April 2013. Vol. 3, No. 1 ISSN 2305-8269
International Journal of Engineering and Applied Sciences

www.eaas-journal.org

IRRIGATION WATER QUALITY EVALUATION IN EL-SALAM CANAL PROJECT

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ABSTRACT

Egypt in the world of scarcity is not an exception. The present per capita availability of water is approximately 985 m^3/yr today, while the per capita availability of cultivated land is as low as 0.12 acre. The main and almost exclusive source of water for Egypt is the Nile River, which represents 97% of the country's fresh water resources. El-Salam Canal will greatly increase the water resources of the area west of Suez Canal and Sinai. The canal will convey the required water from Damietta branch of the Nile of the Nile River, after being mixed with drainage water from the main drains of the Eastern Delta. Out of annual supply of water of 4.45 milliard m^3, 2.11 milliard m^3 will constitute fresh water supplied from Nile water and the remainder from Hadous drain (1.905 milliard m^3) and El-Serw drain (0.435 milliard m^3).

Ten different water sampling locations of El-Salam Canal project were selected to cover the implemented studied area to evaluate the chemical properties of this water during the 2007-2008 seasons. Hadous drain (**L1**), El-Serw drain (**L2**), after mixing with El-Serw drain (**L3**), after mixing with Hadous drain (**L4**), El Salam Canal West (**L5**), El Salam Canal East ,(**L6**), Ganoub El-Kantara Canal (**L7**), Balouza drainage East (**L8**), Balouza drainage West (**L9**) and Bahr el-Baqar Drain (**L10**). The results showed that, the Values of EC, Cations and Aninos increased in summer season in comparison with other seasons. The EC values of El Salam Canal increased after mixing with Hadous drain compared with after mixing with El-Serw drain. Soluble cations, anions and SAR of the different locations waters, increased progressively with increasing salinity content of the water. Also, data showed that, $Na^+$and Cl^- increased progressively with increasing salinity levels in the irrigation water. The data showed clearly that increasing salinity levels in the irrigation water had led to an increase in the SAR values on all locations under study.

Keywords: agriculture; irrigation water; canal water

INTRODUCTION

Egypt in the world of scarcity is not an exception. The present per capita availability of water is approximately 985 m3/yr today, while the per capita availability of cultivated land is as low as 0.12 acre. The main and almost exclusive source of water for Egypt is the Nile River, which represents 97% of the country's fresh water resources. The river supplies water to a population of about 65 million inhabitants where the country's growing population is expected to reach 90 million in the year 2025 increasing the demand for the already scarce water and arable land. Of this water almost 85% is allocated for agriculture with overall irrigation efficiency lies between 65-75%, whereas water allocated for domestic and industrial uses is less than 15% (Kandil, 2006 and Refae et al., 2006)

Based on the measures towards water resources management, Egypt is facing serious challenges such as deterioration of water quality and the growing demand-supply gap. Also, Egypt is one of the most overpopulated countries as relative to its cultivated area, mainly due to the limited amount of water needed for irrigation purposes. Therefore, the horizontal extension in arable areas, through the utilization of low-quality water for irrigation, is one

ISSN 2305-8269
International Journal of Engineering and Applied Sciences

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of the main targets of agricultural policy to face the urgent needs for increasing food production.

Some of the objectives and benefits that are gained from implementing El-Salam Canal are: redistributing population in Egypt, protecting the eastern borders of the country, strengthening the Egyptian agricultural policy through increasing the cultivated areas and agricultural yield, increasing agricultural and national production and thus increasing exporting vegetables and fruits while decreasing food import, benefiting and making good use of agricultural drainage water as an important water re- source, creating work opportunities for the youth and establishing tourism, industrial and mining projects (FAO, 1989 and Emam and Hydraulics, 2002).

Sinai Peninsula represents Egypt's eastern strategic extension and its historical link to its Arab neighbors. In the framework of a comprehensive development towards a better future shining with welfare and growth, the Nile water flows to our beloved Sinai to endow it with life and spread prosperity, connecting such a precious part of our country to the Nile valley area. Constructing Al-Salam Canal in front of Damietta Lock and Dam with the purpose of reclaiming 220 thousand feddans west of the Suez Canal; Infrastructure works were completed. Nearly 180 thousand feddans are currently being cultivated. Estimated water requirements needed for reclaiming and cultivating 620 thousand feddans (220 thousand feddans west of the Suez Canal and 400 thousand feddans east of the Suez Canal) are nearly 4.45 billion cubic meters of fresh Nile water mixed with agricultural drainage water at a ratio of 1:1 so that salinity ratio would not exceed 1000 ppm (particles per million) along with selecting the proper crops combinations (Shata, 1995 and Donia, 2008).

