

## THE EFFECT OF DIFFERENT WELL WATER QUALITY AND IRRIGATION METHODS ON SOME CHEMICAL PROPERTIES AND SALINITY DISTRIBUTION OF SOIL IN ARID AREAS: A CASE STUDY OF ISMAILIA GOVERNORATE

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**ABSTRACT:** *The increasing demand for irrigation water to secure food for growing populations with limited water supply suggests re-thinking the use of non-conventional water resources. The study was conducted to monitor the salinity distribution in soil under different well water quality and irrigation methods in specific sites of Ismailia Governorate region. Water and soil samples were collected from hundred randomly selected sites. Both soil and water samples were analyzed for chemical characteristic which included salinity, cations, anions and SAR. The findings indicated that the mean soil pH was 7.35 while the mean EC value was 3.73 dS/m. The mean cations in the water samples were 7.43, 5.98, 0.17, and 23.33 meq/l for  $Ca^{2+}$ ,  $Mg^{2+}$ ,  $K^+$ , and  $Na^+$ , respectively and the a mean value of Sodium Adsorption Ratio (SAR) was 9.11. The mean bicarbonates concentration detected in the irrigation water was 4.43 meq/l, while the mean chloride and sulphate were 29.95 and 2.49meq/l, respectively. The mean values of EC of soil were 3.94, 5.98 and 4.56 for drip, sprinkler and surface irrigation methods in depth 0-20 cm, respectively. While, in soil depth 20-40 cm the mean values of EC were 6.78, 4.94 and 2.99 for drip, sprinkler and surface irrigation methods, respectively. The spatial distribution of soil salinity in the soil horizons were found to be higher at shallow depths of 0-20cm and decreasing gradually up to a depth of 20-40cm. This trend is clear with surface and sprinkler irrigation method. In drip irrigated method, the salinity distribution showed a different pattern from that observed in surface and sprinkler irrigation. Salinity was the lowest in the surface layer (0-20 cm), and increased gradually with soil depth (20-40 cm). Salt concentration factor (SCF) of Ismailia soil under studies ranged between 0.14 to 6.33. The results showed that SCF varies according to water and soil quality and irrigation methods. EC of soil was positively and significantly correlated with  $Ca^{2+}$ ,  $Mg^{2+}$ ,  $Na^+$ ,  $K^+$ ,  $Cl^-$ ,  $HCO_3^-$  but positively and not significantly correlated with pH and  $SO_4^{2-}$ . The general trend showed that soil salinity increased with an increase in water salinity. Correlation coefficient (r) between EC of irrigation water and EC of soil was 0.550\*\*.*

**Key words:** *Salinity, irrigation methods, Salt concentration factor, Ismailia Governorate.*

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### INTRODUCTION

The continuous increase in the earth's population requires increasing quantities of water for domestic, industrial and agricultural needs. The progressive requirement for more water to irrigate crops for food when water resources are limited has led to reuse and recycling of the available water in agriculture (Ragab,

2005). In many regions of the world, drainage water is already used successfully for irrigation even when the water is saline (Grattan et al. 1994). Irrigation with saline water has become necessary not only in parts of the world with limited supplies of good quality water but also in areas affected by shallow

ground water where the main purpose is to reduce the depth of the water table.

Different studies were done in relation to the influence of the irrigation with different qualities on the soil salinity and some physical specifications. Having used saline water for irrigation Zartman and Gicharu, (1984) indicated that the soil salinity process was often slow and depending on the water salinity which may be hidden for years after irrigation. Sajadi *et al.* (2012) assessed the effect of the irrigation water quality on the soil; their results indicated that the soil chemical properties were influenced more by the irrigation water qualities than the physical and fertilization parameters. Gretan *et al.* (1996) studies the waters with high electric conductivity and concluded that if their conductivity was more than 3 (dS/ m), they would be highly limited in view of irrigation; of course, it is possible to use the waters with high salinity according to the conditions special to the product, soil properties, irrigation methods and climatic situation. Moran *et al.* (2001) concluded that the irrigation with inappropriate water, depending on the quality and rate of the consumed water and irrigation system, has different effects on the soil physical and chemical properties. The tests conducted on the soils irrigated with saline water with high percent of sodium indicated that if the salinity increased, the sodium and calcium concentration would increase in the soil saturation extract and the soil electric conductivity would decrease. In a study a great space of a region irrigated with saline water and the results indicated that high amounts of salinity in the irrigation water has considerable effect on the soil properties such as its salinity and the latter decreases the product operation (Perez *et al.* 2003).

Drip irrigation method is not affected by high wind velocity as it applies water directly to the root zone of plants

(Sharma, 2001). Its major advantages as compared to other methods include: higher crop yields, saving in water, increased fertilizer use efficiency, reduced energy consumption, tolerance to windy atmospheric conditions, reduced labor cost, improved disease and pest control, feasible for undulating sloppy lands, suitability on problem soils and improved tolerance to salinity (Michael, 2008). In a study established by Yildirim and Korukcu, (2000) reported that drip irrigation generally achieves better crop yield and balanced soil moisture in the active root zone with minimum water losses. On the average, drip irrigation saves about 70 to 80% water as compared to conventional flood irrigation methods (Camp, *et al.*, 2001). Furrow irrigation is said to be 30% in water use efficiency as compared to other conventional methods, Worldwide furrow irrigation is being adopted at about 90 percent of lands, reason behind is it's less need of energy. The water is being conserved in furrow irrigation method, as the water is applied to the root zones which are refilled at required depth (Tiercelin and Vidal, 2006). There are some disadvantages inherent with this technology (drip irrigation) such as; emitter clogging, which may be removed by the use of good quality filtration system and high material and installation cost. In past many studies have been conducted on drip irrigation method, even this farmers community prefer to adopt traditional flood irrigation methods. The mean target of this work is evaluating salinity status of Ismailia Governorate soils under irrigation with different quality of wells water and different irrigation methods.

## MATERIALS AND METHODS

### Study area:

This study was carried out in Ismailia Governorate located between the

latitudes of 30° 35' 59.99" N and the longitudes of 32° 16' 60.00" E. The climate of Ismailia has the arid climate of the interior desert with a high diurnal range in temperature. The maximum monthly average for temperature is 35.1C° in July, August. 19.9 in January. During night, the temperature decreases where the minimum average limit is 7.1C° in January and 20.6 C° in August. The average annual rainfall for the area is about 50 mm. The area receives approximately 60 % of the total rainfall in the months of November, December, January and February. The rain is usually falling in very heavy showers, which last for a very short period.

#### **Water samples:**

One hundred water samples were collected from 100 wells which present different districts of Ismailia Governorate. Water samples for determining the water quality in general and other elements. Some data about location, irrigation method and cultivated plant were reported in Table (1). The following chemical determinations were conducted for the Water samples: Electrical conductivity (EC, dS/m), pH, sodium and potassium, calcium and magnesium. Soluble anions (meq/l): Carbonate and Bicarbonate, Chloride, Sulphate. Chapman and Pratt (1961). Boron (mg/l) by colorimetric determination using spectrophotometer.

#### **Soil samples;**

The soil samples were taken at two depths (0 – 20 and 20-40 cm) from each area. Total number of the soil samples is 200 sample to present 100 profiles. The collected soil samples were air dried, finely ground to pass through a 2 mm sieve and stored for analysis in plastic bags. The following chemical determinations were conducted for the

soil samples; electrical conductivity (EC), soluble cations and soluble anions (meq/l) were determined in soil saturation extract as mentioned above in water samples analysis. pH was determined in soil suspension 1:2.5 soil water ratio. The data of the soil in the region has been collected to observe the changes in soil salinity and alkalinity for a given soil depth.

The salt concentration factor was measured by following Miyamoto and Chacon, 2006): Where:  $SCF = EC_e/EC_w$

SCF = Salt concentration factor.

EC<sub>e</sub> = Electrical conductivity of soil water paste extract.

EC<sub>w</sub> = Irrigation water conductivity.

## **RESULTS AND DISCUSSION**

The results obtained from water and soil analysis such as soil pH, electrical conductivity (EC), cations, anions and Sodium Adsorption Ratio (SAR) are shown in Table (2). The water quality parameters are also presented and compared with water quality standards. In addition, comparison between the results was also done.

### **Chemical properties of well water pH Values:**

The pH values varied between 6.89 to 7.88 with a mean value of 7.35. All the water pH values are slightly alkaline expect 5 samples having pH values slightly less than 7. (Table, 2). Ayers and West coast (1976) reported that, pH between (6.5) to (8.4) is considered very suitable for irrigation water. Generally, pH values for normal irrigation water should be between 6.00 and 7.00, while values above 7.00 are considered as of increasing hazard (Danko 1997). As it has a marked influence on other characteristics or reactions in the soil and water, as well as the way plants perform.

Table (1): Locality of the wells, irrigation method and cultivated crop.

No	Locality	irrigation method	Cultivated plant	No	Locality	irrigation method	Cultivated plant
1	Kantra Gharb	Surface	Wheat	51	Faid	Surface	Clover.
2		Drip	Maize	52		Drip	Pears
3		Surface	Olive	53		Drip	Olive
4		Drip	Alfalfa	54		Drip	Spear
5		Drip	Alfalfa	55		Drip	Olive
6		Drip	Onion	56	Kantra Gharb	Surface	Onion
7		Surface	Clover	57		Drip	Olive
8		Drip	Cantaloupe	58		Drip	Olive
9		Surface	Clover	59		Drip	Olive
10		Surface	Olive	60		Drip	Olive
11	El-Manaif	Sprinklerr	Wheat	61		Surface	Bean
12		Drip	Botatos	62		Drip	Paper
13		Drip	Olive	63		Surface	Wheat
14		Drip	Alfalfa	64		Sprinklerr	Clover
15		Surface	Olive	65		Drip	Olive
16	Kantra Shark	Drip	Olive	66	Drip	Olive	
17		Drip	Olive	67	Sprinklerr	Clover	
18		Drip	Alfalfa	68	Drip	Olive	
19		Drip	Tomato	69	Drip	Olive	
20		Surface	Wheat	70	Drip	Olive	
21		Drip	Olive	71	Drip	Paper	
22		Sprinklerr	Wheat	72	Drip	Olive	
23		Drip	Olive	73	Surface	Olive	
24		El-Manaiff	Drip	Olive	74	Drip	Olive
25	Drip		Olive	75	Drip	Olive	
26	Drip		Bean	76	Drip	Tomato	
27	Drip		Onion	77	Drip	Onion	
28	Sprinklerr		Wheat	78	Drip	Olive	
29	Drip		Olive	79	Sprinklerr	Wheat	
30	Drip		Alfalfa	80	Drip	Olive	
31	Faid	Drip	Onion	81	Drip	Alfalfa	
32		Surface	Wheat	82	Drip	Olive	
33		Drip	Cantaloupe	83	Drip	Olive	
34		Drip	Cantaloupe	84	Drip	Tomato	
35			Squash	85	Drip	Alfalfa	
36		Drip	Mango	86	Drip	Olive	
37		Drip	Onion	87	Drip	Paper	
38		Drip	Olive	88	Drip	Olive	
39		Drip	Guava	89	Drip	Olive	
40		Surface	Olive	90	Drip	Paper	
41		Drip	Onion.	91	Surface	Wheat	
42		Surface	Onion	92	Surface	Olive	
43		Drip	Olive	93	Drip	Paper	
44		Surface	Clover	94	Drip	Olive	
45		Surface	Clover.	95	Faid	Drip	Olive
46		Drip	Alfalfa	96		Drip	Alfalfa
47		Surface	Wheat	97		Sprinklerr	Clover
48		Drip	Olive	98		Drip	Olive
49		Drip	Olive	99		Drip	Olive
50		Drip	Olive	100		Drip	Olive

