Egypt. J. Soil Sci. **49**, No. 1, pp. 131-144 (2009)

Microbial and Chemical Evaluation of Quality of some Water Sources in South Port-Said Governorate

M.I. Hegazy[*] and K.A. Shaban[**]
[*]Microbiology Department, Faculty of Agriculture, Zagazig University, Zagazig and [**]Soils, Water and Environment Research Institute, Agricultural Research Centre, Giza, Egypt.

DUE to the shortage of irrigation water in south Port-Said Governorate, people are using mixed water resources (canals) with agricultural, industrial and domestic waste water. Six fresh water sources in this area were evaluated for their microbial and chemical quality. Several microbial groups were determined, including total viable bacteria, total coliform, fecal coliform (FC), fecal streptococci (FS), *Salmonella* and *Shigella.* For chemical evaluation, salinity, cations, anions, macronutrients, and micronutrients were determined. In general, there was a high level of microbial contamination, Bahr El-Bakar at Shader Azzam being the most contaminated, followed by Bahr El-Bakar at El-Sharkia, Sahl El-Hossinia mixed with Bahr El-Bakar, Sahl El-Hossinia drain, El-Salam canal, and then Sarhan canal. The high levels of bacterial count of coliform, fecal coliform, and fecal streptococci showed that the water resources are contaminated.

This conclusion was confirmed by detected *Salmonella* and *Shigella.* The ratio of FC/FS showed that the contamination was of fecal origin in all water resources except that for Sarhan and El-Salam canals. Chemical analysis showed that most of the water sources had high levels of salinity, except that for Sarhan and El-Salam Canals. The data showed that salinity was at highest level at Bahr El-Bakar drain II, followed by Bahr El-Bakar drain I, Bahr El-Bakar mixed with Sahl El-Hossinia drains, Sahl El-Hossinia drain, El-Salam canal, then, Sarhan canal. Concentrations of micronutrients, ammonia and nitrate were at safe limits in all water sources. Despite the high levels of phosphate and potassium (in Sahl El-Hossinia drain) and nitrogen (in Bahr El Bakar drain I and II), they remained within the safe limits. Efficient methods for dilution of crop run-off, treatment of municipal and industrial water, and stringent surveillance on the untreated waste water discharge are needed. Such processes are important to ensure a sustainable development for the Egyptian agricultural resources.

Keyword: Irrigation water sources, Microbial and chemical contaminations.

Due to the scarcity of fresh water sources that is limited to 55billion m^3 annually from Nile water, the Ministry of Public Works and Water Resources in Egypt implemented strategies for the re-use of agricultural drainage water, in conjunction with the Nile Water that is spilled into the Mediterranean Sea (about 7.5 billion m^3 annually). The Ministry launched important steps to execute these strategies by expanding new agricultural activities downstream in the northern part of Egypt. In addition, all drainage water between Aswan and Cairo are recycled back to the Nile River and reused in Delta soil irrigation where several main drains discharge into the Rosetta and Damietta Branches (Amer *et al.*, 1996).

The recycling of drain water increased the chemical and microbial loads of the mixed water, and caused negative effects on human health, land fertility, and the balance of water ecosystem. Examples of the diseases caused by microbial water contamination are: typhoid, dysentery, diarrhea, hepatitis, cholera and salmonellosis (WHO, 1992).

From a microbiological standpoint, monitoring of water quality is usually regulated by measuring concentrations of indicating microbes. The microbes utilized are those typically found in human feces in high concentrations, such as total coliform, fecal coliform, and fecal streptococci. An increasing concentration of these indicating microbes in water would indicate that the water has been contaminated by human waste and is unsafe for irrigation. Reports of the Centers for Disease Control in the United States showed that in the past decade, there was an increasing water-borne disease outbreaks caused by enteric pathogens (Santamaria and Toranzos, 2003). Gastrointestinal infections are commonly caused by enteric bacteria, some of which (*E. coli* O157:H7) can have infectious dose as low as ten cells (Teunis *et al.*, 2004). Even though some investigations used fecal coliform as the only indicator for fecal contamination (Giannoulis *et al.*, 2005), using other indicator bacteria such as fecal streptococci, salmonella and shigella would give better insight into the origin and the degree of the water contamination (Doran *et al.*, 1981 and Millaku *et al.*, 2008). Sabae and Rabeh (2007) have studied the microbial quality of the Damietta Branch of the Nile River in seven different locations covering the area from Cairo to the City of Damietta. The results of that study showed that the densities of fecal indicators increased from up- to down stream of the river, as the fecal coliform reached up to 7500 (MPN)/100ml during the summer season. Such changes in microbial population were related to several factors including dissolved organic carbon concentration, discharge, and temperature as reported in another study by Leff *et al.* (1998).

