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Effect of Fresh and Saline Water Intrusion in Bitter Lakes Region on Agricultural Soil Degradation

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TO STUDY the effect of fresh and saline water intrusion on the Bitter lakes region, five transacts have been taken along the southern part of the Bitter Lakes in Ismailia Governorate. Their locations were Deferswar, Abu Sultan, El-Saidia, Fayed and Fanara. These transect have been taken from the shoreline of the Bitter Lakes up to the Suez fresh water canal. Soil profiles were dug at each transect to the water table level and soil samples were collected from different layers of different soil profiles. The data showed that soluble salts of the surface layer (0-60cm) decrease sharply from the shoreline of Bitter Lakes towards the fresh water canal. Total cations such as Na, Ca, Mg, K, Fe and Mn were evaluated at each layer of profiles, and their distribution with the surface layers of the water tables. The data showed that the moisture percent of all soil profiles increased gradually in different layers up to water table level**.** With regard to the probability of impact of sea level rise on the coastal stability of the Bitter lakes, it was found that the area extended between zero and one meter level contributes about 8.0% of the study area. It is extended along the western side of the Bitter lakes and eastern Malaria drainage. The area extended between 1.0-2.0m levels contributes about 11.0 % of the study area and protected from the saline water intrusion by the main Malaria drainage. The area extended between 2.0-3.0m levels contributes about 19% of the studied area. It is located mainly in sarabium, Deferswar and Fayed regions. The area above 3m height represents the rest of the case study area which contributes more than 60%. It is mostly elongated adjacent to the Suez Canal fresh water.

Most areas of Ismailia Governorate soils, which were highly production for the most crops, especially peanuts, sesame and vegetables for many years could be attributed to their higher fertility and its loamy soils. Their crop production became limited and decline. And also some of famous crops such as peanuts and sesame disappear in this region. The agricultural farms under study mostly lower particularly in the vicinity of the Bitter lakes and contribute with an average width of about 1.5 km from Bitter Lakes, extends between a western higher Suez canal fresh water at a level not more than 5m above sea level. The eastern side is lower and discharging from the Bitter Lakes and the Suez Canal which is considered of zero elevation. With this respect, El Raey (2010) reported that the coastal zones of Egypt of host a major part of the agricultural and industrial activities. With regard to coastal zone of Bitter lakes and in case of accelerated sea-level rise, seepage will increase and subsequently the water table will raise and soil salinity will increase and hence upset its ecology.

The intrusion of the saline water into the soil with sea level rise will change the characteristics of crop production. In this case, irrigation and crop yield managements are of much concern. On the other hand, the need for crops with higher salt tolerance would increase. The existence of agriculture drain, such as Malarya drain, near the Bitter lakes may cause some problems with accelerated sea level rise. Therefore, the impact of the intrusion of salty water and seepage from Suez Canal fresh water, ground water and drainage must be investigated.

The soil degradation and decline of crop production may be due to the high water table level and existence of agriculture farms near the Bitter Lakes in the east and Suez canal fresh water in the west. For these reasons the main objective is evaluation of the probability effect of sea level rise in the Bitter Lakes region.

Material and Methods

To study effect of fresh and saline water intrusion in Bitter lakes region on agricultural soils degradation five transacts have been taken along the southern part of the Bitter Lakes in Ismailia Governorate. Their locations were Deferswar, Abu Sultan, El-Saidia, Fayed and Fanara as shown in Fig. 1. These transects have been taken from the shoreline of the Bitter Lakes up to the Suez fresh water canal. Soil profiles were dug at each transect to the water table level and soil samples were collected from different layers of different soil profiles. After the equilibrium of water table in each profile, their depths from the surface were evaluated.

Electrical conductivity (EC) of the saturated soil paste extract was measured using conductivity meter. Soil pH was determined by bench type Beckman glass electrode pH meter, in 1:2.5 soil water suspensions. Calcium and magnesium were extracted in the saturated soil and determined by volumetric titration with ethylene diamine tetra acetic acid (EDTA). Sodium and Potassium were determined by Flame photometer. Chloride was determined by titration with silver nitrate, bicarbonate was determined by titration with sulphuric acid. Cation exchange capacity was determined according to Page *et al.* (1982). Organic matter was determined by walkely and black method (Nelson and Sommer, 1982). Total nitrogen determined; according to was digested and determined by the Black *et al.* (1965). Available phosphorus and available potassium were extracted by DTPA and determined by using Spectrophotometer and Flame photometer, repectively (Soltanpour and Schwab, 1977). Available micronutrients (Fe, Mn were determined by Lindsay and Norvell method (1978) and assayed using atomic absorption spectrophotometer. Total carbonates were determined using Collin's calcimeter (Piper, 1950). Particle Sizes distributions were carried out using the pipette method, (Janitzky, 1986a). Sodium adsorption ratio (SAR) and Exchangeable Sodium Percentage (ESP) were calculated using the following formulas according to Ayers and Westcot (1994).

$$ESP = \frac{[Na^{+}]}{CEC} \times 100 \quad SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

