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ON-SITE QUALITY EVALUATION OF SUBSURFACE DRAINAGE WATER FOR SUPPLEMENTAL IRRIGATION IN MASHTOUL AL-SOUQ AREA، SHARKIA GOVERNORATE, EGYPT

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ABSTRACT: The objective of this study was to assess the quality of irrigation water, groundwater and drainage water in Mashtoul El-Souq District, Sharkia Governorate, for the supplemental irrigation purposes to compensate for the lacke of fresh irrigation water required for crops grown in the study area. Six sampels from Nabtit and El-Serw irrigation canals, 26-sampels from observation wells (groundwater) and 6-sampels from the outlets of main subsurface drainage collectors (drainage water) were collected during summer (2017) and winter (2017/2018). To achieve this study, three neighboring sites with already installed subsurface drainage system were selected. Three drainage collectors were choosen (one for each site). Five pizometers (observation wells) were constructed at the first collector, 4 pizometers at the second collector and 4 pizometers at the third collector. Water samples were periodically taken from the drainage network at the dumps of drainage pools in exchange rooms. Water samples were subjected to chemical analyses and then calculating some quality parameters to assess their validity for supplemental agricultural irrigation. Cations, anions, pH and EC were determined. Results showed that P^H values ranged from7.6 to 8.0 in irrigation water samples, and the average of salinity (EC) and sodicity (SAR) values in irrigation water samples were 0.63 dSm^{-1} and 2.09, respectively, low saline and alkaline water which is good for irrigation. The pH values of the drainage water ranged from 7.8 to 8.2, and the average values of EC and SAR values in drainage water samples were 2.1 dSm^{-1} and 4.52, respectively. According to the division of the US Salinity Lab. (1954), it was classified as C2S1 for irrigation water samples, and for drainage water, the classification lies between C3S2 and C4S2. There were seasonal differences in the concentration of soluble ions. Salinity and sodicity of subsurface water varied from 0.78 to 3.12 dSm^{-1} and 1.75 to 8.42, respectively. A better strategy for dealing with the "disposal" of subsurface agricultural drainage water is that the drainage water could be intercepted, isolated from the good-quality water, and reused for the irrigation of suitably salt-tolerant crops other than blending.

Key words: Subsurface drainage water, irrigation, reuse, salinity, anions, cations.

INTRODUCTION

Egypt is an arid country facing water shortage that has become a critical factor limiting its food production and economic development. Nile River constitutes a vital water resource serving the population along Nile Valley and Delta. With increasing population in Egypt، the per capita shares of farm land and water are reduced considerably. Thus، there is a need to find alternative water resources (**Mosaad، 2017**). In addition، there is a great need for additional water resources to meet the agricultural demands of desert land for the 630 thousand hectares area (1.5 million faddan) which the government intends to reclaim. Such area lies in Toshki، Sinai and the west desert **(Soliman, 1983; Soliman, 2000; Alnaimy *et al.*، 2012; Abd Al-Hamid *et al.*، 2017)**.

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Drainage waters could be a readily available source of water for irrigation. The drainage program in Egypt is unique in its coverage. The area provided by surface and subsurface drainage is 2.9 million and 2.0 million hectares، respectively، and most of old lands have drainage systems **(Van Steenbergen and Dayem، 2007).** Annually, 17 billion cubic metres (BCM) of agricultural drainage water (ADW) is produced in Egypt, and this represents a potential backbone for non-conventional water resources in this country **(Assar *et al.*, 2018)**. An intensive expansion program for the reuse of drainage water in agriculture requires adequate, proper measures and precautions due to salinity and alkalinity problems of waters to avoid accumulation of salts in the long term of applications of these waters.

According to the Food and Agriculture Organization (FAO), there are a number of different water quality guidelines related to irrigated agriculture (**Ayers and Westcot**, **1976)**. Each has been useful, though none has been entirely satisfactory because of the wide variability in environmental conditions. The FAO is mainly concerned about the effect of water quality upon soil and crops, therefore, five categories are applied to water quality-related problems in irrigated agriculture: (a) salinity hazards (electrical conductivity (EC) and total dissolved solids (TDS)), (b) infiltration and permeability hazards (EC and sodium absorption ratio), (c) specific ion toxicity (sodium adsorption ratio (SAR), boron, and chloride), (d) trace element toxicity, and (e) miscellaneous impacts on sensitive crops (P^H, nitrate, and bicarbonates). **Gupta (1979)** suggested that irrigation water may be classified under five classes based on salinity and sodicity hazard and boron. P^H of some wastewaters did not vary widely from that of the Nile water, and ranged from 7.29 to 7.40 in sewage waters to the industrial wastewater (**FAO, 2002)**. **El-Sherbieny *et al.* (1998)** showed that 50% of the agricultural drainage water had P^H ranging from 7.6 to 8.4. **Shaban (1998)** stated that the P^H of irrigation water varied between 8.22 and 9.00, and that the most prevalent values of P^H of Nile water, drainage water and sewage water were 8.33, 8.34 and 8.46, respectively. **Srivastava *et al.* (1962)** reported that using sewage water having P^H 7.8, EC 1.4 dSm^{-1}, 104 mgl^{-1} NO_3-N and SAR 7.5 proved most efficient in reclaiming saline sodic soils.

In water quality classification، water that has an electrical conductivity (EC) exceeding 3 dSm^{-1} (about 2000 mg salts 1^{-1}) is considered unsatisfactory (**Abd Al-Hamid *et al.*، 2017)**. **Wilcox (1955)** classified irrigation water into three classes. Class II (good water) has an EC of 1.0 to 3.0 dSm^{-1}; 0.5 to 2.0 mg boron 1^{-1}; 60 to 75% soluble sodium percent (SSP) and 5 to 10 mmole chloride 1^{-1}. Water having less than such levels are class I (excellent water) and those having higher levels are class III (unsatisfactory water). **Gupta (1984 and 1990)** suggested a classification of five classes based on sodic hazards، boron and the salinity hazards and called it the ABC classification. **Assar *et al.* (2019)** used the irrigation water quality index (IWQI) based on a fuzzy logic approach (FWRI) to assess the agriculture drainage water (ADW) quality according to the results of a hydrodynamic and one-dimensional WQ simulation model. The indices were applied to classify the ADW quality along the largest project in Egypt (El-Salam Canal). Their results indicated that the FWRI and IWQI values can both reasonably explain the current situation. However, the X2 values for FWRI were always larger than the IWQI values, which demonstrated that the FWRI was more relevant to the official classification than the IWQI. Accordingly, the FWRI proved its capability and accuracy in the assessment of ADW quality and pollution compared with those obtained from the simulation model of the canal, potentially enabling it to be applied as a comprehensive approach for the assessment of WQ for reuse in irrigation.

Soluble ions and heavy metals in surface waters are of major interest because they are bio-accumulative and persistent in nature، and they can cause health risk to humans **(Khan *et al.*، 2009; Wu *et al.*، 2017)**. Water quality has been reported in many countries **(Fordyce *et al.*، 2007; Mukherjee *et al.*، 2008; Kavcar *et al.*، 2009; Muhammad *et al.*، 2011; Wu *et al.*، 2011; Bikundia and Mohan، 2014; Islam *et al.*, 2015).** Intensification of urban development، industrial، and agricultural activities have worldwide degraded the water resources quality **(Islam *et al.*، 2015).** Access to high-quality water is decisive for global and local development، especially in arid and semi-arid regions **(Wu *et al.*، 2017).** The most common challenge involved in decisions regarding ADW reuse is how to determine whether the quality of the drainage water is suitable for reuse **(Allam *et al.*, 2015).**

The present study aims at evaluating seasonal variations of on-farm groundwater and subsurface drainage water quality to judge the potential use of such disposal water in the supplemental irrigation purposes.

MATERIALS AND METHODS

Study Area and Water Sampleing

To evaluate the quality of irrigation water, groundwater and subsurface drainage water in Nabtit village, Mashtoul El-Souq District, Sharkia Governorate, for the supplementary irrigation. The location is situated at 30°22′ 30″ N and 31°21′ 30″ E and illustrated in Fig. 1. Subsurface drainage system had been installed long time ago. Three drainage collectors covering three neighbouring sites were choosen (one for each site) numbers 13, 15 and 17. Five pizometers (observation wells) were constructed at the first collector, 4 pizometers for each of the second and third collectors (Figs. 1 and 2). water samples were periodically taken from observation wells and from the drainage network at the dumps of drainage pools in exchange rooms. Installation method for the observation well in the field (Fig. 3).

Thirty-eight samples were collected from irrigation water (6-sampels from El-Serw canal), groundwater (26-sampels from observation wells) and drainage water (6-sampels from outlets of main drainage collectors). Water samples were collected during summer (2017) and winter (2017/2018). The collected water samples transferred immediately to the laboratory. Water samples were filtered and subjected to chemical analyses.

Construction of Observation Wells

Observation wells were installed to monitor the characteristics of ground water and water table fluctuation. The observation wells were installed using polyethylene tubes with a 5-cm diameter and 2 m length. Tubes were perforated at the lower end and covered with permeable materials and screened to allow an easy moving of ground water to the tubes and avoid the clogging by clay and fine particles. The tubes were put in the prepared auger holes to a depth of 170 cm and the residual 30 cm length of tube was above soil surface (**Cavelaars, 1979**).

Water Analyses

Total soluble saltes (EC), P^H, soluble cations (Ca^{2+}, Mg^{2+}, Na^+, and K^+) and anions (CO_3^{2-}, HCO_3^-, Cl^- and SO_4^{2-}) were determined adopting according to the methods of **USDA (1954**) with the sulphate being estimated by difference.

Quality Indices

Using the above chemical analyses, the following quality indices were determined:

Salinity was measured in terms of electric conductivity (EC) measured as dSm^{-1}.

Soluble sodium percentage (SSP) was calculated according to the following formula:

$$SSP = \frac{[Na]}{\sum Cations} \times 100 \text{ ………..... (1)}$$

Where:

Ions are expressed as $mmol_c l^{-1}$

Sodium adsorption ratio (SAR) was calculated as:

$$SAR = \frac{[Na^+]}{\sqrt{[Ca^{++}] + [Mg^{++}]/2}} \text{ …… (2)}$$

Where:

Ions concentratin are expressed in $mmol_c l^{-1}$.