Chemical characteristics are also important for evaluating the quality of reused water (such as agricultural water mixed with drain water). The quality of such water is highly affected as the percentage of discharge or drain water is increased. El-Eweddy (2000) found that the EC values of El-Salam canal water increased as going farther in the Damietta branch and the highest values of water salinity were obtained after blending with Bahr- Hadoos water drain. Water samples taken from El-Serw and Bahr-Hadoos drain had EC ranging from 1.47 to 3.25 dS/m (deciSiemens per metre) and considered as slight to medium saline. Hafiz (2001) studied the pH values of different water types (sewage water, secondary treated sewage water, canal polluted water, and fresh water), and found that the sewage water had slightly decreased pH than the others. Mostafa (2001) noticed that the concentration of nitrogen in Nile water, drainage water and sewage water were 3.78, 7.41, and 13.8 mg/l respectively. Shaban, (1998) showed that the phosphorus contents were 4.10, 6.31, and 6.54 mg/l for drainage water, Nile water mixed with sewage water and sewage water, respectively. Zein *et al*. (2002) studied heavy metal concentrations of Pb, Mn, Zn, Cd, Ni and Cu in the Nile water, and found that their values were 0.03, 0.011, 0.10, 0.004, 0.021 and 0.022 mg/l, respectively. However, the average concentrations of heavy metals in drain water were 0.615, 0.23, 0.185, 0.025, 4.21 and 0.07 mg/l for the same metals, respects.

The purpose of this study was to evaluate the quality of fresh water sources available in the area of south Port-Said Governorate, based on their chemical and microbial characterization. It also aims at providing a model study for other regions in Egypt with similar situation of using mixture of agriculture drain, municipal discharge with fresh water.

Material and Methods

Studied area and sampling

Six irrigation water sources at the area of south Port-Said Governorate, bordering the north of El-Sharkia Governorate were included in the study. The study was conducted over a two-year period between October, 2006 and September, 2008 with four sampling times related to the agricultural activities, being: the average of October, 2006 and 2007, April, 2007 and 2008; June, 2007 and 2008 and September, 2007 and 2008. Samples were collected from subsurface in sterile bottles and kept cold in an insulation box until microbial analysis was made within 24 hr. For chemical analysis, the samples were kept at 4°C until analyzed. At the sampling periods stated before, a total of 48 samples were collected from the following water sources: I- Sarhan Canal (Nile water). II- El- Salam canal (agriculture drainage water mixed with fresh Nile water in the ratio of 1:1), III- Sahl El- Hossinia drain (agriculture drainage water), IV- Sahl El-Hossina drain mixed with Bahr El- Bakar drain (agriculture drainage mixed with sewage water), V- Bahr El-Bakr drain at El-Sharkia Governorate (Bahr El-Bakar drain I) and VI- Bahr El- Bakar drain at south Port Said Governorate (Bahr El-Bakar drain II). Table 1 to 3 show the average microbial and chemical analyses per sampling time over the two-year.

TABLE 1. Mean values of Count of different microbial groups in the examined water sources in tow seasons 2006 – 2007 and 2007 – 2008.

Location	Sample*	TB** 10^7 cfu/ml	TC 10^2 cfu/ml	FC coliform/ 100ml	FS/ 100ml	SS/100 ml	FC/FS
Sarhan Canal	1st	11.3	0.5	983	1080	0.3	0.9
	2nd	12.0	1.9	1064	2025	0	0.5
	3rd	18.6	3.5	1547	2260	1.3	0.7
	4th	10.8	0.9	880	1040	0.3	0.8
El-Salam Canal	1st	18.1	5.6	7068	8896	1.7	0.8
	2nd	26.3	16.7	6739	9289	1.0	0.7
	3rd	43.0	31.5	14588	10567	2.7	1.4
	4th	18.7	6.9	3058	3452	1.3	0.9
Sahl El – Hossinia drain	1st	44.6	7.7	36254	10151	2.3	3.6
	2nd	46.2	41.4	29061	10893	2.7	2.7
	3rd	52.2	67.9	37454	11501	2.3	3.3
	4th	63.4	19.0	31361	7363	1.7	4.3
Sahl-El-Hossinia mixed with Bahr El-Bakar drain	1st	96.3	14.6	45540	7496	2.7	6.1
	2nd	114	72.8	66511	15974	3.0	4.2
	3rd	171	104	93972	15312	3.7	6.1
	4th	77	23.5	39283	6604	2.3	5.9
Bahr El Bakar drain I	1st	120	22.1	54901	6144	3.7	8.9
	2nd	216	58.7	91708	17886	4.3	5.1
	3rd	226	122	106578	19431	5.3	5.5
	4th	161	63.7	55746	8672	3.0	6.4
Bahr El Bakar drain II	1st	172	39.2	82045	9169	4.3	8.9
	2nd	194	119	96248	14205	5.3	6.8
	3rd	255	136	139239	17232	5.7	8.1
	4th	212	38.4	70090	7210	3.7	9.7

*1st sample is an average of October 2006 and 2007, 2nd is average of April 2007 and April 2008, 3rd is an average of June 2007 and 2008 and 4th is average of September 2007 and 2008.
** Microbial groups: TB, total bacterial count x 10^7 cfu/ml; TC, total coliform x 10^2 cfu /ml; FC, fecal coliform /100ml; FS, fecal streptococci /100ml and SS, salmonella & shigella / 100ml.

TABLE 2. Mean values of chemical properties of the different water sourcesas averages of the two seasons 2006- 2007 and 2007 -2008.