*The effect of different well water quality and irrigation methods on some .....*

Table (2): Chemical analysis of the water wells samples of Ismailia Governorate

NO.	pH	EC dS/m	Ca <sup>++</sup>	Mg <sup>++</sup>	Na <sup>+</sup>	K <sup>+</sup>	CO <sub>3</sub> <sup>=</sup>	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>=</sup>	B mg/l	SAR
			meq/l									
1	7.38	4.31	6.70	6.00	30.20	0.16	0.00	5.00	37.60	0.46	1.09	11.98
2	7.24	5.16	7.00	5.00	38.50	0.68	0.00	5.60	45.30	0.28	1.32	15.72
3	7.22	5.27	7.60	5.00	39.50	0.17	0.00	3.20	48.80	0.27	1.01	15.74
4	7.33	3.38	4.70	3.20	25.40	0.13	0.00	4.80	28.30	0.33	1.63	12.78
5	7.13	4.69	9.00	4.30	32.60	0.16	0.00	4.60	40.90	0.56	1.69	12.64
6	7.53	4.68	7.30	4.70	34.00	0.24	0.00	3.80	41.90	0.54	1.16	13.88
7	7.62	4.13	7.00	3.70	29.90	0.14	0.00	4.30	35.60	0.84	1.70	12.93
8	7.32	3.90	4.30	2.00	32.60	0.09	0.00	4.30	33.90	0.79	0.83	18.37
9	7.42	6.79	11.30	7.00	49.20	0.21	0.00	3.80	63.20	0.71	1.01	16.27
10	7.53	5.23	6.30	7.30	37.20	1.13	0.00	4.30	44.60	3.03	1.10	14.27
11	7.76	2.44	2.30	5.00	17.30	0.09	0.00	7.00	17.60	0.09	1.47	9.06
12	7.16	4.45	9.60	5.70	29.00	0.14	0.00	5.30	38.30	0.84	0.94	10.48
13	7.55	3.84	6.30	5.00	27.50	0.13	0.00	7.30	31.30	0.33	1.09	11.57
14	7.30	3.53	6.70	5.30	22.50	0.13	0.00	7.00	27.60	0.03	1.10	9.19
15	7.21	6.64	9.70	14.30	39.20	0.19	0.00	3.30	59.90	0.19	1.16	11.32
16	7.56	5.19	7.00	4.30	40.20	0.12	0.00	4.00	44.60	3.02	0.90	16.91
17	7.29	3.66	5.60	5.70	24.30	0.09	0.00	4.00	27.60	4.09	0.90	10.22
18	7.15	2.60	4.70	4.60	16.50	0.09	0.00	4.00	17.60	4.29	1.09	7.65
19	7.23	3.95	7.00	4.70	27.00	0.09	0.00	4.60	30.60	3.59	1.47	11.16
20	7.60	2.31	4.30	4.30	14.30	0.11	0.00	4.70	18.00	0.31	1.44	6.90
21	7.22	13.83	42.30	32.60	62.90	0.29	0.00	2.00	132.00	3.89	1.64	10.28
22	7.15	6.98	16.30	15.30	38.30	0.13	0.00	2.30	65.90	1.53	2.32	9.64
23	7.15	6.87	13.30	15.30	38.00	0.49	0.00	3.30	62.60	1.19	0.90	10.05
24	7.71	1.57	3.70	3.30	7.90	0.12	0.00	3.00	10.00	2.20	2.32	4.22
25	7.46	3.15	5.40	4.80	20.00	0.11	0.00	3.00	23.00	4.31	2.32	8.86
26	7.38	1.34	3.60	3.00	6.10	0.10	0.00	2.60	8.80	1.40	0.90	3.36
27	7.24	1.32	3.60	3.00	5.90	0.10	0.00	2.20	8.00	2.40	1.00	3.25
28	7.75	2.89	7.00	5.20	15.60	0.10	0.00	4.20	21.00	2.70	0.86	6.32
29	7.35	4.12	9.40	6.80	24.60	0.19	0.00	4.20	34.80	1.99	1.10	8.64
30	7.46	2.18	4.30	3.70	13.50	0.13	0.00	3.00	16.40	2.23	1.15	6.75
31	7.40	3.35	7.40	5.80	19.50	0.16	0.00	4.60	25.80	2.46	1.63	7.59
32	7.39	3.80	9.40	5.80	21.30	0.13	0.00	4.40	29.20	3.03	1.02	7.73
33	7.13	2.50	6.50	4.60	13.70	0.16	0.00	4.00	16.80	4.16	1.32	5.82
34	7.34	3.18	7.60	7.90	14.60	0.35	0.00	3.60	23.80	3.05	0.90	5.24
35	7.36	2.23	7.00	6.90	8.30	0.26	0.00	3.60	13.90	4.96	0.99	3.15
36	7.20	1.60	5.60	5.60	4.20	0.22	0.00	3.90	8.20	3.52	1.01	1.77
37	7.52	3.12	6.60	6.90	16.40	0.35	0.00	4.60	25.10	0.55	1.16	6.31
38	7.27	4.26	17.20	12.90	11.50	0.33	0.00	4.60	33.30	4.03	1.69	2.96
39	7.11	5.21	11.90	13.50	25.70	0.28	0.00	4.60	46.00	0.78	1.10	7.21
40	7.51	2.78	3.30	4.30	19.90	0.13	0.00	3.60	20.50	3.53	1.15	10.21
41	7.41	3.62	4.90	5.60	24.70	0.21	0.00	4.30	28.00	3.11	0.90	10.78
42	7.36	3.34	5.60	5.60	21.40	0.26	0.00	3.60	26.00	3.26	1.69	9.04
43	7.35	3.21	4.90	3.90	22.80	0.15	0.00	3.90	24.10	3.75	0.86	10.87
44	7.19	2.48	5.00	4.20	15.30	0.11	0.00	4.00	18.40	2.21	1.37	7.13
45	7.79	2.12	4.20	3.60	12.90	0.34	0.00	3.40	14.00	3.64	0.94	6.53
46	7.48	2.76	4.80	4.00	18.70	0.07	0.00	3.80	19.00	4.77	0.73	8.91
47	7.16	3.65	6.60	4.00	24.90	0.14	0.00	4.00	28.00	3.64	1.32	10.82
48	7.55	2.16	4.80	3.60	12.90	0.11	0.00	3.00	14.00	4.41	0.89	6.29
49	7.76	2.41	5.80	5.00	12.80	0.12	0.00	3.40	14.20	6.12	0.59	5.51
50	7.56	2.89	6.40	5.00	17.40	0.12	0.00	4.00	19.00	5.92	1.79	7.29

Table (2): Cont.

NO.	pH	EC dS/m	Ca <sup>++</sup>	Mg <sup>++</sup>	Na <sup>+</sup>	K <sup>+</sup>	CO <sub>3</sub> =	HCO <sub>3</sub> -	Cl-	SO <sub>4</sub> =	B mg/l	SAR
			meq/l									
51	7.44	2.70	6.20	5.80	15.00	0.11	0.00	4.00	17.40	5.71	1.02	6.12
52	7.56	2.29	6.40	4.80	10.70	0.07	0.00	3.80	11.20	6.97	0.67	4.52
53	7.32	4.83	10.60	6.60	29.60	0.16	0.00	3.80	38.60	4.56	1.24	10.09
54	7.36	4.47	10.00	7.60	26.30	0.16	0.00	5.20	38.40	0.46	1.53	8.87
55	7.41	2.82	6.60	5.00	16.70	0.09	0.00	4.00	19.20	5.19	0.64	6.93
56	7.25	2.61	5.50	4.40	16.10	0.08	0.00	4.00	17.80	4.28	1.07	7.24
57	7.33	3.86	6.60	4.60	25.70	0.14	0.00	4.20	29.20	3.64	1.03	10.86
58	7.21	2.92	5.80	4.40	19.60	0.11	0.00	4.00	22.40	3.51	1.31	8.68
59	6.98	3.11	6.40	5.20	19.30	0.11	0.00	3.80	23.60	3.61	0.92	8.01
60	7.46	2.88	6.40	3.40	18.90	0.09	0.00	4.00	21.00	3.79	1.01	8.54
61	7.68	2.09	5.00	4.60	10.70	0.10	0.00	4.00	12.30	4.10	0.92	4.88
62	7.21	3.68	5.80	4.60	25.50	0.14	0.00	3.40	28.00	4.64	0.64	11.18
63	7.47	2.09	4.90	4.60	10.80	0.08	0.00	4.00	12.00	4.38	1.71	4.96
64	7.47	2.01	4.70	4.20	10.50	0.10	0.00	3.60	11.30	4.60	1.24	4.98
65	7.25	3.20	6.20	4.40	22.30	0.16	0.00	4.00	26.00	3.06	1.64	9.69
66	7.38	2.87	6.40	4.80	15.70	0.11	0.00	3.80	19.00	4.21	1.37	6.63
67	7.35	3.50	6.30	4.20	23.70	0.14	0.00	3.40	27.80	3.14	1.44	10.34
68	7.64	2.37	5.00	4.20	14.30	0.11	0.00	3.50	16.00	4.11	1.01	6.67
69	7.22	6.90	14.40	8.60	45.90	0.16	0.00	4.00	61.00	4.06	1.44	13.54
70	7.36	4.83	8.20	6.40	27.60	0.16	0.00	5.00	37.20	0.16	1.70	10.22
71	7.53	2.38	4.00	5.80	15.90	0.16	0.00	3.20	22.40	0.26	1.71	7.18
72	7.33	4.62	10.00	6.60	29.10	0.16	0.00	3.40	38.00	4.46	1.09	10.10
73	7.46	7.12	15.40	8.20	46.50	0.16	0.00	6.00	60.80	3.46	1.16	13.54
74	7.51	2.96	7.40	6.00	16.10	0.13	0.00	4.20	22.40	3.03	0.83	6.22
75	7.41	7.51	14.00	9.00	51.70	0.16	0.00	5.60	66.80	2.46	1.01	15.25
76	7.24	3.38	7.90	6.30	18.90	0.13	0.00	4.00	26.00	3.23	1.10	7.09
77	7.33	3.15	6.20	6.10	18.30	0.16	0.00	3.70	23.90	3.16	0.54	7.38
78	7.23	3.17	4.30	5.70	21.20	0.17	0.00	3.60	23.30	4.47	1.01	9.48
79	6.94	7.37	17.90	10.00	44.80	0.16	0.00	4.90	64.60	3.36	1.06	11.99
80	7.25	6.53	10.70	10.00	44.30	0.22	0.00	4.90	58.00	2.32	1.63	13.77
81	7.23	3.37	5.70	3.70	23.90	0.17	0.00	4.30	26.00	3.17	0.90	11.02
82	7.19	4.35	8.30	7.70	27.20	0.19	0.00	3.30	36.90	3.19	1.09	9.62
83	6.89	3.89	8.70	6.30	23.00	0.22	0.00	4.90	31.90	1.42	0.94	8.40
84	7.12	2.27	4.70	3.70	14.10	0.14	0.00	3.90	15.30	3.44	0.54	6.88
85	7.06	5.94	13.30	9.00	36.80	0.09	0.00	5.00	53.00	1.19	1.79	11.02
86	7.51	3.44	7.70	4.80	23.50	0.09	0.00	6.30	29.60	0.19	1.23	9.40
87	7.80	3.15	6.00	5.30	18.90	0.13	0.00	6.70	22.30	1.33	0.64	7.95
88	7.25	4.22	9.00	7.70	25.30	0.20	0.00	5.60	35.90	0.70	0.73	8.76
89	6.97	2.48	5.70	4.00	14.50	0.13	0.00	6.30	18.00	0.03	1.01	6.58
90	7.22	2.96	5.70	3.70	19.90	0.14	0.00	6.30	23.00	0.14	1.22	9.18
91	7.88	2.84	4.00	6.70	17.50	0.14	0.00	6.90	21.30	0.14	1.23	7.57
92	7.05	3.11	4.00	4.30	21.50	0.14	0.00	4.90	24.60	0.44	1.53	10.55
93	7.52	2.76	4.00	3.40	19.50	0.14	0.00	6.30	20.30	0.44	0.90	10.14
94	7.19	2.65	5.00	3.90	16.90	0.13	0.00	6.70	19.00	0.23	1.16	8.01
95	7.27	5.57	9.40	6.00	39.50	0.14	0.00	5.80	46.80	2.44	1.09	14.23
96	7.39	3.23	4.60	4.40	23.10	0.14	0.00	6.80	25.20	0.24	0.90	10.89
97	7.02	3.89	6.40	5.40	26.30	0.13	0.00	7.40	29.80	1.03	1.70	10.83
98	7.45	2.53	5.00	4.60	15.90	0.11	0.00	7.00	18.20	0.41	1.47	7.26
99	7.70	2.33	5.00	3.40	14.80	0.11	0.00	7.00	16.30	0.01	1.08	7.22
100	7.27	3.20	6.60	5.00	20.80	0.16	0.00	4.60	23.00	4.96	1.22	8.64