Adjusted Sodium Adsorption Ratio (adj. SAR) was calculated according to the following equation (**Ayers and Westcot, 1976**):

$$Adj.\ SAR = SAR\ [1 + (8.4 - P^H{}_c)] \text{ …..........…. (3)}$$

$$P^H{}_c = (PK'_2 - PK'_c) + p(Ca^{2+} + Mg^{2+}) + p(Alk) \text{ …. (4)}$$

Adjusted sodium hazard (adj.^{R} Na) was calculated according to (**Suarez, 1981)** as follows:

$$Adj.^R\ Na = \frac{[Na^+]}{\sqrt{[Ca_x^{2+}] + [Mg^{2+}]/2}} \text{ ……… (5)}$$

Where:

Ca_x valueis modified according to the salinity of the water, its HCO_3/Ca ratio and the estimated

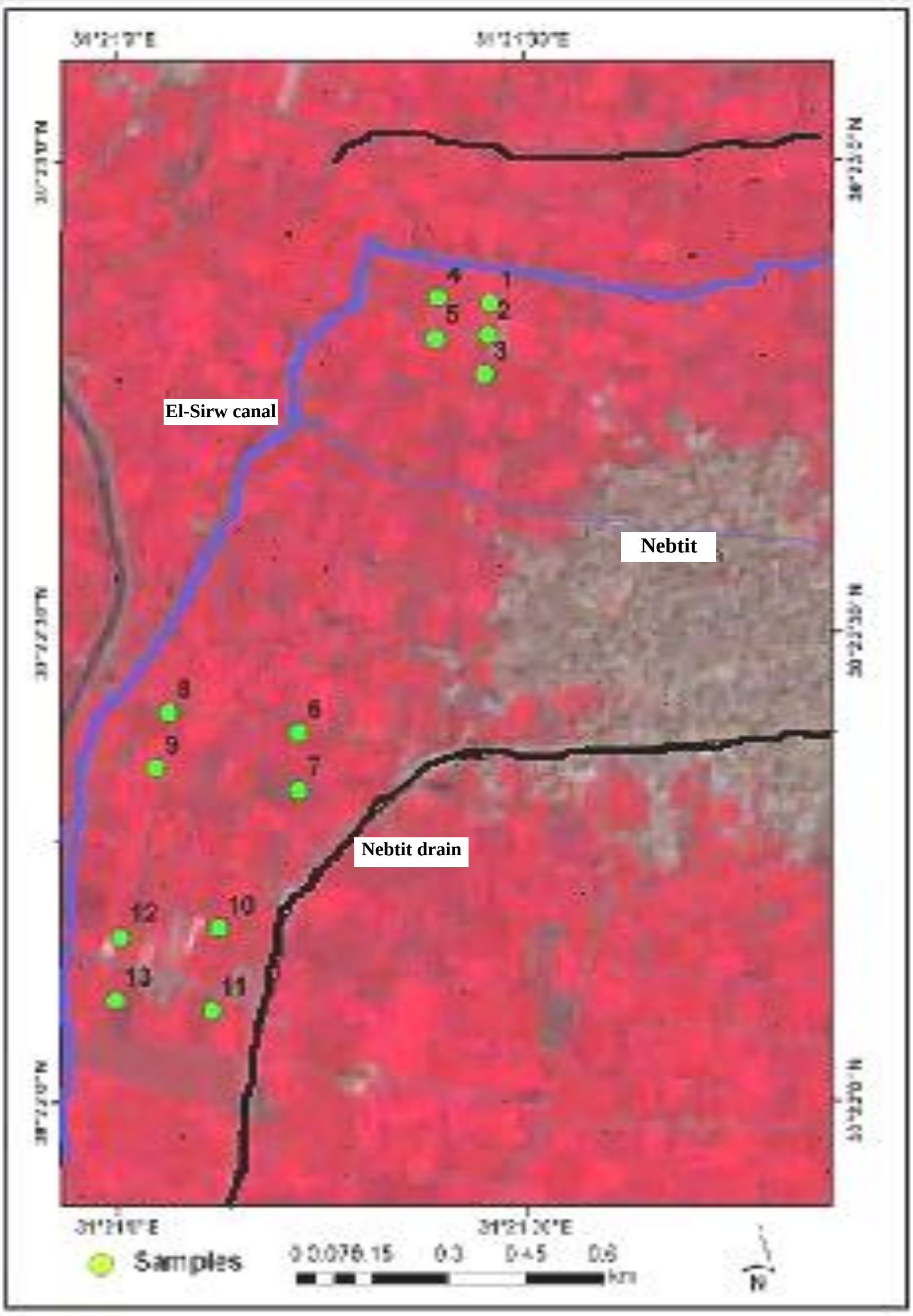


Fig. 1. Samples location map of the study areas

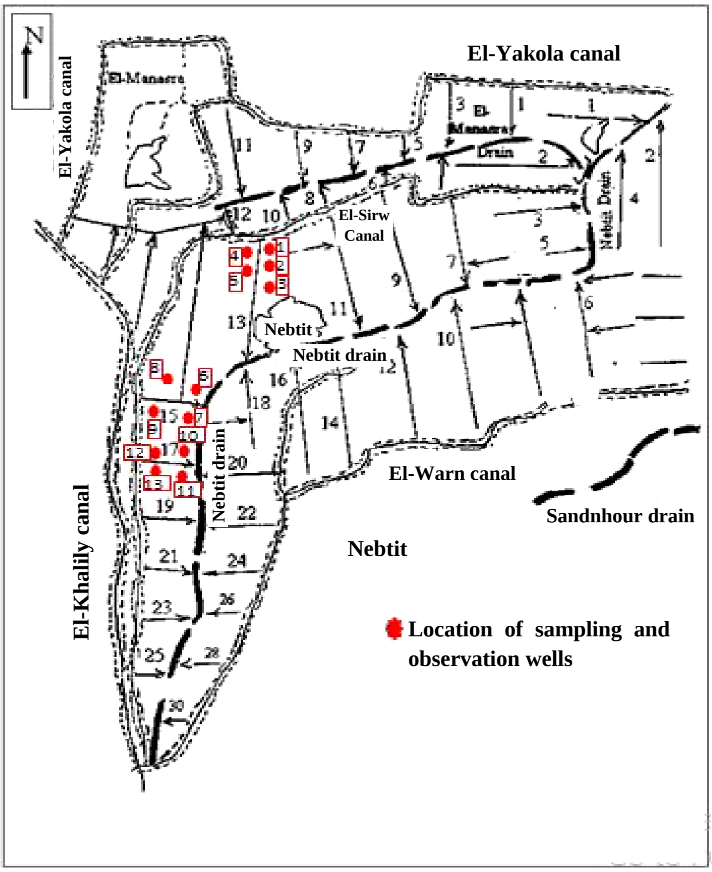


Fig. 2. Location map of the selected drain collectors and observation wells in Nebtit area (After Drainage Projects Mangement-Zagazig, MWRI)

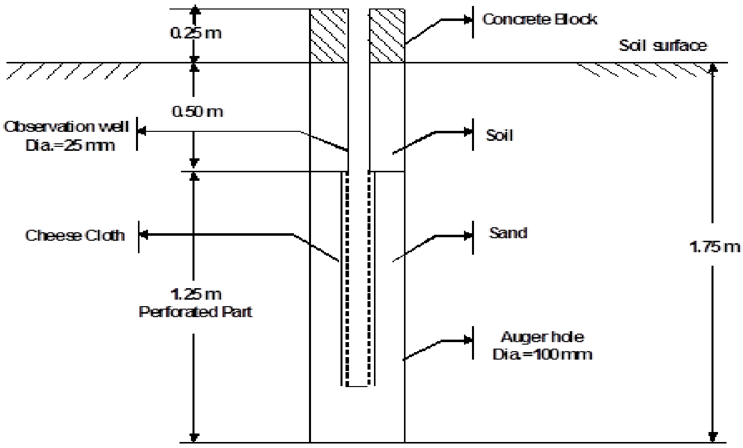


Fig. 3 Installation method for the observation well in the field

partial pressure of CO_2 in the surface few millimeters of soil (PCO_2=0.0007 atmospheres), and Mg in the water. The Ca_x, value represents the Ca that is expected to remain in solution in the soil water at equilibrium. The obtained adj.^{R}Na is used in place of the SAR to evaluate the potential Na hazard which can cause an infiltration problems if used for irrigation.

Estimated exchangeable sodium percent (ESP) expected in the soil using the SAR of water, this equation was as follows (**USDA, 1954**).

$$\text{ESP} = \frac{100(-0.0126 + 0.001745\,SAR)}{1 + (-0.0126 + 0.001745\,SAR} \ldots\ldots\ldots\ldots(6)$$

The Permeability Index (PI) was calculated according to **Doneen (1964**) as follows:

$$\text{PI} = \frac{\left[\text{Na}^+\right] + \sqrt{\text{HCO}_3^-}}{\left[\text{Na}^+\right] + \left[\text{Ca}^{2+}\right] + \left[\text{Mg}^{2+}\right]} \times 100 \quad ..(7)$$

RESULTS AND DISCUSSION

Water quality was evaluated on the basis of pH, salinity, sodicity, residual sodium carbonate, and expected soil sodicity and permeability problems. Tables 1, 2, 3, 4, 5 and 6 show the chemical analyses of water samples of irrigation water, drainage water and groundwater for collectors 13, 15 and 17. These samples were taken during the years of 2017 and 2018 in the study area. There is a network of subsurface drains run through many sites of the old Delta lands and that range from highly productive Nile alluvium to saline lacustrine soils. Thus, effluent drainage water characteristics of subsurface drains would be affected by the nature, chemo-physical composition and salinity levels of soils from which the drainage water were emitted. Also, agricultural prctices and human activities would affect the properties of subsurface drainage water.

P^H and Alkalinty

The pH values presented in Tables 1, 2, 3, 4, 5 and 6 show that water were slightly alkaline in the fresh irrigation water canals and it ranged between 7.6 and 8.0 with an average value of 7.8. In the subsurface main drainage collectors No. 13, 15 and 17, the pH values ranged between 7.8 and 8.2 with an average value of 7.9 (Tables 1 and 2). In groundwater collected from the observation wells, P^H values ranged from 7.3 to 8.3 with an overall average value of 7.8. Such values are within the normal range of the FAO guidelines for water quality (**Ayers and Westcot, 1976**). Where the normal P^H for irrigation water ranges from 6.5 to 8.4. High P^{H}'s above 8.5 are often caused by high bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) concentrations, known as alkalinity. The residual sodium carbonate (RSC) and residual sodium bicarbonate (RSBC) values, expressed in $mmol_c$/l units, for most water samples were very low and less than 0.5 except for some samples of the collector No. 15 where it was more than 1. RSC should not be higher than 1 and preferably less than +0.5 for considering the water use for irrigation. Calcium and magnesium ions become insoluble due to high carbonates and bicarbonates thereby leaving sodium as the dominant ion in solution. This alkaline water could intensify the impact of high SAR water on sodic soil conditions. Irrigation water with a P^H outside the normal range may cause a nutritional imbalance or may contain a toxic ion.