El-Salam Canal is one of the national promising projects for reusing drainage water in irrigation. Namely, drainage water from Hadous drain (1.905 B m3/year) and El-Serw drain (0.435 B m3/year) in a 1:1 mixing ratio with the Nile river water (2.11 B m3/year) delivered from Damietta branch, (JICA, 1989). El-Salam Canal project has been planned to cultivate about 620,000 feddans, of which 220,000 feddans are in Hussenya plain and south Port Said areas at the western bank of Suez Canal, about 400,000 feddans in south El-Qantara Shark, Tina plain, Rabaa, Bir El-Abd and El-Sir and Quarir areas at the eastern bank of the Suez Canal. The total length of El-Salam Canal is 242 km, 87 km in the west and 155 km in the east side of the Suez Canal. The water in the canal from Bir El-Abd to El-Manarah will be under pressure in pipes to allow lifting of water to the area of El-Sir and El-Quarir, and to avoid the sand dunes in this area. The tunnel underneath the Suez Canal delivers 14 million m3 of water/day (Balaba, 1997).

The sources of water available in the project are rainfall, surface water (runoff water), ground water and the Nile water mixed with drainage water, which will be conveyed by El-Salam Canal. Salinity should not exceed 1250 ppm generally in the canal. Many structures are constructed along El-Salam Canal. The first group of these structures is for water regulation purposes, consisting of pump stations and regulators. The second groups of structures are crossing structures such as siphons and bridges.

El-Salam Canal will greatly increase the water resources of the area west of Suez Canal and Sinai. The canal will convey the required water from Damietta branch of the Nile of the Nile River, after being mixed with drainage water from the main drains of the Eastern Delta. Out of annual supply of water of 4.45 milliard m3, 2.11 milliard m3 will constitute fresh water supplied from Nile water and the remainder from Hadous drain (1.905 milliard m3) and El-Serw drain (0.435 milliard m3). The estimated flows for the project, as provided by DRI (1993) showed in Table (1) reveal that water shortage occur in May and June when monthly average drain flows are compared with the estimated monthly water (Ahmed, 2003 and El-Degwi, et al., 2004)

ISSN 2305-8269
International Journal of Engineering and Applied Sciences

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Month	Serw		Hadous		Damietta		Q total	After mixing	
	Design flow	EC average 1984-90	Design flow	EC average 1984-90	Design flow	EC average 1984-90		EC	Salinity
	Million m^3	dSm^{-1}	Million m^3	dSm^{-1}	Million m^3	dSm^{-1}	Million m^3	dSm^{-1}	ppm
Jan	30	1.99	90	2.69	120	0.65	240	1.58	1075
Feb	15	2.65	55	4.52	230	0.65	300	1.46	992
Mar	30	1.66	150	2.64	125	0.65	305	1.73	1175
Apr	30	1.49	125	2.72	155	0.65	310	1.56	1063
May	45	1.42	185	2.58	75	0.65	305	1.93	1313
June	45	1.59	240	2.99	285	0.65	570	1.71	1163
July	45	1.89	240	2.85	285	0.65	570	1.67	1138
Aug	45	1.51	240	2.63	255	0.65	540	1.60	1089
Sep	60	1.43	135	2.51	225	0.65	420	1.36	925
Oct	45	1.42	65	2.35	50	0.65	160	1.56	1058
Nov	30	1.44	155	2.54	155	0.65	340	1.58	1076
Dec	15	1.84	225	2.27	150	0.65	390	1.63	1109
Total	435	-	1905	-	2110		4450		

Table (1) Electrical conductivity and salinity values of irrigation water

The proposed mixing ratio of the flows from the drains and Damietta branch for the month of May are not 1:2, suggested as design mixing ratio, but 1:3. The three times higher quality of drainage results in the higher salinity value for May.