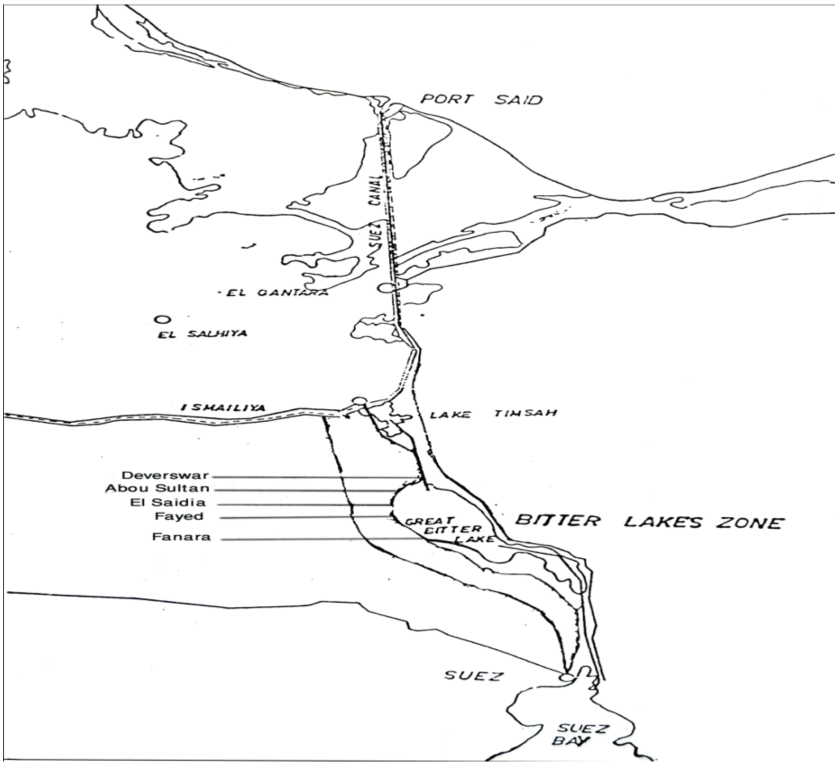

Fig.1. The study area.

Results and Discussion

Most of the agriculture land located at the east side of Suez Canal fresh water from Ismailia up to Suez Governorates characterized by low level from the contour line of Suez canal fresh water. Since establishing High Dam Project, dredge of Suez Canal fresh water had led to water seepage from the canal to the adjacent lands at the both sides and this may be attributed to their high permeability because it is varies between sandy and sandy loam soils (Table 1). This land now is greatly affected with increasing water table depth which reached to about 30cm in depth in some locations.

The studied area also is bounded from the west by Suez fresh water canal and from the east by the Bitter lakes. The vulnerable area varies in width from 3km at Serabium Village to 0.5 km at Fayed and Fanara.

TABLE 1. Particle size distribution of studied soil profiles of investigated area.

Location	Profile No.	Distance from Bitter Lakes (m)	Soil depth (cm)	% Clay	%Silt	% Sand	Texture Class
Deferswar	1	230	0-30	12.5	2.50	85.0	Loamy Sand
			30-60	15.0	5.00	80.0	Loamy Sand
			60-90	15.0	10.0	75.0	Sandy Loam
			90-120	10.0	30.0	60.0	Sandy Loam
	2	530	0-50	10.0	12.5	77.5	Sandy Loam
			50-65	7.50	5.00	87.5	Loamy Sand
	3	680	0-30	45.0	30.0	25.0	Clay
			30-60	50.0	12.5	37.5	Clay
			60-90	20.0	5.00	75.0	Sandy Clay Loam
			90-120	37.5	25.0	37.0	Clay Loam
	4	850	0-30	5.00	20.0	75.0	Loamy Sand
			30-60	12.5	11.7	75.8	Sandy Loam
	5	940	0-30	12.5	12.5	75.0	Sandy Loam
			30-60	10.0	15.0	75.0	Sandy Loam
			60-90	5.00	10.0	85.0	Loamy Sand
Abu Sultan	1	150	0-70	20.0	5.00	75.0	Sandy Clay Loam
			70-80	12.5	10.0	77.0	Sandy Loam
	2	500	0-90	10.0	15.0	75.0	Sandy Loam
			90-100	18.0	12.0	70.0	Sandy Loam
	3	1000	0-90	60.0	20.0	20.0	Sandy Clay Loam
			90-100	70.0	13.5	12.5	Sandy Loam
El Saidia	1	50	0-30	10.0	10.0	40.0	Silt Loam
			30-40	15.0	5.0	80.0	Sandy Loam
	2	100	0-30	15.0	55.0	30.0	Silt Loam
			30-80	26.7	13.3	60.0	Sand Clay Loam
			60-80	2.5.0	2.50	95.0	Sand
	3	570	0-30	20.0	40.0	40.0	Loam
			30-60	25.0	45.0	30.0	Loam
			60-69	2.50	12.5	85.0	Loamy Sand
	4	970	0-30	15.0	55.0	30.0	Silt Loam
			30-60	26.7	13.3	60.0	Sandy Clay Loam
Fayed	1	25	0-30	12.5	12.5	75.0	Sandy Loam
			35-100	27.5	22.5	50.0	Sandy Clay Loam
	2	150	0-40	17.5	5.00	77.5	Sandy Loam
			40-75	12.5	2.50	85.0	Loamy Sand
			75-100	25.0	25.0	50.0	Sandy Clay Loam
	3	500	0-75	5.00	7.50	87.5	Loamy Sand
			75-85	70.0	20.0	10.0	Clay
Fanara	1	200	0-50	5.00	5.00	90.0	Sand
			50-75	20.0	10.0	70.0	Sandy Clay Loam
	2	700	0-25	25.0	25.0	50.0	Sandy Clay Loam
			25-70	10.0	20.0	70.0	Sandy Loam
			70-90	5.00	10.0	85.0	Loamy Sand

Total soluble salts (ECe)

The data showed that the water soluble salts at every soil profile in the transects increased in the surface layer. This increase depends on the depth of water table, soil characterizations and location. The data also showed that the layers above the water table level continued rather higher salts than those submerged (Table 2 & 3).

