا نهر النيل . والطريقة المقترحة روعى أن تغطى ثلاث مشاكل متعلقة بالتربة تحت الدراسة، وهى غسيل الأملاح الزائدة، خفض قيم الصوديوم المتبادل، الحصول على بناء أرضى مناسب .

والأراضى تحت الدراسة غالبا ما تقع تحت تأثير مستوى ماء أرضى مرتفع، مما أدى إلى تصنيفها ضمن الأراضى الملحية الغدقة تحت ظروف المناخ الجاف فى منطقة شمال أفريقيا Aquisalids wetland، كما تنتمى إلى رتبة الأراضى الغير صالحة للزراعة تحت ظروفها الحالية فى الوقت الحاضر (*N1tws1s4n*) تسود بها محددات لإنتاجية التربة ممثلة فى خاصية الترطيب والتى يتسبب فيها الماء الزائد فى طرد الهواء الأرضى من مسام التربة ومن ثم نقص الكسجين الأرضى، كما وأن ثقل قوامها له تاثير سلبى ومباشر على نفاذية التربة ومدى الماء الميسر بها، بالإضافة إلى أن إرتفاع الماء الأرضى المالح يقلل من عمق التربة الفعال ويشجع من حدوث تملح سطحى وقلونة التربة تحت ظروف المناخ الحار الجاف .

وبالنسبة للإسلوب الغير تقليدى فى إصلاح الأراضى المتأثرة بالأملاح تحت الدراسة، فانه يتلخص فى عملية الغسيل المستمر للأملاح مستخدما مياه الصرف الملحية، مع إستغلال المساحة المغمورة بمياه الغسيل إقتصاديا بزراعتها باسماك البلطى فى مارس ٢٠٠٢، وقد استمرت عملية الغسيل المستمر فى ظل المزرعة السمكية حتى نفس الوقت من صيف ٢٠٠٣، بعد ذلك تم تجفيفها ومعالجة التربة بالإحتياجات الجبسية ومخلفات الدواجن كمحسنات تربة طبيعية فى صورة معاملات منفردة أو مشتركة، وقد تم خلط هذه المحسنات جيدا بالتربة لعمق ٦٠ سم عن طريق عمليات الحرث السطحى والعميق، وذلك بهدف تحسين خواص التربة الفيزيوكيميائية ورفع مستوى خصوبتها . ثم استكملت عملية الغسيل المستمر تحت إستغلال إقتصادى أيضا للمساحة تحت الدراسة عن طريق زراعتها بمحصول الأرز مع إستخدام مياه النيل العذبة فى الرى وفى وجود نظام صرف مكشوف وفعال على أبعاد ٢٥ م .

وتشير نتائج الدراسة إلى حدوث تعديل فى حالة البناء الأرضى المتدهور من المنشورى أو العمودى (Prismatic or columnar) إلى الكتلى المهذب الحواف (Subangular)، مع تحسين حالة الترطيب فى التربة وذلك لحدوث تبادل نشط فى دورات الترطيب والتجفيف، وزيادة عمق التربة الفعال كنتيجة لإنخفاض مستوى الماء الأرضى من عمق ٨٥ سم إلى أكثر من ١٤٠سم، بالإضافة إلى إختفاء ظاهرة التملح السطحى للتربة وكذا التبقع اللونى فى طبقات تحت التربة دلالة على تلاشى ظروف الإختزال وتحسين نفاذيتها وحالة الصرف فى التربة وكذا ظروف تهويتها . كما قد أدت هذه المعاملات إلى تحسن فى صفات التربة الفيزيوكيميائية ممثلة فى تحسين قيم الكثافة الظاهرية، درجة الإندماج، المسامية الكلية، نسبة تجمعات التربة، التوزيع الحجمى للمسام، التوصيل الهيدروليكى، مدى الماء الميسر، الرقم الهيدروجينى، ملوحة التربة، نسبة الصوديوم المتبادل، وقد تحققت أفضل القيم لمعظم هذه الصفات فى حالة المعاملة المشتركة (٤ طن/فدان مخلفات دواجن + ٨ طن جبس زراعى/فدان)، وذلك من خلال إنطلاق الأحماض العضوية النشطة كنتيجة لتحلل مخلفات الدواجن، وكذا أيونى الكالسيوم والكبريتات الذائبين من الجبس الزراعى، والتى شجعت من تجمع حبيبات التربة المتفرقة وزيادة نسبة مسام الصرف، ومن ثم زيادة فى قيم التوصيل الهيدروليكى للتربة مما شجع من التخلص من أملاح الصوديوم الذائب بمعدل أسرع، مما إنعكس إيجابيا على إنخفاض نسبة الصوديوم المتبادل فى التربة . وعلى الجانب الأخر فان محتوى التربة من المادة العضوية والمغذيات الميسرة للنبات قد حقق افضل حالاته فى حالة المعاملة ٨ طن/فدان مخلفات دواجن، ويعزى ذلك لغنى هذا المحسن العضوى فى كل من المكون العضوى والمغذيات الضرورية للنبات خاصة الصغرى منها .

وهذه النتائج توضح التأثيرات المفيدة لتلك المعاملات الزراعية، والتى شجعت من النمو الخضرى لنباتات الأرز المنزرعة، مما إنعكس إيجابيا على تطوروزيادة إنتاجية محصولى الحبوب والقش لنباتات الأرز بحوالى ٧٣، ٤٦ % على الترتيب أعلى من معاملة الكنترول (التربة الغير معاملة) فى حالة المعاملة المشتركة (٤ طن/فدان مخلفات دواجن + ٨ طن جبس زراعى/فدان) .