**EC Values:**

The concentration of total salt content in irrigation waters is estimated in terms of EC<sub>w</sub> and it may be the most important parameter for assessing the suitability of irrigation waters, Ajayi *et al.*, (1990). It gives an estimate of the total amounts of dissolved salts in the water and the total amount and kinds of salts determine the suitability of the water for irrigation use (Belan, 1985). The wells water EC ranged from 1.32 to 13.83 with mean value 3.73 dS/m. Generally, the suitability for irrigation water ranged from <0.7 to 2.0 dS/m. Comparing with FAO EC<sub>w</sub> blow 3.0 was suitable limit for irrigation (FAO., 1985).

According to the classification of saline waters as shown in Table (3), It can be noticed that 4% of the water samples were slightly saline, 95% were moderately saline, while 1% highly saline

**Soluble Na**

The amount of Na ions in the water predicts the sodicity danger of the water (Singah, 2000). The Na ions of wells water ranged from 4.20 to 62.90with a mean value of 23.33 meq/l,. Sodium ions are important criteria for irrigation water

quality because of its effect on soil permeability and water infiltration (Ajayi *et al.*, 1990). Sodium also contributes directly to the total salinity of the water and may be toxic to sensitive crops such as fruit trees. Sodium ions cause deflocculating of particles and subsequent sealing of soil pores thereby preventing water passage into the soil. Sodic water causes excess Na to be adsorbed to exchange complex and in the process causes dispersion of aggregates and thereby blocking pores in the soil and preventing or reducing infiltration of applied water. Generally, values greater than 0.4meq/l in terms of Na concentrations are regarded as posing increasing severity of sodicity especially in soils high in clay content (Davis and Dewest, 1966). The value recorded in a few well irrigation water may therefore be interpreted as posing severe risk factor of sodium toxicity to the soil. Na concentration below 900 mg/lis within the permissible limit for irrigation water. Based on the results and on the standards given by FAO, 1985 for using the water and for discharging them on land for irrigation (FAO, 1985).

**Table (3). Classification of saline waters\***

Water class	Electrical conductivity dS/m	Salt concentration mg/l	Type of water
Non-saline	<0.7	<500	Drinking and irrigation water
Slightly saline	0.7 – 2	500-1500	Irrigation water
Moderately saline	2 – 10	1500-7000	Primary drainage water and groundwater
Highly saline	10-25	7000-15 000	Secondary drainage water and groundwater
Very highly saline	25 – 45	1 5 000-35 000	Very saline groundwater
Brine	>45	>45 000	Seawater

\*FAO, 1992, The use of saline waters for crop production - FAO irrigation and drainage paper 48

### **Soluble Ca<sup>2+</sup> and Mg<sup>2+</sup>:**

The calcium in well water ranged from 2.30 to 42.30 meq/l, with a mean value of 7.43 meq/l. The normal range of Ca<sup>2+</sup> in irrigation water should be between 0 – 1.0 meq/l. The magnesium in well water ranged from 2.00 to 32.60 meq/l, with a mean value of 5.98 meq/l, while the normal range of Mg<sup>2+</sup> should be between 0 – 0.2 meq/l (Christenson, *et al.*, 1977). By these criteria the calcium content of irrigation water could be described as being above the safe limit. This also applies to the magnesium content which is above the recommended mean. The magnesium content of water is also considered as important qualitative criteria in determining the quality of water for irrigation because more magnesium in water will adversely affect crop yields, as the soils become more alkaline. Generally, calcium and magnesium maintain a state of equilibrium in most waters (Christenson, *et al.*, 1977). The combined effect of these two ions is in their countering the negative effect of the sodium by lowering the SAR. According by FAO, 1985 standard limit for calcium and magnesium in Irrigation water were below 400 and 60 mg/l) for calcium and magnesium, respectively (FAO, 1985).

### **Soluble potassium:**

The potassium in well water ranged from 0.07 to 1.13 meq/l with a mean value of 0.17. The presence of potassium ions in excessive amounts does not constitute any risk and may even supplement crops' needs as only values exceeding 1.3 meq/l may be considered as posing any serious risk factor with irrigation water. The standard limit for irrigation water recorded 0.2 mg/l for potassium (FAO, 1985).

### **Anions**

#### **Soluble carbonate and bicarbonates:**

The quality of the irrigation water in

terms of anions is as shown in Table (2) . The bicarbonate in well water ranged from 2.00 to 7.40 meq/l, with a mean value of 4.43 meq/l. The normal safe ranking for carbonate (CO<sub>3</sub><sup>2-</sup>) and bicarbonates (HCO<sub>3</sub><sup>-</sup>) are 0.03 and 0.16 meq/l, respectively (Landon, 1991). By this criteria therefore, the irrigation water could be described as being at severe risk with regards bicarbonates. High carbonate and bicarbonate in water essentially increases the sodium hazard of the water to a level greater than that indicated by the SAR. High HCO<sub>3</sub><sup>-</sup> tend to precipitate calcium carbonate (CaCO<sub>3</sub>) and magnesium carbonate (MgCO<sub>3</sub>), when the soil solution concentrates during soil drying. If the concentrations of calcium and magnesium in soil solution are reduced relative to sodium, the SAR of the soil solution tends to increase (Michael, 1985). High alkalinity indicates that the water will tend to increase the pH of the soil or growing media, possibly to a point that is detrimental to plant growth. Another aspect of alkalinity is its potential effect on sodium. Soil irrigated with alkaline water may, upon drying, cause an excess of available sodium. Several potential sodium problems as mentioned above could therefore result. Among the components of water alkalinity, bicarbonates are normally the most significant concern. The concentration of the CO<sub>3</sub><sup>2-</sup> in groundwater is generally lower than of the HCO<sub>3</sub><sup>-</sup> ions (El-Aassy *et al.* 2015). High levels of bicarbonates can be directly toxic to some plant species. Bicarbonate levels above 3.3 cmol/l will cause lime (calcium and magnesium carbonate) to be deposited on soils and even on foliage especially when irrigated with overhead sprinklers. This may be undesirable for vegetable plants. Similar levels of bicarbonates may also cause lime deposits to form on roots, which can be especially damaging too many tree species (Adamu, 2013).



### **Soluble chloride:**

The chloride in well water ranged from 8.00 to 132.0 meq/l, with a mean value of 29.95 meq/l. Chloride (Cl<sup>-</sup>) ions are one of the anions in irrigation water responsible for the potential of the water phytotoxicity. The normal and safe limit for chloride ions in irrigation water should not exceed 0.85 meq/l (Landon, 1991).

### **Soluble sulphate:**

Sulphate (SO<sub>4</sub><sup>2-</sup>) is one of the major anion occurring in natural waters. The permissible limit of sulphate (SO<sub>4</sub><sup>2-</sup>) is 20.8 meq/L according to FAO., (1985). The sulphate (SO<sub>4</sub><sup>2-</sup>) concentrations in well water ranged from 0.01 to 6.47 meq/l, with mean value 2.53, from the studied samples fall within the desirable limit.

### **SAR values:**

The SAR values ranged between 1.77 and 18.37 with a mean value of 9.11. The limit recommended of SAR by the FAO, (1985) for irrigation water is (6.0-12.0). The SAR relates the relative concentration of Na to the combined concentrations of Ca and Mg ions. Increasing sodicity hazards may be associated with values exceeding 6. As SAR is a factor of sodium against calcium and magnesium, the high values recorded may not be a surprise as the sodium values are also relatively high. The results reveal that water may have the potential to be hazardous in some locations to the soil as well as to the crop grown, because the two most important parameters used in assessing the safety of irrigation water; namely, Water salinity (EC<sub>w</sub>), Sodium ions and the associated SAR are above the safe limits.