At the transect of Deferswar region , the nearest profile to the shore of Bitter lakes (230m) the total soluble salts was 3.43 dSm^{-1} at the water table depth of 120cm, while at 940m from the shore of Bitter lake the soluble salts was 1.30 dSm^{-1}. On the Other hand, the highest concentration of total soluble salt 13.03 dSm^{-1} was found in the surface layer (30cm) of the transect of El Saidia at the nearest profile to the shore of the Bitter lakes (50m). This result may be due to the high water table at 40cm soil depth. From these results it is interested to conclude that the soluble salts of the surface layer (0-60cm) decrease sharply from the shoreline of Bitter lakes towards the fresh water canal, i.e. from east to west, whereas it increases from north to south towards Fayed and Fanara. Accordingly, one may conclude that salt water intrusion can occur in the coastal areas of the Bitter Lakes.

Soluble cations

The data in Tables (2 & 3) showed that Na concentration increased gradually with increasing the water table level. The data showed that the higher water table contains the highest concentration of soluble Na amounting to 135.4 $meql^{-1}$ and 22.6 $meql^{-1}$ in Fayed and Fanara, respectively in the soil profiles near the Bitter lakes shore and not more than 15.1 $meql^{-1}$ and 11 $meql^{-1}$ in Fayed Fanara, respectively in the soil profiles near the Suez Canal fresh water. This led to the degradation of the soils of those transects and become salty and sodic soils.

The data showed that increasing water table level decreased soluble Ca with depth; the minimum values of soluble Ca were obtained near and / or under the water table. These results were in harmony with that obtained by Anter *et al.*, (1977) who found that the soluble Ca content sharply decreases with depth reaching its minimum in the layer adjacent to the water table. At the same time, the highest content of Ca (24 $meql^{-1}$) was found in the water table level of (90-120 cm) in the transect of Deferswar near the Bitter lakes.

The highest Mg content (49 $meql^{-1}$) was found in the water table of the transect in Fayed. The minimum of Mg content (1.5 $meql^{-1}$) was found in the bottom of the 30cm water table level in the transect of Deferswar. It is interested to note that under increasing water table levels mostly of the highest concentration of Mg (from 1.5 to 2.5 $meql^{-1}$) were found in the surface layer. In this respect Barber (1974) stated that mass flow plays an important role for nutrients percent in the soil solution in high concentrations, such as Ca^{2+} and Mg^{2+}, when transpiration is high. On the other hand, the data of Fayed and Fanara showed that the highest concentration of K was found at the depth adjacent to the water table level and it decreased gradually toward the soil surface. This may be attributed to the rate of K movement in the soil, whether by mass flow or diffusion depends highly on the soil moisture.

TABLE 2. Some chemicals analysis of different soil profiles of Deferswar and Abu Sultan.

Location	.Profile No	Distance from the Bitter Lakes (m)	Soil Depth (cm)	pH	E.C dSm^{-1}	(Cations (mel^{-1}				(Anions (mel^{-1}			% $CaCO_3$	CEC me/100g soil	% O.M	SAR	ESP %
						$^{+}Ca^{2}$	$^{+}Mg^{2}$	^{+}Na	^{+}K	$^{-}HCO_3$	^{-}Cl	$^{-}SO_4^{2}$					
Defers war	1	230	30-0	7.57	1.77	6.90	4.60	5.70	0.50	6.80	3.55	7.35	5.2	27.0	1.9	2.37	10.2
			60-30	7.36	1.82	7.70	5.23	4.70	0.57	5.55	6.77	5.88	5.6	12.2	0.57	1.85	18.0
			90-60	7.62	1.83	8.80	3.30	5.35	0.85	5.50	5.53	7.27	10.3	10.9	0.46	2.17	25.5
			120-90	7.28	3.43	24.0	6.00	3.00	1.40	2.00	4.50	27.8	5.2	34.8	0.39	0.77	13.9
	2	530	50-0	7.52	0.93	4.00	2.50	2.60	0.20	3.00	5.00	1.30	3.6	37.4	1.5	1.44	11.6
			65-50	7.51	0.90	3.50	2.00	3.26	0.24	2.50	3.00	3.50	7.0	9.40	0.04	1.57	20.8
	3	680	30-0	6.72	0.88	3.50	1.50	3.24	0.56	2.50	4.50	1.80	7.4	28.6	0.87	2.04	19.1
			60-30	7.55	0.90	3.50	2.50	2.33	0.67	3.00	3.50	2.50	9.0	29.6	0.98	1.35	15.6
			90-60	6.82	1.50	7.50	4.50	2.13	0.87	2.50	3.50	9.00	3.2	39.2	0.37	0.87	7.90
			120-90	7.47	1.30	4.00	6.00	2.39	0.61	3.50	3.50	6.00	5.2	12.8	0.06	0.48	15.2
	4	850	30-0	6.92	0.86	3.50	2.00	2.39	0.71	3.50	1.50	3.60	0.82	26	1.1	1.44	7.5
			60-30	7.10	0.74	2.50	1.50	3.17	0.23	2.50	2.50	2.40	4.50	8.6	-	2.24	13.6
	5	940	30-0	7.49	0.75	3.50	1.50	2.30	0.20	2.50	3.50	1.50	3.80	30.4	0.73	1.45	35.3
			60-30	7.53	1.80	5.00	1.50	11.0	0.5	3.00	5.50	9.50	3.20	22.0	0.39	6.00	33.0
			90-60	7.52	1.40	6.00	2.50	5.39	0.11	3.00	6.00	5.00	0.82	17.4	-	2.60	12.1
Abu Sultan	1	150	70-0	7.9	40 .2	11.0	16.5	6.49	2.41	7.50	15.0	10.0	5.00	30.6	0.41	1.75	40.8
			80-70	7.8	2.90	13.5	14.0	8.17	2.41	6.00	3.50	18.0	11.0	37.4	0.79	2.20	29.2
	2	500	90-0	7.9	1.51	2.50	7.50	4.73	0.27	7.50	6.0	2.1	8.00	11.4	0.48	2.11	27.1
			100-90	7.4	1.60	5.00	4.00	6.00	1.0	6.00	4.2	5.80	7.00	12.8	0.79	2.83	34.6
	3	1000	90-0	7.2	0.70	2.00	0.60	4.00	0.40	1.50	4.00	1.50	9.00	9.00	0.70	4.13	77.8
			110-90	7.3	0.80	3.00	2.00	2.22	0.78	2.50	3.50	2.00	7.70	6.20	0.04	1.97	61.0

