86 *Egypt. J. Soil Sci.* **Vol. 64**, No. 4, pp: 1407 - 1417 (2024)

Egyptian Journal of Soil Science

http://ejss.journals.ekb.eg/

Effect of Irrigation Water Quality on Chemical and Physical Properties of Soils

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IRRIGATION water quality is a crucial parameter for crop production, which was reported to be deteriorated due to its closer to the coast of Mediterranean sea. Six profiles were selected as a clay texture in the curret study. Profiles 1 and 2 represent soil irrigated with a good quality water, while profiles 3, and 4 refer to soil irrigated partially with lower quality of irrigation water, whereas the last two profiles 5, and 6 represent the irrigated soil with the lowest water quality. Soil samples comprise all soil profiles for different required analyses and also water samples were collected from different locations related to soil profiles. The main purpose of the study is to inquire and evaluate the effect of irrigation water quality and its impacts on soil physical and chemical properties. As a consequence, profiles 5 and 6 have the highest values of soil salinity and exchangeable cations as a sequence of using the lowest quality of irrigation water. Water salinity of irrigation resources for profiles 5, and 6 were 0.87 dS/m and 0.83 dS/m, which reflected in salt content of profiles 5 and 6 to be 1.6 and 0.99 dS/m, respectively. ESP has also the highest values in profiles 5 and 6, which reached 23.4 % for each. On the contrary, profile 2 has the highest value of exchangeable calcium (27.6 meq/100g soil). Total water stable aggregates (> 0.25 mm) has a high negative correlation with salinity of irrigation water and ESP. The correlation was found to be -0.683** for ECiw and –0.547** for ESP. Structure Coefficient revealed a similar negative correlations to be (-0.544**), (-0.411*) and (-0.502*) for EC_{iw}, SAR and soluble Sodium of irrigation water, respectively. On the contrary, ECaP has a positive correlation with each of optimum size of aggregates to be (0.458*) and water stable aggregates (1-0.5mm) to be (0.543*). EC_{iw} as well as soluble magnesium and soluble sodium has a negative effect on soil bulk density due to increased salts. It is concluded that low quality of irrigation water affect negatively the most of structure parameters, i.e. aggregates criteria and other soil physical properties. Therefore, sustainable soil conservation especially at North Nile Delta depend on irrigation water quality, which is needed to maintain its potentiality and productivity.

Keywords: fresh water, irrigation water quality, aggregation index, water stable aggregates, exchangeable Sodium percentage and physical properties.

1. Introduction

Water availability remains the major obstruction for sustainable agricultural production, especially in Egypt with scarcity of freshwater coupled with increasing population. Nearly 86% of Egypt is hyper-arid and 14% is semiarid **(Embabi, 2020)**. Thus, agricultural sector in Egypt consumes more than 85% of available water which leads to use extraordinary water sources as agricultural drainage water and treated sewage water via mixing with the Nile fresh water **(El-Quosy, 2019)**. Annual reuse of drainage water is about 13.1 billion cubic meters which consider as an integral supplement to the country's water supply **(CAPMAS, 2019).** Because such water includes high soluble salts, nutrients,

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Received: 03/06/2024; Accepted: 10/07/2024
DOI: 10.21608/EJSS.2024.295064.1784

agrochemical and pollutants, soil salinity and sodicity is one of the main factors affecting soil deterioration in arid and semiarid regions **(Peng et al., 2019).** Frequent irrigation with saline water accelerates soil salinization process, significantly degrading soil and crops as a result of an alteration in soil physical and chemical properties **(Yerasi et al., 2013). Paudel et al. (2016)** found that low quality water that contains high concentrations of saline components, suspended organic and inorganic particles lead to soil structure degradation, high osmotic potential, low aeration and root growth and decrease in hydraulic conductivity. Currently, irrigation with treated wastewater is performed on more than 20 million hectares worldwide which significantly increase over the coming decades as water stress intensifies **(Chen et al., 2013)**. Soil salinity and sodicity can affect soil hydraulic properties through changing the pore size distribution because of clay dispersion and flocculation **(Leuther et al., 2019).** Treated wastewater is generally characterized by higher load of dissolved organic matter, suspended solids, sodium adsorption ratio and considerable levels of salinity (**Frederic et al., 2019). Farid et al., (2020)** reported that soil infiltration of low irrigation water quality may affect negatively the soil properties in contrasting to use of fresh water to irrigate arable lands. Use agricultural drainage water and sewage effulent water had a negative effect on soil chemical and physical index by increasing pH, salinity of irrigation water (EC_i) and SAR of water used in irrigation, **(Abuzaid et al., 2021)**. **Zein et al., (2020)** found that there are a highest negative correlation between cotton seed yield and soluble and or/ exchangeable Na due to its high toxcicity as well as restriction of water movement and aeration. **Hussien et al., (2020)** recommended that ther is an urgent need to remerdiation contaminated wastewater before discharge into the surrounding environment. Applicatio of nano biochare improve remediation industrial waste effluent water and contribute improve quality of water and sustainable agricultural practices, **(Soliman et al., 2024)**. This study aims to evaluate the quality of irrigation water and its affect on soil physical and chemical properties .

2. Materials and methods

2.1. Study area

Field ivesitgation was performed in three sites representing three levels of irrigation water quality, soils were irrigating with these sources of irrigation water for along time exceed 30 yeares or more as traditional irrigation practice. 1st site was irrigated using good quality water which embrace profiles 1 and 2. The second site irrigated partially, sometimes irrigated with drainage water as represented with profile 3 and 4, whereas site three was irrigated almost (frequentily) with drainage water as for profile 5 and 6.