Salinity Problems and EC

Classification of irrigation water and subsurface drainage water with respect to salinity hazard is based primarily on the anticipated possible development of salinity in soil that will be irrigated with such water to the extent that yields are adversely affected. The EC values of fresh irrigation water from canals were around 0.6 dSm^{-1} with some minor variations in summer and winter seasons (Tables 1 and 2; Figs. 4 and 5). The average EC values for drainage water collected from subsurface drainage collectors No. 13, 15 and 17 were 1.95, 2.13, and 2.95 dSm^{-1}, respectively. That values lie in the moderate category of salinity (Tables 1 and 2; Figs. 4 and 5). The average values of EC for water collected from the observation wells illustrated in Fig. 1 and Tables 3, 4 and 5 were 1.1, 1.7, and 2.65 dSm^{-1} at the observation wells situated in site of collectors No. 13, 15 and 17, respectively. The classification caegories of these water according to the **USDA (1954)** lie in C3 class with moderate limitation for use and eaching required at higher range.

Table 1. Chemical composition of irrigation and drainage water‹ some calculated indices, and classification for collector No.13 at study area

Site		Collector 13					
Water source		**Irrigation water**			**Drainage water**		
Season		**Summer 2017**	**Winter 2017-2018**	**Average**	**Summer 2017**	**Winter 2017-2018**	**Average**
pH		7.70	7.60	7.65	8.00	7.80	-
EC (dSm^{-1})		0.68	0.63	0.65	1.90	2.00	1.95
Soluble catinos (mmole l^{-1})	**Ca^{++}**	2.11	1.80	1.96	5.53	5.47	5.50
	Mg^{++}	1.19	1.10	1.15	3.44	4.76	4.10
	Na^{+}	3.20	3.16	3.20	9.64	9.44	9.54
	K^{+}	0.33	0.27	0.30	0.41	0.34	0.38
Soluble aninos (mmole l^{-1})	**CO_3^{--}**	0.00	0.00	0.00	0.00	0.00	0.00
	HCO_3^{-}	1.83	1.28	1.60	3.75	4.10	3.90
	Cl^{-}	2.74	2.85	2.80	8.83	6.11	7.50
	SO_4^{--}	2.26	2.20	2.20	6.44	9.80	8.12
SSP		45.07	43.84	44.45	51.28	49.75	50.51
SAR		2.42	2.29	2.36	4.69	4.47	4.58
Adj.SAR		3.73	3.23	3.48	9.55	9.49	9.52
Adj.^{R} Na		2.41	2.15	2.28	5.53	5.28	5.40
ESP		2.33	2.14	2.24	5.71	5.39	5.55
RSC		-1.60	-2.60	-2.10	-5.60	-5.50	-5.55
RSBC		-0.30	-1.50	-0.90	-2.10	-1.30	-1.70
SCAR		2.16	1.91	2.04	4.23	4.22	4.23
PI		68.33	61.13	64.73	62.15	60.95	61.55
PS		3.90	4.60	4.25	12.00	11.10	11.55
KR		0.91	0.82	0.87	1.10	1.02	1.06
MAR		37.14	28.21	32.67	38.46	43.75	41.11
Salinity hazard		C2	C2		C3	C3	
Sodicity hazard		S1	S1		S2	S2	
USSL index		C2S1	C2S1		C3S2	C3S2	
USSL class		Good	Good		acceptable	acceptable	

1- Water quality class according to **USDA (1954)**; C_1, C_2, C_3, C_4 are low, medium, high and very high salinity; S_1, S_2, S_3, S_4 are low, medium, high and very high sodicity, respectively.

2- ICAR water quality class according to **Gupta (1979)**; C_0, C_1, C_2, C_3, C_4 ,C_5 are non, normal, low, medium, high and very high salinity; S_0, S_1, S_2, S_3, S_4,S_5 are non, normal, low, medium, high, and very high sodicity, respectively.

3- SCAR : Sodium, Calcium activity ratio = Na/√Ca.in mmolel^{-1} **(Gupta, 1984)**.

4- SAR: Sodium: Calcium Activity Ratio‹ ESP: Exchangeable Sodium Percentage, RSC: Residual Sodium Carbonate, RSB: Residual Sodium Bicarbonate and PI: Permeability Index.

Table 2. Chemical composition of irrigation and drainage water، some calculated indices, and classification for collector No.15 at study area

Site		Collector 15					
Water source		Irrigation water			Drainage water		
Season		Summer 2017	Winter 2017-2018	Average	Summer 2017	Winter 2017-2018	Average
pH		7.80	7.80	7.80	8.00	8.10	8.05
EC (dSm^{-1})		0.65	0.63	0.64	2.15	2.10	2.13
Soluble catinos (mmole l^{-1})	Ca^{++}	2.04	2.13	2.13	5.87	6.20	6.04
	Mg^{++}	1.13	1.30	1.22	4.91	5.30	5.11
	Na^{+}	3.02	2.40	2.71	10.13	9.19	9.66
	K^{+}	0.32	0.41	0.37	0.58	0.30	0.44
Soluble aninos (mmole l^{-1})	CO_3^{--}	0.00	0.00	0.00	0.00	0.00	0.00
	HCO_3^{-}	1.76	1.40	1.58	4.75	3.90	4.33
	Cl^{-}	2.52	2.26	2.39	9.23	9.85	9.54
	SO_4^{--}	2.23	2.66	2.45	7.51	7.24	7.38
SSP		46.39	37.97	42.18	47.14	43.78	45.46
SAR		2.40	1.81	2.11	4.36	3.83	4.10
Adj.SAR		3.55	2.58	3.07	9.68	8.26	8.97
$Adj.^{R}$ Na		2.34	1.70	2.02	5.23	4.46	4.86
ESP		2.30	1.43	1.87	5.23	4.44	4.83
RSC		-1.41	-2.11	-1.80	-6.03	-7.60	-6.82
RSBC		-0.28	-0.81	-0.55	-1.12	-2.30	-1.71
SCAR		2.11	1.61	1.86	4.18	3.69	3.94
PI		70.22	60.63	65.43	58.87	53.96	56.42
PS		3.64	3.59	3.6	12.99	13.47	13.23
KR		0.95	0.68	0.82	0.94	0.80	0.87
MAR		35.65	37.04	36.35	45.55	46.09	45.82
Salinity hazard		C2	C2		C3	C3	
Sodicity hazard		S1	S1		S2	S1	
USSL index		C2S1	C2S1		C3S2	C3S1	
USSL class		Good	Good		Acceptable	Appropriate	

1- Water quality class according to **USDA (1954)**; C_1, C_2, C_3, C_4 are low, medium, high and very high salinity; S_1, S_2, S_3, S_4 are low, medium, high and very high sodicity, respectively.
2- ICAR water quality class according to **Gupta (1979)**; C_0, C_1, C_2, C_3, C_4 ,C_5 are non, normal, low, medium, high and very high salinity; S_0, S_1, S_2, S_3, S_4,S_5 are non, normal, low, medium, high, and very high sodicity, respectively.
3- SCAR : Sodium, Calcium activity ratio = Na/√Ca.in me/l **(Gupta, 1984)**.
4- SAR: Sodium: Calcium Activity Ratio،ESP: Exchangeable Sodium Percentage, RSC: Residual Sodium Carbonate, RSB: Residual Sodium Bicarbonate and PI: Permeability Index.

Table 3. Chemical composition of irrigation and drainage water، some calculated indices, and classification for collector No.17 at study area

Site		Collector 17					
Water source		Irrigation water			Drainage water		
Season		Summer 2017	Winter 2017-2018	Average	Summer 2017	Winter 2017-2018	Average
pH		8.00	7.90	7.95	8.20	8.10	8.15
EC (dSm^{-1})		0.61	0.59	0.60	2.80	3.10	2.95
Soluble catinos ($mmole\ l^{-1}$)	Ca^{++}	1.74	1.30	1.52	6.58	8.87	7.65
	Mg^{++}	1.26	1.68	1.47	7.46	7.86	7.95
	Na^{+}	2.48	2.41	2.45	13.33	13.77	13.50
	K^{+}	0.63	0.50	0.57	0.61	0.61	0.61
Soluble aninos ($mmole\ l^{-1}$)	CO_3^{--}	0.00	0.00	0.00	0.00	0.00	0.00
	HCO_3^{-}	1.35	0.87	1.11	7.34	9.35	8.35
	Cl^{-}	3.14	2.63	2.89	8.92	9.19	9.06
	SO_4^{--}	1.62	2.39	2.01	11.72	12.57	12.10
SSP		39.34	39.34	39.34	47.83	44.23	46.03
SAR		1.93	1.90	1.91	5.03	4.76	4.89
Adj.SAR		2.67	2.26	2.46	11.47	11.94	11.71
$Adj.^{R}$ Na		1.78	1.60	1.69	5.84	5.99	5.92
ESP		1.60	1.55	1.58	6.21	5.82	6.02
RSC		-1.70	-2.33	-2.02	-9.00	-9.69	-9.35
RSBC		-0.50	-0.43	-0.47	-1.60	-1.79	-1.69
SCAR		1.74	2.10	1.92	5.22	4.63	4.92
PI		65.15	59.51	62.33	57.0	53.81	55.41
PS		4.15	4.10	4.13	16.95	18.75	17.85
KR		0.77	0.75	0.76	0.96	0.82	0.89
MAR		38.71	59.38	49.04	53.62	47.02	50.32
Salinity hazard		C2	C2		C4	C4	
Sodicity hazard		S1	S1		S2	S2	
USSL index		C2S1	C2S1		C4S2	C4S2	
USSL class		Good	Good		Poor	Poor	

1- Water quality class according to **USDA (1954)**; C_1, C_2, C_3, C_4 are low, medium, high and very high salinity; S_1, S_2, S_3, S_4 are low, medium, high and very high sodicity, respectively.

