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Water Quality Assessment of Agricultural Drains for Irrigation in Northern Delta of Egypt

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ABSTRACT

The amount of water available to Egypt is limited and present water demands approaches that limit. For this reason, plans were suggested to re-use agricultural drainage water directly or often mixing with fresh water to extend the limited water supplies. The indiscriminate use of drainage water for irrigation as a result of freshwater shortage could impair soil functions and cause environmental pollution. This study aims to evaluate the suitability of wastewater from different sources, for irrigation purposes in the Northern Nile Delta of Egypt. Therefore, this study was carried out on three water drainage sources El- Gamalia , El-Serw and El-Harna drain with El-Shoka canal as a fresh water source as the control along a year starting from May 2016 to February 2018. The EC, SAR and the concentration of some macronutrients and some heavy elements in the water of all sources are evaluated. Water EC and SAR value increased slightly from upstream to downstream of all irrigation sources in the study area. The quality of study drainage water from drains belongs to C3 S1 and C4 S1 classes and could be re-use in irrigation purpose under special management, while the water from El-Shoka canal belongs to C2 S1 in the study area. Phosphorus concentration in sample water from El-Gamalia drain only was greater than 2 mg L^{-1}, which indicate this water can't be used for irrigation purpose. Also, Nitrate –N concentrations in water samples from El-Gamalia drain only was between 5-30 mg L^{-1}, therefore there is a slight to moderate degree of restriction when using this water in irrigation. While heavy metal ions concentration (Ni, Co and Cd) was greater than permissible levels at all selected water samples, except water samples from El-Shoka canal from a distance of 0 km to 4 km. While, Pb concentration was less than the critical limits (5 mg L^{-1}). The conclusion from this study could be re-used of drainage water from drains of the northern delta of Egypt for irrigation purpose under special management.

Keywords: Water, Irrigation, Drain, Drainage water, Water quality.

INTRODUTION

Water is a vital resource but a severely limited one in most countries for forestation especially in the arid zones. Therefore, there is an urgent need to conserve and protect fresh water and use water of lower quality for irrigation (Al-rashed and Sherif, 2000). In suburban areas, the use of industrial or municipal wastewater is a common practice in many ports of the world (Singh *et al*., 2004). The quality of irrigation water may be considered as an important factor but it should be never forgotten that it is only one factor, and that no classification of irrigation water can be present which may be utilized under all circumstances. The suitability of water for irrigation depends upon its own quality, as well as the other factors, the same quality of water may be considered suitable for a certain type of soil or crop, but unsuitable for others (Ayers and Westcot , 1985).

The indiscriminate use of wastewater for irrigation as a result of freshwater shortage could impair soil functions and cause environmental pollution (Abegunrin, *et al*. 2016). Wastewater may contain undesirable chemical constituents and pathogens that pose negative environmental and health impacts (podapoulous 1995). Consequently, mismanagement of wastewater irrigation would create environmental and health problems to the ecosystem and human beings (Mohammad and Ayad, 2004) when waste water will be used continuously as the sole source of irrigation water for field crops in arid regions, excessive amounts of nutrients and toxic chemical substances could simultaneously be applied to the soil plant system. This would cause unfavorable effects on productivity and quality parameters of crops and the soil (Vazquez-montiel *et al*., 1996).

Saline wastewater originating from sources such as agriculture, aquaculture, and many industrial sectors usually contains high salts and other contaminants, which adversely affect both aquatic and terrestrial ecosystems (Liang *et al*., 2017). Pascale *et al*., (2005) observed that in coastal regions of Mediterranean areas, summer crops are often irrigated with saline water. Therefore, salts may accumulate in the root zone, damaging the following winter crops, if the rainfall is insufficient to leach them.

Oron *et al*., (2002), Cetin and Kirda, (2003) and Schoups *et al*., (2005) suggested that degradation of soils using alkali water constitutes a major threat to irrigate agriculture especially for the cultivation of sodicity sensitive crops long-term sodic water irrigation increased sodium adsorption ratio (SAR). El-Komy (2012) found that sodium adsorption ratio (SAR) values increased slightly with north words direction, the quality of drainage water classified as from none degree of restriction to slight degree of restriction to a moderate degree of restriction on use according to (FAO, 1985).

Wastewater irrigation reduces the pressure on freshwater usage but leads to the accumulation of heavy metals in soils (Cao, *et al*., 2018). Heavy metals are extremely persistent in the environment, they are non-biodegradable and non-thermo- degradable and thus readily accumulate to toxic levels. Wastewater irrigation is known to contribute significantly to the heavy metal content of soils (Mapanda *et al*., 2005) one important dietary uptake pathway could be through crops irrigated with contaminated waste water. Soils irrigated by wastewater accumulate heavy metals such as Zn, Pb, Cr and Ni in surface soil. When the capacity of the soil to retain heavy metal is reduced due to repeated use of waste water, soil can release heavy metals into ground water or soil solution available for uptake (Aghabarati *et al*., 2008). Also, (Cao, *et al*., 2018) found that the greenhouse soils had higher concentrations and percentages of metals (except Pb) in bio-accessible fractions compared with field soils.