Location	Sample *	pH	EC (dSm^{-1})	Cations (meq^{-1})				Anions (meq^{-1})				SAR
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO^{-}_{3}	HCO^{-}_{3}	Cl^{-}	SO^{-}_{4}	
Sarhan Canal	1^{st}	8.02	1.66	2.92	4.46	8.49	0.63	nil	3.24	6.67	6.65	4.42
	2^{nd}	8.00	1.25	2.25	3.07	6.49	0.66	nil	2.87	4.58	5.73	3.36
	3^{rd}	8.05	2.14	3.76	5.53	11.42	0.71	nil	5.18	9.23	7.00	5.31
	4^{th}	7.94	1.25	2.45	3.53	5.87	0.62	nil	2.77	4.88	4.81	3.39
El-Salam Canal	1^{st}	8.00	2.34	3.35	4.17	15.13	0.76	nil	4.83	12.76	5.82	3.03
	2^{nd}	8.04	1.48	2.13	3.23	8.81	0.65	nil	3.54	7.35	3.92	5.37
	3^{rd}	8.11	2.60	4.15	5.20	15.91	0.70	nil	5.98	13.37	6.61	7.36
	4^{th}	8.07	1.51	2.87	3.87	7.67	0.70	nil	4.36	6.46	4.29	4.19
Sahl El –Hossinia drain	1^{st}	8.15	4.32	6.68	9.01	26.71	0.77	nil	7.68	23.89	11.59	9.54
	2^{nd}	8.13	2.81	5.00	6.99	15.42	0.64	nil	5.82	12.70	9.53	6.29
	3^{rd}	8.20	4.28	6.87	8.93	26.25	0.75	nil	8.51	23.26	11.03	9.44
	4^{th}	8.15	2.50	3.77	5.92	14.63	0.64	nil	4.80	12.22	7.95	6.65
Sahl-El-Hossinia mixed with Bahr El-Bakar drain	1^{st}	8.22	4.11	6.74	9.18	24.34	0.80	nil	8.38	21.34	11.34	8.63
	2^{nd}	8.16	2.87	4.47	6.44	17.09	0.66	nil	5.75	14.63	8.28	7.33
	3^{rd}	8.27	4.36	6.53	9.22	27.09	0.72	nil	8.45	23.57	11.54	9.64
	4^{th}	8.24	2.63	4.76	5.74	15.09	0.72	nil	5.50	12.26	8.55	6.56
Bahr El Bakar drain I	1^{st}	8.20	3.39	5.00	7.36	20.88	0.67	nil	5.75	16.99	11.17	8.42
	2^{nd}	8.16	2.21	3.59	5.13	12.66	0.68	nil	4.20	10.34	7.51	6.03
	3^{rd}	8.30	3.63	5.09	7.99	22.49	0.77	nil	7.52	18.23	10.58	8.78
	4^{th}	8.25	2.23	3.03	4.86	13.67	0.74	nil	4.86	9.86	7.59	6.87
Bahr El Bakar drain II	1^{st}	8.28	3.76	5.20	8.26	23.35	0.75	nil	7.62	20.57	9.37	9.01
	2^{nd}	8.20	2.54	3.86	6.05	14.69	0.75	nil	5.81	13.41	6.14	6.59
	3^{rd}	8.22	3.93	5.52	7.87	25.11	0.81	nil	7.38	21.36	10.56	4.85
	4^{th}	8.23	2.91	4.05	6.28	17.97	0.76	nil	6.28	14.26	8.52	7.91

* 1^{st} sample is an average of October 2006 and 2007, 2^{nd} is average of April 2007 and April 2008, 3^{rd} is an average of June 2007 and 2008 and 4^{th} is average od September 2007 and 2008.

TABLE 3. Mean values of macro- and micro-nutrient contents of the water sources as averages of the two seasons 2006 -2007 and 2007 - 2008.