Table (2) showed that limits with respect to salinity and sodium adsorption ratio for irrigation water were set by the FAO and Doorenbos and Pruitt (1992). Categories were established depending on their effects on crop yield and soil physical. Most of El-Salam Canal water falls within the "increasing problem" category with a salinity level of 500-1750 ppm. The sodium adsorption ratios (SAR) are calculated by the Drainage Research Institute (1993) and Moubarak (1999) after mixing the Nile water with drainage water to a ratio of one to one, its value ranges between 8 and 11. Irrigation water with this range is considered "high sodium water" and can adversely affect the soil structure and reduce permeability of the soils.

Irrigation problem	No problem	Increasing problem	Severe problem
Salinity of irrigation water (gm/m^3) which affects crop availability	< 500	500 - 1750	>1750
Salinity of irrigation water (gm/m^3) which affects soil permeability	> 300	300 - 125	< 125
Adjusted sodium adsorption ratio which affects soil permeability	< 6.0	6.0 – 9.0	> 9.0

Table (2) FAO Guidelines for irrigation water quality.

MATERIAL AND METHODS

Water Sampling and Analysis

The total length of the El-Salaam Canal is 242 km. Update the implemented parts are: 87 km West Suez Canal and 35 km East Suez Canal. Ten different water sampling locations of El-Salam Canal project were selected to cover the implemented studied area. Ten locations are: Hadous drain (location 1), El-Serw drain (location 2), after mixing with El-Serw drain (location 3), after mixing with Hadous drain (location 4), El Salam Canal West (before El-Sahara) (location 5), El Salam Canal East (El Sheikh Gaber Canal) (location 6), Ganoub El-Kantara Canal (location 7), Balouza drainage East (location 8), Balouza drainage West (location 9) and Bahr el-Baqar Drain (location 10). Water Samples were taken in plastic bottles.

Eight major ions can be used to evaluate most quality water, as they represent the majority of dissolved species present. These eight ions consist of four cations and four anions. Major cations are Calcium (Ca2+), Magnesium (Mg2+), Sodium (Na+) and Potassium (K+); major anions are chloride (Cl-), sulfate (SO42-), carbonate (CO3-2) and bicarbonate (HCO3-). Other cations and anions may also be present, but their concentrations are generally lower that those of the major eight in normal water.

Electrical conductivity (EC dSm-1) was measured using conductivity meter model 710 according to Richards (1954). Sodium and K+ were determined flamephotometerically, Ca2+, Mg2+, were volumetrically determined by titration with ethylene diamine tetra acetic acid (versinate), Cl- was determined by titration with silver nitrate, HC¬¬¬O3- was determined by titration with standard sulphuric acid according Page et al., (1982). Sulfate anions (SO42-) were precipitated by barium chloride as barium sulfate and gravimetrically determined (Jackson, 1964). Sodium adsorption ratio (SAR): was calculated from the equation

where Na+, Ca2+ and Mg2+ in meql-1 according to Ayers and Westcot (1994).

RESULTS AND DISCUSSION

Chemical properties of water samples from ten locations (1-10) (Hadous drain, El-Serw drain, after mixing with El-Serw drain, after mixing with Hadous drain, El Salam Canal West (before El-Sahara), El Salam Canal East (El Sheikh Gaber Canal), Ganoub El-Kantara Canal, Balouza drainage East, Balouza drainage West and Bahr el-Baqar Drain respectively were analyzed for four seasons Winter 2007, Spring 2008, Summer 2008 and Autm 2008 respectively. Data are presented in Tables (3-6). There are differences were observed in chemical properties of the different locations of waters throughout the recording time. Electrical conductivity for El-Salam water was in the range (1.37- 1.60) dSm-1.The low value of EC was recorded in winter season (1.37dSm-1), the lower in the value may be due to the decrease of temperature in winter, and thus decrease evaporation. Rainfall may cause dilution of salts in water of El-Salam Canal. On the contrary, the high value of EC was recorded in summer season (1.60dSm-1). Chemical analysis of water samples from Balouza drainage are presented in Table (3-6).