### **Status of boron in well water of Ismailia Governorate area**

Boron is widely distributed in surface water and groundwater. The boron concentrations vary greatly depending on

boron content of local geologic formations and anthropogenic sources of boron. Boron is naturally released to soil and water by rainfall, weathering of boron - containing minerals, desorption from clays and decomposition of boron containing organic matter (Deshmukh, 2015). Due to over irrigation the soils from the well of Ismailia area are suffering from the problems like salinization and alkalization. To minimize their problems and considering the importance of boron in the fertility of soils, it was decided to estimate the boron concentration in the groundwater from Ismailia area. 100 well water samples were analyzed for B (Table, 2). The boron concentrations ranged from 0.54 to 2.32 mg/l, with a mean value of 1.19 mg/l. It is seen from the above table that the boron content in 39% samples was below 1 ppm. This indicates that 39% samples have lower values of boron thereby reflecting less toxicity hazard, 53% between 1 to 2 ppm boron (medium) and 8% over 2 ppm boron (high). The high concentrations of B are not expected to cause any toxicity for plant grown in Ismailia soils. This is attributed to B precipitates as calcium borate in soils (Gupta, 1974). The possible means to counteract the toxicity of boron is through proper selection of crops. Alfalfa, wheat, barley, oats, cotton, sugar beet, sorghum and maize are reported to be tolerant to boron (5-10 mg/l). The oil seeds, legumes, citrus and horticultural plants are in general sensitive to boron. The tolerance of crops to boron increases in the presence of soluble calcium, nitrogenous and phosphates fertilizers and decreases with increase in salinity (Gupta, 1974). Therefore, adequate fertilization could help in minimizing boron toxicity. However, it is further inferred that boron is in toxic concentration in saline groundwater from irrigated agriculture possibly due to restricted leaching.

However, high levels of boron in saline soils can be easily reduced by leaching alone and in alkali soils by leaching after treatment with gypsum.

### Assessment of soil quality

The results of the soils analysis of the various collected samples are presented in Table (4). The results include soil pH, soil salinity, (ECe), chlorides, sulphate, carbonate and bicarbonates, calcium, magnesium, potassium, sodium.

### Soil salinity (ECe)

Electrical conductivity of soil saturation paste extracts (ECe) for each soil according to depth was presented in Table (4). The ECe of soil irrigated with well water ranged from 0.47 to 22.3 dS/m, with a mean value of 5.03 dS/m. However, even when water with a relatively low level of salinity is used for irrigation, soil salinity can increase under arid conditions. This is because of salts accumulations during the weathering process and was not leached from the root zone due to low precipitation. When irrigation is introduced, the salts present in arid soils become soluble and are redistributed within the root zone (Ganjegunte *et al.*, 2017). Moreover, the amount of irrigation is not sufficient to overcome the high potential evapotranspiration demands resulting in accumulation of salts close to surface due to evapo-concentration. For example, the sandy textured nature of the soil as found in study area of Ismailia Governorate (no shown data) may necessitate higher irrigation frequency which in semi-arid climate like the area under study may not be desirable because of the tendency of excessive evaporation which may precipitate salts on the surface of the soil and which may be disadvantageous to non-tolerant varieties. As expected, mean

of root zone soil salinities decreased depending on soil depth. Ben Ahmed *et al.* (2012) investigated the effects of saline irrigation water on soil salinity distribution and some physiological traits. They concluded that saline water irrigation has led to a significant increase in soil salinity; soil salinity and soil moisture variations were not only dependent on water salinity level but are also controlled by a multitude of factors particularly the soil texture, the distance from the irrigation source and climatic conditions (rainfall pattern, temperature average).

### pH Values:

Data in Table (4) show that the pH of soil irrigated with well water ranged from 8.10 to 8.70 with a mean value of 8.28. The pH readings across the soil profile depth were slightly alkaline for almost profile of soil under study. The presence of higher concentrations of carbonates and bicarbonates in the soil further supports the alkalinity in the soil because it implies that most of the dissolved carbon dioxide and carbonates must have been increased to either carbonic acid ( $H_2CO_3$ ) or in the transitional state of bicarbonate. The slightly alkaline nature of the soil will not enhance the availability of nutrients and may further facilitate the solubilization of sodium ions which are the primary agents of salinization and alkalization in irrigated soils (Alhasn, 1996).

### Soluble cations and anions:

The sodium concentrations of soil irrigated with well water ranged from 2.80 meq/l to 136.1 meq/l, with mean value 27.65 meq/l. The higher sodium concentrations and higher concentration of chloride makes the salinity in the soil to be in a form of sodium chloride (NaCl).

***The effect of different well water quality and irrigation methods on some .....***

**Table (4): Chemical analysis of the soil water paste extract and pH of Ismailia soil samples.**

No	Depth Cm	SP	EC dS/m	pH	Ca <sup>++</sup>	Mg <sup>++</sup>	Na <sup>+</sup>	K <sup>+</sup>	CO <sub>3</sub> <sup>=</sup>	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>=</sup>
					meq/l							
1	0-20	20.00	1.65	8.40	3.50	4.50	7.80	0.33	0.00	3.00	12.70	0.43
	20-40	21.00	1.42	8.40	3.00	4.50	5.80	0.38	0.00	3.00	7.80	2.88
2	0-20	25.00	1.79	8.20	4.50	2.50	9.80	0.18	0.00	2.10	14.70	0.18
	20-40	23.00	1.59	8.20	3.50	2.50	9.50	0.13	0.00	2.60	12.70	0.33
3	0-20	24.50	1.21	8.30	2.50	3.50	5.80	0.15	0.00	3.00	6.90	2.05
	20-40	24.00	1.13	8.10	3.00	2.50	5.30	0.13	0.00	3.00	6.40	1.53
4	0-20	20.50	0.47	8.20	1.00	0.50	2.90	0.11	0.00	1.50	3.00	0.01
	20-40	23.00	0.71	8.40	2.00	1.20	3.50	0.16	0.00	2.50	4.00	0.36
5	0-20	21.50	1.59	8.30	3.50	4.00	7.60	0.56	0.00	2.50	12.00	1.16
	20-40	22.50	1.93	8.10	7.00	5.00	5.00	1.94	0.00	2.00	12.00	4.94
6	0-20	24.00	1.35	8.20	2.50	3.50	6.70	0.23	0.00	2.50	10.00	0.43
	20-40	21.00	1.65	8.50	3.00	6.50	4.80	1.50	0.00	2.50	9.50	3.80
7	0-20	23.00	2.11	8.30	5.50	5.50	8.90	0.30	0.00	2.50	17.50	0.20
	20-40	22.00	0.83	8.20	2.50	2.50	2.80	0.29	0.00	1.50	6.50	0.09
8	0-20	21.50	1.45	8.30	2.70	1.60	8.10	1.51	0.00	3.50	9.50	0.91
	20-40	23.00	1.79	8.20	3.50	4.70	8.00	0.97	0.00	5.00	12.00	0.17
9	0-20	67.00	9.93	8.40	30.50	25.50	41.40	1.50	0.00	4.50	93.00	1.40
	20-40	48.00	2.46	8.40	4.00	3.50	16.50	0.19	0.00	2.00	22.00	0.19
10	0-20	24.00	2.21	8.20	6.50	4.20	10.80	0.26	0.00	3.00	18.00	0.76
	20-40	22.50	0.95	8.20	3.00	3.00	3.20	0.13	0.00	3.00	5.50	0.83
11	0-20	25.50	1.53	8.30	6.00	5.00	3.50	0.23	0.00	2.50	7.50	4.73
	20-40	24.00	1.21	8.20	3.50	1.00	6.60	0.11	0.00	2.50	8.00	0.71
12	0-20	25.00	1.10	8.30	3.90	2.50	3.60	0.22	0.00	6.00	4.00	0.22
	20-40	22.50	7.79	8.20	22.50	22.00	31.70	0.43	0.00	3.50	71.60	1.53
13	0-20	25.00	4.75	8.20	18.00	14.50	14.00	0.36	0.00	3.50	42.00	1.36
	20-40	26.50	7.73	8.70	22.50	22.00	31.50	0.41	0.00	3.50	71.50	1.41
14	0-20	24.50	3.57	8.30	7.50	5.00	22.30	0.48	0.00	5.50	27.50	2.28
	20-40	23.50	6.87	8.20	11.50	14.50	41.60	0.85	0.00	5.50	58.50	4.45
15	0-20	21.50	5.93	8.20	10.00	7.00	40.90	0.67	0.00	5.00	50.50	3.07
	20-40	21.00	1.97	8.20	4.00	3.50	11.90	0.26	0.00	5.00	12.50	2.16
16	0-20	23.00	4.65	8.30	16.50	12.70	15.30	0.59	0.00	4.00	40.20	0.89
	20-40	20.00	7.65	8.20	12.00	15.30	46.70	0.97	0.00	2.50	70.70	1.77
17	0-20	23.00	2.85	8.10	6.80	5.80	15.60	0.31	0.00	3.50	21.30	3.71
	20-40	21.00	4.79	8.40	18.00	14.60	14.20	0.36	0.00	3.50	42.10	1.56
18	0-20	23.50	1.28	8.10	3.80	2.50	5.60	0.18	0.00	3.80	6.00	2.28
	20-40	25.00	2.25	8.10	4.50	4.00	13.80	0.26	0.00	4.50	15.00	3.06
19	0-20	22.50	6.10	8.10	13.00	13.00	33.50	1.30	0.00	4.00	53.50	3.30
	20-40	25.50	9.13	8.50	15.50	13.50	60.20	1.10	0.00	3.50	85.50	1.30
20	0-20	22.00	2.67	8.30	10.50	6.30	9.30	0.17	0.00	2.50	23.70	0.07
	20-40	21.00	2.10	8.20	8.80	5.20	6.10	0.20	0.00	2.50	14.40	3.40
21	0-20	28.50	11.20	8.50	23.50	23.00	62.40	0.76	0.00	4.00	104.50	1.16
	20-40	27.50	22.30	8.20	41.00	43.50	136.10	1.12	0.00	4.00	216.50	0.72
22	0-20	23.00	6.15	8.30	13.00	12.50	33.40	1.30	0.00	4.00	53.40	2.80
	20-40	21.00	4.72	8.50	9.50	8.00	26.30	1.30	0.00	4.60	39.60	0.90
23	0-20	32.50	4.63	8.10	16.50	12.50	15.10	0.59	0.00	4.00	40.00	0.69
	20-40	23.50	10.10	8.50	27.00	20.50	51.10	1.70	0.00	3.50	95.50	1.30
24	0-20	23.00	2.20	8.20	7.10	4.60	9.00	0.20	0.00	2.50	16.80	1.60
	20-40	25.50	2.40	8.10	4.00	3.40	16.50	0.19	0.00	2.00	22.00	0.09
25	0-20	23.40	2.97	8.30	6.00	4.00	18.50	0.51	0.00	4.00	24.00	1.01
	20-40	26.80	3.36	8.10	7.00	6.00	19.70	0.49	0.00	3.50	22.50	7.19

Table (4): Cont.