Location	Sample *	N (mgl^{-1})		P (mgl^{-1})	K (mgl^{-1})	Micronutrients (mgl^{-1})					Heavy metals (mgl^{-1})		
		NO3	NH4			Fe	Mn	Zn	Cu	B	Pb	Co	Ni
Sarhan Canal	1st	10.63	7.67	2.25	19.17	1.70	1.71	0.93	0.22	0.045	2.04	0.010	0.005
	2nd	9.44	6.19	2.79	25.61	1.99	1.52	1.03	0.19	0.038	1.94	0.009	0.002
	3rd	12.14	9.75	2.84	27.57	1.89	1.91	0.85	0.17	0.051	2.08	0.010	0.007
	4th	12.17	6.23	2.68	18.99	1.76	1.63	0.77	0.16	0.046	1.94	0.012	0.003
El-Salam Canal	1st	14.94	11.70	3.29	29.72	2.63	2.11	1.27	0.27	0.081	2.26	0.036	0.008
	2nd	12.93	9.99	3.11	25.13	2.43	1.80	1.09	0.24	0.077	2.11	0.030	0.005
	3rd	17.51	13.30	3.34	27.17	2.61	2.35	1.30	0.31	0.082	2.67	0.033	0.009
	4th	13.64	10.20	3.02	27.17	2.64	2.04	1.02	0.24	0.077	2.56	0.024	0.008
Sahl El –Hossinia drain	1st	18.56	18.54	4.49	29.92	3.39	2.90	1.38	0.39	0.111	3.04	0.047	0.016
	2nd	14.23	14.50	4.02	25.03	3.14	2.61	1.24	0.31	0.122	2.82	0.047	0.019
	3rd	19.94	19.49	4.55	29.33	3.81	3.02	1.49	0.39	0.165	3.27	0.053	0.024
	4th	18.57	15.71	4.48	25.03	2.82	2.87	1.34	0.30	0.220	3.16	0.047	0.016
Sahl-El-Hossinia mixed with Bahr El-Bakar drain	1st	24.49	15.53	4.14	31.32	3.58	3.62	1.74	0.44	0.400	3.54	0.060	0.030
	2nd	19.78	11.67	4.01	25.81	3.01	3.18	1.62	0.35	0.325	3.15	0.051	0.025
	3rd	25.19	17.34	4.28	27.18	3.55	3.61	1.85	0.52	0.430	3.53	0.066	0.033
	4th	21.20	14.51	3.96	26.00	2.96	3.10	1.84	0.36	0.439	3.45	0.055	0.025
Bahr El Bakar drain I	1st	27.46	19.66	3.96	28.55	3.80	3.56	1.85	0.43	0.505	3.87	0.060	0.041
	2nd	24.57	15.65	3.83	27.18	3.40	3.41	2.00	0.45	0.440	3.64	0.054	0.037
	3rd	27.86	19.67	3.76	26.81	3.97	3.80	1.84	0.45	0.550	3.79	0.064	0.041
	4th	24.76	15.89	3.65	30.32	3.34	3.36	1.98	0.44	0.455	3.80	0.064	0.036
Bahr El Bakar drain II	1st	25.80	19.60	4.78	30.50	4.36	3.60	1.94	0.49	0.565	3.91	0.067	0.046
	2nd	21.84	16.35	4.53	31.09	3.82	3.58	1.83	0.37	0.402	3.69	0.059	0.043
	3rd	27.94	21.13	4.81	29.48	4.41	3.60	1.81	0.56	0.555	3.93	0.074	0.036
	4th	22.42	17.68	4.68	28.55	3.92	3.39	1.70	0.47	0.530	3.84	0.068	0.045

1st sample is an average of October 2006 and 2007, 2nd is average of April 2007 and April 2008, 3rd is an average of June 2007 and 2008 and 4th is average od September 2007 and 2008.

Water analysis

Salinity of the water expressed as EC (dS/m), soluble Boron, soluble cations (Ca^{+2}, Mg^{+2}, Na^{+}, and K^{+}) and anions (Cl^{-}, CO^{-}_{3}, HCO^{-}_{3} and SO^{-}_{4}) were determined according to Black *et al.* (1965). Sodium adsorption ratios (SAR) were collated for each sample. Nitrogen in the form of ammonium nitrate was determined following the method described by Markus *et al.* (1982). Phosphorus, potassium and trace elements were determined as described by Soltanpour and Schwab (1977) using Inductively Coupled Spectrometry (ICP) model 400.

Microbiological analysis

Total viable bacteria were counted using the spread-plate method on medium, and incubated at 30°C for 48 hr *Salmonella* and *Shigella* were counted using SS agar (*Salmonella* and *Shigella*agar medium) and incubated at 35°C for 24 hr, pink to red colonies and colonies that have black centre were counted (APHA, 1992). Total coliform counts were performed by the Most Probable Number technique (APHA, 1992) using McConkey broth medium. The tubes containing the media were inoculated with water samples and incubated for 24 – 48 hr at 37°C.

Fecal coliform count was performed by the membrane filtration technique (Santiago and Hazen, 1987). Several volumes of the water samples (to produce appropriately countable number) were passed through 0.45 m membrane filterates. Filterates were then removed and aseptically placed onto a petri dish containing M-7h FC agar medium, which is composed of (gm/liter) 5.0g proteose peptone No.3, 3.0g yeast extract, 10.0g Lactose, 5.0g d-mannitol, 7.5g NaCl, 0.2g sodium lauryl sulfate, 0.1g sodium desoxycholate, 0.35g bromocresol purple, 0.3g phenol red, 15g agar. Plates were incubated at 41.5°C for 7 hr and yellow colonies were counted as fecal coliform.

Fecal streptococci were counted using Membrane Filter technique and KF (Kenner Fecal Streptococcus Agar) streptococcus agar medium according to APHA (1992). The medium was composed of (gm/liter) 10.0g protease peptone No.3, 10.0g yeast extract, 5.0g NaCl, 10.0g sodium glycerophosphat, 20.0g maltose, 1.0gm lactose, 0.4g sodium azide (N_3Na), 0.015g bromocresol purple and 15g agar. After mixing the ingredients, the medium was cooled to 50°C and 10 ml sterile aqueous 1% solution of 2.3.5 triphenyl tetrazolium chloride (TTC) was added. Plates were incubated at 37°C for 48hr and red or pink colonies were counted as fecal streptococci.

