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EVALUATION OF IRRIGATION WATER QUALITY IN DIFFERENT REGIONS OF NORTH EAST DELTA-EGYPT

BASSUONY[1] M.A., ALI[1] M.E., ABDEL HAMEED [1] A.H. & JAHIN [2] H.S

Department of Soil Sci., Fac. Agric., Benha University. Egypt.[1]
Central Laboratory, National Water Research Center. Egypt. [2]

Abstract

Water quality has great significance in arid and semi-arid regions and it is based on the salinity, sodicity and permeability. In this study water samples were collected representing different sources for irrigation in the peak dry season from various regions of north east Delta, Egypt. Different tests were conducted to determine the salinity (EC, TDS, and TH) as well as sodciety and permeability (pH, SSP, SAR, Adj SAR, RSC and Mg ratio). According to the parameters and system of University of California, water of canals was considered suitable for irrigation. While waters wells in some locations were considered unsuitable. Also, waters drains in El-Gabel El-Asfar were unsuitable, because of their high EC, Cl^-, SAR and RSC.

Key Words: Water quality; Salinity; Sodicity; Permeability; North East Delta

1. Introduction:

Irrigation water quality refers to the suitability for its use for irrigation purposes. Good quality water has the potential to maximize crop yield under good soil and water management practices. However, with poor quality water, soil and cropping problems can be expected to reduce yield unless special management practices are adopted to counteract these problems. Capability problems, resulting from using poor quality water, vary according to the kind and the degree of hazards caused by the use of such water (Tanji 1990; Shamsad & Islam 2005).

Hazards may arise from high salinity or high contents of some specific constituents such as sodium (causing sodicity of soil if in high contents). Sodicity hazards may also be caused by residual soluble carbonates; if soluble sodium carbonate is present in contents exceeding those of (Ca + Mg), sodium carbonate would be present (Akinbile 2012). Also, high contents of magnesium may cause alkalinity. High contents of chlorides and presence of boron would cause toxicity to plants. Other constituents as some heavy metals may be hazardous. High salinity reduces growth of plants and hinders water absorption by plant roots due to the high osmotic pressure of water, caused by high concentration of soluble ions in water around the roots (UCCC 1974; Tanji 1990).

Management of water resources in its best means the capability of maintaining a good balance between the supply and demand that helps to keep the good water quality. In Egypt, it is a well known fact that the major source of water comes mainly from the River Nile. However, this quantity of water is not sufficient for some old cultivated lands which suffer from irrigation water shortage as well as short and long term programs of land expansion and reclamation which depend mainly on two main schemes. Firstly, raising the productivity of the cultivated areas and, secondly increasing the area of reclaimed soils (El-Gazzar 1996; Rizk 2010). Now, Egypt in its efforts to increase the agricultural production is intensifying farming input in the old Valley and Delta lands and is also expanding the cultivated area outside them in the newly reclaimed desert lands. The main goal of this investigation is to assess irrigation water quality for agricultural purposes in some regions in north east Delta.

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2. Materials and Method:

A field research was conducted to evaluate the suitability of water for irrigated agriculture of north east delta. Water samples from twenty six different locations were collected to represent four different irrigation sources i.e. 15 canals, 9 wells, one agricultural daring and one sewage water in the July-August 2011.

The collected water samples were preserved in separate containers according to the parameters needed to be measured and they were preserved in cold icebox until they reach the laboratory. The conservation for metals was done by adding acid to the sample until the pH reached < 2 (0.7ml of 65% HNO_3 is usually enough to neutralize alkalinity and to acidify 100 ml sample), acidification stops most bacterial growth, blocks oxidation reaction and prevents adsorption or precipitation of cations. Prior to acidification, the water sample was filtered, using 0.45 membranes, to remove suspended materials, which could dissolve when acid is added.

The chemical analyses were measured according to the Standard methods for the analysis of water and wastewater (APHA 2005). The pH was measured using pH meter. Conductivity was measured using a conductivity meter calibrated with KCl. Acidified samples with pure nitric acid (pH<2) were analyzed for the content and major cations using ICP-OES (Inductively Coupled Plasma-Optical Emission Spectroscopy). The concentration of the major anions was determined using ion chromatography.