No	Depth Cm	SP	EC dS/m	pH	Ca++	Mg++	Na+	K+	CO3=	HCO3-	Cl-	SO4=
					meq/l							
26	0-20	20.00	1.25	8.40	4.00	3.50	4.74	0.46	0.00	2.50	7.50	2.70
	20-40	20.50	1.46	8.20	5.00	5.50	3.20	0.65	0.00	3.00	8.00	3.35
27	0-20	21.50	1.96	8.30	6.50	3.00	9.30	0.46	0.00	2.50	16.00	0.76
	20-40	24.50	5.17	8.20	9.00	7.50	33.30	0.33	0.00	2.00	48.00	0.13
28	0-20	21.50	4.62	8.50	9.50	8.00	26.20	1.30	0.00	4.50	39.50	1.00
	20-40	21.00	3.75	8.20	7.50	5.50	21.50	1.50	0.00	3.50	32.00	0.50
29	0-20	21.50	6.75	8.20	13.00	11.00	37.90	2.56	0.00	4.00	57.00	3.46
	20-40	22.50	12.35	8.30	23.50	19.00	72.30	2.20	0.00	4.50	106.00	6.50
30	0-20	21.50	1.43	8.20	3.50	2.00	8.20	0.19	0.00	3.00	10.50	0.39
	20-40	21.00	2.16	8.20	5.00	4.00	11.60	0.16	0.00	3.50	16.50	0.76
31	0-20	24.00	3.25	8.20	11.50	12.50	5.60	2.20	0.00	4.50	10.00	17.30
	20-40	22.50	3.42	8.20	11.00	13.50	6.30	2.50	0.00	4.00	12.00	17.30
32	0-20	24.10	6.93	8.50	12.00	9.50	45.70	1.00	0.00	3.50	63.50	1.20
	20-40	23.80	6.46	8.40	12.50	8.00	42.90	1.03	0.00	4.00	60.00	0.43
33	0-20	27.00	2.68	8.50	11.50	9.00	6.00	0.16	0.00	3.00	19.60	4.06
	20-40	27.50	2.85	8.20	13.50	8.50	5.30	0.20	0.00	3.50	17.00	7.00
34	0-20	25.50	3.00	8.20	9.00	8.00	12.00	0.82	0.00	4.50	22.50	2.82
	20-40	27.50	3.29	8.30	11.00	8.00	12.00	0.89	0.00	4.50	22.00	5.39
35	0-20	24.50	2.67	8.30	6.00	6.00	14.00	0.62	0.00	5.00	17.00	4.62
	20-40	24.70	2.71	8.20	6.50	7.00	11.60	1.10	0.00	4.00	16.00	6.20
36	0-20	22.50	1.99	8.30	6.50	6.00	6.10	1.08	0.00	3.50	11.50	4.68
	20-40	22.50	3.20	8.20	13.50	6.50	10.50	0.85	0.00	3.50	23.00	4.85
37	0-20	25.20	3.52	8.20	8.20	6.30	19.00	0.83	0.00	4.00	25.20	5.13
	20-40	24.10	3.66	8.20	8.00	8.30	19.00	0.41	0.00	4.00	26.00	5.71
38	0-20	26.50	5.10	8.40	13.00	7.00	29.20	0.77	0.00	4.50	42.50	2.97
	20-40	25.70	7.23	8.10	18.50	8.50	43.10	0.95	0.00	4.50	63.00	3.55
39	0-20	23.50	5.10	8.20	22.50	14.50	8.90	2.20	0.00	2.50	42.00	3.60
	20-40	20.00	5.86	8.70	22.00	17.50	15.60	2.30	0.00	3.00	52.50	1.90
40	0-20	22.70	4.39	8.20	6.50	5.50	30.20	1.49	0.00	4.00	35.00	4.69
	20-40	21.00	4.36	8.20	4.50	4.00	32.20	2.51	0.00	4.00	36.00	3.21
41	0-20	23.30	3.23	8.30	4.50	3.00	22.30	0.85	0.00	3.50	26.00	1.15
	20-40	24.30	7.73	8.30	10.00	15.00	48.30	2.95	0.00	4.50	68.00	3.75
42	0-20	24.00	5.29	8.30	13.50	15.00	21.60	1.46	0.00	4.50	44.00	3.06
	20-40	16.00	3.65	8.50	7.50	12.00	16.80	0.61	0.00	3.50	27.50	5.91
43	0-20	21.00	2.73	8.20	9.00	11.00	6.00	0.46	0.00	2.50	17.00	6.96
	20-40	20.00	3.52	8.30	16.00	6.70	11.70	0.26	0.00	3.00	29.00	2.66
44	0-20	17.50	2.58	8.30	8.00	6.70	9.40	0.30	0.00	4.00	16.40	4.00
	20-40	21.00	1.34	8.20	2.80	2.00	7.20	0.26	0.00	4.00	8.00	0.26
45	0-20	22.50	3.89	8.30	18.50	13.50	6.30	0.31	0.00	2.00	22.50	14.11
	20-40	20.80	2.75	8.20	10.50	6.50	9.10	0.17	0.00	2.50	23.50	0.27
46	0-20	24.80	2.56	8.20	2.50	3.50	18.70	0.37	0.00	3.50	21.50	0.07
	20-40	20.00	6.32	8.20	9.00	9.50	43.60	0.67	0.00	2.00	60.00	0.86
47	0-20	24.00	5.70	8.20	19.50	13.00	22.60	1.89	0.00	2.50	52.50	1.99
	20-40	21.50	2.87	8.30	6.00	4.00	17.40	0.80	0.00	1.50	25.50	1.20
48	0-20	22.50	0.83	8.20	2.00	1.00	4.60	0.20	0.00	2.00	5.50	0.30
	20-40	23.00	4.46	8.50	12.00	11.00	19.50	0.72	0.00	4.00	39.00	0.22
49	0-20	23.10	1.97	8.20	5.50	3.30	10.20	0.18	0.00	4.00	12.00	3.18
	20-40	23.10	2.89	8.30	6.80	5.80	15.40	0.31	0.00	3.50	21.50	3.31
50	0-20	22.00	2.54	8.20	4.50	3.50	15.90	0.33	0.00	4.00	20.00	0.23
	20-40	20.00	10.52	8.40	31.50	19.50	51.70	1.54	0.00	5.50	97.00	1.74

***The effect of different well water quality and irrigation methods on some .....***

**Table (4): Cont.**

No	Depth Cm	SP	EC dS/m	pH	Ca++	Mg++	Na+	K+	CO3=	HCO3-	Cl-	SO4=
					meq/l							
51	0-20	19.30	2.48	8.50	6.20	6.40	10.30	2.40	0.00	4.50	17.90	2.90
	20-40	15.00	2.35	8.40	5.30	5.50	8.90	3.60	0.00	2.50	15.00	5.80
52	0-20	21.70	2.31	8.20	7.00	6.00	8.20	0.74	0.00	4.00	16.00	1.94
	20-40	26.50	2.75	8.10	7.00	5.00	13.80	0.56	0.00	3.50	22.00	0.86
53	0-20	29.70	5.37	8.50	6.50	8.00	37.10	0.67	0.00	3.50	47.00	1.77
	20-40	33.00	5.66	8.50	12.00	10.50	32.60	0.54	0.00	3.00	50.00	2.64
54	0-20	28.10	7.64	8.30	10.50	11.50	52.70	1.03	0.00	4.00	64.00	7.73
	20-40	21.80	7.68	8.20	21.00	10.50	43.60	0.56	0.00	4.50	65.00	6.16
55	0-20	23.40	2.76	8.30	8.50	3.00	15.30	0.51	0.00	5.00	22.00	0.31
	20-40	23.00	6.11	8.20	11.00	8.00	41.00	0.50	0.00	6.00	48.00	6.50
56	0-20	23.10	3.10	8.30	8.50	3.00	17.80	0.24	0.00	4.50	24.00	1.04
	20-40	21.10	2.41	8.30	6.50	3.00	13.90	0.13	0.00	7.00	16.00	0.53
57	0-20	23.50	6.12	8.20	20.00	13.50	23.20	2.72	0.00	3.00	53.00	3.42
	20-40	23.10	6.82	8.70	23.90	15.00	26.90	2.15	0.00	5.00	56.20	6.75
58	0-20	28.10	2.63	8.70	4.50	4.00	16.80	0.26	0.00	3.50	21.00	1.06
	20-40	21.50	3.85	8.20	5.50	6.50	25.30	0.26	0.00	3.00	33.50	1.06
59	0-20	18.00	3.67	8.30	8.90	7.60	19.80	0.28	0.00	4.00	23.20	9.38
	20-40	17.80	3.88	8.20	9.00	7.90	21.60	0.18	0.00	4.00	28.00	6.68
60	0-20	28.10	3.92	8.40	5.00	6.50	26.60	0.46	0.00	5.00	32.50	1.06
	20-40	29.70	5.18	8.40	12.50	12.00	25.90	0.61	0.00	3.00	46.50	1.51
61	0-20	28.50	2.15	8.20	7.50	3.60	9.60	0.54	0.00	4.50	13.40	3.34
	20-40	28.50	2.08	8.40	7.00	3.50	8.30	1.00	0.00	4.00	12.50	3.30
62	0-20	19.80	2.38	8.20	4.00	3.00	15.90	0.41	0.00	5.00	18.00	0.31
	20-40	20.50	5.18	8.50	12.00	7.00	30.80	0.95	0.00	3.00	46.00	1.75
63	0-20	24.00	2.93	8.30	5.00	2.70	18.70	0.61	0.00	3.00	23.00	1.01
	20-40	22.00	1.86	8.20	2.50	4.50	9.70	0.46	0.00	3.50	13.50	0.16
64	0-20	23.30	2.53	8.20	8.00	2.00	14.60	0.31	0.00	7.00	17.50	0.41
	20-40	23.30	2.16	8.50	7.00	3.50	8.60	2.00	0.00	6.50	12.50	2.10
65	0-20	28.40	6.65	8.40	13.50	11.00	42.30	0.46	0.00	3.00	62.00	2.26
	20-40	37.00	14.10	8.20	19.50	14.50	103.60	1.95	0.00	3.50	132.00	4.05
66	0-20	26.40	1.81	8.20	4.00	1.50	11.90	0.23	0.00	2.50	14.50	0.63
	20-40	31.50	4.23	8.30	7.50	6.50	27.40	0.39	0.00	2.00	39.00	0.79
67	0-20	33.00	4.21	8.50	8.00	12.00	20.60	0.54	0.00	2.50	37.00	1.64
	20-40	29.40	2.58	8.40	4.50	4.00	16.40	0.29	0.00	5.50	19.50	0.19
68	0-20	25.40	1.56	8.40	4.00	3.50	8.70	0.21	0.00	4.00	11.00	1.41
	20-40	28.70	5.43	8.50	9.00	8.70	34.70	1.07	0.00	2.50	45.50	5.47
69	0-20	22.80	5.13	8.20	14.50	12.50	22.60	0.72	0.00	2.50	46.00	1.82
	20-40	23.10	22.30	8.30	47.50	34.00	128.60	1.12	0.00	2.50	203.00	5.72
70	0-20	17.20	5.48	8.20	8.00	7.00	38.80	0.87	0.00	5.00	46.50	3.17
	20-40	17.20	9.73	8.40	15.50	7.00	68.70	2.35	0.00	5.00	86.00	2.55
71	0-20	26.50	3.29	8.20	8.00	7.50	15.00	1.30	0.00	5.50	26.50	0.20
	20-40	27.50	3.63	8.20	8.50	6.40	21.40	1.28	0.00	6.50	29.00	2.08
72	0-20	28.00	6.92	8.20	13.00	12.20	42.80	1.24	0.00	3.50	64.50	1.24
	20-40	21.70	7.23	8.70	13.50	13.00	44.10	1.58	0.00	3.50	66.50	2.18
73	0-20	23.10	16.20	8.20	21.00	9.00	123.60	6.23	0.00	4.00	152.00	3.83
	20-40	23.60	13.20	8.30	20.00	7.30	108.60	3.20	0.00	6.00	129.60	3.50
74	0-20	24.60	4.69	8.20	8.30	8.10	28.60	1.30	0.00	5.50	38.40	2.40
	20-40	24.10	4.98	8.20	10.00	9.00	29.00	1.26	0.00	6.00	41.00	2.26
75	0-20	25.00	11.95	8.20	34.00	29.00	53.40	1.82	0.00	5.00	109.00	4.22
	20-40	24.30	14.82	8.20	29.00	33.00	81.70	1.65	0.00	8.50	135.00	1.85

Table (4): Cont.

