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SUITABILITY OF AGRICULTURAL DRAINAGE WATERS FOR IRRIGATION

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ABSTRACT

The area under studying is bounded from the west by Suez fresh water canal and from the east by the Bitter Lakes and Suez Canal. The area is generally flat and slopes gently towards the east, i.e. towards the Bitter Lakes and Suez Canal. This feature plays an important role in its hydraulic properties. Most of the area lies beneath the contour line of 6m height. The water table level is mostly moderate to high near the surface especially in the coastal plain of the Bitter Lakes.

Many soil profiles were dug in this area up to the water table levels and water table samples were taken after water equilibrium. Many small drains were found and they pour their water in the main drains of Malaria, Abu Sultan and serabium. The chemical analysis, such as EC,SAR and macro and micro nutrients, were evaluated for the water tables of the studied area and the main drains in the area included the biggest drains of El Mahsama and El Manayef drains in Ismailia Governorate to their suitability for irrigation.

Keywords: Agriculture, irrigation, drainage water

INTRODUCTION

There are real needs in Egypt for increasing food production, for improving the utilization of land and water resources, for improving the utilization of land and water resources, for minimizing drainage outflow from irrigation projects, and for findings productive uses for waste water. Utilizing agricultural drainage waters for irrigation will help meet all of these needs. Food production can be increased by either increasing yield per unit land areas, or by expanding the base of production. There is insufficient fresh water available to develop all the potential irrigable land. However, an appreciable volume of agricultural drainage water is produced annually which could be used on this land.

Donnan and Houston (1967) estimated that about one-half to two-thirds of all irrigated land has drainage problems. The disposal problem is often great. Any decrease in need for disposal, as would result from utilizing of drainage water for irrigation would lessen this problem.

The chemical properties of agricultural drainage water have been described in detail by **Rhoades and Bernstein (1971)**, **Rhodas et al.,(1973) and Bower (1974).** They stated that agricultural drainage water are generally mixtures of overflow, run off, and percolated water.

El Salam Canal is one of the national promising projects for reusing drainage water in irrigation. Namely Hadous drain (1.90 B m^3/year) and El Serw drain (0.435 B m^3/year) in a 1:1 mixing ration with the Nile river water (2.11 B m^3/year), (Jica, 1989).

MATERIAL AND METHODS

Water tables of the soil profiles:

In the Vulnerable areas, which are bounded from the west of Suez fresh water canal and from the east by the Bitter Lakes and Suez Canal, many soil profiles were dug up to the water table level. After the equilibrium of the water table, water samples

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were taken from each soil profile. The main source of the fresh water supplied to the cultivated these areas are coming from River Nile through Ismailia fresh water canal.

Also, water samples were taken from the drains of Malaria, Abu Sultan, Serabium, El Mahsama and El Manayef. El Manyef drain was consist of 4 portions and water sample was taken from each portion, and its total length in 33.48m. Two huge pumps have been established at the outlet of the drains at Fayed and Fanara to remove the drainage water into the Bitter Lakes. From each of El Mahsama and El- Manayef drains 5 water samples were taken along each of the drains which their length are 38.8km and 15.4km, respectively.

Eight major ions were evaluated which they are ordinary used to evaluate most quality water, as they present the majority of dissolved species persent. These ions consist of 4 cations and 4 anions. Major cations are Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}; major anions are Cl^{-}, SO_4^{2-}, CO_3^{2-} and HCO_3^{-}. These ions were evaluated according to the methods of **Page *et al*.,(1982)**. Other cations and anions may also present, but their concentrations are generally lower than those of the major eight in normal water. Ferrous (Fe^{2+}) and manganese (Mn^{2+}) also were evaluated according to **Lindsay** and **Norvell** method **(1978)** and assayed using atomic absorption spectrophotometer. Sodium adsorption ratio (SAR) was calculated from the equation:

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

where Na^{+}, Ca^{2+}, and Mg^{2+} represent concentrations expressed in milliequivalents per liter for each constituent according to **Ayers** and **Westcot (1994)**.