Similarly, compared with irrigation using treated municipal wastewater, irrigation with treated industrial wastewater resulted in higher concentrations and percentages of all the studied metals in the bio-accessible fractions of soils.

Due to global population increasing, the gap between supplies and demands for water is widening and is reaching such alarming levels that in some parts of the world it is posing a threat to human existence. For human life, water scarcity is not only about droughts or rivers running dry, above all, it is about guaranteeing the fair and safe access they need to sustain their lives and secure their livelihood. Therefore, this study aims to evaluate the suitability of wastewater from different sources, for irrigation purposes in the Northern Nile Delta of Egypt.

MATERIALS AND METHODS

Water Sampling:

The present experiment was carried out on three water drainage sources., El-Gamalia, El-Serw and El-Harana drain with El-Shoka canal as a fresh water source as the control along a year starting from May 2016 to February 2018. The first source was taken as control (El- Shoka canal) involved six sites (0,2,4,6,8 and 10 km)from the start , El Harana drain (12.5 km), involved the drain 6 sites (EL-Harana (0,2.5, 5, 7.5, 10 and 12.5 km) from the start,this drain lies at Damietta governorate, the second drain is EL-Gamalia drain (6.770 Km.) involved the drain 5 sites (EL-Gamalia (0,1.5, 3.0, 4.5 and 6.0 km) from the start this drain lies at Dakahlia governorate and the two drains pour their water in EL-Serw drain (25 km) which is taken as the third drain in the study the drain involved six sites (0, 5, 10,1 5, 20, 25) from the start this drain is between Dakahlia and Damietta governorates.

Water samples were collected, every three months (May 2016, August 2016, November 2016, February 2017, March 2017, May 2017, August 2017, November 2017 and February 2018) from suitable intervals for each drain. The collected water samples were preserved according to standard methods outlined by APHA (1985).

Water Analysis:

Analysis of water samples were carried out to evaluate the quality of waters with respect to irrigation. The water parameters determined to asses the following salinity hazards, sodicity , NO_3 hazards, heavy metals hazards. These hazards have been achieved as follows: -

1- United states salinity according to laboratory system (USDA,1954) which gave 4 classes for salinity hazards (C1 toC4 on the basis of EC).
2- FAO guideline (FAO,1985) which gave 3 categories designed as (i) no-problem, (ii)increasing problem and (iii) severe- problem.
3- USDA (1954) employed the sodium adsorption ratio (SAR) parameter as sodium hazard include 4 classes designated from S1 to S4.
4- NO_3-N hazards: The assessment is divided into the 3 classes system according to (FAO, 1985).
5- Heavy metal hazards: The assessment is one of the basis recommended by American National Academy of Science (NAS) and National Academy of Engineering (NAE) as presented by (NAS/ NAE, 1972).

Few drops of toluene were added to the collected water samples to stop biological activities, tightly stoppered and transferred to the laboratory. Suitable quantity of each water sample was filtered for immediate chemical analysis. Samples of water were analyzed during 24 hours after collection. For heavy metals analysis, water samples were collected in 500 ml polyethylene bottles. Samples were previously soaked for 48 hours in 10% nitric acid and rinsed with distilled water. The chemical analysis of water was carried out to determine EC and soluble cations and anions, as follows:

1- Water EC value and soluble cations and anions were determined according to Jackson (1973).
2- Sodium adsorption ratio (SAR) was calculated using Richard's equation Richards (1954); Ayers and Westcott (1985); Suarez, 1981 and Rhoades, (1982).
3- NO_3 –N was measured using automatic microkjeldahl model 1035 analyzer.
4- Heavy metals (Pb, Ni, Co and Cd): For determination of total metals, water samples were digested using nitric acid as described in standard method-302 A (APHA,1985) those were measured using GBC Σ Aventavir 1.3 atomic absorption.

Statistical Analysis

Mean values were compared, at a level of $P<0.05$ by using the Least Significance Difference (LSD) test. CoStat (v. 6.400 CoHort software., California, USA) was used to statistical analysis for data.

RESULTS AND DISCUSSION

Chemical properties of Nile water in the study area from May 2016 to May 2018 (El-Shoka canal):

The data in Table 1 showed that the salinity values of the Nile water were not significantly affected by sampling distances from 0 to 10 km. The values of salinity (EC) of Nile water vary between 0.42 dS m^{-1} at a distance 0 km to 0.64 dS m^{-1} at a distance 10 km during May 2016 to May 2018. A simplified classification according to EC is restricted to Class 2 (C2 = Ec from 0.25 to 0.75 dS m^{-1}). This water group belongs to C2-class according to USDA classification (1954) and it is considered to increase the salinity problem moderately(FAO ,1985).