Total hardness (TH) expressed as mg L^{-1} was calculated using the following equation:

$$\mathbf{TH = (Ca^{+2} + Mg^{+2}) \times 50} \qquad \mathbf{(1)}$$

Where concentration of Ca^{+2} and Mg^{+2} is expressed as $mmol_c\ L^{-1}$ and 50 is the equivalent weight of calcium carbonate (Twort *et al.* 1994).

Total dissolved solids were considered as the sum of all cations and anions in mg L^{-1}. For total dissolved solids, a water sample is filtered through a standard glass fiber filter. The filtrate is evaporated and dried at 103-105 °C.

According to the following equation:

$$\mathbf{TDS\ (mg/L^{-1}) = (A-B) \times 1000 / C} \qquad \mathbf{(2)}$$

A= weight of the filtrated sample + weight of the empty dish (mg) after evaporation, B = weight of the empty dish (mg) and C = the sample volume (ml) (Lloyd & Heathcote 1985).

The sodium adsorption ratio (SAR) was estimated by the equation using the values obtained for, Ca^{2+}, Mg^{2+} in meq/L (USDA 1954). The Adjusted Sodium Adsorption Ratio (Adj. SAR) was determined by the equation using the values obtained for Na^{+}, Ca^{+2} , Mg^{+2} and the soluble anions of CO_3^{-2} and HCO_3^{-} meq/L (Ayers & Westcot 1976). The soluble sodium percentage (SSP) was determined by the equation using the values obtained for Na^{+} , K^{+}, Ca^{2+} , Mg^{2+} in meq/L (FAO-UNESCO 1973). The residual sodium carbonate (RSC) was determined by the equation using the values obtained for CO_2^{-3}, HCO^{-3} in meq/L (USDA 1954) and the Mg^{+2} ratio was determined by the equation using the values obtained for Ca^{2+} and Mg^{2+} in meq/L (FAO-UNESCO 1973).

3. Results and Discussion:

The most influential water quality guideline on plant growth and its production is the salinity hazards which measured by electrical conductivity (EC) as described by Jahin & Gaber (2011). It is clearly shown that the highest mean values of EC averaged overall the studied samples (Table 1) were recorded in samples of wells water followed by samples of drains water and finally samples of canals water where values of 1.65, 1.175 and 0.71 dS m^{-1} were obtained, respectively. Similar results were obtained by El-Gazzar (1996) who found that EC values of well were higher than the water drains and canal. El-Bordini (2001) and Rizk (2010) also found that EC values of drain were higher than the water canal.

Data of TDS as presented in Table 1 indicate that the highest mean value was recorded in samples of wells water where 1057.2 mg L^{-1} was obtained. This mean value decreased in drains water where 751.0 mg L^{-1} was obtained. On the other hand, sample of canals water exhibited the lowest mean values where value of 456.9 mg L^{-1} was recorded. Rizk (2010) found that TDS values of drain were higher than the water canal.

In addition to above parameters, it is also important to consider the TH in water. According to Twort et al. (1994), the studied samples ranged between slightly hard and very hard in canals water, moderately hard and very hard in wells water and hard and very hard in drains water. Meanwhile, most of water sources specially exceed in their hardness more than 200 mg L^{-1} which lead to scale deposits in the piping system unsuitable for sprinkle or dripping irrigation systems (Vander 2003).

Values of pH which obtained from water samples analysis of the twenty regions are shown in Table 2. Data indicate that the highest mean value averaged over all the studied water samples was 8.0 in drains water followed by those values in samples of wells water and canals water where values of 7.67 and 7.40 were obtained, respectively. Abdel-Aziz (1992) and El-Bordini (2001) found that pH values of drain were higher than canal water. On the other hand, WHO (1990) stated that the optimum desirable level for pH is within the range of 6.5 to 8.5.