RESULTS AND DISCUSSION

It is known that fresh water is not sufficient to develop all the potential irrigable land in Egypt. Furthermore, agricultural drainage waters are not generally composed only of root zone drainage water. Rather they are mixtures including root zone run off, canal seepage, regulatory water, and root zone drainage water. While the ultimate goal is to maximize the utilization of irrigation water in a single cycle, until this becomes possible and implemented, every attempt should be made to use agricultural drainage water for irrigation. A major limitation to their use is their increased level of salt, relative to irrigation water. Hence, the quality of drainage water must be considered before we can assess its real potential for irrigation.

The main source of the fresh water of irrigation for the studied area in the coastal plain of the Bitter Lakes coming from River Nile through Ismailia fresh water canal, which its salinity is not more than 0.40 dSm^{-1}.

Chemical analysis of water table samples of studied area and their suitability for irrigation.

After water equilibrium in different soil profiles of studied area, water samples were taken from each soil profile. Table (1) showed some chemical analysis of these samples. The data indicated that the salinity content of the water samples which taken from the soil profiles near the Suez canal fresh water were varied between 0.87 and 2.0 dSm^{-1} and sodium adsorption ratio (SAR) varied

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Location	Profile No.	Distance from the Bitter Lakes (m)	Depth (cm)	pH	EC dSm^{-1}	Cations ($meqL^{-1}$)				Anions ($meqL^{-1}$)			SAR	NO_3^- mgL^{-1}	P mgL^{-1}	Fe mgL^{-1}	Mn mgL^{-1}
						Ca^{2+}	Mg^{2+}	Na^+	K^+	HCO_3^-	Cl^-	SO_4^{2-}					
Deferswar	1	530	65	7.16	1.538	6.00	4.50	4.50	0.38	8.00	3.50	3.88	1.96	19.6	0.98	0.007	0.005
	2	680	120	6.79	1.048	2.90	3.50	3.73	0.35	6.00	3.00	1.48	2.08	5.60	1.20	0.009	0.006
	3	850	60	7.62	1.055	2.50	2.00	5.39	0.66	5.00	4.00	1.55	3.59	11.2	0.99	0.004	0.003
	4	940	90	7.22	1.883	6.50	5.00	7.00	0.30	7.00	4.00	7.83	2.90	2.80	2.00	0.008	0.005
Abu Sultan	1	150	80	7.80	2.90	10.75	8.28	10.2	3.81	16.57	11.2	5.23	3.29	5.60	0.82	0.02	0.070
	2	500	100	7.78	1.61	5.28	3.70	6.38	0.74	5.27	7.40	3.43	3.00	5.60	0.88	0.004	0.003
	3	1000	110	7.92	0.87	2.00	1.40	5.00	0.30	3.00	3.60	2.10	3.83	8.40	1.90	0.009	0.002
El Saidia	1	50	40	7.88	5.34	8.00	10.4	38.7	0.87	12.2	19.6	26.2	12.76	5.60	0.86	0.007	0.009
	2	100	80	8.17	1.98	10.8	4.80	3.56	0.64	8.60	4.60	6.62	1.27	8.40	0.86	0.004	0.110
	3	570	69	8.36	2.02	11.00	4.00	8.00	2.00	7.80	7.00	10.2	2.92	8.40	2.50	0.007	0.044
	4	970	60	8.09	1.84	9.40	2.80	5.60	0.60	6.00	2.60	9.80	2.26	2.80	1.50	0.002	0.003
Fayed	1	25	100	6.73	20.6	51.5	42.5	165.1	0.90	13.5	186.0	61.0	24.08	8.40	0.70	0.001	0.009
	2	150	100	7.00	8.66	26.5	12.0	60.3	1.16	7.00	78.0	15.0	13.75	5.60	0.74	0.002	0.044
	3	500	85	7.00	6.50	19.9	10.0	45.3	0.87	15.3	58.5	11.3	11.71	8.40	0.76	0.007	0.008
Fanara	1	200	75	7.20	4.58	20.8	14.5	20.2	4.53	18.7	23.0	18.3	4.80	8.40	0.69	0.007	0.009
	2	700	90	7.15	3.50	15.8	11.1	15.4	3.46	14.3	17.6	14.0	4.19	5.20	0.70	0.006	0.005
Suez canal fresh water				6.92	0.40	0.70	0.80	2.22	0.28	1.00	1.20	1.80	2.56	2.80	0.73	0.008	0.009
Malarya Drainage				6.91	1.90	3.50	4.00	11.0	0.5	4.70	12.5	1.80	5.68	9.10	3.83	0.060	0.005
Abu Sultan Drainage				7.00	0.40	0.50	0.20	3.02	0.28	1.60	1.80	0.60	5.10	16.8	2.17	0.060	0.004
Serabium Drainage				6.99	0.79	0.60	0.40	6.52	0.38	6.40	3.80	2.30	9.22	7.00	1.02	0.050	0.001