The whole irrigated area is located nearby territory Elhamoul-Kafr El-Shiekh **(Figure 1)** in which profiles 1 and 2 located aside El-Shawada village, profiles 3 , 4 are by Hazek village and profiles 5 , 6 are located by Al-Ezba Al-Hamra.

2.2. Soil sampling

Disturbed and undisturbed soil samples were gothered from the six profiles from the depths (0-20 cm),(20-40 cm), (40-60 cm) and (60-80 cm) for each profiles. Disturbed samples were air dried, gently ground, sieved through 2 mm sieve and kept in bags for chemical analysis. Undisturbed samples were collected from the different four depths using core samplers with three replicates for measuring saturated hydraulic conductivity . A little undisturbed samples (small clods) were kept for structure evaluation (aggregate analysis), **Figure 2**.

2.3. Water sampling

Irrigation water was collected according to soil site locations, which differentiated in three categories. A good quality water was for site 1 (profiles 1 ,2) and partially lower quality for site 2 (profiles 3,4),while the lowest quality water was for site 3 (profiles 5,6). Another water samples were sampled from the drains beside selected profiles. All water samples were kept ideally to evaluate different water parameters.

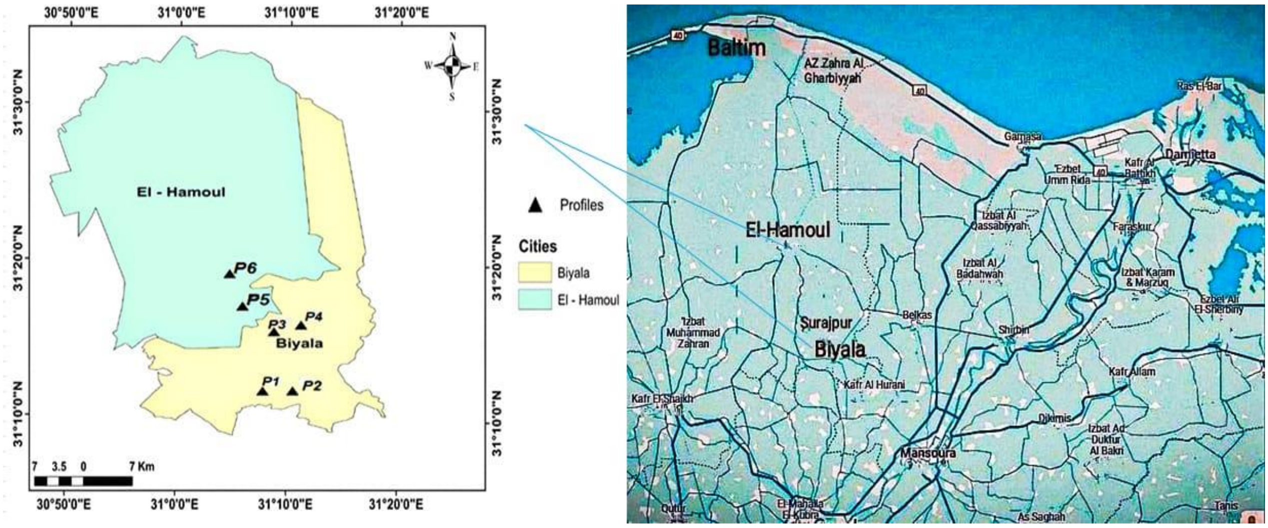

Fig. 1. Locations of irrigaion water quality and soil profiles in Kafr El-Shiekh Governorate.

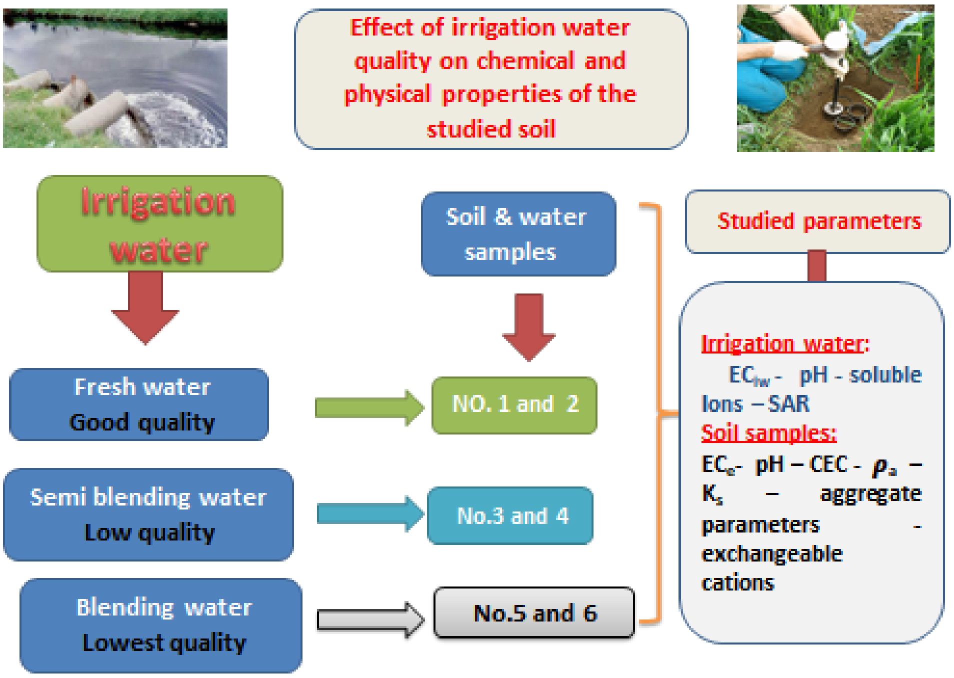

Fig. 2. The flowchart of current study.