2- ICAR water quality class according to **Gupta (1979)**; C_0, C_1, C_2, C_3, C_4 ,C_5 are non, normal, low, medium, high and very high salinity; S_0, S_1, S_2, S_3, S_4,S_5 are non, normal, low, medium, high, and very high sodicity, respectively.

3- SCAR: Sodium, Calcium activity ratio = Na/√Ca.in me/l **(Gupta, 1984)**.

4- SAR: Sodium: Calcium Activity Ratio، ESP: Exchangeable Sodium Percentage, RSC: Residual Sodium Carbonate, RSB: Residual Sodium Bicarbonate and PI: Permeability Index.

Table 4. Chemical composition of groundwater samples (collector No.13) for different studied observation wells، some calculated indices, and classification for water samples at study area

Site		Collector 13										
Well		Well 1		Well 2		Well 3		Well 4		Well 5		Average
Point		31° 21' 27.630" E		31° 21' 27.464" E		31° 21' 27.217" E		31° 21' 23.826" E		31° 21' 23.658" E		
		30° 22' 50.835" N		30° 22' 48.842" N		30° 22' 46.300" N		30° 22' 51.189" N		30° 22' 48.578" N		
Season		Summer 2017	Winter 2017-2018	Summer 2017	Winter 2017-2018	Summer 2017	Winter 2017-2018	Summer 2017	Winter 2017-2018	Summer 2017	Winter 2017-2018	
pH		7.9	7.70	7.84	8.00	7.28	7.72	7.90	7.60	8.00	7.40	4.73
EC (dSm^{-1})		0.78	0.92	0.99	1.10	0.89	0.84	1.2.00	0.99	1.3.00	1.10	1.01
Soluble catinos ($mmole\ l^{-1}$)	Ca^{++}	2.50	1.80	2.50	2.80	2.50	1.9	4.50	3.10	2.00	4.10	2.77
	Mg^{++}	1.80	2.10	1.50	2.40	1.50	2.20	2.50	2.10	3.20	0.90	2.02
	Na^{+}	3.20	5.10	5.90	6.20	5.20	4.10	5.30	3.40	7.50	7.10	5.30
	K^{+}	0.30	0.20	0.20	0.20	0.30	0.20	0.20	0.30	0.40	0.20	0.25
Soluble aninos ($mmole\ l^{-1}$)	CO_3^{--}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	HCO_3^{-}	1.40	1.60	1.80	2.40	1.90	2.40	3.10	0.50	2.50	2.90	2.05
	Cl^{-}	4.50	6.00	5.90	4.60	2.20	3.10	5.20	4.30	4.90	2.10	4.28
	SO_4^{--}	2.18	1.92	2.10	3.80	4.60	3.14	3.67	4.28	6.20	7.50	3.94
SSP		41.03	55.43	58.42	53.45	54.74	48.81	42.40	38.20	57.25	57.72	50.74
SAR		2.18	3.65	4.17	3.85	3.68	2.86	2.83	2.11	4.65	4.49	3.45
Adj.SAR		3.21	5.40	6.38	6.65	5.73	4.80	5.48	2.28	8.08	8.05	5.61
$Adj.^{R}$ Na		2.07	3.46	4.12	4.03	3.69	2.91	3.28	1.59	4.72	5.32	3.52
ESP		1.98	4.17	4.94	4.46	4.21	2.99	2.95	1.87	5.66	5.42	3.87
RSC		-2.90	-2.30	-2.20	-2.80	-2.10	-1.70	-3.90	-4.70	-2.70	-2.10	-2.74
RSBC		-1.10	-0.20	-0.70	-0.40	-0.60	0.50	-1.40	-2.60	0.50	-1.20	-0.72
SCAR		2.02	3.80	3.73	3.71	3.29	2.97	2.50	1.93	5.30	3.51	3.28
PI		58.44	70.72	73.15	67.98	71.50	68.89	57.40	47.76	71.51	72.75	66.01
PS		5.59	6.96	6.95	6.50	4.50	4.67	7.04	6.44	8.00	5.85	6.25
KR		0.74	1.31	1.48	1.19	1.30	1.00	0.76	0.65	1.44	1.42	1.129
MAR		41.86	53.85	37.50	46.15	37.50	53.66	35.71	40.38	61.54	18.00	42.65
Salinity hazard		C3	C3	C3	C3	C3	C3	C3	C3	C3	C3	
Sodicity hazard		S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	
USSL index		C3S1	C3S1	C3S1	C3S1	C3S1	C3S1	C3S1	C3S1	C3S1	C3S1	
USSL class		Appropriate	Appropriate	Appropriate	Appropriate	Appropriate	Appropriate	Appropriate	Appropriate	Appropriate	Appropriate	

1- Water quality class according to **USDA (1954)**; C_1, C_2, C_3, C_4 are low, medium, high and very high salinity; S_1, S_2, S_3, S_4 are low, medium, high and very high sodicity, respectively.

2- ICAR water quality class according to **Gupta (1979);** C_0, C_1, C_2, C_3, C_4 ,C_5 are non, normal, low, medium, high and very high salinity; S_0, S_1, S_2, S_3, S_4,S_5 are non, normal, low, medium, high, and very high sodicity, respectively.

3- SCAR: Sodium, Calcium activity ratio = Na/√Ca.in me/l (**Gupta, 1984)**.

4- SAR: Sodium: Calcium Activity Ratio،ESP: Exchangeable Sodium Percentage, RSC: Residual Sodium Carbonate, RSB: Residual Sodium Bicarbonate and PI: Permeability Index.

Table 5. Chemical composition of ground water samples (collector No.15) for different studied observation wells‹ some calculated indices, and classification for water samples at study area

Site		Collector 15								Average
Well		Well 6		Well 7		Well 8		Well 9		
		31° 21' 13.509" E		31° 21' 13.486" E		31° 21' 3.937" E		31° 21' 3.027" E		
		30° 22' 23.484" N		30° 22' 19.805" N		30° 22' 24.775" N		30° 22' 21.208" N		
Season		Summer 2017	Winter 2017-2018	Summer 2017	Winter 2017-2018	Summer 2017	Winter 2017-2018	Summer 2017	Winter 2017-2018	
pH		7.90	8.00	8.00	7.80	8.00	8.10	7.90	8.00	7.9625
EC (dSm^{-1})		0.99	1.20	1.30	0.98	1.80	1.60	2.10	1.70	1.45875
Soluble catinos (mmole l^{-1})	Ca^{++}	2.90	1.90	2.00	1.90	2.60	2.10	3.10	3.20	2.4625
	Mg^{++}	1.90	1.70	3.30	4.10	2.70	3.40	6.20	5.60	3.6125
	Na^{+}	4.85	8.90	7.90	4.60	13.70	11.20	12.20	8.70	9.00625
	K^{+}	0.20	0.30	0.20	0.30	0.20	0.50	0.30	0.20	0.275
Soluble aninos (mmole l^{-1})	CO_3^{--}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	00
	HCO_3^{-}	2.50	2.70	2.70	2.40	2.80	4.40	4.90	3.90	3.2875
	Cl^{-}	3.60	7.30	9.40	3.10	8.70	6.80	9.20	5.60	6.7125
	SO_4^{--}	2.78	1.30	1.79	4.90	6.90	5.70	9.10	7.80	5.03375
SSP		49.24	69.53	58.96	42.20	71.35	65.12	55.96	49.15	57.6887
SAR		3.13	6.63	4.85	2.66	8.42	6.75	5.66	4.15	5.28125
Adj.SAR		5.43	10.93	8.61	5.14	14.79	13.34	12.32	8.63	9.89875
$Adj.^{R}$ Na		3.34	6.84	4.97	2.77	8.83	7.28	6.15	4.48	5.5825
ESP		3.39	8.61	5.96	2.68	11.26	8.79	7.16	4.91	6.595
RSC		-2.30	-0.90	-2.60	-2.60	-2.50	-1.10	-4.40	-4.90	-2.6625
RSBC		-0.40	0.80	0.70	1.50	0.20	2.30	1.80	0.70	0.95
SCAR		2.85	6.46	5.59	3.34	8.50	7.73	6.93	4.86	5.7825
PI		66.64	84.35	72.30	60.79	80.91	79.63	67.04	61.00	71.5825
PS		6.79	8.95	10.30	4.85	12.15	9.65	11.95	10.60	9.405
KR		1.01	2.47	1.49	0.77	2.58	2.04	1.31	0.99	1.5825
MAR		39.58	47.22	62.26	68.33	50.94	61.82	66.67	63.94	57.595
Salinity hazard		C3	C3	C3	C3	C3	C3	C3	C3	
Sodicity hazard		S1	S2	S1	S1	S2	S2	S2	S1	
USSL index		C3S1	C3S2	C3S1	C3S1	C3S2	C3S2	C3S2	C3S1	
USSL class		Appropriate	Acceptable	Appropriate	Appropriate	acceptable	Acceptable	Acceptable	Appropriate	

1- Water quality class according to **USDA (1954)**; C_1, C_2, C_3, C_4 are low, medium, high and very high salinity; S_1, S_2, S_3, S_4 are low, medium, high and very high sodicity, respectively.

2- ICAR water quality class according to **Gupta (1979)**; C_0, C_1, C_2, C_3, C_4 ,C_5 are non, normal, low, medium, high and very high salinity; S_0, S_1, S_2, S_3, S_4,S_5 are non, normal, low, medium, high, and very high sodicity, respectively.

3- SCAR: Sodium, Calcium activity ratio = Na/√Ca.in me/l **(Gupta, 1984)**.

4- SAR: Sodium: Calcium Activity Ratio‹ ESP: Exchangeable Sodium Percentage, RSC: Residual Sodium Carbonate, RSB: Residual Sodium Bicarbonate and PI: Permeability Index.