Location	EC dSm^{-1}	Cations, $meql^{-1}$				Anions, $meql^{-1}$			SAR
		Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	HCO_3^-	Cl^-	$SO4^{-2}$	
1	1.56	4.10	1.55	9.46	0.41	2.90	10.75	1.85	5.63
2	0.75	1.75	1.35	4.30	0.22	2.65	3.60	1.28	3.45
3	0.41	1.50	0.80	2.00	0.21	1.23	1.80	1.50	1.87
4	0.81	1.70	0.85	5.55	0.28	2.44	4.20	1.56	4.92
5	1.40	3.40	3.01	7.45	0.15	5.12	7.81	0.39	4.16
6	1.37	3.00	3.10	7.55	0.15	5.21	7.62	0.41	4.36
7	1.30	3.00	2.80	7.10	0.13	5.21	7.03	0.37	4.17

April 2013. Vol. 3, No. 1 ISSN 2305-8269
International Journal of Engineering and Applied Sciences

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8	29.2	26.0	83.0	179.0	4.15	6.25	265.0	12.15	24.25
9	18.7	20.0	70.0	94.0	3.50	4.21	170.0	10.05	14.01
10	3.40	4.41	7.77	19.9	0.71	5.76	22.70	3.70	8.06

Table (3). Some chemical properties of selected locations in Winter 2007

Location	EC	Cations, meql^{-1}				Anions, meql^{-1}			SAR
	dSm^{-1}	Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	HCO_3^-	Cl^-	$SO4^{-2}$	
1	1.69	4.81	1.89	10.35	0.42	2.95	11.84	1.91	5.65
2	0.85	1.95	1.48	5.31	0.28	2.86	4.25	1.82	4.05
3	0.46	1.61	0.92	2.12	0.25	1.34	1.91	1.52	1.88
4	0.86	1.82	0.92	6.21	0.31	2.54	4.81	1.55	5.31
5	1.46	3.50	3.00	7.95	0.15	4.00	6.84	0.36	4.41
6	1.46	2.40	2.20	9.89	0.11	4.40	4.18	0.22	6.52
7	1.65	2.60	2.00	11.80	0.10	4.60	6.65	0.35	7.78
8	29.6	24.0	71.0	197.5	3.55	6.01	270	20.00	28.66
9	19.8	21.0	42.0	132.9	2.10	5.03	189.1	9.95	23.68
10	3.54	4.61	7.90	20.12	0.82	5.79	25.20	3.91	8.04

Table (4). Some chemical properties of selected locations in Spring 2008

Location	EC	Cations, meql^{-1}				Anions, meql^{-1}			SAR
	dSm^{-1}	Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	HCO_3^-	Cl^-	$SO4^{-2}$	
1	1.88	5.33	2.15	11.32	0.40	3.10	13.24	2.16	5.85
2	1.10	2.51	1.88	5.45	0.31	3.88	5.51	1.91	3.68
3	0.55	1.91	0.85	2.82	0.28	1.54	2.10	1.63	2.40
4	1.01	2.70	1.20	6.33	0.28	3.21	5.10	1.80	4.53
5	1.60	3.61	3.11	9.14	0.16	6.41	9.07	0.43	4.99
6	1.55	3.02	2.40	9.98	0.12	6.22	8.78	0.32	6.07
7	1.73	3.65	2.62	9.97	0.13	6.85	9.17	0.43	5.66
8	35.2	35.0	94.6	196.7	4.73	5.20	330	18.40	24.44
9	22.4	28.3	65.4	110.7	3.27	4.36	193.8	10.20	16.17
10	3.71	5.10	8.25	21.20	1.12	6.14	26.81	4.51	8.21

Table (5).Some chemical properties of selected locations in Summer 2008

Location	EC dSm^{-1}	Cations, meql^{-1}				Anions, meql^{-1}			SAR
		Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	HCO_3^-	Cl^-	$SO4^{-2}$	
1	1.81	5.21	1.97	10.87	0.4	2.95	12.75	1.92	5.74
2	0.98	2.37	1.74	5.41	0.26	3.12	5.12	1.90	3.77
3	0.51	1.82	0.8	2.64	0.25	1.42	2.01	1.57	2.31
4	0.92	2.41	0.97	6.15	0.28	3.01	4.82	1.58	4.73
5	1.54	3.50	3.20	8.54	0.16	4.80	9.60	0.40	4.67
6	1.53	3.20	3.02	8.95	0.15	5.20	8.84	0.36	5.08
7	1.69	3.40	3.20	10.14	0.16	6.40	9.41	0.39	5.58
8	34.5	34.2	88.5	217.6	4.43	5.60	330	18.75	27.78
9	20.8	26.4	63.0	118	3.05	4.40	184	19.2	17.65
10	3.62	4.92	7.96	20.61	1.01	5.76	25.69	4.20	8.12