Table 1. Values of pH, EC, TDS and TH in different sources of water of the studied area

water source	Locations	EC (dS m^{-1})	TDS (mg L^{-1})	TH (mg L^{-1})
Canals water	Kafr El-Hosafa	0.62	398	175
	Shibeen El-Kanater	0.55	357	225
	Kafr Hamza	0.47	301	200
	Kom El-Samn	1.10	705	375
	Meet Kenana	1.41	902	215
	Benha	0.47	304	165
	Kafr Tahla	0.52	335	150
	Degwa	0.47	304	170
	El-Amaar El-Kobra	0.68	440	165
	Karkashanda	0.54	349	190
	Shalakan	1.47	940	350
	Bahteem	0.45	293	150
	Kalama	0.42	272	110
	Meet Halfa	0.47	304	175
	Moshtohor	1.01	650	310
	Mean	0.71	456.93	208.33
	SD	0.35	220.01	78.06
Wells water	Kafr El-Hosafa	1.76	1126	335
	Abu El-Ghait	1.79	1145	475
	El-Gabel El-Asfar	1.18	755	220
	Kom El-Samn	2.30	1472	475
	Meet Kenana	0.55	352	190
	Moshtohor	1.48	947	375
	El-Baradaa	2.16	1382	500
	Shobra El-Khema	1.75	1120	425
	Kafr El-Sheikh Ibraheem	1.90	1216	435
	Mean	1.65	1057	381.11
	SD	0.52	339.10	112.49
Drains water	El-Gabel El-Asfar (Sewage water)	1.51	966	340
	Moshtohor (Agricultural darain)	0.84	537	225
	Mean	1.71	751.5	282.5
	SD	0.47	303.34	81.31

The SSP values of different water sources of sampling were in the following order: wells water> drains water > canals water, where values of 45.48, 42.28 and 28.14 were obtained, respectively. According to the University of California Committee of Consultants (UCCC

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1974) all the studied water samples in canals, wells and drains are classified as good (class 1) to permissible (class 2). Mean while, water of different sources was not sodicity hazards since it did not exceed 60%, the highest sodicity of wells water could be ascribed due to their higher content of sodium which averaged 8.06 mmol$_c$ L^{-1} as compared with drains and canals water which contain 5.1 and 2.45 mmol$_c$ L^{-1}, respectively.

High SAR in any irrigation water implies hazard of sodium (Alkali) replacing Ca and Mg of the soil through cation exchange process, a situation eventually damaging to soil structure, namely permeability which ultimately affects the fertility status of the soil and reduce crop yield (Gupta 2005). According to the UCCC (1974), the studied water samples fall in class 1 (low sodium hazards) except canal water of Meet Kenana which have SAR 6.24 fall in the S_3 class (high sodium hazards), the data indicate that rating of sodicity hazards based on SAR values for all sources of wells water was of medium hazards (S_2) except Meet Kenana canals water which rating of low sodium hazards (S_1) where values of SAR was 0.73, the studied water sources show low sodium hazards in Moshtohor drains and ratting S_1 as compared with El-Gabel El-Asfar drain which exhibit medium sodium hazard and it rates S_2. It is quite obvious from the obtained results that SAR values of the different water sources were in the following order: wells water > drains water > canals water.

All sources of canals water based on the recommendations of Ayers & Wescot (1976) were no-problem except sample of Meet Kenana where rating was severe problem since Adj SAR was > 9. 44.4% of the studied samples rating increasing problems where values of Adj SAR ranged between 6-9 and other 44.4% of the studied samples rating severe problems since values of Adj SAR were above 9. On the other hand, there was sample of Meet Kenana which rating no-problem. Its value of Adj SAR was 1.08, rating the studied water sources ranged from no-problem in Moshtohor drain to severe problems in El-Gabel El-Asfar drain, Adj SAR values of different water sources were in the following order: well water > drains water > canals water.

According to the RSC data presented in Table 2, the classification of different water samples for irrigation in the studied area indicate that all of the studied samples are below 1.0 and classified as class 1 and hence no RSC hazards (safe water), this indicates that water is suitable for irrigation, USDA (1954). According to FAO-UNISCO (1973), all the studied water samples were within the safe limit (less than 50%), data also, indicated that values of Mg ratio in different water sources were in the following order: drains water > wells water > canals water.