Table (1) Some chemicals analysis of different water table samples and water drains of studied area.

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between 2.9 and 3.8. The water samples also rich in NO_3^- which varied between 2.8 and 11.2mgL^{-1} and phosphorus content also varied between 0.9 and 2.0 mgL^{-1}.

Because of the high water table of this area the farmers had dug many small drains. These drains poured their water in the main drains of El Malaria, Abu Sultan and Serabium.

Regarding to the reliability of the drainage water of these soil profiles for irrigation the EC figures indicate that it could be used for irrigation as stated by **Nikos et al.,(2003)**. They stated that the electrical conductivity (EC) is good estimators of the total amounts of mineral salts that dissolved in water. It is often used to measure salinity problems related to irrigation, According to their permissible limits in Table (2) for classes of irrigation water, all of the water of the soil profiles except Fayed and Fanara were class 3 category, permissible water which leaching is necessary process when using this kind of water for irrigation.

Table (2) Classes of irrigation water **(Nikos et al., 2003)**

Classes of water	**Electric 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

The data also showed that Na^+, Cl^- increased progressively with increasing salinity content of the water of different soil profiles. It is interested to showed that NO_3^- concentration in the water more than 19mgL$^-$ at the soil profiles near of the Bitter Lakes.

And this may be due to the heavily fertilizer of nitrogen which ordinary added. In this respect **Elgala(1978)** stated that about 50% of nitrogen added in soils was found in the drainage water.

With regard to the concentration of phosphorus the data indicated no great difference in the water of soil profiles. It is known that most of added phosphate rapidly fixed in soils, and its solubility is very low. Also, soluble Fe^{2+} and Mn^{2+} in the drainage water is very low due to their fixation and less their solubility.

Sodium adsorption ratio (SAR) of the water of soil profiles showed clearly that increasing salinity levels in the water of the soil profiles had led to an increase in SAR values on all studied area. It is varied between 1.27 and 3.83 for cultivated soils, while it reached 23.08 for uncultivated soils of Fayed. Similar results were obtained by **El Kholy and Kandil (2004)**. According to the sodium hazards of water based on sodium adsorption ratio (SAR) values, Table (2) (modified from **Ayers and Westcot, 1994**) of the water of soil profiles indicate that except profiles of Fayed and Fanara were suitable for irrigation.

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Table (3) Sodium hazards of water based on SAR values (modified from **Ayers and Westcot, 1994**)

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

The study also included the suitability of the biggest drains in Ismailia Governorate i.e. El Mahsama and El Manayef drains for irrigation. These drains pour their drainage water in Temsah Lake. At the same time, the sewage water of Serabium Plant also pour its water at the end of El Mahsama drain. Five water samples were taken from each drain and also water sample was taken from the end of El Mahsama drain after the addition of sewage water of Serabium Plant.