Table 6. Chemical composition of ground water samples (collector No. 17) for different studied observation wells، some calculated indices, and classification for water samples at study area

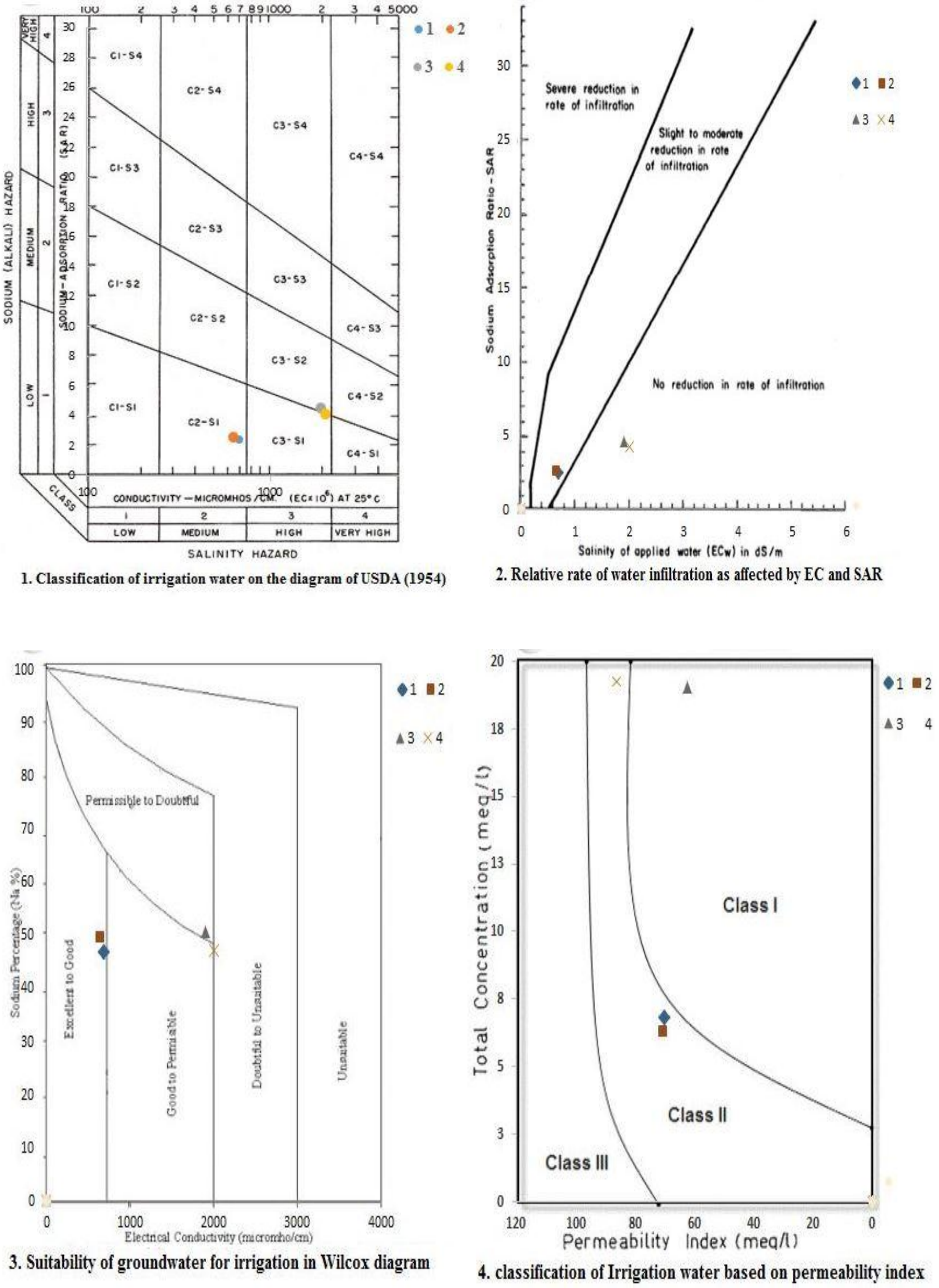
Site		Collector No. 17								Average
Well		Well 10		Well 11		Well 12		Well 13		
Point		31° 21' 7.509" E		31° 21' 7.015" E		31° 21' 0.372" E		31° 20' 59.962" E		
		30° 22' 11.023" N		30° 22' 5.801" N		30° 22' 10.504" N		30° 22' 6.438" N		
Season		Summer 2017	Winter 2017-2018	Summer 2017	Winter 2017-2018	Summer 2017	Winter 2017-2018	Summer 2017	Winter 2017-2018	
pH		7.80	8.00	8.10	7.90	8.00	8.10	7.90	8.30	8.01
EC (dSm^{-1})		2.70	2.40	3.12	2.60	2.40	2.10	2.20	2.60	2.56
Soluble catinos (mmole l^{-1})	Ca^{++}	4.30	4.70	6.70	7.20	4.50	5.10	5.50	6.20	5.53
	Mg^{++}	6.30	7.40	8.60	11.20	9.70	7.40	11.50	8.60	8.84
	Na^{+}	16.40	12.30	15.70	7.50	10.20	8.60	5.10	11.40	10.9
	K^{+}	0.30	0.20	0.60	0.30	0.50	0.30	0.50	0.20	0.36
Soluble anin((mmole l^{-1})	CO_3^{--}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	HCO_3^{-}	3.80	6.30	7.20	6.50	2.50	4.90	3.00	5.40	4.95
	Cl^{-}	14.50	8.40	14.30	10.30	13.60	9.40	10.30	11.80	11.57
	SO_4^{--}	8.40	8.90	10.40	9.40	8.30	6.70	9.20	8.60	8.74
SSP		60.07	50.00	49.68	28.63	40.96	40.19	22.57	43.18	41.91
SAR		7.12	5.00	5.68	2.47	3.83	3.44	1.75	4.19	4.19
Adj. SAR		14.91	11.82	14.08	6.22	7.74	7.84	3.80	9.89	9.54
Adj. ^{R} Na		7.81	5.71	6.75	2.87	3.99	3.90	1.87	4.83	4.72
ESP		9.34	6.18	7.18	2.41	4.43	3.85	1.33	4.97	4.96
RSC		-6.8	-5.8	-8.1	-11.9	-11.7	-7.6	-14.0	-9.4	9.41
RSBC		-0.50	1.6	0.5	-0.70	-2	-0.2	-2.5	-0.8	0.58
SCAR		7.91	5.67	6.07	2.8	4.81	3.81	2.17	4.58	4.73
PI		67.96	60.70	59.30	38.80	48.28	51.25	30.91	52.38	51.2
PS		18.7	12.85	19.50	15.0	17.75	12.75	14.9	16.1	15.94
KR		1.55	1.02	1.03	0.41	0.72	0.69	0.30	0.77	0.81
MAR		59.43	61.16	56.21	60.87	68.31	59.20	67.65	58.11	61.37
Salinity hazard		C4	C4	C4	C4	C4	C3	C3	C4	
Sodicity hazard		S2	S2	S2	S1	S1	S1	S1	S2	
USSL index		C4S2	C4S2	C4S2	C4S1	C4S1	C3S1	C3S1	C4S2	
USSL class		poor	poor	poor	Poor	poor	appropriate	appropriate	poor	

1- Water quality class according to **USDA (1954)**; C_1, C_2, C_3, C_4 are low, medium, high and very high salinity; S_1, S_2, S_3, S_4 are low, medium, high and very high sodicity, respectively.

2- ICAR water quality class according to **Gupta (1979)**; C_0, C_1, C_2, C_3, C_4 ,C_5 are non, normal, low, medium, high and very high salinity; S_0, S_1, S_2, S_3, S_4,S_5 are non, normal, low, medium, high, and very high sodicity, respectively.

3- SCAR : Sodium, Calcium activity ratio = Na/√Ca.in me/l **(Gupta, 1984)**.

4- SAR: Sodium: Calcium Activity Ratio،ESP: Exchangeable Sodium Percentage, RSC: Residual Sodium Carbonate, RSB: Residual Sodium Bicarbonate and PI: Permeability Index.



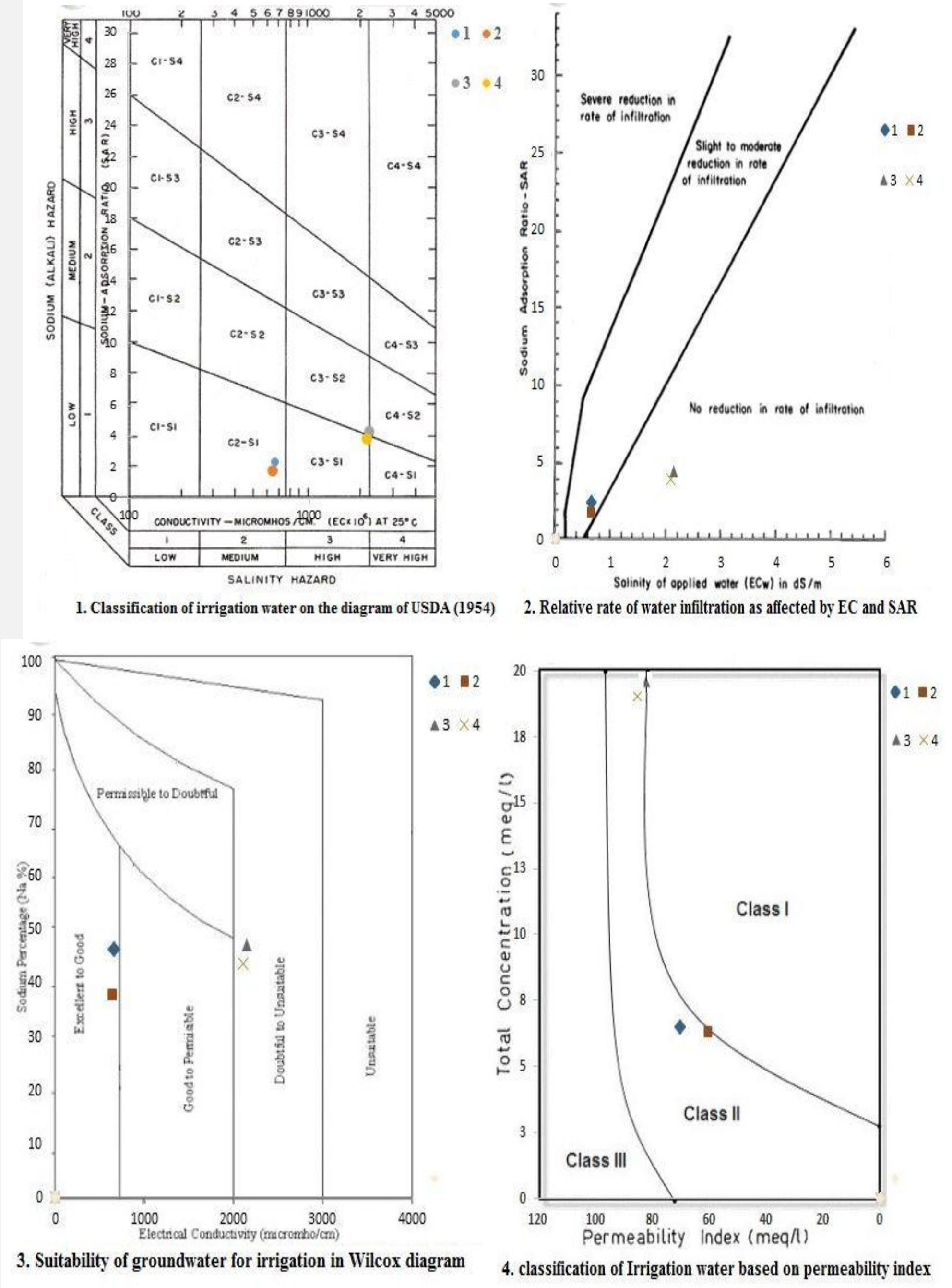
1. Classification of irrigation water on the diagram of USDA (1954)