TABLE 2. Some chemicals analysis of different soil profiles of Deferswar and Abu Sultan.

Location	.Profile No	Distance from the Bitter Lakes (m)	Soil Depth (cm)	pH	E.C dSm^{-1}	(Cations (mel^{-1}				(Anions (mel^{-1}			% $CaCO_3$	CEC me/100g soil	% O.M	SAR	ESP %
						$^{+}Ca^{2}$	$^{+}Mg^{2}$	^{+}Na	^{+}K	$^{-}HCO_3$	^{-}Cl	$^{-}SO_4^{2}$					
Defers war	1	230	30-0	7.57	1.77	6.90	4.60	5.70	0.50	6.80	3.55	7.35	5.2	27.0	1.9	2.37	10.2
			60-30	7.36	1.82	7.70	5.23	4.70	0.57	5.55	6.77	5.88	5.6	12.2	0.57	1.85	18.0
			90-60	7.62	1.83	8.80	3.30	5.35	0.85	5.50	5.53	7.27	10.3	10.9	0.46	2.17	25.5
			120-90	7.28	3.43	24.0	6.00	3.00	1.40	2.00	4.50	27.8	5.2	34.8	0.39	0.77	13.9
	2	530	50-0	7.52	0.93	4.00	2.50	2.60	0.20	3.00	5.00	1.30	3.6	37.4	1.5	1.44	11.6
			65-50	7.51	0.90	3.50	2.00	3.26	0.24	2.50	3.00	3.50	7.0	9.40	0.04	1.57	20.8
	3	680	30-0	6.72	0.88	3.50	1.50	3.24	0.56	2.50	4.50	1.80	7.4	28.6	0.87	2.04	19.1
			60-30	7.55	0.90	3.50	2.50	2.33	0.67	3.00	3.50	2.50	9.0	29.6	0.98	1.35	15.6
			90-60	6.82	1.50	7.50	4.50	2.13	0.87	2.50	3.50	9.00	3.2	39.2	0.37	0.87	7.90
			120-90	7.47	1.30	4.00	6.00	2.39	0.61	3.50	3.50	6.00	5.2	12.8	0.06	0.48	15.2
	4	850	30-0	6.92	0.86	3.50	2.00	2.39	0.71	3.50	1.50	3.60	0.82	26	1.1	1.44	7.5
			60-30	7.10	0.74	2.50	1.50	3.17	0.23	2.50	2.50	2.40	4.50	8.6	-	2.24	13.6
	5	940	30-0	7.49	0.75	3.50	1.50	2.30	0.20	2.50	3.50	1.50	3.80	30.4	0.73	1.45	35.3
			60-30	7.53	1.80	5.00	1.50	11.0	0.5	3.00	5.50	9.50	3.20	22.0	0.39	6.00	33.0
			90-60	7.52	1.40	6.00	2.50	5.39	0.11	3.00	6.00	5.00	0.82	17.4	-	2.60	12.1
Abu Sultan	1	150	70-0	7.9	40 .2	11.0	16.5	6.49	2.41	7.50	15.0	10.0	5.00	30.6	0.41	1.75	40.8
			80-70	7.8	2.90	13.5	14.0	8.17	2.41	6.00	3.50	18.0	11.0	37.4	0.79	2.20	29.2
	2	500	90-0	7.9	1.51	2.50	7.50	4.73	0.27	7.50	6.0	2.1	8.00	11.4	0.48	2.11	27.1
			100-90	7.4	1.60	5.00	4.00	6.00	1.0	6.00	4.2	5.80	7.00	12.8	0.79	2.83	34.6
	3	1000	90-0	7.2	0.70	2.00	0.60	4.00	0.40	1.50	4.00	1.50	9.00	9.00	0.70	4.13	77.8
			110-90	7.3	0.80	3.00	2.00	2.22	0.78	2.50	3.50	2.00	7.70	6.20	0.04	1.97	61.0