Table (4) showed the chemical analysis of these drainages water of the two studied drains

Samples	pH	E.C dSm^{-1}	Cations ($meqL^{-1}$)				Anions ($meqL^{-1}$)			SAR	NO_3^- mgL^{-1}	P mgL^{-1}	Fe mgL^{-1}	Mn mgL^{-1}
			Ca^{2+}	Mg^{2+}	Na^+	K^+	HCO_3^-	Cl^-	SO_4^{2-}					
Mahsama Drain (beforepollution)	6.86	1.78	4.80	3.80	8.66	0.54	7.40	12.6	2.20	4.17	7.00	4.37	0.03	0.00
Mahsama Drain (after pollution)	6.83	1.79	5.40	3.60	8.31	0.59	6.40	12.4	0.90	3.91	15.5	3.88	0.00	0.00
El Manayef Drain	7.10	1.80	5.80	3.41	7.90	0.89	5.80	10.3	1.90	3.68	9.20	4.10	0.02	0.01

The chemical properties of agricultural drainage water for their suitability for irrigation have been described in detail by **Rhoades and Bernstein (1971), Rhoades et al.(1973), and Power(1974).** They concluded that agricultural drainage water is generally mixtures of overflow, runoff, and percolated water. Overflow is the excess water needed to maintain a head in the irrigation distribution laterals and often returns directly to the drainage canal with little change in quality. Runoff is the excess water applied to the land which does not infiltrate, and which runs off into the surface drain system. This water may be relatively high in turbidity and suspended organic matter and may contain pesticides and be slightly enriched in nutrient elements, especially N and P.

They also stated that salinity is not generally increased to any appreciable extent in either overflow or runoff water. Ideally, overflow and runoff should be returned to the irrigation supply system without allowing them to mix with drainage water. Infiltrated water that percolates through the root zone always increases in salinity thus creating the salt problem associated with the use of agricultural drainage water. When percolated waters are not isolated but are mixed back with the overflow and runoff waters, the mixture is available for reuse.

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The composition of agricultural drainage water is determined by several factors including:

1) The composition of the original water used for irrigation.
2) The proportions of overflow, runoff and percolated waters comprising the drainage water.
3) The fraction of infiltrated water that percolate through the root zone, i.e. the leaching fraction (LF). **Rhoades et al. (1973)** stated that this factor influences the extent of solution and precipitation of salt and minerals and cation exchange reactions, which modify the applied water composition while in transit through the root zone.
4) The presence of dissolvable salts in the path of the percolating water as it flows to the drain.
5) The presence of non-root zone derived water in the flow "tubes" to the drains.
6) Amounts of chemical amendments or fertilizers added to the soil, removal of solutes by crops, presence of lime and gypsum in soil, composition of soil solution at time of initiate of drainage, and CO_2 concentration, etc.

From the above enumeration, obviously no single composition in descriptive of agricultural drainage water but representative compositions may be identified. Numerous criteria have been proposed over the years. As **Rhoades (1975)** pointed out, the suitability of waters for irrigation should be evaluated based on criteria indicative of their potentials to create soil conditions hazardous to crop growth or animals or humans consuming those crops. The prevailing criteria of irrigation water quality and their associated potential hazards to crop growth are: 1) salinity-the general salt effects on crop growth thought to be largely osmotic in nature and related to total salt concentration, rather than to the individual concentrations of specific salt constituents, whose effects generally are retarded plant growth, i.e., smaller plants with fewer and smaller leaves; 2) sodicity – the effect of an excessive amount of exchangeable soil Na on soil permeability, soil structure, and plants specifically sensitive to Na. The soil effects are evidence by puddling and by reduced rate of water intake; and 3) toxicity- the specific affects of excessive accumulations of solutes especially those of Na, Cl and B that cause leaf burn and defoliation.

From these deep discussions on suitability of the agricultural drainage water of all drains in Ismailia Governorate are more suitable for irrigation directly without any mixing with Nile water. At the same time, there are more than twenty thousands feddan east of Bitter Lakes in Sinai no fresh water available for irrigate these available soils for increasing food production and for finding productive uses for waste water.

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