2.4. Methods of analyses

2.4.1. Water analyses

EC, pH and soluble cations and anions, according to Estefan et al., (2013). Also, sodium adsopation ratio (SAR) was calculated according to **Richard's (1954)** as follows:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{1}{2}(Ca^{+2} + Mg^{+2})}}$$

Where: Na, Ca, and Mg concentrations are expressed in milliequivalents/liter (mEq/L). Sodium adsorption ratio (SAR) means a value representing the relative amount of sodium ions to the combined amount of calcium and magnesium ions in water where all concentrations are expressed as milliequivalents of charge per liter.

2.4.2. Soil analyses

In undisturbed soil samples, wet sieving technique described by **Yoder (1936)** was carried out using a set of sieves having 2.00, 1.00, 0.05 and 0.25 mm screen opening to determine the aggregate size distribution. Water stable aggregates (WSA), aggregation index (AI), optimum size of aggregates (Opt. size), mean weight diameter (MWD) and structure coefficient (SC) were calculated and recorded. Optimum size of aggregates: was calculated as a percentage of the peds ranged between 0.5 and 2 mm in diameter according to **Baver et al. (1972).**

Water stable aggregates (WSA): They refer to the wet-sieving data and were determined using the formula modified by Ibrahim (1964):

$$WSA = m/M \times 100$$

Where: m= Weight of the wet sieving fractions (gm) , M = Weight of the soil sample (gm).

Structure coefficient (SC): It was calculated by using the wet sieving data and applying the equation suggested by **El-Shafei and Ragab (1975)** as follows :

$$SC= \frac{\%\ \text{aggregates} > 0.25\ \text{mm diameter}}{\%\ \text{aggregates} < 0.25\ \text{mm diameter}}$$

Mean weight diameter (MWD) : It was calculated to **Baver et al. (1972)** by using the following equation :

$$MWD = \sum_{i=1}^{n} \overline{x_i}\ wi$$

Where: $\overline{x_i}$ = The mean diameter of each size fraction, Wi = The proportion of the total sample weight occurring in the corresponding size fraction and $\sum_{i=1}^{n}$ = Summation is carried out overall n size fraction.

- Saturated hydraulic conductivity with constant head method **(Saffan, 1984)**.

- Soil bulk density **(Estefan et al., 2013)**.

In soil paste, the following was conducted:

-pH, EC, soluble cations and anions using usual and recommended instruments.

- Exchangeable cations (Ca^{2}, Mg^{2+}, $Na^{+}$and K^{+}) as by **(Kelley,1984)** ,while Cation exchange capacity (CEC) as by **(Sumner and Miller, 1996)** and Exchangeable sodium percentage (ESP) was calculated as flow:

$$ESP\% = \frac{exchangeable\ Na, meq/100g\ soil}{CEC, meq/\ 100g\ soil} \times 100\%$$

2.4.3 Statistical analyses

Simple Correlation analysis was done between different parameters according to **(Snedecor and Cochran ,1967)**.

3. Results

3.1 Quality of irrigation water

Table.1. and **Figure 4** explain values of EC for different locations of studied area, in which the highest value (0.87 dS/m) was found in the location where profile 5 lies and the lowest Ec value was in the location of profile 1 (0.44 dS/m).The salt concentration was found to be in the order of profile 5 >profile 6> profile 4> profile 3> profile 2> profile 1. Soluble cations of irrigation water in the studied area were found to be almost in the sequence of Na^{+}>Mg^{++}>Ca^{++}>K^{+}. Soluble Na^{+} was the dominant cation in all sites of irrigation water, in which the highest values were found in the location of profile 3 and 4 (5.2 meq/L), while the lowest one was recorded in location of profile 1 (1.05 meq/L).

On the other hand, anions were governed by Cl^{-} in all sites, followed by SO_4^{-2}. The highest value of Cl^{-} was 3.2 meq/L at the site of profile 6 , while the lowest one was 1.0 meq/L by the site of profile 1. So, the above mentioned data classily the different locations of irrigation water to be as (C_2-S_1) for locations of profiles 1,2,3 and 4 ,while locations of profile 5,6 were classified as (C_3-S_1). These classification is based on the digram for classifying irrigation water its depending on the electrical conductivity of irrigation water, micromhos per centemeter and SAR, **Richards (1954).**

It is to note that the less the distance from Mediterranean coast is ,the more the salt concentration in irrigation water was found ,owing to the use of more drainage water by irrigation in the North of Nile Delta .

Sodium Adsorbed Ratio (SAR) was computed which found to be less than 7.0 as low ratios in all sites of profiles. The highest value of SAR was (5.5) in the site of profile 3 and 4, while the lowest value was registered in the site of profile 1 (1.5). These results were in agreement with those obtained by (Saffan, 1984) and (El-Henawy, 2000).

Table 1. Properties of irrigation water sources in the studied area.