No	Depth Cm	SP	EC dS/m	pH	Ca++	Mg++	Na+	K+	CO3=	HCO3-	Cl-	SO4=
					meq/l							
76	0-20	22.00	3.35	8.10	10.50	5.50	16.10	0.36	0.00	3.00	28.50	0.96
	20-40	21.50	0.86	8.20	3.00	1.00	4.20	0.15	0.00	2.50	5.50	0.35
77	0-20	23.50	4.22	8.20	9.00	7.00	25.20	0.81	0.00	3.00	38.00	1.01
	20-40	22.50	4.78	8.20	8.50	7.40	30.70	0.76	0.00	3.00	38.20	6.16
78	0-20	22.00	4.75	8.20	14.00	13.00	19.00	1.18	0.00	6.00	39.90	1.28
	20-40	23.50	5.59	8.30	14.50	13.00	27.20	1.17	0.00	6.00	47.50	2.37
79	0-20	25.00	15.80	8.10	28.50	20.00	102.70	0.97	0.00	5.50	142.00	4.67
	20-40	20.00	12.35	8.10	17.50	18.00	82.40	1.10	0.00	5.50	112.00	1.50
80	0-20	24.30	7.95	8.20	16.00	10.50	50.80	1.28	0.00	4.00	72.00	2.58
	20-40	20.30	15.87	8.10	34.00	21.00	94.60	2.03	0.00	4.50	142.00	5.13
81	0-20	25.40	3.76	8.20	12.00	11.00	13.40	1.18	0.00	2.00	34.50	1.08
	20-40	25.00	4.98	8.40	13.00	12.50	14.10	1.21	0.00	3.00	36.50	1.31
82	0-20	39.00	7.39	8.10	17.00	14.00	40.20	1.65	0.00	3.50	68.00	1.35
	20-40	20.20	11.42	8.30	31.00	17.50	64.20	1.00	0.00	3.00	109.00	1.70
83	0-20	15.50	5.89	8.30	13.00	11.50	32.60	1.89	0.00	2.50	45.50	10.99
	20-40	17.20	6.73	8.10	13.00	12.00	32.60	1.26	0.00	4.50	53.20	1.16
84	0-20	22.00	4.35	8.30	13.00	11.30	17.60	0.26	0.00	3.30	38.50	0.36
	20-40	21.00	5.22	8.20	12.50	11.60	26.90	0.59	0.00	2.50	48.50	0.59
85	0-20	21.30	6.50	8.40	14.00	13.00	36.40	1.33	0.00	3.50	60.00	1.23
	20-40	17.00	7.30	8.20	13.50	12.00	44.60	2.13	0.00	2.50	58.50	11.23
86	0-20	16.30	4.65	8.20	13.50	13.00	19.00	0.61	0.00	5.00	40.80	0.31
	20-40	16.00	5.47	8.20	12.50	12.00	29.20	0.83	0.00	2.50	51.00	1.03
87	0-20	21.00	3.56	8.30	9.50	8.00	15.30	0.46	0.00	3.00	29.00	1.26
	20-40	23.00	5.42	8.20	14.00	12.70	26.20	1.20	0.00	4.00	48.50	1.60
88	0-20	18.00	5.98	8.20	18.50	12.00	23.90	2.50	0.00	3.50	52.00	1.40
	20-40	23.00	17.30	8.40	33.50	14.90	116.80	2.95	0.00	3.50	162.00	2.65
89	0-20	24.10	1.92	8.30	4.00	3.00	11.30	0.31	0.00	4.00	13.50	1.11
	20-40	24.80	7.83	8.40	18.50	9.50	48.60	0.76	0.00	5.00	70.50	1.86
90	0-20	27.40	2.97	8.20	4.50	3.00	20.90	0.31	0.00	5.00	23.00	0.71
	20-40	26.30	6.85	8.40	9.50	10.50	46.80	1.00	0.00	3.50	63.00	1.30
91	0-20	20.80	5.96	8.10	18.50	7.00	31.80	1.43	0.00	3.00	53.00	2.73
	20-40	28.10	2.39	8.20	7.50	5.00	9.60	1.05	0.00	7.00	15.50	0.65
92	0-20	16.00	3.86	8.20	15.00	6.00	14.60	1.82	0.00	3.50	32.00	1.92
	20-40	16.70	2.78	8.10	6.50	4.50	15.20	0.46	0.00	3.00	22.50	1.16
93	0-20	23.10	5.67	8.40	15.00	10.50	29.30	0.61	0.00	6.00	48.00	1.41
	20-40	23.00	7.90	8.20	18.00	15.00	38.00	0.42	0.00	6.00	56.00	9.42
94	0-20	24.80	2.18	8.40	6.50	2.80	10.90	0.15	0.00	6.50	13.00	0.85
	20-40	21.40	6.95	8.20	26.00	8.50	32.80	0.82	0.00	9.00	58.00	1.12
95	0-20	22.50	6.18	8.30	6.00	4.50	50.20	0.85	0.00	7.50	54.00	0.05
	20-40	23.00	11.00	8.20	14.00	10.00	84.00	0.50	0.00	7.00	99.00	2.50
96	0-20	20.00	5.29	8.50	19.00	9.00	21.60	2.00	0.00	3.00	46.50	2.10
	20-40	19.50	5.37	8.30	17.50	9.00	25.40	1.18	0.00	3.00	49.00	1.08
97	0-20	25.00	7.00	8.50	20.00	11.00	48.00	0.40	0.00	4.00	58.00	17.40
	20-40	26.40	7.83	8.20	20.50	17.50	37.80	0.87	0.00	3.50	71.00	2.17
98	0-20	20.50	6.72	8.20	8.50	9.00	48.30	0.51	0.00	4.50	61.00	0.81
	20-40	21.10	8.28	8.30	27.00	10.50	43.20	1.08	0.00	9.00	71.00	1.78
99	0-20	24.00	3.20	8.20	6.60	5.00	21.00	0.33	0.00	3.50	26.00	3.43
	20-40	27.10	14.76	8.10	50.50	31.00	62.40	1.64	0.00	3.50	139.00	3.04
100	0-20	20.10	3.26	8.40	15.00	6.70	9.10	0.51	0.00	6.50	23.50	1.31
	20-40	24.80	16.36	8.20	28.00	10.50	120.60	1.51	0.00	6.00	153.00	1.61

The calcium concentrations of soil irrigated with well water ranged from 1.0 meq/l to 50.0 meq/l, with a mean value of 11.74 meq/l. The  $\text{Ca}^{2+}$  values across soil profile are generally higher because values greater than 20 mg/kg are generally considered high (Landon, 1991). The higher values calcium recorded here are a result of slightly alkaline pH, because soils with pH values within the range of neutral to slightly alkaline are associated with high values of exchangeable calcium. However, the sandy textured nature of the soils and the need for frequent irrigation encourages its leaching, which explains its deviation from the assertion of its accumulation in arid and semi-arid environments.

The magnesium concentrations of soil irrigated with well water ranged from 0.50 meq/l to 43.5 meq/l, with a mean value of 9.01 meq/l. The  $\text{Mg}^{2+}$  values are however within the medium range across the soil profile, values greater than 30-60 mg/kg are usually low-moderately sufficient in soil, according to (Landon, 1991).

The potassium concentrations of soil irrigated with well water ranged from 0.11 meq/l to 6.23 meq/l, with a mean value of 0.92 meq/l. The  $\text{K}^+$  values are however fairly high. The high amount of  $\text{K}^+$  in the soil may have also contributed to the low  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  values because of its better competitive ability for exchange sites, although their values are not extremely bad (Foloronsho, 1998). Both  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  are hovering above the  $\text{Na}^+$  concentration the advantage of which is their effect in lowering the SAR values. This may significantly offset the salinity condition in the soil.

The chloride concentrations of soil irrigated with well water ranged from 3.0 meq/l to 216.5 meq/l, with a mean value of 42.81 meq/l. Furthermore, the tendency for chloride build up in the soil may cause chloride ions approaching toxic levels, also lead to further salt formation.

Irrigation, fertilizer and agrochemicals management, as well as close monitoring of soil and water conditions should be adopted as strategies to maintain and/or improve the salinity status of the soil.

The bicarbonate in soil irrigated with well water ranged from 1.5 to 9.0 meq/l, with a mean value of 3.88 meq/l.

The sulphate ( $\text{SO}_4^{2-}$ ) concentrations in soil irrigated with well water ranged from 0.01 to 17.4 meq/l, with a mean value of 2.56 meq/l, from the studied samples fall within the desirable limit.

### **Salt concentration factor (SCF)**

Data in Table (5) show that the salt concentration factor (SCF) of Ismailia soil under study ranged between 0.14 to 6.33. The results showed that SCF was variable according to water and soil quality and irrigation methods. The highest value of salt concentration factor was 6.33 which does not meet with the higher value of irrigation water, because  $\text{EC}_w$  for this area was  $2.33 \text{ dSm}^{-1}$ . On the other hand, 44% and 27% of salt concentration factor for two depth 0-20 and 20-40 cm were under  $\text{EC}_e/\text{EC}_w=1$ , because of their method of irrigation and quality of water that it shows leaching fraction. The results indicate that soil salinity does not necessarily increase with increasing salinity of irrigation water. This finding is rather surprising, because  $\text{EC}_e$  should increase, in proportion to salinity of irrigation water if LF (leaching fraction) is the same. We must assume that soil salinity was affected by other factors besides salinity of irrigation water. Maskooni and Afzali (2015) showed that there is a polynomial relationship between  $\text{EC}_e$  and  $\text{EC}_w$ , saturation water content and field moisture content in all of the lands. Also showed that a polynomial relationship between the SCF and saturation water content with high correlation in all of the sampling.

Table (5): The value of salt concentration factor (SCF) of studied soil of Ismailia area.