Table 2. Values of pH, SSP, SAR, AdjSAR, RSC, and Mg Ratio in different sources of water in of studied area:

water source	Locations	pH	SSP	SAR	Adj SAR	RSC	Mg Ratio
Canals water	Kafr El-Hosafa	7.55	33.06	1.55	2.58	-1.50	22.85
	Shibeen El-Kanater	7.18	11.80	0.44	0.69	- 3.40	40.00
	Kafr Hamza	7.14	4.67	0.15	0.25	- 2.40	37.50
	Kom El-Samn	7.88	26.9	1.53	3.09	- 5.40	48.00
	Meet Kenana	7.90	46.96	6.24	11.85	- 2.10	13.95
	Benha	7.15	20.00	0.73	1.37	-1.10	18.18
	Kafr Tahla	7.17	33.96	1.45	2.72	-0.20	33.33
	Degwa	7.15	18.73	0.68	1.35	-0.80	8.82
	El-Amaar El-Kobra	7.60	51.01	2.73	5.05	-0.80	33.33
	Karkashanda	7.22	19.04	0.75	1.41	-1.50	15.78
	Shalakan	7.95	45.78	2.11	4.64	- 6.06	20.08
	Bahteem	7.13	24.61	0.92	1.72	-0.40	33.33
	Kalama	7.12	36.38	1.47	2.35	0.20	22.72
	Meet Halfa	7.15	16.63	0.59	1.10	-0.90	42.85
	Moshtohor	7.84	32.64	1.88	4.56	-3.21	48.38
	Mean	7.40	28.14	1.54	2.98	-1.97	29.27
	SD	0.33	13.46	1.47	2.85	-1.84	12.70

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Wells water	Kafr El-Hosafa	7.45	56.70	5.45	12.42	- 4.24	32.83
	Abu El-Ghait	7.50	42.19	3.47	7.84	-6.50	46.31
	El-Gabel El-Asfar	7.32	56.18	4.47	8.13	-1.90	18.18
	Kom El-Samn	8.20	51.87	5.48	12.27	-6.50	31.57
	Meet Kenana	7.22	18.18	0.73	1.08	-2.60	21.05
	Moshtohor	7.81	44.03	3.38	6.69	-5.40	37.33
	El-Baradaa	8.10	50.46	4.87	10.90	-7.50	35.00
	Shobra El-Khema	7.44	48.57	4.11	8.87	-5.90	30.58
	Kafr El-Sheikh Ibraheem	7.95	50.15	4.56	10.30	-5.71	35.63
	Mean	7.66	46.48	4.05	8.72	-5.13	32.05
	SD	0.35	11.65	1.45	3.48	-1.87	8.43
Drains water	El-Gabel El-Asfar (Sewage water)	8.10	46.00	3.77	8.67	- 3.90	45.50
	Moshtohor (Agricultural darain)	7.90	38.57	2.16	4.19	-1.90	31.11
	Mean	8	42.28	2.96	6.43	-2.9	38.30
	SD	0.14	5.25	1.13	3.16	-1.41	10.17

Determination of the common ions such as calcium, potassium, magnesium and sodium, SO_4^{2-}, Cl^-, HCO^{3-} an often is desirable to water and / or to assess the need for specific treatment, values of measured ions are shown in Table 3. The most abundant cation was Ca^{+2} in canals water and Na^+ in both drains and wells water, respectively. However, Cl^- was the least abundant anion in canals water and CO_3^{2-} + HCO^{3-} recorded the least abundant anion in both wells and drains, respectively. The most abundant anion was SO_4^{2-} in canals and wells water and Cl^- in drains water.

According to Ayers & westcot (1976) for using water for irrigation, the Cl^- values in canals water are classified to class 1 (No problem) and 2 (Increasing problems). Ninety four percent (94%) of the studied water samples were belonged to class 1 and 6% of the studied water samples which represented by Shalakan location were belonged to class 2. In wells water, rating of water quality boned on Cl^- hazard.