WQ	**locations**	**pH**	**EC** dS/m	**Cations** (meq/L)				**Anions** (meq/L)				**SAR**	**Class**
				Ca^{++}	**Mg^{++}**	**Na^{+}**	**K^{+}**	**CO_3^{--}**	**HCO_3^{-}**	**Cl^{-}**	**SO_4^{--}**		
GQ	**1**	6.98	0.440	1.2	1.2	1.65	0.32	-	3.0	1.0	0.4	1.5	C2-S1
	2	7.03	0.455	1.1	0.8	2.13	0.37	-	1.6	1.2	1.6	2.2	C2-S1
LQ	**3**	6.89	0.699	1.0	0.8	5.2	0.37	-	1.2	1.4	4.8	5.5	C2-S1
	4	6.89	0.699	1.0	0.8	5.2	0.37	-	1.2	1.4	4.8	5.5	C2-S1
LSQ	**5**	7.56	0.871	1.6	2.0	4.72	0.23	-	2.0	3.0	3.6	3.5	C3-S1
	6	6.99	0.829	1.0	2.2	3.72	0.27	-	2.4	3.2	1.6	2.9	C3-S1

WQ= irrigation water quality, GQ= good quality, LQ= low quality and LSQ= Lowest quality

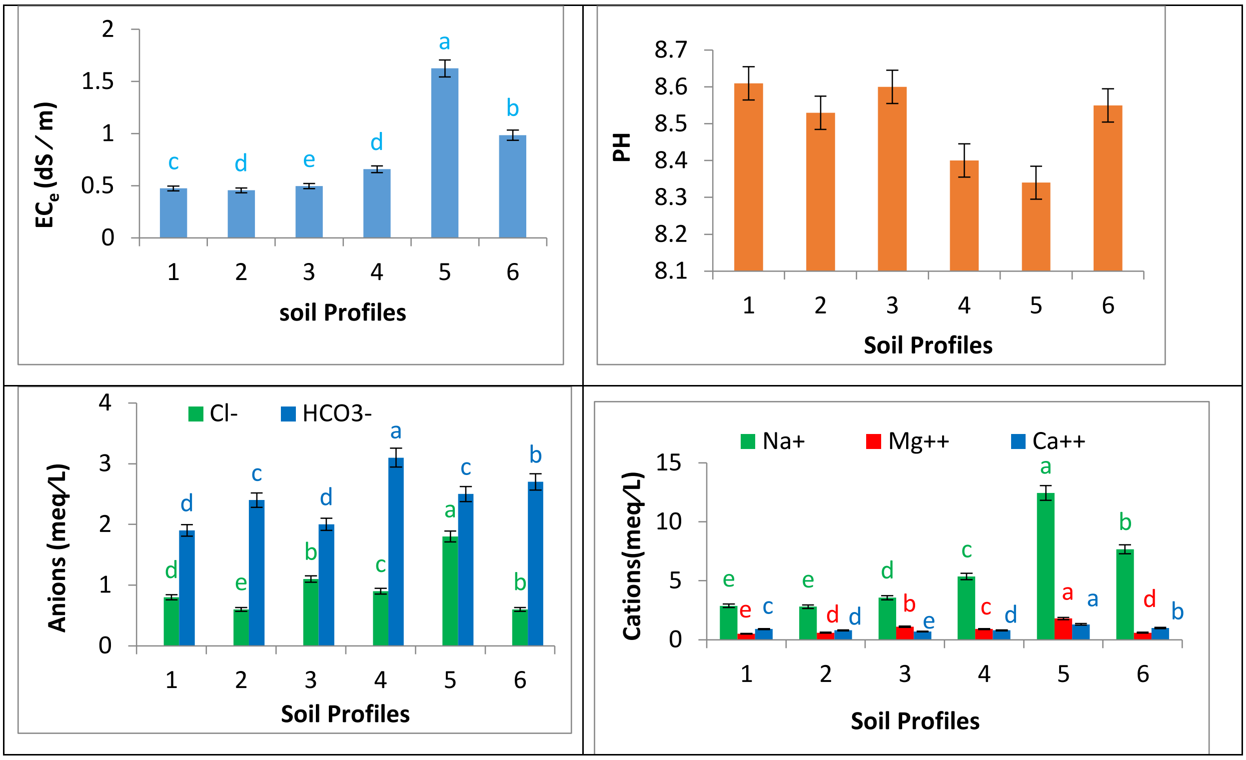

Fig. 3. EC$_e$, pH and soluble anions in the studied soils.