Soil pH

The soil pH values of different profiles in the transects of different locations varied between 7.10 and 8.60. Results indicate that as the pH of soil increased with rising water table and vice versa as shown in Deferswar, El Saidia and Fayed profiles. This increase in pH_s with the rise of water table was due to the reason that $Ca(HCO_3)_2$ was released from calcareous material because of water table rise where Ca^{2+} was precipitated as $CaCO_3$. The continuity of this process resulted in the formation of lime concentration and increased soil reaction in the profile, as also reported by Khan (1993). Regarding to the effect of nearest of the profiles of different transect of different locations, the data in Tables 2 & 3 showed the soil pH of different profiles near the shore of Bitter lakes, except El Saidia profiles, slightly high than other profiles of the same transect and far from the shore of Bitter lakes. This result may be due to the high content of Na^+ in that profiles near the Bitter lakes.

Sodium adsorption ratio (SAR)

The sodium adsorption ratio (SAR) almost indicated the same pattern as that electrical conductivity. Originally SAR of surface layers of different soil profiles of different transects as shown in Tables 2 & 3 varied between 1.44 and 23.40 for cultivated and fallow soils. At the same time the surface layers of the shallow water table recorded the highest values of SAR, while the surface layers of deep soil profiles recorded the lowest figures for the cultivated soils. In this respect Sarwar *et al.* (2002) stated that these was a significant correlation between water table depth and SAR of the soil with rising water table and vice versa. With regard to effect of salt water intrusion of the Bitter lake on SAR, the results as shown in Tables 2 & 3 there is no significant correlation between SAR and different layers of soil profiles of different transects of studied area.

Chemically available phosphorus, potassium, ferrous and manganese

Available P

The highest values of DTPA-extractable P were found in the cultivated fields where heavily superphosphate fertilizers were added. At the same time the DTPA-P was increased with the depth of soil profiles, especially at the layers adjacent to the water table. These results may be attributed to the transformation of inorganic soil phosphate under reducing soil conditions. In this respect, Ibrahim *et al*. (2011) reported that P concentration in soil solution increased gradually with increasing moisture regimes. They added that the increase in solubility of water soluble P may be attributed to a) release of P from organic matter, b) increase in solubility of calcium phosphates associated with decrease in pH caused by accumulation of CO_2 in the calcareous soils. The adverse effects of increase water table level on plants are often ascribed to decrease availability of O_2 and accumulation of phytotoxins and oxygen deficiency inhibits aerobic respiration, resulting in reverse energy deficiency and eventually death (Greenway and Gibbs, 2003). With regard to the availability of P in different soil profiles of different transects of studied area, the data in Table 4 showed that the available – P of the soil profiles of the transects of Deferswar, Abou Sultan, and

El Saidia were higher than those of soil profiles of the transects of Fayed and Fanara. This result may be due to the first group are cultivated with different crops and fertilized with superphosphate. While the second group were degraded soils and not cultivated with any crops. At the same time, the available –P was group were degraded soils and not cultivated with any crops. The available –P was moderately high in the nearest areas of the Bitter lakes and this may be due to some organic materials rich in phosphate contaminated the shore of the lake.

Available-K

Concerning the effect of water table level on the chemically available-K, data in Table 4 show that the DTPA-extractable K increased with increasing moisture content of soil. In this respect, Jones (1975) reported that, when cation exchange capacity of the soil is low, submergence may increase soluble potassium somewhat in the soil solution through displacement of exchangeable-K from the exchange complex by competing ions most likely that newly dissolved reduced iron and manganese. The results confirmed this view where the highest amounts of DTPA-extractable K were ordinary found in the layer more adjacent to the water table or the saturated with water. The data also indicated that the DTPA-extractable K from the surface of soil profiles (0-30 cm) of different transects were less than any layers of different soil profiles. The DTPA-extractable K was high in different layers of the profile nearest the Bitter lakes than that beside the Suez Canal fresh water. For example the DTPA-extractable K in the profiles of adjacent to the Bitter lakes increased with 74%, 61%, 119%, 91% and 1% than the DTPA-extractable K of the profiles of their transects near the Suez canal fresh water. This result may be due to defuse of the plant roots which exhausted K.

Available iron and manganese

The data in Table 4 showed clearly that the availability of Fe and Mn in the different profiles of different transects of the studied area increase gradually with increasing depth of the water table level and they much higher in the layer adjacent the water table. Yaduvanshi et *al.* (2010) stated that increasing water table level can reduce the availability of some essential nutrients, *e.g.* nitrogen, and increase the availability of nutrient, *e.g*. Fe and Mn.

With regard to the effect of Bitter lake on the concentration of DTPA-extractable Fe, the data in Table 4 showed that, except the profiles of the transect of ElSaidia, Fe increase gradually at the nearest of the shore of the Bitter lakes. Also, the concentration of Fe at the bottom layer which adjacent of the water table progressively increase at the nearest of the Bitter lakes. Concerning the available Mn, the same behavior as Fe was also found. The data in Table 4 showed clearly that Mn-DTPA increased gradually in the soil profiles of different transects of the studied area. The highest amounts of Mn was found in the layers adjacent to the water table and with increasing depth, especially in higher water table levels. This result may be due to the biological activities in deeper layers was more active in reducing the different forms of manganese.