Table (6).Some chemical properties of selected locations in Autumn 2008

Data show that the electrical conductivity in the drainage water varied in the range from 18.7 to 34.5dSm-1 during the sampling period, this is an indication of the observed variability in the leaching processes among the different locations and Temperature changes through the seasons of the year. The much higher increase in the concentration of Chloride and Sodium relative to the concentration of Calcium and Magnesium reflects the very high levels of their existence in soils. Also, data showed that:

1- The Values of EC, Cations and Aninos increased in summer season in comparison with other seasons and this may be because high temperature and high evaporation in the summer season.

2- The EC values of El Salam Canal increased after mixing with Hadous drain compared with after mixing with El-Serw drain and these results may be due to the high values of initial values of Hadous drain. Also, Hadous drain, many researched referred to that mixed with sewage effluent.

3- At the same time, soluble cations, anions and SAR of the different locations waters, increased progressively with increasing salinity content of the water.

4- Data showed clearly that, Na+and Cl- increased progressively with increasing salinity levels in the irrigation water

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5- Sodium adsorption ratio (SAR) is a measure of the relative preponderance of dissolved sodium in soil solution of soil paste compared to the amount of dissolved calcium and magnesium. The data showed clearly that increasing salinity levels in the irrigation water had led to an increase in the SAR values on all locations under study. Similar results was obtained by El Kholy 2004 and El-Kholy and Kandil 2004).

Nikos et al., (2003) stated that the electrical conductivity (EC) is good estimator of the total amounts of mineral salts that dissolved in water. It is often used to measure salinity problems related to irrigation of crops and it is known that soils irrigated with saline water will contain a similar mix but usually at a higher concentration than in the applied water. According to the permissible limits (Table 7) for classes of irrigation water , all of location except (8 , 9 and 10) at any recording time were class 3 category, permissible water which leaching is necessary process when using this kind of water for irrigation. In contrary, location 8, 9 and 10 were class 5 category, unsuitable for irrigation because these drainage water. Drainage water at all locations and recording time was characterized with the high salt content

ISSN 2305-8269
International Journal of Engineering and Applied Sciences

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Classes of water	Electrical conductivity, dSm^{-1}
Class 1, excellent	>0.25
Class 2, good	0.25-0.75
Class 3, permissible	0.75-2.00
Class 4, doubtful	2.00-3.00
Class 5, unsuitable	<3.00

Table (7) Classes of irrigation water.

According to the sodium hazards of water based on Sodium adsorption ratio (SAR) values, Table (8) (modified from Ayers and Westcot, 1994), of canal water at any recoding time followed class 1, low sodium hazards, use for sodium sensitive crops. In Contrary, the drainage water (location 8 and location 9) at any recording medium and high and very high , must added soil amendments and leaching needed or generally unsuitable for continuous irrigation or unsuitable for use.

SAR values	Sodium hazard of water	Comments
1-10	Low	Use in sodium sensitive crops
10-18	Medium	Amendments (such as gypsum) and leaching needed
18-26	High	Generally unsuitable for continuous
>25	Very high	Generally unsuitable for use

Table (8). Sodium hazards of water based on SAR values (modified from Ayers and Westcot, 1994).

CONCLUSION

The data obtained of this study referred that:

1- The chemical analyses of El-Salam Canal irrigation water showed that the water from the chemical analyses view permissible for plants in all seasons of the year because the highest value of El-Salam Canal irrigation water recorded (1.6 dSm-1) = 1024 ppm (mgl-1) approximately.

2- Sodium adsorption ratio (SAR) values of El-Salam Canal water at any recoding time followed class 1, low sodium hazards, use for sodium sensitive crops. But, the drainage water at any recording medium and high and very high sodium hazard for plants.

3- Largest source of salts in water of El-Salam Canal from Hadous drain water because this drain contain highest salt , cations and anions which is greater than the El-Serw drain.

4- This project requires several studies integrated in terms of water quality and irrigation systems to know the most suitable crops, fertilizers and soil amendments to soils.

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