2. Relative rate of water infiltration as affected by EC and SAR

3. Suitability of groundwater for irrigation in Wilcox diagram

4. classification of Irrigation water based on permeability index

Fig. 4. Diagram of chemical composition of irrigation and drainage water، some calculated indices, and classification for collector No. 13 at study area



1. Classification of irrigation water on the diagram of USDA (1954)

2. Relative rate of water infiltration as affected by EC and SAR

3. Suitability of groundwater for irrigation in Wilcox diagram

4. classification of Irrigation water based on permeability index

Fig. 5. Diagram of chemical composition of irrigation and drainage water، some calculated indices, and classification for collector No.15 at study area

In general, results show that the EC values were_below 3.0 dSm^{-1} and salinity was lower in the summer than in the winter and the highest values occurred at collector No. 17, due to holding back of canal irrigation water during the winter closer period in January to February, in addition to the use of large quantities of Nile water for irrigating summer crops particularly rice. Results also illustrated that, drainage water for collectors No. 13, 15 and 17 were ranged from 1.59 to 3.10 with an average of 2.34 dSm^{-1}. Results in Tables 4, 5 and 6 show that, salinity of groundwater for collectors No. 13, 15 and17 varied from 0.78 to 3.12 with an average of 1.66 dSm^{-1}. Based on the classification of the U.S. Salinity laboratory staff (**USDA, 1954**), the water of irrigation water could be classified as class C2 (medium - salinity water) with EC between 0.59 and 0.68 dSm^{-1} (less than 0.75 dSm^{-1}), whereas water of drainage water could be classified as class C3 (high- salinity water) with EC between 1.59 and 3.1 dSm^{-1}, and groundwater could be classified as class C3 (high-salinity water) with EC between 0.78 and 3.12 dSm^{-1} which indicates increasing problems. Based on the FAO Guidelines (**Ayers and Westcot, 1976**). The effects of management and salinity and their interaction on yield and water productivity should be considered.

Sodicity Proplems

Although plant growth is primarily limited by the salinity (ECw) level of the irrigation water, the application of water with a sodium imbalance can further reduce yield under certain soil texture conditions. Reductions in water infiltration can occur when irrigation water contains high sodium relative to the calcium and magnesium content (**Hamid *et al.*, 2012**). The SAR values of fresh irrigation water from canals were around 2.12 with some minor variations in summer and witer seasons and it lies in the S1 category with no limitation for use (Tables 1, 2 and 3 and Figs. 4, 5 and 6). The average SAR values for drainage water collected from subsurface drainage collectors No. 13, 15 and 17 were 4.58, 4.1, and 4.89, respectively. That values lie in the moderate category of sodicity (Tables 1, 2 and 3 and Figs. 4, 5 and 6). The average values of SAR for water collected from the observation wells illustrated in Fig. 1 and Tables 4, 5 and 6 were 3.44, 5.28 and 4.19 at the observation wells situated in site of collector No. 13, 15, and 17, respectively. The classification caegories of these water according to the **USDA (1954)** lie in S1 and S2 class with moderate limitation for use and adding gypsum is required to modify the SAR value to lower extent.

Generally, results showed that, SAR in irrigation water (Tables 1, 2 and 3) varied from 1.81 to 2.4 and in drainage water (Tables 1, 2 and 3) ranged from 3.83 to 5.03 as well as groundwater (Tables 4, 5 and 6) varied from 1.75 to 8.42 for all the studied areas.The parameter of "sodium adsorption ratio" (SAR) proposed by the **USDA (1954)**, the waters range from no-sodicity hazard to sodicity hazard. The annual mean values for water were between 2.47 and 7.12, which is high during the winter and low during the summer. The high value indicates a sodicity hazard.

Regarding the parameter of adjusted sodium hazard (adj.^{R} Na) proposed by **Gupta (1979)**, values ranged between 1.6 and 5.99 indicating low to high sodium hazards. It was reported that the adj. SAR would be more correctly predict the sodicity hazard of an irrigation water than either the SAR or the RSC concept. However, in their revision and updating of Irrigation and Drainage, they state that the procedure is no longer recommended.

Surplus exchangeable sodium causes the stable soil aggregates to disperse and impart poor air/water permeability only in the absence of excess electrolytes. In natural world generally, as the salinity of the waters increases, the SAR also increases. Thus most irrigation water that has a high salinity hazard also has a high SAR but such water does not have a sodicity (alkali) hazard. Thus it is extremely doubtful if SAR or adj. SAR alone could predict the sodicity hazard of an irrigation water. On the other hand, when appreciable quantities of residual sodium carbonate (RSC) are present, the total salinity of water is often low to medium and rarely more than 2 dSm^{-1}. Under conditions of low to medium total salinity, water having high residual sodium carbonate (RSC) can have an appreciable sodicity hazard. The concept of residual sodium carbonate appears to relate better to the sodicity problem in the field (**FAO, 1988**).

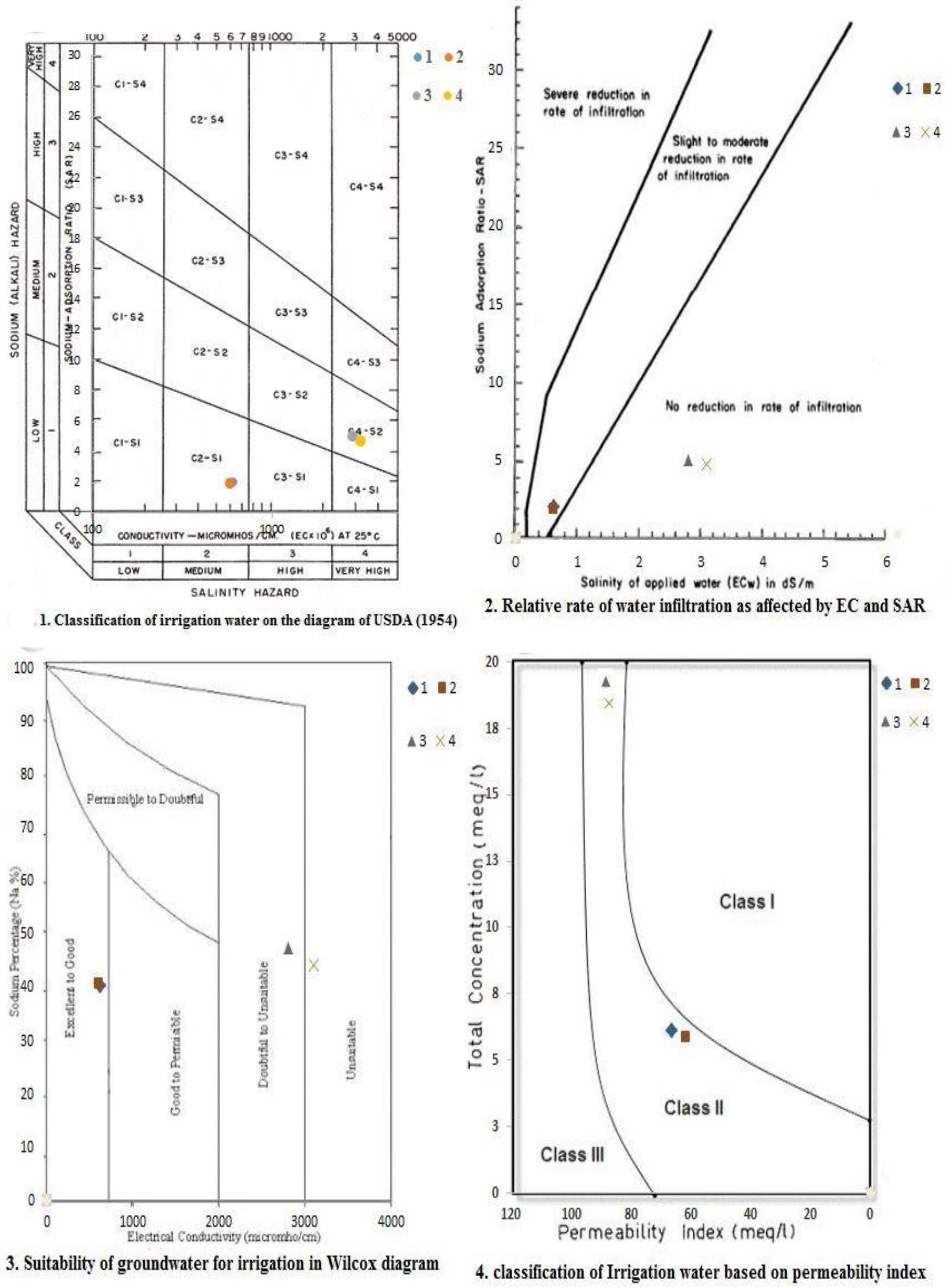


Fig. 6. **Diagram of chemical composition of irrigation and drainage water، some calculated indices, and classification for collector No.17 at study area**

Chlorides and Bicarbonates

Chloride is a common ion in most of the irrigation waters. Although chloride is essential to plants in very low amounts however, it can cause toxicity to sensitive crops at high concentrations. Results presented in Tables from 1 to 6 show that chlorides concentration ranged between 6.2 and 9.9 mmole l^{-1} indicating that classes ranging from no problem to increasing problems according to the FAO Guidelines (**Ayers and Westcot, 1976**). The water of the subsurface drains had higher values than water of irrigation water of El-Serw fresh water canal. It is usually first evidenced as marginal leaf burn and interveinal chlorosis. If the accumulation is great enough, reduced yields result. The more tolerant annual crops are not sensitive at low concentrations but almost all crops will be damaged or killed if concentrations are amply high.

Also, according to FAO Guidelines, values of bicarbonate (HCO_3) concentration found in the water samples ranged between 2.9 and 9.11 which indicating no problem. Water taken from the main drain collectors and attributed observation wells showed higher values than water of fresh water canal.