Results and Discussion

The water sources chosen in this study impose a considerable effect on the residents of south Port-Said area due to their direct exposure to those water sources for either irrigation or fishing purposes. Due to the water scarcity in Port-Said Governorate, people have to compromise using water sources mixed with agriculture drainage or some levels of industrial or municipal discharge. Such water is expected to carry a high load of chemical and microbial contaminations that would affect the soil, the ecosystem, and human health in both short and long term. Table I showed that the numbers of microbial groups were highly variable based on the location and the sampling period. For instance, the average numbers of fecal coliform were 118, 7.863 and 96.905 cfu/100ml in locations I, II and VI, respectively. Such a substantial difference applies to the other microbial groups, which can be explained by the difference in nature between the different water sources. For example, Sarhan canal (location .I) has irrigation water that does not receive drain water, while El-Salam canal (location. II) is a mixture of pure water with drain water from Bahr Hadoos. Bahr El-BakarII (location .VI), on the other hand, is a mixture of drains containing agricultural, municipal and industrial discharges. The data show a close positive relationship between the total numbers of bacteria and indicator bacteria in different water sources. Similarly, the counts of total coliforms and other indicator bacteria were positively related, which agrees with the results found by Chao *et al.* (2003) and Overcash & Davidson (1980). The levels of indicator bacteria shown in Table 1 (total coliform, fecal coliform and fecal streptococci) suggest that the water sources are heavily contaminated and from a microbiological standpoint is of poor quality.

That is based on the WHO (1992) guideline limits for microbial indicators in fresh water which is 500/100 ml for total coliforms and 100/100ml for both fecal coliforms and fecal streptococci.

Beside the indicator bacteria, counting of salmonella and shigella as pathogens was performed to confirm whatever the water sources have fecal contamination. The results in our study showed a positive relationship between the indicator organisms and salmonella and shigella counts. While these results disagrees with the findings of El-Fadaly *et al.* (2002), it concurs with the data of Sabae and Rabeh (2007) and is highly expected, in view of the high numbers of the indicator bacteria, which no doubt existential of fecal contamination in the examined water sources. Also, Townsend (1992) reported a significant correlation between the indicator organisms and salmonella in pools located in tropical northern Australia.

The results in Table 1 show a seasonal pattern in the microbial populations, where the highest numbers were always recorded in the summer (June). This is most likely due to the warm temperature of the summer season which allows faster bacteria growth. Similar seasonal. trend was observed by Isobe *et al.* (2004) while studying the indicator bacteria in some Japanese rivers and also Sabae and Rabeh (2007) during their study of the Nile River. Giannoulis *et al.* (2005) showed a reverse seasonal trend of fecal coliform counts, being greater during the winter, decreased during spring and autumn and lower during summer. Besides, higher bacterial densities were observed in October as compared to September, very likely due to the higher bacterial inputs from soil particles with runoff that usually occurs in this period. This assumption is also supported by the higher levels of chemical nutrients such as N, P and K as shown in Table 3. The ratio of fecal coliform to fecal streptococci is used as an indicator of the origin of fecal pollution, with the value of four or indicates that the source is human, while a value of less than one indicates nonhuman origin (Novotny and Olem, 1994). In our study, this ratio generally ranged between 0.5 and 9.7, in locations III to VI showing a ratio of more than 1, which indicate human or mixed source of contamination. Only two locations (I and II) showed a FC/FS ratio of less than 1, indicating nonhuman origin of contamination.

Chemical analysis

Total soluble salts of the water sources, as expressed by electric conductivity (EC_{iw} dSm^{-1}) presented in Table 2 show that the highest EC_{iw} values were found in the samples 3^{rd} (an average of June 2007 and June 2008) in the following ascending order; Sarhan canal > El-Salam canal > Bahr El-Bakar drain II > Sahl El-Hossinia drain > Bahr El-Bakar drain I > Sahl El-Hossinia mixed Bahr El-Bakar drains. The results show that the EC values are higher in June followed with them in October than these in September and April. Such variation may be attributed to the dilution effect of the lateral seepage of agricultural drainage water, especially with using large amounts of water in summer for rice irrigation. These results are in agreement with those obtained by El- Sherbieny *et al.* (1998), Shaban (2005) and Sallam *et al.* (2008).

The average EC for locations I and II indicate that they fell in the category of moderate salinity, while the other sources were in the severe salinity level. These data along with the microbiological data for the same locations show that they have the best water quality characteristics compared to all other water sources. Ayers and Westcot (1985) discussed the salinity level classification, stating that the none salinity level was expected when the EC value is lower than 0.7 dS/m, and the moderate salinity level is expected when the EC value is between 0.7 and 3.0 dS/m, and the severe salinity level is expected when the EC value exceeds 3.0 dS/m.