No	SCF (0-20 cm)	SCF (20-40 cm)	No	SCF (0-20 cm)	SCF (20-40 cm)
1	0.38	0.33	51	0.92	0.87
2	0.35	0.31	52	1.01	1.20
3	0.23	0.22	53	1.11	1.17
4	0.14	0.21	54	1.71	1.72
5	0.34	0.41	55	0.98	2.17
6	0.29	0.35	56	1.19	0.92
7	0.51	0.20	57	1.58	1.77
8	0.37	0.46	58	0.90	1.32
9	1.46	0.36	59	1.18	1.25
10	0.42	0.18	60	1.36	1.80
11	0.63	0.50	61	1.03	0.99
12	0.25	1.75	62	0.65	1.41
13	1.24	2.01	63	1.40	0.89
14	1.01	1.95	64	1.26	1.07
15	0.89	0.30	65	2.08	4.41
16	0.90	1.47	66	0.63	1.47
17	0.78	1.31	67	1.20	0.74
18	0.49	0.86	68	0.66	2.29
19	1.54	2.31	69	0.74	3.23
20	1.16	0.91	70	1.13	2.01
21	0.81	1.61	71	1.38	1.52
22	0.88	0.68	72	1.49	1.56
23	0.67	1.47	73	2.27	1.85
24	1.40	1.53	74	1.58	1.68
25	0.94	1.07	75	1.59	1.97
26	0.93	1.09	76	0.99	0.25
27	1.48	3.92	77	1.34	1.52
28	1.60	1.30	78	1.50	1.76
29	1.64	2.99	79	2.14	1.68
30	0.66	0.99	80	1.22	2.43
31	0.97	1.02	81	1.12	1.48
32	1.82	1.70	82	1.70	2.62
33	1.07	1.14	83	1.25	1.73
34	0.94	1.03	84	1.92	2.30
35	1.20	1.20	85	1.09	1.23
36	1.24	2.00	86	1.35	1.59
37	1.13	1.17	87	1.13	1.72
38	1.20	1.69	88	1.42	4.10
39	0.98	1.12	89	0.77	3.16
40	1.58	1.57	90	1.00	2.31
41	0.89	2.13	91	2.10	0.84
42	1.58	1.09	92	1.24	0.89
43	0.85	1.10	93	2.05	2.86
44	1.04	0.54	94	0.82	2.62
45	1.83	1.30	95	1.11	1.97
46	0.93	2.29	96	1.64	1.66
47	1.56	0.79	97	1.80	2.01
48	0.38	2.06	98	2.66	3.27
49	0.82	1.20	99	1.37	6.33
50	0.88	3.64	100	1.02	5.11



### **The spatial distribution of soil salinity**

Salinity is a serious problem in irrigated crop lands in arid and semi-arid regions so; evaluating the salinity distribution under various irrigation methods can be effective for salinity management. Comparison of surface, sprinkler and drip irrigation methods used soil salinity values in the 0-20 and 20-40 cm soil layer, expressed by the EC. The mean values of EC of soil were 3.94, 5.98 and 4.56 for drip, sprinkler and surface irrigation methods in depth 0-20 cm, respectively. While, in soil depth 20-40 cm the mean values of EC were 6.78, 4.94 and 2.99 for drip, sprinkler and surface irrigation methods, respectively. The EC values are lower in case of surface irrigation than both of drip and sprinkler irrigation in most soils under study. As expected the difference observed between irrigation methods is mainly due to the difference in soil moisture content since the irrigation water supplies were similar. According to the soil moisture content values for each irrigation method, we can conclude that the surface irrigation keeps higher soil water content in the root zone which may help maintain continuous leaching of accumulated salts and thus reduce the soil salinity values. Oron *et al.* (2002) reported that high moisture content in the root zone with surface irrigation could increase the leaching process of accumulated salts; whereas the conventional drip irrigation facilitated sufficient leaching just below the emitter in the top soil layer, contributing to extra accumulation of salts in the active root zone of the crop and the soil salinity level remained high under the drip irrigation system. Singh and Bhumbla (1968) observed that the extent of salt accumulation depends on soil texture and reported that in soils containing less than 10% clay the ECe values remains lower than ECiw.

The spatial distribution of soil salinity in the soil horizons were found to be higher at shallow depths of 0-20cm and decreasing gradually up to a depth of 20-40cm. This trend shown with surface and sprinkle irrigation method. Therefore, when the soil temperature raised some salinity bicarbonates were pushed to the surface of the soil. The ECe values were very much higher than the safe limit, much higher than the 4dS/m describing the soil as being slightly alkaline (Landon, 1991). In drip irrigated method, the salinity distribution showed a different pattern from that observed in surface and sprinkler irrigation. Salinity was low in the surface layer (0-20 cm), and increased gradually with soil depth (20-40 cm).

Traditionally, irrigation was effected by flooding with water, but such methods allow significant losses of water to drainage and evaporation. The use of drippers reduces these losses but attracts additional costs for equipment. Consequently, farmers require good reasons if they are to invest in new technologies. Where water is in short supply, there may be clear advantages in using a drip system in preference to a more traditional method of water application, especially for a farmer who has to pay for water. These advantages may be greater if saline water can or has to be used. Saline water may be cheaper than fresh water and reducing water use by drip system which should reduce the quantity of water required for leaching. However, if drip systems are to be used, the farmer must be convinced that any additional costs would be covered by improvements in yield (Malash *et al.*, (2008).

According to Table (6) and our results in Ismailia area we can classify of soil samples percent according to salinity class under different irrigation methods in surface and subsurface soil samples

(Table, 7). In surface soil samples, about 57 % of soil samples occurred as none and slightly saline, moreover about 42% of subsurface soil samples were in moderately and strongly saline classes only 1% occurred in very strongly saline classes. About irrigation method effect, about 54.8, 42.9 and 70.0 % were in none and slightly saline classes in surface soils under drip, sprinkler and surface irrigation method, respectively. While there were about 43.8, 57.1 and 30.0% occurred in moderately and strongly saline classes under drip, sprinkler and surface irrigation method, respectively.

As for, the subsurface samples about 44 % of soil samples occurred as none and slightly saline, moreover about 52% of subsurface soil samples were in moderately and strongly saline classes only 4% occurred in very strongly saline classes. About irrigation method effect, about 39.5, 42.8 and 50.0 % were in none and slightly saline classes in subsurface soils under drip, sprinkler and surface irrigation method, respectively. While there were about 52.1, 57.1 and 50.0% occurred in moderately and strongly saline classes under drip, sprinkler and surface irrigation method, respectively. Only, 5% occurred in very strongly saline classes for drip irrigation method.

Table (6). Soil salinity classes and crop growth\*

Soil Salinity Class	Conductivity of the Saturation Extract (dS/m)	Effect on Crop Plants
Non saline	0 - 2	Salinity effects negligible
Slightly saline	2 - 4	Yields of sensitive crops may be restricted
Moderately saline	4 - 8	Yields of many crops are restricted
Strongly saline	8 - 16	Only tolerant crops yield satisfactorily
Very strongly saline	> 16	Only a few very tolerant crops yield satisfactorily

\*FAO, 1988, Salt-Affected Soils and their Management, Bulletin 39.

Table (7): Classification of soil samples percent as salinity class under different irrigation methods in surface and sub surface soil samples.

Irrigation method	Salinity classes				
	Non saline	Slightly saline	Moderately saline	Strongly saline	Very strongly saline
Soil depth 0-20 cm					
Drip	20.55	34.25	39.73	4.11	1.37
Sprinkler	28.57	14.29	57.14	-	-
Surface	10.00	60.00	25.00	5.00	-
All	19.00	38.00	38.00	4.00	1.00
Soil depth 20-40 cm					
Drip	6.59	32.88	34.25	17.81	5.48
Sprinkler	28.57	14.29	57.14	-	-
Surface	30.00	20.00	45.00	5.00	-
All	15.00	29.00	38.00	14.00	4.00

**Correlation between selected well water parameters.**

The relationship between different water quality parameters was worked out through simple correlation analyses of the data (Table, 8).pH was negatively correlated with EC ( $r=-0.306^*$ ),  $Ca^{++}$  ( $r=-0.290^*$ ),  $Mg^{++}$  ( $r=-0.237^*$ ),  $Na^+$  ( $r=-0.278^*$ ),  $K^+$  ( $r=-0.038$ ),  $Cl^-$  ( $r=-0.308^*$ ), SAR ( $r=-0.171$ ), B( $r=-0.061$ ), and positively correlated with  $HCO_3^-$  ( $r=0.066$ ) and  $SO_4^{--}$  ( $r=0.034$ ). Also, EC was positively correlated with  $Ca^{++}$  ( $r=0.885^{**}$ ),  $Mg^{++}$  ( $r=0.813^{**}$ ),  $Na^+$  ( $r=0.931^{**}$ ),  $K^+$  ( $r=0.290^*$ ),  $Cl^-$  ( $r=0.996^{**}$ ), SAR ( $r=0.605^{**}$ ), B( $r=0.178$ ), and negatively correlated with  $HCO_3^-$  ( $r=0.046$ ),  $SO_4^{--}$  ( $r=-0.121$ ). It was noted that SAR and ECs significantly correlated with each other ( $r=0.605$ ). It shows that SAR is a function of salinity i.e. the SAR together with total salt concentration (EC) may be used as an index to indicate salinity/sodicity hazard. However,  $Ca^{++}$  was positively correlated with  $Mg^{++}$  ( $r=0.905^{**}$ ),  $Na^+$  ( $r=0.674^{**}$ ),  $K^+$  ( $r=0.182$ ),  $Cl^-$  ( $r=0.874^{**}$ ),  $SO_4^{--}$  ( $r=0.057$ ) SAR ( $r=0.215^*$ ), B( $r=0.193$ ), and negatively correlated with  $HCO_3^-$  ( $r=-0.146$ ). As for,  $Mg^{++}$  was positively correlated with

$Na^+$  ( $r=0.563^{**}$ ),  $K^+$  ( $r=0.286^*$ ),  $Cl^-$  ( $r=0.810^{**}$ ),  $SO_4^{--}$  ( $r=0.005$ ) SAR ( $r=0.086$ ), B( $r=0.194$ ), and negatively correlated with  $HCO_3^-$  ( $r=-0.195$ ).

Likewise,  $Na^+$  was positively correlated with  $K^+$  ( $r=0.272^*$ )  $HCO_3^-$  ( $r=0.060$ ),  $Cl^-$  ( $r=0.933^{**}$ ), SAR ( $r=0.840^{**}$ ), B( $r=0.134$ ), and negatively correlated with  $SO_4^{--}$  ( $r=-0.214^*$ ). The  $Na^+$  and sodium adsorption ratio (SAR) showed a positive relationship with the groundwater EC (Ghassemi *et al.*, 1995). Furthermore,  $K^+$  was positively correlated with  $Cl^-$  ( $r=0.295^*$ ) SAR ( $r=0.204^*$ ) and negatively correlated with  $HCO_3^-$  ( $r=-0.048$ ),  $SO_4^{--}$  ( $r=-0.079$ ) B( $r=-0.011$ ). However,  $HCO_3^-$  was negatively correlated with  $Cl^-$  ( $r=-0.055$ )  $SO_4^{--}$  ( $r=-0.553^{**}$ ) B( $r=-0.036$ ) and positively correlated with SAR ( $r=0.199^*$ ). As for,  $Cl^-$  was positively correlated with SAR ( $r=0.614^{**}$ ) B( $r=0.194$ ) and negatively correlated with  $SO_4^{--}$  ( $r=-0.178$ ). But,  $SO_4^{--}$  was negatively correlated with SAR ( $r=-0.319^*$ ) B( $r=-0.156$ ). Only, SAR was positively correlated with B( $r=0.047$ ). The results are in conformity with results obtained by Ghodek, *et al.*, (2016).