Permeability Hazards

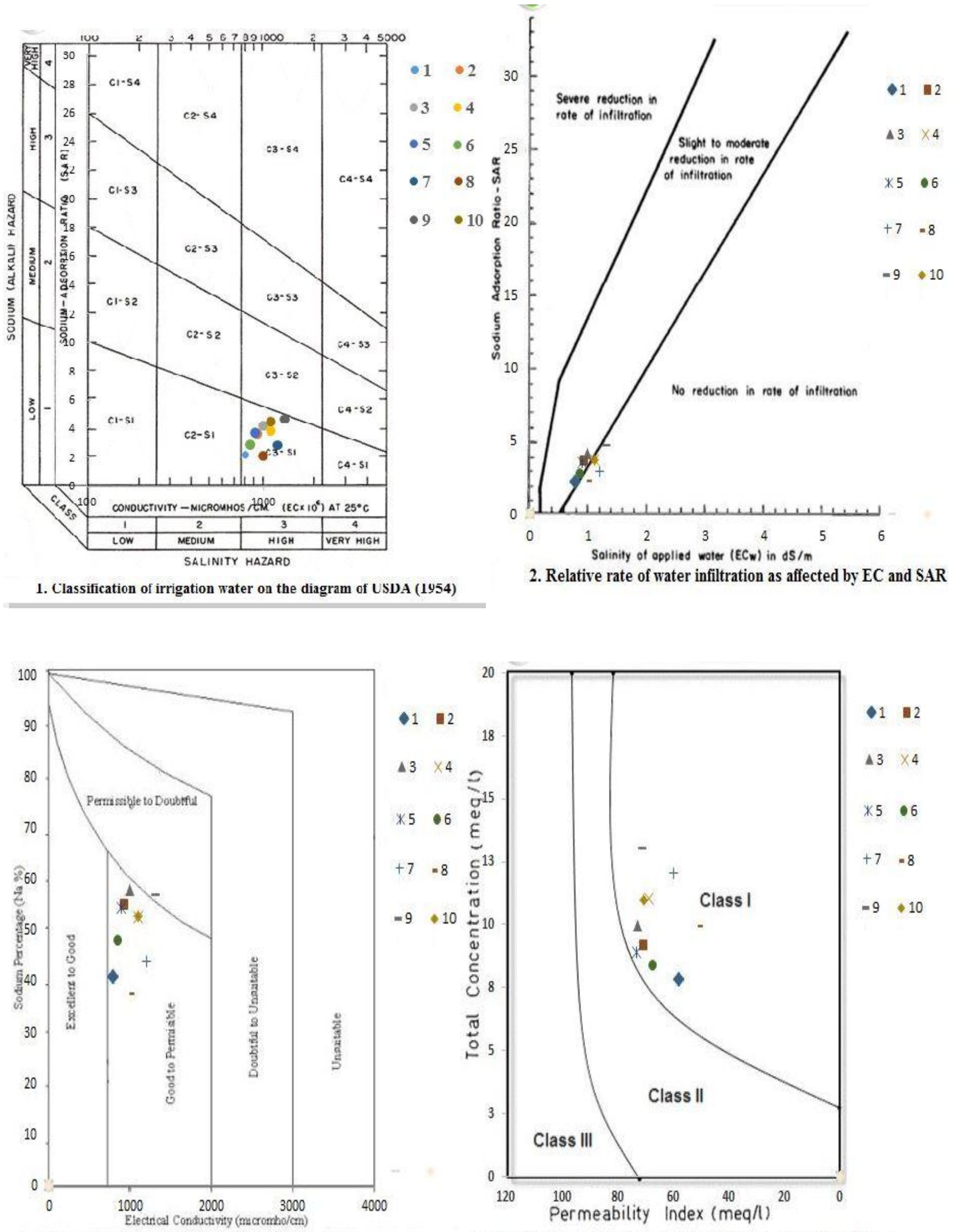
The soil permeability is affected by long term use of irrigation water as it influenced by sodium, calcium, magnesium, and bicarbonate content of the soil. **Doneen (1964)** gave a criterion for assessing the suitability of groundwater for irrigation based on the permeability index (PI). Where concentrations are in meq/l.

Accordingly, the permeability index is classified under class I (>75%), class II (25-75%) and class III (<75%) orders. Class I and class II waters are categorised as good for irrigation with 75% or more of maximum permeability. Class III waters are unsuitable with 25% of maximum permeability. Therefore, all the samples fall into the class I and II category of **Doneen (1964)** as in Figs. 4, 5, 6, 7, 8 and 9. In the study area, the PI in fresh water canal varies from 59.5 to 70.2 with an average of 64.60, while PI values in subsurface drainage collectors and their attributed observation wells vary from 30.9 to 71.5 with an average value of 51.2. As the PI indicates that the subsurface drainage water of the study area have no severe permeability and infiltration problems and can be utilised for irrigation.

Conclusions and Future Outlook

The obtained results collected from the three collectors of subsurface drainage system in the study are showed that drainage water were classified as class C_3S_1 at collector No. 13 with high salinity low sodicity hazards, C_3S_2 at collector No. 15 with high salinity medium sodicity hazards and C_4S_2 at collector No. 17 with very high salinity medium sodicity hazards according to the classification of the US Salinity Laboratory (**USDA, 1954**). Water samples taken from El-Serw fresh water canal was classified as C_2S_1 medium salinity low sodicity. The on-farm water subsurface drainage of the study area can be reused for irrigation with care for grown crops. Tolerant -salinity crops such as cotton and barley are recommended with such water. Coarse textured soils may be the best choice for reusing such subsurface drainage water to irrigate the growing crops and that will be less hazards than those grown on fine textured ones.

An integrated system of drainage plus irrigation, called drainage water recycling, may be recommended as a strategy for managing seasonal variations in water availability. Drainage water recycling is a practice that utilizes drainage systems to route surface and subsurface drainage water from the field, which is usually in excess during the early months of the year, to an on-farm pond or reservoir where it can be temporarily stored. Later in the summer, when water is often in high demand and fresh irrigation water from irrigation canals is not sufficient to meet crop needs, drainage water that was previously stored in the reservoir can be applied to the field.



1. Classification of irrigation water on the diagram of USDA (1954)

2. Relative rate of water infiltration as affected by EC and SAR

3. Suitability of groundwater for irrigation in Wilcox diagram

4. classification of Irrigation water based on permeability index

Fig. 7. Chemical composition of groundwater samples (collector No.13) for different studied observation wells، some calculated indices, and classification for water samples at study area

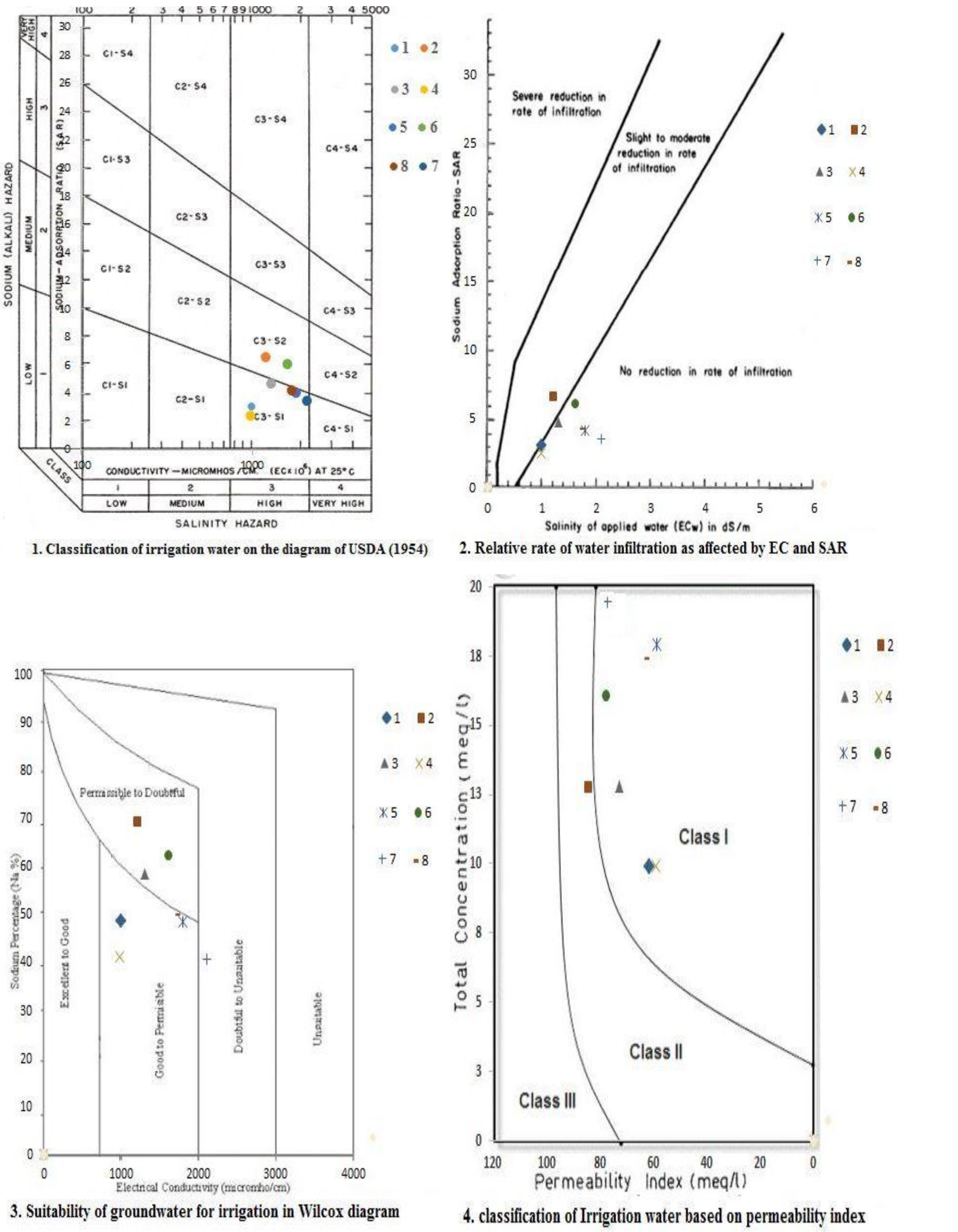
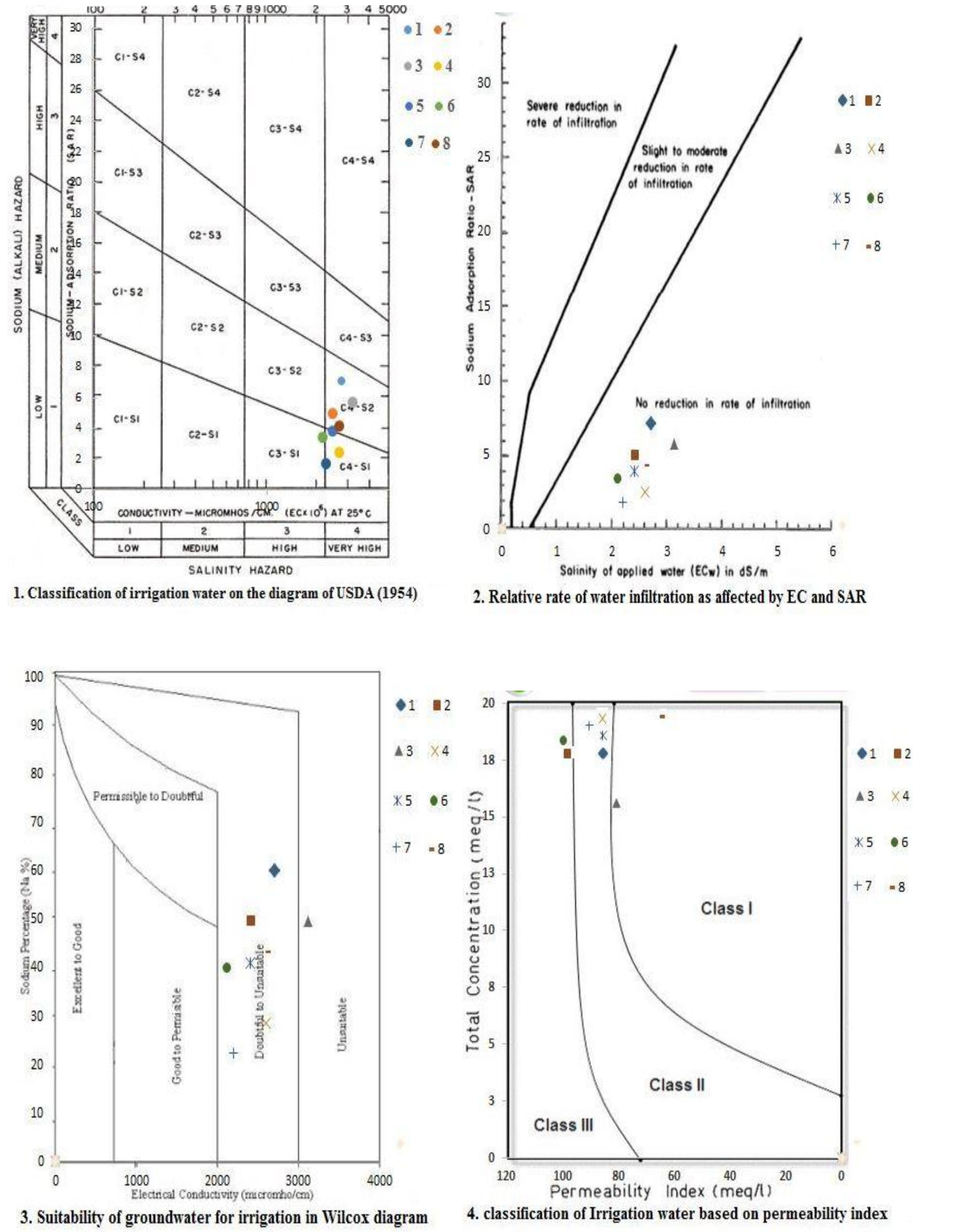