On the other hand, SAR values were also not significantly affected by water sampling distances from May 2016 to May 2018 (Table 1). The values of SAR of Nile water in Table 1 varied between 1.04 at a distance 0 km to 1.61 at a distance 8 km from May 2016 to May 2018. A simplified classification according to SAR is restricted to section 1 (S1 = SAR from 0 to 10). This water group belongs to S1-class and it can be used for irrigation in all studied location with little adverse effect of the development of harmful levels of exchangeable Sodium (Richards, 1954) and it can be used without any restriction according to FAO (1985). According to USDA (1954) water of the studies sites is entirely S1-class. The description of this class "alkalinity hazard" of water as low concentration of sodium so, this water can be used for irrigation in most months, with adverse effects when using it. However, sodium sensitive crops many accumulate injurious amounts of sodium.

Also, data presented in Table 1 showed some macronutrients concentration (mg kg^{-1}) in Nile water (El-Shoka canal) from May 2016 to May 2018. Data in tables 1 showed that the effect of sampling distances from 0 to 10 km is not significant on phosphorus concentration, but its effect was very significantly ($p<0.01$) on nitrate (No_3 -N and significantly ($p<0.05$) on potassium concentration from May 2016 to May 2018. The concentration of dissolved macronutrients from the upstream to the downstream has been increased.

Also, data presented in Table 1 showed some heavy metals concentration (mg kg^{-1}) in Nile water (El-Shoka canal) from May 2016 to May 2018. Data in Table 1 showed that the effect of sampling distances from 0 to 10 km is not significant on Pb, Ni, Co and Cd concentrations. Also, the concentrations of dissolved heavy metals from the upstream to the downstream has been slightly increased. According to FAO, (1985) and NAS/NAE (1972) the values of Pb and Ni concentrations in El-Shoka canal was less than the critical limits (5 mg L^{-1} for Pb and 0.2 mg L^{-1} for Ni). This water can be used for irrigation purposes without causing serious problems for both plants and soil. But the value of Co concentration was greater than the critical limit (0.05 mg L^{-1}) at a distance 2 km to 10 km. Thus, the high concentration of cobalt in irrigation water can lead to toxicity in plants. Tomato toxicity was recorded when irrigation with water with a cobalt concentration greater than 0.1 mg L^{-1} (FAO, 1985). But this toxicity can disrupt the soil to moderate alkalinity (FAO, 1985), as is the case in agricultural soil in Egypt. Therefore, there is no fear of using this water in irrigation. While, the value of Cd concentration was less than the critical limit (0.01 mg L^{-1}) at a distance of 0 to 6 km, but this concentration at a distance of 8 to 10 km was greater than critical limit of Cd. Therefore, this water can be used for irrigation from a distance of 0 to 6 km without causing serious problems for both plants and soil, but it can be causing serious problems for both plants and soil when irrigation from a distance of 8 to 10 km on El-Shoka canal. Toxic impact to beans, beets and turnips at concentrations as low as 0.1 mgL^{-1} in nutrient solutions (FAO, 1985). Conservative limits recommended due to its potential for accumulation in plants and soils to concentrations that may be harmful to humans (FAO, 1985). In general, it is not recommended to take irrigation from the end of El-Shoka canal.

Table 1. Chemical properties of Nile water in the study area from May 2016 to May 2018 (El-Shoka canal):

Distance km from start	EC, dSm^{-1}	SAR	W. Cl.	Macronutrients (mg L^{-1})			Heavy metals (mg L^{-1})			
				No^3–N	P	K	Pb	Ni	Co	Cd
0	0.42	1.04	C2S1	1.700	0.540	6.863	0.088	0.007	0.046	0.002
2	0.53	1.18	C2S1	1.733	0.573	6.907	0.138	0.015	0.062	0.007
4	0.53	1.30	C2S1	1.833	0.697	6.973	0.150	0.015	0.065	0.007
6	0.55	1.29	C2S1	2.400	0.700	7.187	0.153	0.039	0.072	0.008
8	0.60	1.61	C2S1	2.467	0.720	7.333	0.372	0.041	0.074	0.013
10	0.64	1.50	C2S1	2.567	0.763	7.390	0.387	0.042	0.075	0.015
LSD(0.05)	ns	ns	----	0.45**	ns	0.35*	ns	ns	ns	ns

W. Cl. = Water classification A=distance factor B=time factor
ns = not significant * = significant (p<0.05) ** = highly significant (p<0.01)

Chemical properties of El-Gamalia drain in the study area from May 2016 to May 2018:

The data in Table 2 indicated that the salinity values (EC) dS m^{-1} of El-Gamalia drain water were not significantly affected by sampling distances from 0 to 6 km and sampling time during May 2016 to May 2018 and their interaction effect. The values of salinity (EC) of El-Gamalia drain water varied between 1.74 dS m^{-1} at a distance of 0 km to 2.08 dS m^{-1} at a distance 6 km during May 2016 to May 2018. On the other hand, the highest EC values of El-Gamalia drain water were recorded in the summer months (May and August). The lowest values were recorded in the winter months (November, February and March) from 2016 to 2018. A simplified classification according to EC is restricted to Class 3 (C3 = Ec from 0.75 to 2.25 dS m^{-1}). This water group belongs to C3-class according to USDA classification (1954) and it is considered to cause a high salinity problem according to FAO (1985).