The data (Table 2) show that all water sources had pH values within the range of 7.94 to 8.3, which is a moderate pH level for fresh water sources according to the limits of Ayers and Westcot (1985). The variations in pH values were only 0.36 units, which eliminates the hazard factor of the wide pH changes on plants (Shaban, 2005). Calcium concentration showed the lowest value (2.13 meq/l) in April at El-Salam canal and showed the highest value (6.87 meq/l) in June at Sahl El –Hossinia drain. The highest value of Mg^{++} (9.22 meq/l) was in Sahl El-Hossinia mixed with Bahr El-Bakar drain in June, while the lowest value (3.07 meq/l) was in Sarhan canal in April. Sodium concentration showed the highest value (29.09 meq/l) in June in Sahl- El- Hossina Mixed with Bahr El-Bakar drain, while the lowest value (5.87 meq/l) in September at Sarhan canal. With regard to bicarbonates concentrations, data presented in the same table show that almost all values fall in the slight to moderate levels (1.5 –8.4 meq/l) according to the guidelines of the water quality for irrigation (FAO, 1985). Generally, one can notice clear fluctuations in soluble ion contents (cations and anions) which could be due to the repeated soil washing to decrease salt contents, or the summer evaporation that is increased in summer much more than winter. These results are in agreement with El- Sherbieny *et al.* (1998) and Shaban (2005). The chloride ranged between 4.58 in April at Sarhan canal, to 23.89 in October at Sahl El-Hossina drain, which fall in the slight to moderate levels (Ayers and Westcot 1985).

Sodium adsorption ratio (SAR) in water sources presented in Table 2 show great variations among the different sampling periods. The SAR values ranged between 3.03 and 9.64 for all the taken water samples through the two seasons. Respecting to the effect of water sources on SAR values, obtained data reveal that water of Sahl El-Hossinia mixed with Bahr El-Bakar drains have the highest SAR values followed by Sahl El-Hossinia drain water, while the lowest ones are recorded in the case of El-Salam canal water. According to the water sodicity classes undertaken by Ayers and Westcot (1985) all the used water resources are slight-moderate. Therefore these waters can be safety used as a source of irrigation in the studied soils, especially for those mixed of the drainage water and the fresh Nile water in the situation of El-Salam canal. These obtained results were in agreement by Shaban (2005).

The concentrations of NO_3–N and NH_4–N in the water sources are presented in Table 3. The data show that the NO_3–N content ranged between 9.44 mg/l in April at Sarhan canal, and 27.94 mg/l in June at Bahr El-Bakar drain II. Those levels are in the slight-moderate category according to Ayers and Westcot (1985) who assigned this category for chloride levels between 5.0–30 mg/L. Also, NH_4–N ranged between 6.19 and 21.13 in the same corresponding locations as the nitrate levels. The reason for the differences in HN_4-N content might due primarily to the different rates of nitrification. These findings are in agreement with those found by El-Sherbiny *et al.* (1998) and El-Sayed (2001). The data also show that the phosphorus content in all water sources ranged between 2.25 and 4.81 mg/L. Excess phosphorus in irrigation water has not been a problem and it has no guidelines for its hazardous effects, however, determination of its level can be valuable for fertilization planning. These results are in agreement with those obtained by Mostafa (2001) and Shaban (2008). Similarly, potassium level in water is not known for causing adverse effects on plants and is also essential macronutrient for plants. Potassium in irrigation water can be taken into consideration in formulating the fertilization programs according to Shaban (1998). Data presented in Table 3 indicate that the potassium content in all water sources ranged between 19.17 mg/l in October at Sarhan canal and 31.32 mg/l in October at Sahl El-Hossinia mixed with Bahr El-Bakar drain. These results are in agreement with those reported by Sallam *et al.* (2008).

Results of micronutrient analysis (Table 3) showed that Fe, Mn, Zn, Cu, Pb, B, Co, and Ni concentrations were generally at safe level. Appendix 1 shows the maximum safe limits set by the National Academy of Engineering (1972) for trace elements in reclaimed water used for irrigation. It suggests the trace element limits for long term use, under which the water can be used permanently and also the short term use, within which the water should not be used for more than 10 years.

Appendix 1. Maximum safe limits of micronutrients set by the National Academy of Engineering.

Treatment	Fe	Mn	Zn	Cu	Pb	B	Co	Ni
Long term use (mg/l)	5.0	0.2	2.0	0.2	5.0	0.75	0.05	0.2
Short- term use(mg/l)	20.0	10.0	10.0	5.0	10	2.0	5.0	2.0

The data show that most of the micronutrient concentrations are within the limits of long term use, except for Mn, Cu and Co, which showed values up to 3.8 mg/l Mn in Bahr El-Bakar drain I, 0.52 mg/l Cu in Sahl- El-Hossinia mixed with Bahr El-Bakar drain and 0.068 mg/l Co in Bahr El-Bakar drain II. In accordance with the previously noticed trend of chemical analysis data, the concentrations of micro nutrients are gradually increasing as we go from location I to location VI. This can also explain the close corresponding trend of increasing bacterial counts in the same order for the water sources. The changes in concentrations of micronutrients in different irrigation water reflect the leaching process of the soil, different types of crop production, water drained from fish ponds and the types of fertilizers used over the time. These results are in agreement with those reported by FAO (1992), Shaban (2005) and Sallam *et al.* (2008).