TABLE 4. Effect of water table level on the DTPA - extractable P, K, Fe and Mn ($mgkg^{-1}$soil) of the studied area.

Location	Profile No.	Distance from the Bitter Lakes (m)	Depth (cm)	Total N (mg/100g soil)	Available P $mgkg^{-1}$	Available K $mgkg^{-1}$	Available Fe $mgkg^{-1}$	Available Mn $mgkg^{-1}$
Deferswar	1	230	0-30	126	2.41	42.0	4.04	0.90
			30-60	56	2.25	46.0	6.57	1.54
			60-90	84	1.72	64.0	7.10	2.04
			90-120	35	2.60	80.0	7.40	4.24
	2	530	0-50	126	1.70	26.0	2.04	0.76
			50-65	63	2.02	46.0	6.32	5.41
	3	680	0-30	77	1.85	46.0	3.48	2.60
			30-60	70	1.72	60.0	4.27	3.64
			60-90	70	2.12	70.0	5.63	4.15
			90-120	35	2.25	80.0	5.69	4.90
	4	850	0-30	119	2.21.	36.0	1.21	0.77
			30-60	56	2.51	66.0	3.90	1.65
	5	940	0-30	119	2.05	36.0	1.18	2.70
			30-60	63	2.10	36.0	4.81	3.86
			60-90	49	2.12	46.0	6.52	4.90
Abu Sultan	1	150	0-70	56	3.40	130	10.10	5.00
			70-80	49	4.10	164	21.40	11.7
	2	500	0-90	42	2.10	34.0	6.51	5.60
			90-100	42	2.15	40.0	7.90	9.03
	3	1000	0-90	56	2.01	34.0	5.21	0.65
			90-110	35	2.20	102.0	9.71	1.20
El saiedia	1	50	0-30	70	1.98	36.0	2.98	1.14
			30-40	35	2.34	36.0	7.63	2.77
	2	100	0-30	70	1.65	68.00	7.04	2.02
			30-60	42	1.58	146.0	8.46	2.67
			60-80	14	1.91	183.0	9.33	3.35
	3	570	0-30	70	2.67	68.0	0.82	2.11
			30-60	35	2.80	146.0	7.54	3.93
			60-69	42	3.46	183.0	7.80	4.12
	4	970	0-30	42	1.88	60.00	10.20	5.22
			30-60	56	2.24	62.00	14.88	8.31
Fayed	1	25	0-35	2.80	1.55	56.0	3.08	0.87
			35-100	14	1.88	88.0	7.85	12.55
	2	150	0-40	70	1.22	42.00	1.76	1.68
			40-75	21	1.35	68.00	12.83	5.11
			75-100	42	1.45	212.0	14.88	12.0
	3	500	0-70	77	1.42	36.00	2.87	4.24
			75-85	28	1.45	46.00	15.37	6.43
Fanara	1	200	0-50	28	1.15	46.00	1.96	1.85
			50-75	42	1.32	82.00	13.29	5.40
	2	700	0-25	20.3	0.83	33.4	1.42	1.34
			25-70	24.5	1.00	40.0	1.72	1.62
			70-90	31.5	1.28	51.4	2.21	2.08

The highest Mn content was found in the transects of Fayed near the Bitter lakes and the lowest amounts of DTPA-extractable Mn was found in the surface profiles of transects of abou Sultan near the Suez canal fresh water. At the same time, the solubility of Mn was not related to the changes in the pH as shown in Tables 2 & 3. In this respect Diatta (2008) reported Mn solution activity was less sensitive to be changes and the effect of high pH on the increase of Mn activity was limited, which implied that Mn^{2+} activity was moisture-dependent, basically. This result indicated that care should be taken to avoid any increase in water table level subjected to contamination or pollution by trace metals, such as Fe^{2+} and Mn^{2+}, since any excess of stagnant water leads to increased solubility and simultaneous activity of trace metals in the solution.

Moisture percent

Moisture percent of the profile layers of different transects are shown in Table 5 The data showed that the moisture percent of all soil profiles increased gradually in different layers up to water table level. The data also showed that the moisture percent of the surface profile highly connected with the level of water table. Increasing water table level, led to increasing moisture percent of soil surface and vice versa. In this respect, Russell (1977) stated that evaporation from a bare soil with a water table fairly close to the surface, and by this is usually meant within 2m of the surface, is controlled both by the evaporative power of the air and by the rate at which water will move up from the water table to the soil surface by liquid flow through the capillary pores and water films in the soil under the suction gradient caused by the soil surface drying out. This, in turn, depends on the relation between the capillary conductivity and the suction in the soil profile.

The influence of salt and fresh water intrusion on soil degradation

Soil degradation is defined as the deterioration in the physical and chemical properties of the soil due to environment changes and causing soil erosion, loss of fertility and salinization. From the soils of studied area affected greatly by soil degradation are Fayed and Fanara which are affected by many factors such as:

- Most of these areas are extended between 0.0-1.0 m level.
- Fits characterized by its high content of $CaCO_3$ with salinity range value of 6.9-16.18 dSm^{-1} .
- High water table level.

In addition, the water table level will rise upward, and will reduce the root zone, *i.e.* will reduce the productivity of this area. In such situation, the activity must be changed. The impact of excessive soil moisture due to the rise of water table does not only produce a lack of oxygen demand to the plant but also the mineral deficiency and hence affects the growth of the plant. It may also increase the toxic compounds in the soil such as methane, ethylene, ferrous, manganese ions and disease organisms.