SAR values were also not significantly affected by sampling distances from 0 to 6 km and sampling time from May 2016 to May 2018 and their interaction effect (Table 2). The values of SAR of El-Gamalia drain water in Table 3 vary between 3.25 at a distance of 1.5 km to 3.57 at a distance of 6 km during May 2016 to May 2018. On the other hand, the highest SAR values of El-Gamalia drain water were recorded in the summer months. The lowest values were recorded in the winter months from 2016 to 2018. A simplified classification according to SAR is restricted to section 1 (S1 = SAR from 0 to 10). This water group belongs to S1-class and it can be used for irrigation in all studied location with little adverse effect of the development of harmful levels of exchangeable Sodium (Richards, 1954) and it can be used without any restriction according to FAO (1985). According to USDA (1954) water of the studies sites is entirely S1-class. The description of this class "alkalinity hazard" of water as low concentration of sodium thus, this water can be used for irrigation in most months, with adverse effects when using it. However, sodium sensitive crops many accumulate injurious amounts of sodium.

Data presented in Table 2 showed some macronutrients concentration (mg kg^{-1}) in El-Gamalia drain water from May 2016 to May 2018. Data in tables 4 showed that the effect of sampling distances from 0 to 6 km and sampling time from May 2016 to May 2018 and their interaction is not significant on nitrogen, phosphorus and potassium concentration. The concentration of dissolved macronutrients from the upstream to the downstream has been increased. On the other hand, the highest N, P, and K concentrations of El-Gamalia drain water were recorded in the summer months. The lowest values were recorded in the winter months from 2016 to 2018. According to nitrogen concentration in Table 4 the water in El-Gamalia drain were classified in the second group according to the guideline FAO (1985). The concentration of nitrate ranged from 5 to 30 mg L^{-1} and therefore there is slight to moderate degree of restriction when using this water in irrigation. Also, according to FAO (1985), the concentration of P in the water samples in all studied sites was greater than 2 mg L^{-1} which indicate that this water cannot be used for irrigation purpose because there are problems due to the presence of phosphorus in this water. Also, the concentration of k in the water samples in all studied sites was greater than <2 mg L^{-1} which indicate that this water cannot be used for irrigation purpose.

Also, data presented in Table 2 shows some heavy metals concentration (mg kg^{-1}) in El-Gamalia drain water from May 2016 to May 2018. Data in Tables 4 showed that the effect of sampling distances from 0 to 6 km and sampling time during May 2016 to May 2018 and their interaction are not significant ($p<0.05$) on Pb, Ni, Co and Cd concentration. Also, the concentrations of dissolved heavy metals from the upstream to the downstream has been slightly increased. On the other hand, the highest heavy metals concentraions of El-Gamalia drain water were recorded in the summer months. The lowest values were recorded in the winter months from 2016 to 2018. According to FAO, (1985) and NAS/NAE (1972) the values of Pb concentration in El-Gamalia drain was less than the critical limits (5 mg L^{-1}). But the value of Ni, Co and Cd concentration was greater than the critical limit (0.2, 0.05 and 0.01 mg L^{-1}) at a distance 0 km to 10 km. Thus, the high concentration of cobalt in irrigation water can lead to toxicity in plants. Tomato toxicity was recorded when irrigation with water with a cobalt concentration greater than 0.1 mg L^{-1} (FAO, 1985). But this toxicity can disrupt the soil to moderate alkalinity (FAO, 1985), as is the case in agricultural soil in Egypt. Conservative limits recommended of heavy metals in irrigation eater due to its potential for accumulation in plants and soils to concentrations that may be harmful to humans (FAO, 1985). In general, it is not recommended to take irrigation from El-Gamalia drain. However, when the irrigation is required from this drain, the necessary precautions should be taken such as near irrigation times, while the amount of water discharged per irrigation is reduced, taking into account the non-cultivation of leaf crops.