Conclusion

In conclusion, the high level of water salinity in most of the water sources in the studied area presents a possible threat to the land fertility and chemical characteristics. That makes it necessary to adopt more efficient methods for water dilution by introducing larger amounts of fresh water. The microbiological results presented in this paper are shedding the light on the human risk factor for those who are exposed to such contaminated water sources, as well as the possible contact of the agricultural crops with the microbial pathogens. Further epidemiological studies are needed to assess the impact relationship between agriculture workers exposure to of human exposure to these contaminated water sources and those worker health status.

References

Amer, M. Abdel wahab and Mohsen Sherif, M. (1996) An integrated study for sea water in treason in the Nile Delta aquifer. Water Resources Strategic Research Activity (WRSR). Ministry of Public Works and Water Resources, Cairo, Egypt.

APHA (American Public health Association) (1992) *"Standard Methods for the examination of Water and Waste Water"* 18th ed., Washington, D.C., American Public Health Association.

Ayers, R.S. and Westcot, D.W. (1985) *"Water Quality for Agriculture. Irrigation and Drainage"*, p. 29, Rev. 1, Food and Agric. Organ. of U.N., Rome.

Black, C. A. (1965) "*Method of Soil Analysis*", Soil Science Society of American Inc. Publisher, Madison, Wisconsin, U.S.A

Chao, K.K., Chao, C.C. and Chao, W.L. (2003) Suitability of the traditional microbial indicators and their enumerating methods in the assessment of fecal pollution of subtropical freshwater environments. *J. Microbiol Immunol Infect.* **36**(4): 288-93.

Doran, J.W., Schepers, J.S. and Swanson, N.P. (1981) Chemical and bacteriological quality of pasture runoff. *Journal Soil & Water Conservation*, May-June:166-171.

El-Eweddy, A. (2000) Factors Affecting the Accumulation Rate of Pollutants in Desert Soils under the Condition of Irrigation with El- Salam Canals Water. *Ph. D. Thesis*, Fac. of Agric., Monufiya Univ., Egypt.

El-Fadaly, H., El-Defrawy, M., El-Zawawy, F. and Makia, D. (2002) Chemical and microbiological evaluation of River Nile water in Dakahlia Governorate. *J. Environ. Sci.* **22**: 1-18.

El-Sayed, A.A. (2001) long term effect of irrigation with polluted drainage water on nitrate accumulation. *Egypt. J. Soil Sci.* **41** (1-2): 205- 218.

El-Sherbieny, A.E., El-Saadany, S.M. and Fatma, A.A. Osman. (1998) Seasonal variations on quality of some drainage water in Sharkia Governorate. *Egypt. J. Soil Sci.* **38** (1-4): 185-198.

FAO (1985) Guidelines for interpretation of water quality for irrigation. Adapted from FAO Irrigation and Drainage, Paper No. 29, Rev. 1.

FAO (1992) Waste water treatment and use in agriculture. FAO Soils Bull., No.47, Rome.

Giannoulis, N., Maipa, V., Konstantinou, I., Albanis, T., and Dimoliatis, I. (2005) Microbiological risk assessment of Agios Georgios source supplies in Northwestern Greece based on faecal coliforms determination and sanitary inspection survey. *Chemosphere* **58** (9): 1269-1276.

Hafiz. W. A. (2001) Effect of Drainage Water on Some Egyptian Soils and Plant. *M.Sc. Thesis*, Fac. of Agric. Moshtohor, Zagazig Univ., Egypt.

Isobe, K.O., Tarao, M., Chiem, N.H., Minh, L.Y. and Takada, H. (2004) Effect of environmental factors on the relationship between concentrations of coprostanol and fecal indicator bacteria in tropical (Mekong Delta) and temperate (Tokyo) freshwaters. *Appl. Environ. Microbiol.* **70**: 814–821.

Leff, L.G., Leff, A.A. and Lemke, M. J. (1998) Seasonal changes in planktonic bacterial assemblages of two Ohio streams. *Freshwater Biology* **39**: 129-134.

Markus, D.K., Mckinnon, J.P. and Buccafuri, A.F. (1982) Automated analysis of nitrate and ammonium nitrogen soils. New Jersey, Agric. Exp. Stn. Publication N.D. 15117 – 84.

Millaku, A., Plakolli, M. and Vehapi, I. (2008) The impact of biological, chemical and physical pollution on the water quality in river Klina. *BALWOIS* **23** (31): 1-9.

Mostafa, M.M. (2001) Nutrition and productivity of Broad Bean plant as affected by quality and source of irrigation water. *Zagazig J. Agric. Res.* **28** (3): 517-532.

National Academy of Science and National Academy of Engineering (1972) *Water Quality Criteria* (5): 232- 253.

Novotny, V. and Olem, H. (1994) Water Quality: Prevention, Identification, and Management of Diffuse Pollution. Van Nostrand Reinhold, New York.

Overcash, M.R. and Davidson, J.M. (1980) Environmental impact of nonpoint source pollution. Ann Arbor Science, Mich.

Sabae, S. Z. and Rabeh, S. A. (2007) Evaluation of the microbial quality of the river Nile waters at Damietta branch, Egypt. *Egyptian Journal Aquatic Research* **33** (1): 301-311.