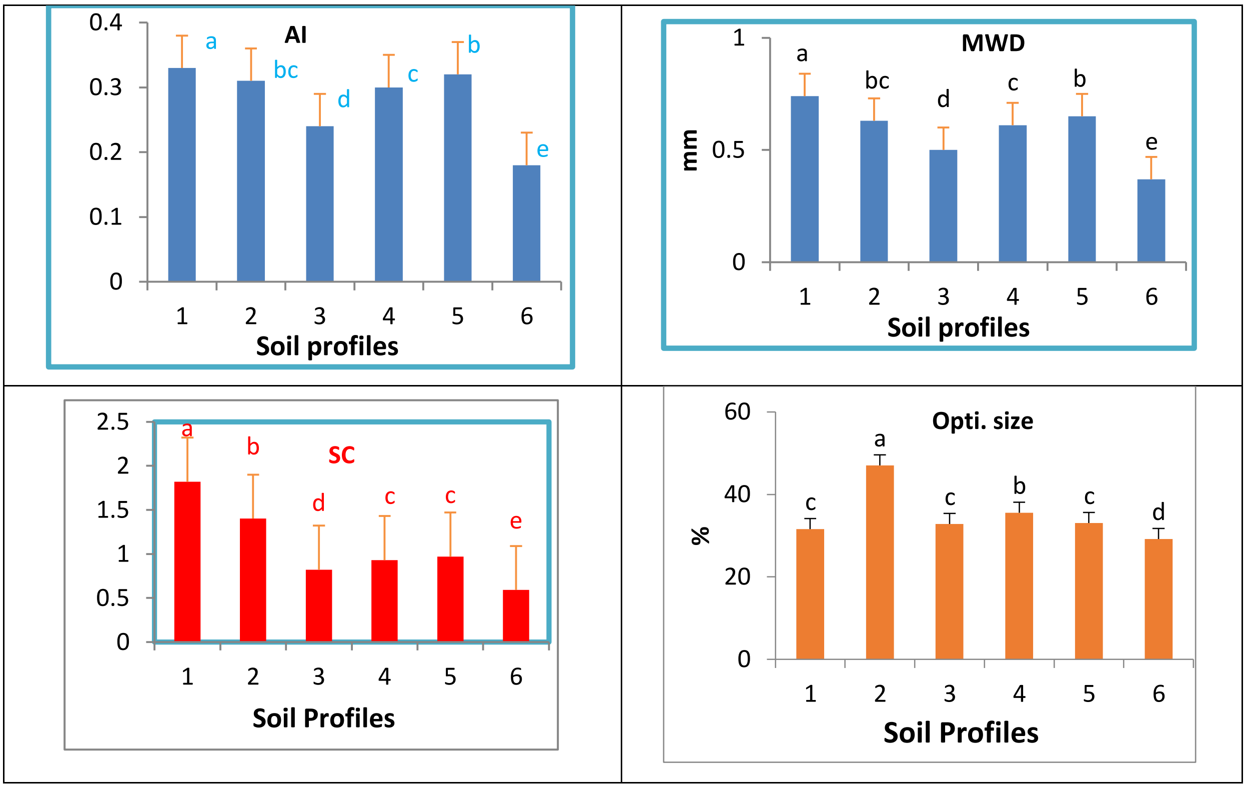

Fig. 4. Aggregation parameters (mean values) for different profiles as affected by quality of irrigation water.

(AI= aggregation index, SC= structure coeffeiceint, MWD= mean weight diameter and Opti. size= optimum size ogf aggregtes)

3.2 Soil chemical properties as affected by irrigation water quality

Exchangeable cations, cation exchange capacity (CEC) and exchangeable sodium percentage (ESP) for the studied area were tabulated in **Table.2.** Mean values of CEC revealed to be in the order of: profile 6> profile 4> profile 2> profile 3> profile 5> profile 1 .Otherwise, the highest value (54.1 meq/100g) was recorded in profile 2 (40-60cm), whereas the lowest one (28.7 meq/100g) was in profile 1(40-60cm).

On the other hand, ESP was in the series of profile 6> profile 5> profile 4> profile 3> profile 1> profile 2. Such orientation reflects the correspondence of ESP to the quality of irrigation water. The highest value of ESP (26.9 meq/100g) was recorded by profile 6 (40-60cm), while the lowest one (8.7 meq/100g) by profile 2 (40-60cm).Criterion of soil sodicity (ESP>15 meq/100g) was realized in the studied profiles (mean values) of profile 6, profile 5 and profile 4 with values of 23.4 , 23.4 and 16.9 meq/100g,respectively .

Exchangeable cations explained that exchangeable Ca^{++} was prevailed in most locations of studied area, especially in locations irrigated with the more adequate quality of irrigation water. Consequently , the highest mean value of exchangeable Ca^{++} (27.6 meq/100g) was found by profile 2,while the lowest mean one (13.3 meq/100g) was found in profile 5. A similar data was recorded by **Alvarez et al. (2006), Jahany and Rezapour (2020)** as well as **Rezapour et al. (2018).**

Table. 2. Cations Exchangeable Capacity (CEC), Exchangeable Sodium Percentage (ESP) and Exchangeable Cations.

Soil profile No.	Depth (cm)	CEC(meq/ 100g soil)	ESP (%)	Exchangeable Cations (meq/100g soil)			
				Na^+	K^+	Ca^{++}	Mg^{++}
1	**0-20**	31.9	11.8	3.7	1.2	15.9	**10.9**
	20-40	29.2	9.2	2.7	0.7	16.9	**9.9**
	40-60	26.6	11.8	3.4	1.2	14.9	**6.9**
	60-80	27.1	10.7	2.9	1.4	15.9	**6.9**
	Mean	**28.7**	**10.8**	**3.1**	**1.1**	**15.9**	**8.6**
2	**0-20**	48.7	12.4	6.0	2.9	26.9	**11.9**
	20-40	46.8	9.6	4.5	2.2	20.9	**18.9**
	40-60	53.5	8.7	4.6	1.6	32.9	**13.9**
	60-80	55.3	10.3	5.7	1.3	29.9	**17.9**
	Mean	**51.0**	**10.2**	**5.2**	**2.0**	**27.6**	**15.6**
3	**0-20**	39.5	10.3	4.1	1.8	20.9	**11.9**
	20-40	39.1	11.2	4.4	1.2	22.9	**9.8**
	40-60	43.8	11.2	4.9	1.6	22.9	**13.9**
	60-80	37.4	13.7	5.1	2.3	21.9	**7.9**
	Mean	**39.9**	**11.6**	**4.6**	**1.7**	**22.1**	**10.8**
4	**0-20**	54.9	16.2	9.6	1.9	29.8	**12.9**
	20-40	52.6	16.2	8.5	2.1	27.9	**12.9**
	40-60	45.3	16.9	7.6	2.3	21.9	**12.9**
	60-80	53.0	18.3	9.7	2.4	24.9	**15.8**
	Mean	**51.4**	**16.9**	**8.8**	**2.1**	**26.1**	**13.6**
5	**0-20**	36.5	24.7	9.0	2.5	14.8	**8.8**
	20-40	35.2	26.1	9.1	2.3	15.8	**7.8**
	40-60	34.4	19.6	6.7	3.3	11.9	**11.8**
	60-80	31.6	23.2	7.3	3.4	10.9	**9.8**
	Mean	**34.4**	**23.4**	**8.0**	**2.8**	**13.3**	**9.5**
6	**0-20**	55.0	19.8	10.9	2.8	27.9	**12.9**
	20-40	52.9	20.8	11.1	3.2	26.9	**10.9**
	40-60	54.7	26.9	14.7	3.3	22.9	**12.9**
	60-80	54.1	26.2	14.2	3.9	21.9	**13.9**
	Mean	**54.1**	**23.4**	**12.7**	**3.3**	**24.9**	**12.6**