Table 2. Chemical properties of El-Gamlaia drain in the study area from May 2016 to May 2018:

Distance km from start		EC, dSm^{-1}	SAR	W. Cl.	Macronutrients (mg L^{-1})			Heavy metals (mg L^{-1})			
					No_3-N	P	K	Pb	Ni	Co	Cd
Distance km from start											
0		1.74	3.28	C3S1	14.880	2.486	13.652	0.836	0.495	1.086	0.055
1.5		1.87	3.25	C3S1	14.980	2.493	13.744	0.907	0.529	1.099	0.058
3.0		1.91	3.27	C3S1	15.600	2.571	13.922	0.930	0.533	1.099	0.058
4.5		1.94	3.45	C3S1	15.660	2.789	14.154	0.939	0.592	1.101	0.059
6.0		2.08	3.57	C3S1	16.130	3.839	14.478	0.973	0.641	1.106	0.062
LSD (0.05)		ns	ns	---	ns	ns	ns	ns	Ns	ns	ns
Date											
2016	May.	2.02	4.19	C3S1	13.650	1.866	13.591	0.890	0.510	1.051	0.060
	Aug.	2.16	4.45	C3S1	16.430	3.868	15.047	0.927	0.515	1.135	0.064
	Nov.	1.40	3.79	C3S1	13.090	1.547	13.064	0.853	0.497	1.044	0.050
2017	Feb.	1.69	1.90	C3S1	14.550	2.536	14.060	0.893	0.552	1.107	0.048
	Mar.	1.75	2.54	C3S1	16.160	2.705	14.474	1.004	0.439	1.121	0.052
	AUG.	2.19	4.19	C3S1	17.450	3.794	14.195	1.013	0.722	1.138	0.061
	Nov.	2.01	3.97	C3S1	14.350	3.092	13.798	0.890	0.668	1.071	0.059
Feb. 2018		2.06	1.60	C3S1	17.92	3.279	13.693	0.867	0.559	1.119	0.074
Mean S. M.		2.12	4.28	C3S1	15.843	3.176	14.278	0.943	0.582	1.108	0.062
Mean W. M.		1.78	2.76	C3S1	14.538	2.470	13.849	0.910	0.539	1.086	0.052
LSD (0.05)		ns	ns	---	ns	ns	ns	ns	Ns	ns	ns
A×B		ns	ns	---	ns	ns	ns	ns	Ns	ns	ns

W. Cl. = Water classification ns = not significant * = significant ($p<0.05$) A=distance factor B=time factor
S. M. = summer months W. M. = Winter months

Chemical properties of El-Serw drain in the study area from May 2016 to May 2018:

The data in table 3 showed that the salinity values (EC) dS m^{-1} of El-Serw drain water were not significantly affected by sampling distances from 0 to 25 km and sampling time during May 2016 to May 2018 and their interaction effect. The values of salinity (EC) of El-Serw drain water vary between 1.58 dS m^{-1} at a distance of 0 km to 2.06 dS m^{-1} at a distance of 25 km during May 2016 to May 2018. On the other hand, the highest EC values of El-Serw drain water were recorded in the summer months (May and August). The lowest values were recorded in the winter months (November, February and March) from 2016 to 2018. A simplified classification according to EC is restricted to Class 3 (C3 = Ec from 0.75 to 2.25 dS m^{-1}). This water group belongs to C3-class according to USDA classification (1954) and it is considered to cause a high salinity problem FAO (1985).

On the other hand, SAR values of El-Serw drain were also not significantly affected by sampling distances from 0 to 25 km and sampling time during May 2016 to May 2018 and their interaction effect (Table 3). The values of SAR in Table 5 varied between 2.98 at a distance of 5 km to 3.36 at a distance of 10 km during May 2016 to May 2018. On the other hand, the highest SAR values of El-Serw drain water were recorded in the summer months from 2016 to 2018. A simplified classification according to SAR is restricted to section 1 (S1 = SAR from 0 to 25 km). This water group belongs to S1-class and it can be used for irrigation in all studied location with little adverse effect of the development of harmful levels of exchangeable Sodium (Richards, 1954) and it can be used without any restriction according to FAO (1985). According to USDA (1954) water of the studies sites is entirely S1-class. The description of this class "alkalinity hazard" of water as low concentration of sodium thus, this water can be used for irrigation in most months, with adverse effects when using it. However, sodium sensitive crops many accumulate injurious amounts of sodium. Irrigation from El-Serw drainage from a point away from the start of the drainage about 20 km (EC 3.2:3.3 ds m^{-1}, SAR 10.5:11.3), therefore it's considered to cause increase salinity problems (Tagour and Mosaad, 2017).

Data presented in Table 3 showed some macronutrients concentration (mg kg^{-1}) in El-Serw drain water from May 2016 to May 2018. Data in Tables 3 indicated that the effect of sampling distances from 0 to 25 km is not significant on phosphorus and potassium concentration, but this effect on nitrogen concentration is significant at ($p<0.05$). While, the effect of sampling time during May 2016 to May 2018 and their interaction effect between distances and sampling time were not significantly on nitrogen, phosphorus and potassium concentration. The concentration of dissolved macronutrients from the upstream to the downstream has been increased. On the other hand, the highest N, P, and K concentrations of El-Serw drain water were recorded in the summer months. The lowest values were recorded in the winter months from 2016 to 2018. According to nitrate concentration in Table 6 the water in El-Serw drain were classified in the first group according to the guideline FAO (1985). The concentration of nitrogen is less than 5 mg L^{-1} and therefore there is none degree of restriction when using this water in irrigation. Also, according to FAO (1985), the concentration of P in the water samples in all studied sites were less than <2 mg L^{-1} which indicate that this water can be used for irrigation purpose and there are no problems due to the presence of phosphorus in this water. But the concentration of k in the water samples in all studied sites were greater than <2 mg L^{-1} which indicate that this water cannot be used for irrigation purpose.