TABLE 5. Effect of water table on the moisture content of different layers of soil profiles.

Location	Profile No.	Distance from the Bitter Lakes (m)	Depth (cm)	Moisture %
Deferswar	1	230	0-30	9.20
			30-60	11.0
			60-90	18.3
			90-120	19.7
	2	530	0-25 25-30 30-50 50-65	10.4 13.1 18.4 19.6
	3	680	0-30	15.2
			30-60	15.4
			60-90	16.1
			90-120	17.6
	4	850	0-30	14.4
			30-60	15.4
	5	940	60-90	15.9
			90-120	16.4
Abu Sultan	1	150	0-25	12.3
			25-50	14.9
			50-80	16.9
	2	500	0-30	18.4
			30-60	22.8
			60-100	28.1
	3	1000	0-30	12.4
			30-70	13.8
			70-110	20.6
El Saidia	1	50	0-15	16.4
			15-30	16.8
			30-40	19.3
	2	100	0-30	15.3
			30-60	12.9
			60-80	13.3
	3	570	0-30	13.8
			30-45	15.0
			45-69	21.2
	4	970	0-30	12.9
			30-45	16.4
			45-60	19.9
Fayed	1	25	0-35	13.6
			35-100	15.4
	2	150	0-40	14.2
			40-75	15.6
			75-100	28.0
	3	500	0-75	24.0
			75-85	25.0
Fanara	1	200	0-50	11.6
			50-75	13.8
	2	700	0-25	10.5
			25-70	13.5
			70-90	24.6

Another problem which appears as a result of high water table level, is the salty and sodicity of the soil. The most unfavorable side effects are the accumulation of salt by the higher flux of capillary flow and the higher evaporation rate. It this clear from the results in the Tables 2 & 3 that the salts accumulates near the surface of sandy soils at the transects of Deferswar, Abou Sultan, and ElSaidia when the water table level is less than 100cm deep. To overcome the increasing of the water table level, many drains are found . The main drains are: ElSaidia, Abou Sultan and Malaria. The last one plays a prominent part in preventing the intrusion of saline water into land. It is located at the border line of the coastal plain of the Bitter lakes. Two huge pumps have been established at the outlet of the Malaria drains at Fayed and Fanara Villages to remove the drainage water into the Bitter lakes.

Probability of impact of sea level rise on the coastal stability of the Bitter Lakes

El-Shahawy (2004) at scope committee in Ismailia stated that, studies on the trends of Mediterranean shoreline revealed an increase in the sea level. It has been estimated that continuous elevation of sea surface level provided from global warming could lead to direct inundation from1 to 2 meters contour. The result would be a destruction of about one-quarter of the agricultural land of the delta and displacement of 8 million people, in addition to severe deficit of Egyptian crop production since the Nile Delta is the main source. Under this study the coastal zone of vulnerable area is divided into four subdivisions according to the height over mean sea level (zero level).

The area extended between zero and one meter level

This stretch contributes about 8.0% of the case study area. It is located in the coastal plain. This area extended along the western side of the Bitter lakes and eastern Malaria drainage (Fig. 2). This area varied greatly in the salinity which reached to 16.20dSm^{-1} in Fayed and 2.90dSm^{-1} in Abou Sultan. Also, this area is characterized by high content of Na (about 135meql^{-1}) and most of this area is uncultivated because of their high sodicity. The relative rise of sea level up 50 cm would affect greatly the soil productivity of this area due to the salt intrusion and the shift of the location of the salt water wedge westward (Greish, 1989). In addition, the water table level will rise upward , which in turn will reduce the productivity of this area. In case of 1.0m sea level rise, the whole cultivated area in this stretch will be inundated and flooded with the saline water.

The area extended between 1.0-2.0 m levels

This stretch will be classified with the accelerated sea level rise of 1.0m as area at change. It contributes about 11.0% of the case study area. Presently, this area is protected from the saline water intrusion by the main Malaria drainage which has salinity varied between 1.9, 3.65 dSm^{-1}. This are its soil salinity varies between 8.76 dSm^{-1} in Fayed and 0.93 dSm^{-1} in Deferswar. Sodium concentration in this area varies greatly between 135meqL^{-1} in Fayed and 2.60 in Deversoir. Most of this area, except Fayed city is cultivated and highly productive with different crops, except fruit trees.

If sea level rises expected due to Global Warming, the role of the Malaria Drain will change according to the following aspects:

- The drain itself will be flooded with saline water. In this case, the drain would be transferred to another location.
- The amount of drainage water will increase, and hence more powerful pumping machine will be needed to pump the water from the drain to the Bitter lakes.

Meanwhile, the cultivated land must be either upraised to increase the depth of the water table to acquire the suitable soil conditions for the present crops, or replaced with other crops tolerated to the new soil conditions.

The area extended between 2.0-3.0 m levels

This stretches about 4000 fed. contributes about 19% of the studied area. It is located mainly in sarabium, Deferswar and Fayed regions (Fig.2). The water table is found at depths of 90-120cm. The soil salinity is less than 0.86dSm^{-1} at Deferswar and may reach 1.82dSm^{-1} at Elsaidia. The deep soil profile with low salinity values, encourages the cultivation of some fruit trees beside most of vegetable crops.