3.3 Soil physical properties as affected by quality of irrigation water

Structure Coefficient (SC) is the ratio between WSA>0.25mm and WSA<0.25mm. Therefore, the more SC value is the soil contained, the more the good quality is the soil structure. SC values **(Table.3 and Figure 4)** indicates that profile 1 and profile 2 has the highest values, whereas profile 6 has the lowest value. Hence, mean values of SC were 1.82 , 1.4 and 0.59 for profiles 1,2 and 6, respectively. In the same correspondence, Optimum size (opt.size %) has the highest values by profile 2 (47.01), while profile 6 has the lowest one (29.17).At the same time, WSA <0.25mm has the opposite trend,in which profile 6 has the highest value (62.78),whereas profile 2 has the lowest one (42.68).These results reveal the effect of low quality of irrigation water in some locations as profile 6 as compared to profile 2 which irrigated with more adequate quality of irrigation water.

Correlation coefficient between some soil properties and water criteria as EC_i ,ESP , SAR , Na_i^+ and etc were presented in **Table.4** .

Table 3. Soil aggregates parameters as affected by irrigation water quality.

Soil Profile No.	Depth (cm)	Distribution of WSA % > 0.25 mm					TWSA% <0.25 (mm)	MWD (mm)	AI	SC	Opti. size (%)
		8-2 mm	2-1 mm	1-0.5 mm	0.5-0.25 mm	Total %					
1	0-20	14.11	12.06	16.57	8.88	51.62	48.37	1.04	0.38	1.07	**28.63**
	20-40	4.32	17.87	19.42	13.74	55.36	44.63	0.67	0.33	1.26	**37.30**
	40-60	4.75	6.22	21.48	20.07	52.52	47.47	0.56	0.28	1.10	**27.70**
	60-80	5.32	15.24	17.50	18.12	56.19	43.80	0.69	0.34	3.88	**32.74**
	Mean	**7.12**	**12.84**	**18.74**	**15.20**	**53.92**	**46.06**	**0.74**	**0.33**	**1.82**	**31.59**
2	**0-20**	5.33	20.17	26.06	8.28	59.86	40.14	0.79	0.39	1.50	**46.24**
	20-40	3.85	15.36	23.37	7.30	49.89	50.10	0.62	0.30	1.02	**38.74**
	40-60	0.44	21.23	35.15	3.52	60.36	39.64	0.61	0.30	1.52	**56.39**
	60-80	0.27	12.20	34.47	14.60	61.55	38.44	0.50	0.25	1.59	**46.67**
	Mean	**2.47**	**17.24**	**29.76**	**8.42**	**57.91**	**42.68**	**0.63**	**0.31**	**1.40**	**47.01**
3	**0-20**	6.31	14.38	23.85	7.02	51.57	48.43	0.73	0.36	1.06	**38.23**
	20-40	2.27	11.7	18.53	7.20	39.71	60.29	0.45	0.22	0.66	**30.23**
	40-60	0.96	11.27	18.30	11.29	41.83	58.16	0.39	0.19	0.71	**29.57**
	60-80	1.43	9.80	23.37	11.63	46.23	53.76	0.43	0.21	0.85	**33.17**
	Mean	**2.74**	**11.78**	**21.01**	**9.28**	**44.83**	**55.16**	**0.50**	**0.24**	**0.82**	**32.80**
4	**0-20**	10.99	16.51	18.95	3.00	49.46	50.53	0.94	0.47	0.97	**35.47**
	20-40	2.36	23.35	25.37	2.60	53.70	46.29	0.66	0.33	1.15	**48.73**
	40-60	4.42	15.36	19.24	6.72	45.74	54.25	0.61	0.30	0.84	**34.60**
	60-80	0.07	2.11	21.16	20.12	43.47	56.52	0.26	0.13	0.76	**23.28**
	Mean	**4.46**	**14.33**	**21.18**	**8.11**	**48.09**	**51.89**	**0.61**	**0.30**	**0.93**	**35.52**
5	**0-20**	0.41	9.65	14.37	26.91	51.34	48.65	0.36	0.18	1.05	**24.02**
	20-40	0.88	18.17	22.39	5.83	47.28	52.72	0.50	0.24	0.89	**40.56**
	40-60	0.85	15.79	12.88	15.34	44.88	55.12	1.28	0.64	0.83	**28.68**
	60-80	0.78	13.20	25.69	13.02	52.70	47.29	0.47	0.23	1.13	**38.90**
	Mean	**0.73**	**14.20**	**18.83**	**15.27**	**49.05**	**50.94**	**0.65**	**0.32**	**0.97**	**33.04**
6	**0-20**	0.78	16.25	16.17	4.20	37.42	62.58	0.41	0.20	0.60	**32.43**
	20-40	0.71	15.00	16.36	33.77	35.84	64.16	0.39	0.19	0.55	**31.36**
	40-60	0.46	13.31	16.92	7.86	38.56	61.44	0.37	0.18	0.63	**30.23**
	60-80	0.76	11.12	11.57	13.58	37.04	62.96	0.33	0.16	0.58	**22.69**
	Mean	**0.67**	**13.92**	**15.25**	**7.35**	**37.21**	**62.78**	**0.37**	**0.18**	**0.59**	**29.17**

WSA % = Water stable aggregates percent

MWD = Mean weight diameter of aggregates

SC= Structure coefficient

AI = Aggregation index

Table 4. Correlation Coefficient between Some Properties of Studied soil.