Table (8) Simple correlation between different parameters of well water

	pH	EC	Ca <sup>++</sup>	Mg <sup>++</sup>	Na <sup>+</sup>	K <sup>+</sup>	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>--</sup>	SAR	B
EC	-0.306*										
Ca <sup>++</sup>	-0.290*	0.885**									
Mg <sup>++</sup>	-0.237*	0.813**	0.905**								
Na <sup>+</sup>	-0.278*	0.931**	0.674**	0.563**							
K <sup>+</sup>	-0.038	0.290*	0.182	0.286*	0.272*						
HCO <sub>3</sub> <sup>-</sup>	0.066	-0.046	-0.146	-0.195	0.060	-0.048					
Cl <sup>-</sup>	-0.308*	0.996**	0.874**	0.810**	0.933**	0.295*	-0.055				
SO <sub>4</sub> <sup>--</sup>	0.034	-0.121	0.057	0.005	-0.214*	-0.079	-0.553**	-0.178			
SAR	-0.171	0.605**	0.215*	0.086	0.840**	0.204*	0.199*	0.614**	-0.319*		
B	-0.061	0.178	0.193	0.194	0.134	-0.011	-0.036	0.194	-0.156	0.047	

### Correlation between selected soil properties.

Correlations between selected soil properties are presented in Table (9). SP was positively and not significantly correlated with pH, EC,  $\text{Ca}^{++}$ ,  $\text{Na}^+$ ,  $\text{Cl}^-$ ,  $\text{HCO}_3^-$  and significantly only with  $\text{Mg}^{++}$  ( $r=0.167^*$ ) but negatively and not significantly correlated with  $\text{K}^+$  and  $\text{SO}_4^-$ . Soil water content (which expressed as SP) increased with irrigation water salinity (EC). This result indicated that excessive irrigation with water of high salinity could affect the structural characteristics of soil to a great extent. These results are similar to those previously reported by Feng *et al.* (2011) explained that the higher soil water content in saline treatments resulted from the relatively low water consumption of vines under medium and high salinity. Jiang *et al.* (2010) found that severe salt stress markedly inhibited the water uptake and that more water was left in the soil. We speculate that the exchange and adsorption happens between the salt ions brought by the saline water and the soil colloid and the native ions of the soil during irrigation periods. The increasing sodium content enlarges the hydration degree of the soil particles, which easily results in the separation of those particles. Along with the water movement, the particles move down and deposit and then block the flow of water, decrease the actual discharge area of the water flow, form compacted weak water layer and reduce soil permeability. Ultimately, the deep percolation is reduced and the soil water content increases relatively. However, the effect of water salinity on soil water content is limited comprehensively. Also, EC was positively and significantly correlated with  $\text{Ca}^{++}$ ,

$\text{Mg}^{++}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Cl}^-$ ,  $\text{HCO}_3^-$  but positively and not significantly correlated with pH and  $\text{SO}_4^-$ . In alkaline soils, pH usually increases with an increase in salinity due to the presence of sodium bicarbonate and carbonate (Gupta *et al.*, 1989). However, Tan (1993) reported that increasing sodicity in soil does not necessarily yield a rise in pH. Many sodic soils are neutral in reaction, whereas some are even acidic in reaction. The strongly alkaline reaction (pH around 10) of most sodic soils is caused by alkalization during which sodium carbonate and bicarbonate are formed. Under less alkaline conditions, i.e. where calcium carbonate dominates the soil mineralogy, soil pH has been shown to drop with an increase in salinity (Lai and Stewart, 1990). However, pH was positively and not significantly correlated with  $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$ ,  $\text{K}^+$ ,  $\text{Cl}^-$ , but negatively and not significantly correlated with  $\text{Na}^+$ ,  $\text{HCO}_3^-$  and  $\text{SO}_4^-$ . while,  $\text{Ca}^{++}$  was positively and significantly correlated with  $\text{Mg}^{++}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Cl}^-$ ,  $\text{HCO}_3^-$  and  $\text{SO}_4^-$ . As for,  $\text{Mg}^{++}$  was positively and significantly correlated with  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Cl}^-$ , and  $\text{SO}_4^-$  but positively and not significantly correlated with  $\text{HCO}_3^-$ . Anywise,  $\text{Na}^+$  was positively and significantly correlated with  $\text{K}^+$ ,  $\text{Cl}^-$ , and  $\text{HCO}_3^-$  but positively and not significantly correlated with  $\text{SO}_4^-$ . Whatever,  $\text{K}^+$  was positively and significantly correlated with  $\text{Cl}^-$ , and  $\text{SO}_4^-$  but positively and not significantly correlated with  $\text{HCO}_3^-$ . As well,  $\text{HCO}_3^-$  was positively and significantly correlated with  $\text{Cl}^-$ , and but positively and not significantly correlated with  $\text{SO}_4^-$ . Only,  $\text{Cl}^-$  was positively and not significantly correlated with  $\text{SO}_4^-$ . The results are in conformity with results obtained by Bikash *et al.*, (2000).

**Table (9) Simple correlation between selected soil properties.**

	SP	EC	pH	Ca <sup>++</sup>	Mg <sup>++</sup>	Na <sup>+</sup>	K <sup>+</sup>	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>
EC	0.118								
pH	0.103	0.015							
Ca <sup>++</sup>	0.114	0.869**	0.049						
Mg <sup>++</sup>	0.167*	0.815**	0.080	0.871**					
Na <sup>+</sup>	0.100	0.959**	-0.008	0.713**	0.644**				
K <sup>+</sup>	-0.067	0.497**	0.081	0.421**	0.355**	0.475**			
HCO <sub>3</sub> <sup>-</sup>	0.013	0.249**	-0.015	0.210*	0.126	0.263**	0.124		
Cl <sup>-</sup>	0.129	0.996**	0.023	0.861**	0.806**	0.961**	0.484**	0.217*	
SO <sub>4</sub> <sup>-</sup>	-0.065	0.132	-0.017	0.178*	0.206*	0.085	0.236*	0.017	0.063

### **Effect of Saline well water on Soil Salinity**

The general trend line showed that soil salinity increased with an increase in water salinity. Correlation coefficient (r) between EC of irrigation water and EC of soil was 0.550\*\*. Results also showed that EC of irrigation water affected the soil properties, if the average salinity of the soil water is about three times the salinity of the irrigation water. This salinity, however, will vary with depth and method of irrigation the upper root zone will contain less salinity than the lower parts. Salts will normally be leached out of this upper root zone but accumulate to higher concentrations in the lower rooting zone. The extent of this accumulation will depend upon the leaching that takes place. According to Khan, *et al.*, (2014) who reported that of water with low quality has a negative impact on the soil as a result of causing salinity and infiltration problems. Also, Hillel (1998) reported that salt in the irrigation water will eventually be transferred to the soil during irrigation, changing the concentration and composition of salt in the soil water. Since only pure water evaporates at the soil and plant surfaces it implies that the salt will remain in the soil, unless leaching occurs.

Thus, irrigation tends to concentrate the salt in soil water, which lowers the osmotic potential and hence the total soil water potential (matric plus osmotic) of the soil.

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## تأثير جودة مياه الابار المختلفة وطرق الري على بعض الخواص الكيميائية و توزيع الاملاح فى التربة فى المناطق الجافة: دراسة حالة لمحافظة الاسماعلية

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### الملخص العربى

أجريت هذه الدراسة لتقييم توزيع الملوحة فى التربة تحت ظروف الري بمياة الابار المختلفة الجودة وطرق الري المختلفة فى بعض مناطق محافظة الاسماعلية. تم جمع عينات من التربة ومياة الابار من مائة موقع مختلف فى محافظة الاسماعلية. تم تحليل كل من التربة والمياه لتقدير الخواص الكيميائية والتي اشتملت على الملوحة والكاتيونات والانيونات ونسبة الصوديوم المدمص (SAR). اوضحت النتائج أن متوسط درجة الحموضة كان ٧,٣٥ بينما كانت القيمة المتوسطة للملوحة تبلغ ٣,٧٣ مليموز/سم. وكان متوسط الكاتيونات فى مياة الابار ٧,٤ ، ٥,٩٨ ، ٠,١٧ و ٢٣,٣٣ ملليمكافى/لتر لكل من الكالسيوم ، المغنسيوم،البوتاسيوم، الصوديوم على التوالي. ومتوسط قيمة نسبة الصوديوم المدمص (SAR) كانت ٩,١١ بينما كان متوسط تركيز الكلوريد و البيكربونات فى مياة الابار ٢٩,٩٥ و ٢,٤٩ ملليمكافى/لتر. على التوالي.

و كانت القيم المتوسطة للملوحة فى التربة ٣,٩٤ ، ٥,٩٨ و ٤,٥٦ مليموز/سم تحت طرق الري بالتنقيط، الرش والري السطحى وذلك للطبقة السطحية .-٢٠ سم على التوالي، بينما بلغت القيم المتوسطة للملوحة فى التربة ٦,٧٨ ، ٤,٩٤ و ٢,٩٩ مليموز/سم تحت طرق الري بالتنقيط ، الرش والري السطحى وذلك للطبقة التحت السطحية ٢٠-٤٠ سم على التوالي اوضح التوزيع

المكاني لملوحة التربة ان درجة الملوحة فى آفاق التربة تكون أعلى فى الأعماق الضحلة من ٠-٢٠ سم وتقل تدريجياً إلى عمق ٢٠-٤٠ سم. هذاالاتجاه يظهرمع كل من طريقة الري السطحى والرى بالرش. اما فى طريقة الري بالتنقيط، أظهر توزيع الملوحة وجود نمط مختلف عن ذلك حيث لوحظ ان الملوحة كانت أقل فى الطبقة السطحية (٠-٢٠ سم) ،وزاد تدريجياً مع عمق التربة (٢٠-٤٠ سم).

تراوح معامل تركيزالاملاح (SCF) ف بالتربة تحت الدراسة بين ٠,١٤ إلى ٦,٣٣. وأظهرت النتائج أن SCF كان يختلفاً وفقاً لنوعية الماء والتربة وطرق الري.

درجة ملوحة التربة EC ارتبط معنوياً وايجابياً مع كل من الكالسيوم، المغنسيوم، البوتاسيوم، الصوديوم، الكلوريد والبيكربونات فى التربة ولكن ارتبط ايجابياً وغير معنوى مع كل من درجة الحموضة وتركيز ايون الكبريتات . بينما كان معامل الارتباط (r) بين SAR لمياه الري و SAR للتربة ٠,٢٢٩ و ٠,٢٠٤ للاعماق من ٠-٢٠ و ٢٠-٤٠ سم، على التوالي. أظهر الاتجاه العام ارتفاع ملوحة التربة مع زيادة ملوحة المياه. وكان معامل الارتباط (r) بين EC لمياه الري و EC فى التربة ٠,٥٥٠ .

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