Also, data presented in Table 3 shows some heavy metals concentration (mg kg^{-1}) in El-Serw drain water from May 2016 to May 2018. Data in Tables 3 reported that the effect of sampling distances from 0 to 25 km and sampling time during May 2016 to May 2018 and their interaction are not significant ($p<0.05$) on Pb, Ni, Co and Cd concentration. The concentrations of dissolved heavy metals from the upstream to the downstream has been slightly increased. On the other hand, the highest heavy metals concentrations of El-Serw drain water were recorded in the summer months. The lowest values were recorded in the winter months from 2016 to 2018. According to FAO (1985) and NAS/NAE (1972) the values of Pb concentration in El-Serw drain was less than the critical limits (5 mg L^{-1}). But the value of Ni, Co and Cd concentration was greater than the critical limit (0.2, 0.05 and 0.01 mg L^{-1}) at a distance 0 km to 25 km. Thus, the high concentration of cobalt in irrigation water can lead to toxicity in plants. But this toxicity can disrupt the soil to moderate alkalinity (FAO, 1985), as is the case in agricultural soil in Egypt. Conservative limits recommended of heavy metals in irrigation water due to its potential for accumulation in plants and soils to concentrations that may be harmful to humans (FAO, 1985). In general, it is not recommended to take irrigation from El-Serw drain. However, when the irrigation is required from this drain, the necessary precautions should be taken such as near irrigation times, while the amount of water discharged per irrigation is reduced, taking into account the non-cultivation of leaf crops.

Table 3. Chemical properties of El-Serw drain in the study area from May 2016 to May 2018:

Distance km from start		EC, dSm^{-1}	SAR	W. Cl.	Macronutrients (mg L^{-1})			Heavy metals (mg L^{-1})			
					No3-N	P	K	Pb	Ni	Co	Cd
Distance km from start											
0		1.58	3.09	C3S1	2.855	0.663	11.075	0.447	0.425	0.393	0.043
5		1.70	2.98	C3S1	3.319	0.719	11.503	0.458	0.425	0.504	0.047
10		1.76	3.36	C3S1	3.458	0.725	11.509	0.512	0.492	0.511	0.053
15		1.80	3.31	C3S1	3.564	0.753	11.628	0.522	0.511	0.539	0.054
20		1.82	3.29	C3S1	3.967	0.790	11.754	0.545	0.513	0.542	0.064
25		2.06	3.28	C3S1	4.003	0.826	11.770	0.578	0.658	0.547	0.092
LSD (0.05)		ns	Ns	---	0.69*	ns	ns	ns	Ns	ns	ns
Date											
2016	May.	1.86	3.66	C3S1	3.393	0.799	11.008	0.583	0.385	0.443	0.054
	Aug.	2.22	4.38	C3S1	3.691	0.832	12.067	0.612	0.591	0.553	0.063
	Nov.	1.60	3.40	C3S1	3.352	0.647	10.881	0.575	0.328	0.429	0.048
2017	Feb.	1.51	2.50	C3S1	3.064	0.658	11.182	0.363	0.270	0.447	0.051
	Mar.	1.76	2.45	C3S1	3.768	0.656	11.353	0.420	0.583	0.460	0.055
	AUG.	1.96	3.50	C3S1	3.858	0.755	12.019	0.560	0.624	0.624	0.105
	Nov.	1.56	3.07	C3S1	3.772	0.749	11.419	0.476	0.613	0.568	0.056
Feb. 2018		1.81	2.69	C3S1	3.322	0.872	12.390	0.492	0.638	0.522	0.039
Mean S. M.		2.01	3.85	C3S1	3.647	0.795	11.698	0.585	0.533	0.540	0.074
Mean W. M.		1.65	2.82	C3S1	3.489	0.678	11.209	0.459	0.449	0.476	0.053
LSD (0.05)		ns	ns	---	ns	ns	Ns	ns	Ns	ns	ns
A×B		ns	ns	---	ns	ns	Ns	ns	Ns	ns	ns

W. Cl. = Water classification A=distance factor B= time factor ns = not significant * = significant ($p<0.05$)
S. M. = summer months W. M. = Winter months

Chemical properties of El-Harna drain in the study area from May 2016 to May 2018:

The data in Table 4 showed that the salinity values (EC) dS m^{-1} of El-Harna drain water were not significantly affected by sampling distances from 0 to 12.5 km and sampling time from May 2016 to May 2018 and their interaction effect. The values of salinity (EC) of El-Harna drain water vary between 2.33 dS m^{-1} at a distance of 0 km to 2.58 dS m^{-1} at a distance of 12.5 km from May 2016 to May 2018. On the other hand, the highest EC values of El-Harna drain water were recorded in the summer months (May and August). The lowest values were recorded in the winter months (November, February and March) from 2016 to 2018. A simplified classification according to EC is restricted to Class 4 (C4 = EC > 2.25 dS m^{-1}) at all sampling distances and sampling time except in November 2016, this water was classification to C3. This water group belongs to C4 and C3-class according to USDA classification (1954) and it is considered to cause a very high salinity problem FAO (1985).