WSA(8-2)	Opti.size	MWD	SC	AI	WSA% <0.25	WSA>0.25	K_s	ρ_a	$CaCO_3$	Silt %	Clay%	O.M	EMgP	ECaP	ESP	EC_e	Na_i	Mg_i	Ca_i	SAR_i	
-0.469*	-0.385	-0.281	-0.544**	-0.231	0.684**	-0.683**	-0.291	0.583**	-0.049	-0.323	0.146	0.085	-0.129	-0.165	0.842**	0.737**	0.777**	0.658**	0.267	0.497*	EC_i
-0.118	-0.114	-0.16	-0.411*	-0.099	0.358	-0.359	-0.29	0.245	0.154	-0.544**	0.470*	0.042	0.092	0.216	0.115	0.024	0.927**	-0.314	-0.277		SAR_i
-0.139	-0.05	0.247	0.13	0.252	-0.246	0.246	0.136	0.117	-0.207	0.265	-0.322	0	-0.414*	-0.733**	0.364	0.712**	-0.01	0.465*			Ca_i
-0.363	-0.395	-0.184	-0.24	-0.191	0.497*	-0.497*	-0.0374	0.427*	-0.171	0.189	-0.279	-0.004	-0.267	-0.414*	0.816**	0.741**	0.044				Mg_i
-0.276	-0.233	-0.199	-0.502*	-0.133	0.499*	-0.499*	-0.316	0.414*	0.079	-0.510*	0.383	0.063	-0.02	0.028	0.433*	0.363					Na_i
-0.411	-0.219	-0.21	-0.234	-0.188	0.264	-0.264	-0.056	0.452*	-0.197	-0.054	-0.051	0.086	-0.305	-0.442*	0.861**						EC_e
-0.402	-0.394	-0.321	-0.401	-0.305	0.547**	-0.547**	-0.145	0.576**	-0.178	-0.15	0.151	0.017	-0.142	-0.228							ESP
-0.09	0.458*	-0.209	-0.125	-0.171	-0.005	0.005	-0.272	-0.114	0.166	-0.540**	0.569**	0.392	0.559**								ECaP
-0.133	0.229	-0.059	-0.252	-0.047	0.017	-0.017	-0.373	-0.007	-0.045	-0.475*	0.329	0.227									EMgP
0.195	0.32	0.139	-0.224	0.128	-0.12	0.12	-0.19	-0.565**	0.407*	-0.430*	0.289										O.M
-0.035	0.146	-0.09	-0.201	-0.048	0.044	-0.044	-0.345	0.031	0.078	-0.754**											Clay%
0.338	-0.259	0.223	0.424*	0.159	-0.143	0.143	0.449*	-0.121	-0.069												Silt %
0.464*	-0.067	0.195	0.107	0.173	-0.003	0.003	-0.128	-0.405*													$CaCO_3$
-0.637**	-0.267	-0.405*	-0.189	-0.336	0.483	-0.483	-0.203														ρ_a
0.106	-0.198	-0.043	0.063	-0.028	-0.214	0.214															K_s
0.287	0.664**	0.373	0.622**	0.381	-1.00**																WSA>0.25
-0.287	-0.644**	-0.373	-0.622**	-0.381																	WSA% <0.25
0.514*	0.242	0.974**	0.243																		AI
0.213	0.277	0.226																			SC
0.633*	0.195																				MWD
-0.016																					Opti.size

EC i = EC of irrigation water. ECe = EC of soil. ECaP = Exchangeable Calcium percent

E Mg P = Exchangeable Magnesium. Ca_i, Mg_i, Na_i = Soluble Ca^{2+}, Mg^{2+} and Na^{+} in irrigation water.