Sallam, A. M., Khaled, A. Sh. and Mona, M. S. (2008) Effect of irrigation water sources on productivity and grain quality of wheat. *Third Environment Conference, Faculty of Scince, Zagazig Univ.*, 59-75.

Santamaria, J. and Toranzos, G. (2003) Enteric pathogens and soil: a short review. Int Microbiol **6**: 5–9.

Santiago-Mercado, J. and Hazen, TC. (1987) Comparison of four membrane filter methods for fecal coliform enumeration in tropical waters. *Appl. Environ. Microbiol.* **53**: 2922–2928.

Shaban, K.A. (2005) Effect of Irrigation Water Resources on Properties and Productivity of Salt Affected Soil. *Ph. D. Thesis*, Fac. of Agric., Minufiya Univ., Egypt.

Shaban, K.A. (1998) Studies on Pollution of Some Cultivated Soils. *M.Sc. Thesis*, Fac. of Agric., Zagazig Univ., Egypt.

Soltanpour, N. and Schwab, A.P. (1977) A new soil test for simultaneous extraction of macro and micronutrients in alkaline soils. *Commun. Soil Sci. Plant Anal.* **3**, 195.

Teunis, PFM, Takumi, K . and Shinagawa, K. (2004) Found that response for infection by Escherichia coli O157:H7 from outbreak data. *Risk Analysis* **24**: 401–407.

Townsend, S.A. (1992) The relationships between salmonellas and faecal indicator concentrations in two pools in the Australian wet/dry tropics. *J. Appl. Bacteriol.* **73**: 182-188.

WHO (World Health Organization) (1992) Our Plants, Our Health. Geneva, p. **133**.

Zein, F.I., Maani, Z. Abou Amou, El-leithy, A.A. and El-Shami, M.M. (2002) Effect of polluted irrigation water on some crops and their contents of heavy metals. *Wheat Egypt. J. Soil Sci.* **42** (1): 139- 159.

(*Received* 15/11/2008;
accepted 1 /12/ 2008)

التقييم الميكروبيولوجي و الكيميائي لبعض مصادر المياه في جنوب محافظة بورسعيد

محمد إبراهيم حجازى* و خالد عبده حسن شعبان**
*قسم الميكروبيولوجى – كلية الزراعة – جامعة الزقازيق – الزقازيق و **معهد بحوث الاراضى والمياه والبيئة – مركز البحوث الزراعية – الجيزة – مصر.

يتسبب النقص في مصادر المياه في جنوب محافظة بورسعيد إلى استخدام المزارعين لمياه مختلطة بالصرف الزراعي أو الصناعي أو الصحي. تم تقييم ستة منها من الناحية الميكروبيولوجية و الكيميائية. بدراسة العديد من المجموعات الميكروبية و التي شملت أعداد البكتريا الحية و الكولايفورم الكلية و الكولايفورم البرازية و الاستربتوكوكاى البرازية بالإضافة إلى السالمونيللا و الشيجيللا. أما التقديرات الكيميائية، فشملت الملوحة و الكاتيونات و الأيونات و العناصر الصغرى و الكبرى. وقد وجد مستوى مرتفع من الأعداد الميكروبية، حيث كان مصرف بحر البقر جنوب بورسعيد هو الأكثر تلوثا، يليه بحر البقر بالشرقية، ثم سهل الحسينية المختلط ببحر البقر، ثم سهل الحسينية، ثم ترعة السلام، ثم ترعة سرحان .

أوضحت مستويات الميكروبات الدالة على التلوث (الكولايفورم الكلية ، الكولايفورم البرازية، الاستربتوكوكاى البرازية) أن المصادر المائية ملوثة بدرجة واضحة وهذا الاستنتاج تم التحقق منة بوجود أعداد كبيرة من السالمونيللا والشيجيللا، والتي وصلت إلى ٥,٧ خلية / ١٠٠ مل في بحر البقر جنوب بورسعيد. كما أوضحت نسبة الكولايفورم البرازية إلى الاستربتوكوكاى البرازية أن التلوث يعتبر من مصدر أدمى، إلا في حالة ترعة سرحان وترعة السلام . هذا وأوضحت النتائج أن نسبة الملوحة كانت عند أعلى مستوياتها في بحر البقر جنوب بورسعيد، يليه بحر البقر بالشرقية، ثم سهل الحسينية المختلط ببحر البقر، ثم سهل الحسينية، ثم ترعة السلام، ثم ترعة سرحان. و فيما يختص بتركيزات العناصر الصغرى و الامونيا و النترات كانت مستوياتها أمنة على الرغم من التركيزات المرتفعة من الفوسفات والبوتاسيوم في مصرف سهل الحسينية، فإنها لم تتعد مثل تركيزات النيتروجين حدود المستوى الآمن ومن ثم يجب تبنى أساليب أكثر كفاءة لتخفيف مياه الصرف الزراعي قبل استخدامها في الري، و معالجة مياه الصرف الصحي و الصناعي، والمراقبة الجيدة لعدم اختلاطها بالمياه العذبة أن أم تكن معالجة، و ذلك ضمانا للتنمية المستدامة لثرواتنا الزراعية.