4. Conclusion

The parameters of water quality on different regions of north east Delta were compared with water quality standards set for irrigation. The results clearly revealed that waters of canals considered suitable for irrigation. While, well's water of some locations were unsuitable for irrigation purpose. Also, waters drains in El-Gabel El-Asfar were unsuitable, because of their high EC, Cl^-, SAR and RSC. We suggest use different options to management such water namely, amelioration of excessive SAR waters. The data obtained in our study suggest that there is need to be assessed for irrigation waters for knowledge the current situation and work for improvement the water quality in other districts of Egypt.

water source	Locations	Soluble Cation (mmol$_C$ L^{-1})				Soluble Anions (mmol$_C$ L^{-1})		
		Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-	CO_3^{2-} + HCO_3^-	SO_4^{2-}
Canals water	Kafr El-Hosafa	2.60	0.70	2.05	0.57	1.40	2.00	2.63
	Shibeen El-Kanater	2.70	0.80	2.06	0.67	1.50	2.00	2.73

	Kafr Hamza	2.70	1.80	0.66	0.43	1.40	1.10	3.09
	Kom El-Samn	2.50	1.50	0.22	0.49	1.80	1.60	1.31
	Meet Kenana	3.90	3.60	2.97	0.56	1.70	2.10	7.23
	Benha	3.70	0.60	9.16	0.64	1.40	2.20	10.50
	Kafr Tahla	2.70	0.60	0.95	0.50	0.60	2.20	1.95
	Degwa	2.00	1.00	1.78	0.46	0.50	2.80	1.94
	El-Amaar El-Kobra	3.10	0.30	0.89	0.46	0.70	2.60	1.45
	Karkashanda	2.20	1.10	3.51	0.071	1.50	2.50	2.88
	Shalakan	3.20	0.60	1.04	0.62	0.60	2.30	2.56
	Bahteem	5.20	1.80	6.74	0.98	5.30	2.90	6.52
	Kalama	2.00	1.00	1.13	0.46	0.50	2.60	1.49
	Meet Halfa	1.70	0.50	1.55	0.51	0.60	2.40	1.26
	Moshtohor	2.00	1.50	0.79	0.46	0.30	2.60	1.85
	Mean	2.81	1.16	2.36	0.52	1.32	2.26	3.29
	SD	0.91	0.82	2.47	0.18	1.21	0.46	2.66
Wells water	Kafr El-Hosafa	4.50	2.20	9.98	0.92	5.30	2.40	9.84
	Abu El-Ghait	5.10	4.40	7.57	0.83	6.93	3.00	7.97
	El-Gabel El-Asfar	3.60	0.80	6.63	0.77	3.10	2.50	6.20
	Kom El-Samn	6.50	3.00	11.95	1.55	7.74	3.00	12.26
	Meet Kenana	3.00	0.80	1.00	0.70	2.50	1.20	1.8
	Moshtohor	4.70	2.80	6.54	0.76	5.14	2.20	7.56
	El-Baradaa	6.50	3.50	10.88	0.72	6.85	2.95	11.80
	Shobra El-Khema	5.90	2.60	8.48	0.52	6.30	2.60	8.60
	Kafr El-Sheikh Ibraheem	5.60	3.10	9.52	0.78	6.91	2.99	9.10
	Mean	5.04	2.57	8.06	0.83	5.64	2.53	8.34
	SD	1.22	1.17	3.23	0.28	1.81	0.58	3.12
Drains water	El-Gabel El-Asfar (Sewage water)	3.70	3.10	6.96	1.34	6.22	2.90	5.98
	Moshtohor (Agriculturaldarain)	3.10	1.40	3.24	0.66	3.90	2.60	1.90
	Mean	3.40	2.25	5.10	1.00	5.06	2.75	3.94
	SD	0.42	1.20	2.63	0.48	1.64	0.21	2.88

Table 3: Values of soluble a ions in different sources of water in the studied area

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