On the other hand, SAR values of El-Harna drain were also not significantly affected by sampling distances from 0 to 12.5 km and sampling time during May 2016 to May 2018 and their interaction effect (Table 4). The values of SAR in Table 7 varied between 3.98 at a distance of 0 km to 4.38 at a distance of 12.5 km from May 2016 to May 2018. On the other hand, the highest SAR values of El-Harna drain water were recorded in the summer months from 2016 to 2018. A simplified classification according to SAR is restricted to section 1 (S1 = SAR from 0 to 12.5 km). This water group belongs to S1-class and it can be used for irrigation in all studied location with little adverse effect of the development of harmful levels of exchangeable Sodium (Richards, 1954) and it can be used without any restriction according to FAO (1985). According to USDA (1954) water of the studies sites is entirely S1-class. The description of this class "alkalinity hazard" of water as low concentration of sodium thus, this water can be used for irrigation in most months, with adverse effects when using it. However, sodium sensitive crops many accumulate injurious amounts of sodium.

Data presented in Table 4 showed some macronutrients concentration (mg kg^{-1}) in El-Harna drain water from May 2016 to May 2018. Data in Tables 8 showed that the effect of sampling distances from 0 to 12.5 km is not significant on nitrogen phosphorus and potassium concentration. While, the effect of sampling time during May 2016 to May 2018 and their interaction effect between distances and sampling time were not significantly on nitrate, phosphorus and potassium concentration. The concentration of dissolved macronutrients from the upstream to the downstream has been increased. On the other hand, the highest N, P, and K concentrations of El-Harna drain water were recorded in the summer months. The lowest values were recorded in the winter months from 2016 to 2018. According to nitrogen concentration in Table 8 the water in El-Harna drain were classified in the first group according to the guideline FAO (1985). The concentration of nitrogen is less than 5 mg L^{-1} and therefore there is none degree of restriction when using this water in irrigation. Also, according to FAO (1985), the concentration of P in the water samples in all studied sites were less than <2 mg L^{-1} which indicate that this water can be used for irrigation purpose and there are no problems due to the presence of phosphorus in this water. But the concentration of K in the water samples in all studied sites were greater than <2 mg L^{-1} which indicate that this water cannot be used for irrigation purpose.

Table 4. Chemical properties of El-Harna drain in the study area from May 2016 to May 2018:

Distance km from start		EC, dSm^{-1}	SAR	W. Cl.	Macronutrients (mg L^{-1})			Heavy metals (mg L^{-1})			
					NO_3-N	P	K	Pb	Ni	Co	Cd
Distance km from start											
0.0		2.33	3.98	C4S1	2.397	0.753	10.575	0.560	0.382	0.031	0.031
2.5		2.44	3.99	C4S1	2.541	0.779	11.028	0.568	0.398	0.035	0.031
5.0		2.45	4.06	C4S1	2.562	0.815	11.032	0.627	0.423	0.035	0.034
7.5		2.46	4.07	C4S1	2.569	0.815	11.326	0.641	0.454	0.036	0.034
10.0		2.49	4.16	C4S1	2.605	0.820	11.385	0.649	0.473	0.036	0.034
12.5		2.58	4.38	C4S1	2.637	0.835	11.750	0.657	0.474	0.036	0.035
LSD (0.05)		ns	ns	---	ns	ns	Ns	ns	Ns	ns	Ns
Date											
2016	May.	2.27	3.60	C4S1	2.732	0.781	11.224	0.623	0.466	0.034	0.040
	Aug.	2.54	4.83	C4S1	2.819	0.828	12.200	0.750	0.574	0.035	0.042
	Nov.	2.16	3.75	C3S1	2.464	0.793	10.978	0.549	0.463	0.032	0.028
2017	Feb.	2.46	3.91	C4S1	2.559	0.743	11.026	0.558	0.335	0.033	0.028
	Mar.	2.48	3.98	C4S1	2.420	0.782	11.341	0.631	0.444	0.033	0.030
	AUG.	2.60	4.20	C4S1	2.737	0.816	12.202	0.771	0.445	0.045	0.034
	Nov.	2.48	4.03	C4S1	2.379	0.803	10.277	0.469	0.345	0.039	0.028
Feb. 2018		2.68	4.60	C4S1	2.301	0.876	10.216	0.588	0.396	0.027	0.036
Mean S. M.		2.47	4.21	C4S1	2.763	0.808	11.875	0.715	0.495	0.038	0.039
Mean W. M.		2.45	4.05	C4S1	2.456	0.780	10.906	0.552	0.397	0.034	0.029
LSD (0.05)		ns	ns	---	ns	ns	Ns	ns	Ns	ns	Ns
A×B		ns	ns	---	ns	ns	Ns	ns	Ns	ns	Ns