Fig. 8. Chemical composition of ground water samples (collector No. 15) for different studied observation wells، some calculated indices, and classification for water samples at study area



1. Classification of irrigation water on the diagram of USDA (1954)

2. Relative rate of water infiltration as affected by EC and SAR

3. Suitability of groundwater for irrigation in Wilcox diagram

4. classification of Irrigation water based on permeability index

Fig. 9. Chemical composition of ground water samples (collector No.17) for different studied observation wells، some calculated indices, and classification for water samples at study area

App. 1. The FAO guidelines for interpretation of water quality for irrigation according to Ayers and Westcot (1976)

Irrigation problem	Degree of problem		
	No. problem	Increasing problem	Severe problem
Salinity (affects crops water availability) EC_W (dSm^{-1})	<0.75	0.75-3.0	>3.0
Permeability (affects infiltration rate into soil) EC_W (dSm^{-1})			
Adj.SAR	>0.5	0.5-0.2	<0.2
Montmorillonite (2:1 crystal lattice)	>6	6-9	>9
Illite-Vermicultic (2:1 crystal lattice)	<8	8-16	>16
Kaolinite-sesquioxides (1:1 crystal lattice)	<16	16-22	>22
Specific ion Toxicity (affects sensitive crops)			
Sodium (adj.SAR)	<3	3-9	>9
Chloride (mmole l^{-1})	<4	4-10	>10
Boron (mg l^{-1})	<0.75	0.75-2.0	>2.0
Miscellaneous effects (affects susceptible crops)			
NO_3-N(or) NH_4-N(mmole l^{-1})	<5	5-30	>30
HCO_3 (mmole l^{-1}) (overhead sprinkling)	<1.5	1.5-8.5	<8.5
pH	Normal range (6.8-8.4)		

App. 2. USDA classification of irrigation water

Salinity hazard	Class	EC(dSm^{-1})	Sodicity hazard	Class	SAR
Low	C1	0.1-0.25	Low	S1	10<
Medium	C2	0.25-0.75	Medium	S2	10-18
High	C3	0.75-2.25	High	S3	18-26
Very high	C4	2.25-5.00	Very high	S4	>26

App. 3. Gupta's ABC classification of irrigation water (Gupta, 1979)

Class	Adj. SAR	Class	Boron (mgl^{-1})	Class	EC dSm^{-1}
A_1	<10	B_1	<3	C_1	<1.5
A_2	10-20	B_2	3-4	C_2	1.5-3
A_3	20-30	B_3	4-5	C_3	3-5
A_4	30-40	B_4	5-10	C_4	5-10
A_5	<40	B_5	<10	C_5	>10

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تقييـــم جودة ميـــاه الصرف المغطي علي مستوي الحقل لأغراض الـــرى التكميلى بمنطقة مشتول السوق - محافظة الشرقية - مصر

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لتقييم جودة مياه الري والمياه الجوفية ومياه الصرف تحت السطحية في منطقة مشتول السوق، محافظة الشرقية، من أجل استخدام المياه الجوفية ومياه الصرف في عملية الري التكميلية، تم جمع ٦ عينات من ترعة السرو (الري)، و ٢٦ عينة من آبار الملاحظة (المياه الجوفية) و ٦ عينات من مجمعات الصرف الرئيسية المغطاة (مياه الصرف) خلال فصل الصيف (٢٠١٧) و الشتاء (٢٠١٧ / ٢٠١٨) وتم تحليلها، أظهرت النتائج أن قيم الـpH تتراوح من ٧.٦ إلي ٨.٠ في عينات مياه الري، وكان متوسط الملوحة (EC) وقيم الصوديوم المدمص (SAR) في عينات مياه الري كانت ٠.٦٣ dSm^{-1} و ٢.٠٩ ، على التوالي، يعني انخفاض قيم الملوحة والقلوية في منطقة الدراسة أن مياه الري جيدة للري. تتراوح قيم الرقم الهيدروجيني لمياه الصرف من ٧.٨ إلى ٨.٢ ، وكان متوسط قيم EC و SAR في عينات مياه الصرف ٢.١ dSm^{-1} و ٤.٥٢ ، على التوالي ، ووفقًا لتقسيم معمل الملوحة الأمريكي ١٩٥٤ ، تم تصنيف C2S1 في عينات مياه الري بين C3S2 في مياه الصرف حول المجمّع ١٣ و ١٥ و C4S2 في المجمع ١٥، أظهرت نتائج المياه الجوفية للمواقع المختلفة أن هناك اختلافات موسمية في تركيز العناصر القابلة للذوبان، تراوحت ملوحة المياه الجوفية وقدرتها من ٠.٧٨ إلى ٣.١٢ dSm^{-1} ومن ١.٧٥ إلى ٨.٤٢ على التوالي، تراوحت قيم الصوديوم المغمورة ٥.٣٦ و ٧.٧٤ و ١٠.٩ في نفس العينات، تم تقييم كلوريد الصوديوم والبوتاسيوم والمغنيسيوم والكالسيوم والكبريت وبيكربونات، أما تحليلات عينات الماء الأرضي فصنفت جودتها في قسم C3S1 عند المجمعين ١٣ و ١٥ وتتبع قسم C4S2 عند مجمع ١٧ وقد أوضحت نتائج تحليل المياه الارضي للمواقع المختلفة الى وجود اختلافات موسمية فى تركيز العناصر الذائبة حيث تراوحت قيم الملوحة ما بين ٠.٧٨ الى ٣.١٢ ديسسيمنز/متر والصودية ١.٧٥ الى ٨.٤٢ ديسسيمنز/متر وتراوحت قيم معدل الصوديوم المدمص ما بين ١.٧٥ إلى ٨.٤٢، كما تم تقدير الكلوريد والصوديوم والبوتاسيوم والماغنسيوم والكالسيوم والكبريتات والبيكربونات وكذلك تم تقدير معدل SAR/SCAR، وغيرها، يمكن إعادة استخدام الصرف تحت السطحى في منطقة الدراسة لأغراض الري مع الاهتمام بالمحاصيل المزروعة، كما ينصح بزراعة محاصيل اكثر مقامة للملوحة مثل القطن والشعير لاستخدام هذه المياه، وقد تكون التربة الخشنة القوام هي أفضل خيار لإعادة استخدام مياه الصرف تحت السطحية لري المحاصيل الزراعية والتي ستكون أقل خطورة من تلك التي تزرع فى اراضى ناعمة القوام، حيث يمكن استخدام نظام متكامل للصرف والري لإعادة تدوير مياه الصرف كاستراتيجية للتغلب علي نقص مياه الري العذبة في بعض فترات السنة عن طريق تخزين تلك المياه في خزانات داخل المزرعة لحين استخدامها وقت الحاجة، سواء عن طريق خلطها بمياه الري العذبة أواستخدامها مباشرة وهذا يتوقف علي نوعيتها ونوع المحاصيل المزروعة.

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