In case of accelerated sea level rise, seepage will increase and subsequently the water table will rise and soil salinity of this stretch will increase and hence upset its ecology. Lindh (1995) noted that the penetration length of the salt water wedge may depend on the extended of the sea level rise, the slope of the land, river charge and tide. He added, it would not be surprising if a salt wedge could penetrate 10-15km inland. Accordingly, it is expected to find the growing fruit trees and other deep root crops with significant salt tolerance as some cereals, forage and some vegetable crops will dominate.

The area above 3m height

This area (12000Fed.) represents the rest of the case study area which contributes more than 60%. It is mostly elongated adjacent to the Suez canal fresh water. Most of the houses of the farmers are allocated in this area and hence they may be slightly influenced with annual sea level rise due to the rising in the water table. The soil of this stretch is highly productive. Most of the fruit trees (as mango) and all kinds of vegetable crops are cultivated there. It is interested to found that the biggest farm for mango trees was found in this area and it is considered the highest area. The accelerated sea level rise will not affect this area which is high and far enough from any saline water resources. In addition, the hydrostatic pressure of fresh water originating from the fresh water canal will prevent any intrusion of sea water. Therefore, the impact of the sea level rise on the agricultural activity in this area is negligible.

It could be concluded that most of the field land in the studied area lies in low land, which extends nearly parallel to the shore line of the Bitter Lakes; the water table is high near the soil surface particularly in the coastal plain. With accelerated sea level rise.

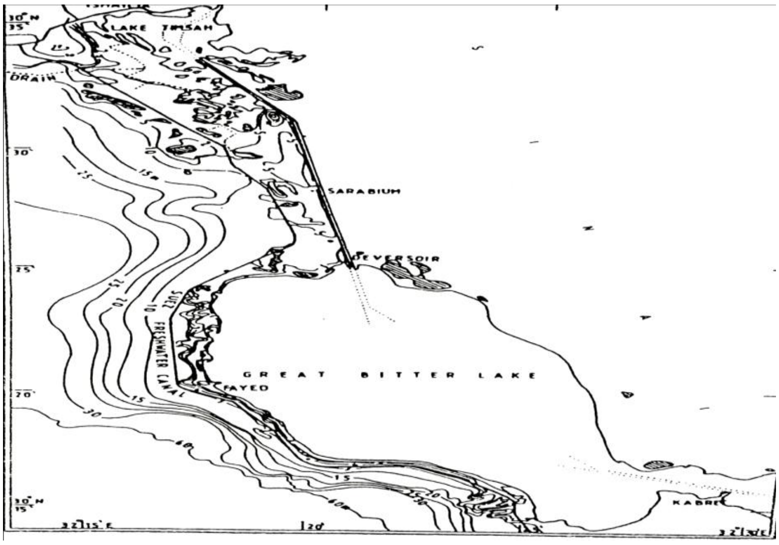

Fig.2. The coastal zone of the vulnerable area showing elevation levels.

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تأثير تداخل المياه العذبة والمالحة في منطقة البحيرات المرة على تدهور الأراضي الزراعية

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لدراسة تأثير تداخـل المياه العذبة والمالحة فــي منطقة البحيرات المرة ، تم اختيار 5 مواقع على طول الساحل الجنوبي للبحيرات المرة في محافظة الإسماعيلية. وكانت تلك المواقع هي الديفرسوار ، أبو سلطان ، السعيدية ، فايد وفنارة. وقد تم تحديدها بداية من شاطئ البحيرات المرة وحتى ترعة السويس العذبة. وتم حفر القطاعات الأرضية لكل خط حتى الوصول الى مستوى الماء الأرضي وجمعت عينات التربة من الطبقات المختلفة للقطاعات الأرضية. وأوضحت النتائج انخفاض حاد للأملاح الذائبة في الطبقة السطحية (0-60 سم) من شاطئ البحيرات المرة باتجاه ترعة السويس العذبة. وقد قدرت الكاتيونات الكلية (الصوديوم ، الكالسيوم ، الماغنسيوم ، الحديد والمنجنيز) لكل طبقة من القطاعات الأرضية وقد تم دراسة توزيعها من الطبقة السطحية وحتى مستوى الماء الأرضي. وتبين النتائج زيادة الرطوبة الأرضية تدريجياً للطبقات المختلفة باتجاه مستوى الماء الأرضي. أما بالنسبة للتأثير المحتمل لارتفاع مستوى سطح البحر على ساحل البحيرات المرة فإنه وجد أن المنطقة الممتدة ما بين المنطقة الممتدة مابين خطي كنتور 0-1 م تمثل 8٪ من منطقة الدراسة وتمتد على طول الجانب الغربي من البحيرات المرة ومن الشرق مصرف الملاريا. وتمثل المنطقة الممتدة بين خطي كنتور 1-2 م حوالي 11٪ من منطقة الدراسة وتتم حماية هذه المنطقة من تداخل المياه المالحة بواسطة مصرف الملاريا. وتمثل المنطقة الممتدة بين خطي كنتور 2-3 م حوالي 19٪ من منطقة الدراسة. وتتمثل في مناطق سرابيوم والديفرسوار وفايد. أما الجزء الباقي من منطقة الدراسة والذي يمثل أكثر من 60 ٪ يتمثل في المنطقة الأعلى من خط كنتور 3 م وتقع تلك المنطقة متاخمة لترعة السويس العذبة.