W. Cl. = Water classification A=distance factor B=time factor ns = not significant S. M. = summer months
W. M. = Winter months

Also, data presented in Table 4 showed some heavy metals concentration (mg kg^{-1}) in El-Harna drain water from May 216 to May 2018. Data in tables 4 reported that the effect of sampling distances from 0 to 12.5 km and sampling time during May 2016 to May 2018 and their interaction are not significant ($p<0.05$) on Pb, Ni, Co and Cd concentrations. The concentrations of dissolved heavy metals from the upstream to the downstream has been slightly increased. On the other hand, the highest heavy metals concentrations of El-Harna drain water were recorded in the summer months. The lowest values were recorded in the winter months from 2016 to 2018. According to FAO, (1985) and NAS/NAE (1972) the values of Pb concentration in El-Harna drain was less than the critical limits (5 mg L^{-1}). But the value of Ni, Co and Cd concentration were greater than the critical limit (0.2, 0.05 and 0.01 mg L^{-1}) at a distance 0 km to 12.5 km. Thus, the high concentration of cobalt in irrigation water can lead to toxicity in plants. But this toxicity can disrupt the soil to moderate alkalinity (FAO, 1985), as is the case in agricultural soil in Egypt. Conservative limits recommended of heavy metals in irrigation water due to its potential for accumulation in plants and soils to concentrations that may be harmful to humans (FAO, 1985). In general, it is not recommended to take irrigation from El-Harna drain. However, when the irrigation is required from this drain, the necessary precautions should be taken such as near irrigation times, while the amount of water discharged per irrigation is reduced, taking into account the non-cultivation of leaf crops.

CONCLUSION

Finally, it could be concluded that drainage water and fresh water from the end of canals in northern Delta of Egypt must be used for irrigation purposes under controlled percautions with good soil management, use of convenient amendments, good tillage, deep ploughing, organic matter application, land leveling, applying soil and water amendments, and finally suitable cropping system.

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تقييم جودة مياه المصارف الزراعية للرى فى شمال دلتا مصر

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كمية المياه المتاحة لمصر محدوده مع وجود قيود لتحديد تلك الكمية. ولهذا السبب ، تم اقتراح خطط لإعادة استخدام مياه الصرف الزراعي مباشرة أو أحيانا بالخلط مع المياه العذبة لزيادة إمدادات المياه المحدودة. ويمكن أن يؤدي الاستخدام العشوائي لمياه الصرف لأغراض الري إلى تلوث التربة . تهدف هذه الدراسة إلى تقييم مدى ملاءمة مياه الصرف الزراعى من مصادر مختلفة ، لأغراض الري في شمال دلتا مصر. لذلك أجريت هذه الدراسة على ثلاثة مصادر لمياه الصرف الزراعى, مصرف الجمالية ، السرو والهرنة مقارنه مع ترعة الشوكة كمصدر للمياه العذبة على مدار السنة تبدأ من مايو ٢٠١٦ حتى فبراير ٢٠١٨. تم تقييم درجة التوصيل الكهربى, نسبة الصوديوم الممتصة وتركيز بعض النترات و الفسفور وبعض العناصر الثقيلة في المياه من جميع المصادر. ارتفعت قيم المياه EC و SAR بشكل طفيف من المنبع إلى المصب فى جميع مصادر الري في منطقة الدراسة. نوعية المياه من تلك المصارف تنتمي إلى فئتي C3 S1 و C4 S1 حيث يمكن إعادة استخدامها في أغراض الري تحت إدارة خاصة ، في حين أن المياه من قناة الشوكة تنتمي إلى C2 S1. كان تركيز الفوسفور في عينات المياه من مصرف الجمالية فقط أكبر من ٢ ملجرام لكل لتر ، مما يشير إلى أن هذه المياه لا يمكن استخدامها لغرض الري. أيضا ، كانت تركيز النترات في مياه مصرف الجمالية فقط بين ٥-٣٠ ملجرام لكل لتر ، لذلك هناك درجة خفيفة إلى معتدلة من التقييد عند استخدام هذا الماء في الري. في حين أن تركيز أيونات المعادن الثقيلة النيكل, الكوبلت والكادميوم كان أكبر من المستويات المسموح بها في جميع عينات المياه من المصارف المذكورة، باستثناء عينات المياه من قناة الشوكة من مسافة كم٠ عند البدايه إلى ٤ كم. في حين أن تركيز الرصاص أقل من الحدود الحرجة (٥ ملجرام لكل لتر). ويستنتج مما سبق أنه يمكن إعادة استخدام مياه المصارف الزراعية فى شمال دلتا مصر لأغراض الري تحت إدارة خاصة و دقيقه و محكمه .