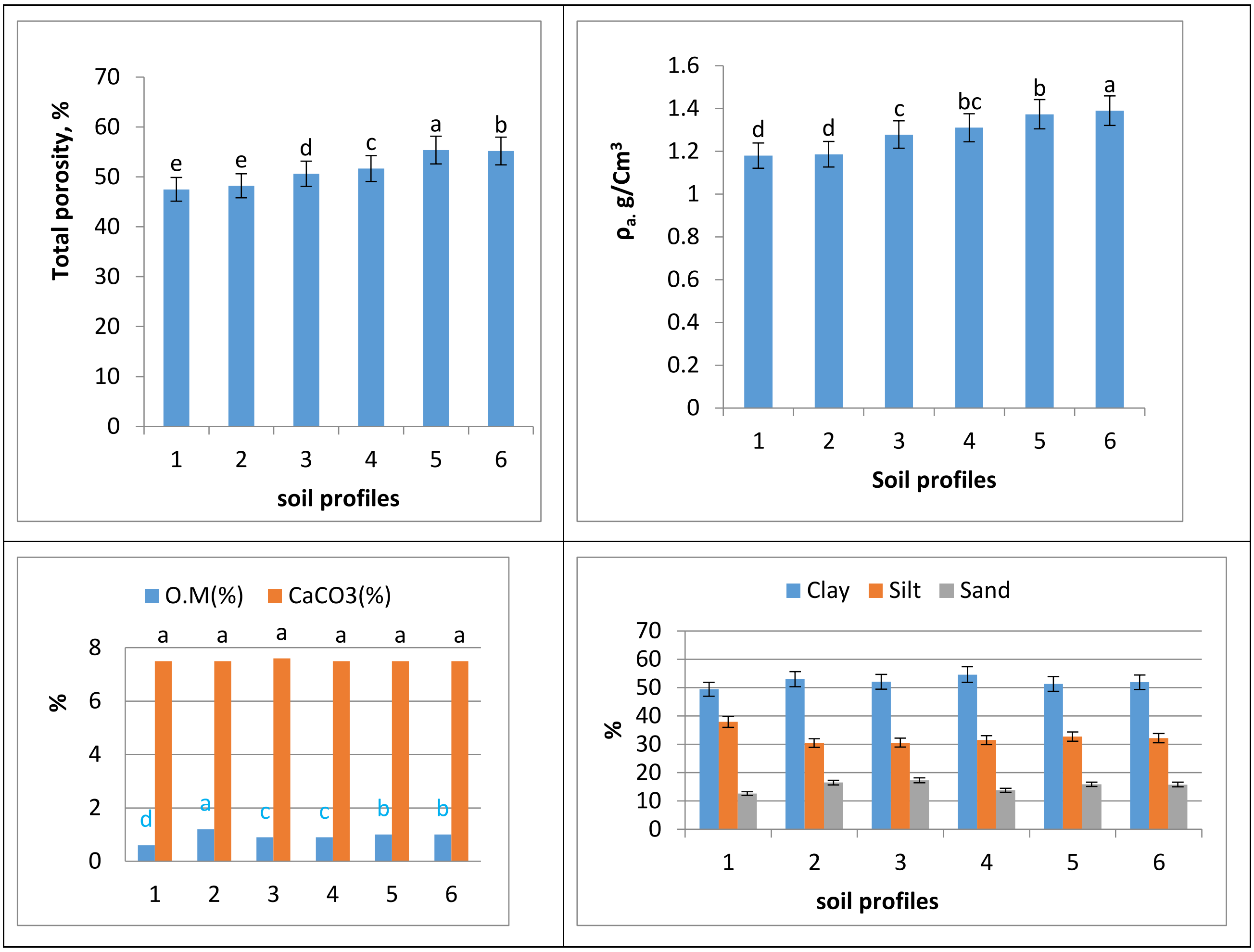

Fig. 5. Bulk density (ρ_a), Particle Size distribution, Organic matter (OM) and total $CaCO_3$.

Structure Coefficient (SC) showed a negative correlation with EC_i ,SAR and soluble $Na^+(Na_i)$ in the sequence of -0.544**,-0.411** and -0.502* . Also ,WSA>0.25mm has a similar negative correlation with EC_i , soluble $Mg^{++}(Mg_i)$, Na_i and ESP in the series of -0.683**, -0.497*, -0.499* and -0.457**, respectively. Such correlations as well as the above mentioned results indicate obviously the distructive effect of low water quality (salinity and effluents) on parameters of soil structure and consequently the necessity perform a sustainable amendment programs of soil reclamation for the arable area in the north of Nile Delta with more scarcity to a good quality of irrigation water .

4. Discussion

As a result of the deficiency of irrigation water to irrigate the whole available arable land in Egypt which includes new extension areas in Sinai and western desert, it is inevitable to use drainage and waste water in irrigation for new projects of crop production. Before decades, we have to use drainage and waste water for supplementation of irrigation requirements, especially in areas located to the Mediterranean Coast. Subsequently, the whole area located to the north of Nile Delta is subjected to hazards of salinity and sodicity **(Saffan,1984)**. Obtained data claimed a highly positive correlation (r =0.744**) between salinity of irrigation water and soil salinity, hence the increase of salinity of profiles 3 , 4 , 5 and 6 as compared to profiles 1 and 2. Exchangeable Na^+ was increased also in locations irrigated with less quality of irrigation water as profiles 4, 5 and 6. A similar data was found by **Amer et al. (1997)**, **Rahimi et al. (2019)** and **Sheferia et al. (2019)**.

Accordingly, many other physical properties of the soil will be influenced by the degradation effect of low quality of irrigation water . The above mentioned results stated that aggregation parameters as SC, WSA, for both groups (>0.25mm and <0.25mm), Optimum Size % and aggregation index were greatly affected by water quality e.g. EC, soluble and exchangeable Na^+ and many other quality of water criteria. Correlation Coefficient between required aggregation parameters and different water criteria has a negative relations, which assured hazards effect of low water quality on aggregation stability and corresponded soil structure . On the other hand, soil bulk density (ρ_a) was negatively influenced by water quality of irrigation water (EC_i and soluble Na as well as soluble Mg). Correlation Coefficient revealed clearly that the more salinity of irrigation water had contained, the more increase of bulk density deteriorate soil structure ,e.g. soil prosity,pore size distribution ,available water and etc.soil physical properties .

The results were in accordance with many authers. **El-Arquan and Kaoud(1981)**, **Saffan, (1984)** and **Zaman et al.,(2018)** explained the effect of water quality ,i.e ESP ,ex Mg, ex Ca as well as calcium carbonate and organic matter on stability of aggregation ,available water ,saturated hydraulic conductivity and pore size distribution**(Figure 5)** .

5. Conclusion

The quality of irrigation water had an effective effect on the physical and chemical properties of the soil. It was found that the highest values of salinity of irrigation water that irrigates profiles 5 and 6 led to increase in soil salinity of these profiles(1.6 , 0.99 dS/m respectively) and ESP of profiles 5 and 6 which reached to 23.4 % for each .Also, the lowest values of salinity of irrigation water that irrigates profiles 1 and 2 led to decrease in soil salinity of these profiles (0.47 , 0.45 dS/m, respectively) and led to lowest value of ESP in profile 2 (10.2%). On the contrary, profile 2 has the highest value of exchangeable calcium (27.6%). Finally, it recommended to place these soils under the study area within conservation and improvement programs, especially in areas irrigated with fully mixed water.

Conflicts of interest: There are no conflicts to declare.

Funding: No external fund for this work.
Acknowledgments: The authors would like to thank their institutions for providing the needed support.

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