LEVELS OF SOME HEAVY METALS, NITRATE, SALINITY AND pH IN FAYOUM WATER RESOURCES

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ABSTRACT

Objective of the present work was to study the levels of some heavy metals (Cd, Ni, Pb), NO_3, salinity and pH values in all water resources of Fayoum Governorate.

Fifty water samples were collected to cover all water resources at Fayoum Governorate (Bahr Yousef, canals water before and after mixing with drainage water, drains water, Qaroun Lake, Wady El-Rayan Lake and tap water.

Data obtained indicated that the concentrations of Cd in all irrigation and drainage waters of Fayoum Governorate exceeded the maximum permissible limits, however Pb concentrations were generally below the maximum allowable limits listed by FAO (1985), National Academy of Science (1972), and Australian Guidelines for irrigation water. The mean values of Ni concentrations in all irrigation, drainage and lakes waters exceeded the maximum permissible limits only in summer (August, 2005), however they were below this critical limit (0.2 mg/l) in winter (December, 2004). pH values of irrigation and drainage waters generally exceeded the normal range recommended by FAO (> 8) in winter and summer seasons. The general means of EC values were 0.49 in tap water, 0.85 in canals Nile water, 1.21 in mixed Nile with drainage water, 1.62 in drains water, 1.55 in Wady El-Rayan Lake and 32.53 dS/m in Qaroun Lake. According to irrigation water salinity guidelines of **FAO (1985)**, Fayoum canals water (mixed or nonmixed with drainage water) as well as Wady El-Rayan lake water are considered of slight to moderate restrictions and their use in irrigation is expected to cause increasing problems with time. Nitrate concentrations in all water resources of Fayoum Governorate including lakes were below the maximum permissible limit listed by FAO for irrigation water. It was generally found that the mean concentrations of Cd, Ni, Pb and pH for all Fayoum water resources were greater in summer (August 2005) in comparison with winter (December 2004).

Concentrations of Ni in Fayoum city tap water were slightly greater, whilst Cd and Pb concentrations greatly exceeded the maximum permissible limits recommended by WHO (2006) for drinking water.

Results of the present investigation emphasizes the necessity of accurate long-term monitoring for heavy metals and salinity in all water resources of Fayoum Governorate. More serious precautions and plans should be started in

order to face the increasing problems of water salinity and contamination with heavy metals.

INTRODUCTION

Wide areas of agricultural lands at Fayoum Governorate are irrigated with mixed Nile with drainage waters through several mixing stations distributed allover the governorate. The concentrations of heavy metals, nitrate and total soluble salts in such mixed water depends mainly on the ratio and efficiency of mixing. Accumulation of heavy metals and salts in soils is expected to increase with time due to the use of low quality water in irrigation.

Detailed long-term monitoring of heavy metals concentrations and total soluble salts is the only way to distinguish between noncontaminated, contaminated and polluted soils and water resources.

Cadmium enters the environment through a variety of industrial operations, it is an impurity found in zinc by-products from mining, smelting, electroplating, pigment, and plasticizer production. Cadmium emissions come from fossil fuel use. Cadmium makes its way into the water supplies as a result of deterioration of galvanized plumbing, industrial waste or fertilizer contamination. The US EPA Primary Drinking Water Standards lists Cadmium with a 0.005 mg/l (Maximum Contaminated Limit) MCL **(EPA, 2003)**. Cadmium may also enter aquatic systems through weathering and erosion of soils and bedrock, atmospheric deposition direct discharge from industrial operations, leakage from landfalls and contaminated sites, and the dispersive use of sludge and fertilizers in agriculture. Much of the cadmium entering fresh waters from industrial sources may be rapidly adsorbed by particulate matter, and thus sediment may be a significant sink for cadmium emitted to the aquatic environment **(WHO, 1992)**.

Nickel (Ni^{+2}) exists in approximately 85% of the water supplies, and is usually around 1 ppb. The US EPA has classified nickel as a possible human carcinogen based on inhalation exposure. Nickel has not been shown to be carcinogenic via oral exposure. No MCLG (maximum contamination level goal) has been proposed. **(EPA, 2003)**.

Lead (Pb^{+2}) found in fresh water usually indicates contamination from metallurgical wastes or from lead-containing industrial poisons. Lead in drinking water comes primarily from the corrosion of the lead solder used to put together the copper piping. Lead in the body can cause serious damage to the brain, kidneys, nervous system, and red blood cells. The US EPA considers lead to be a highly toxic metal and a major health threat. The current level of lead allowable in drinking water is 0.05 mg/l **(EPA, 2003)**.

According to the **standards of FAO (Ayers and Westcott,1989) and The National Academy of Science (Pratt,1972)** recommended maximum concentrations of Cadmium, Nickel and Lead in wastewater for agriculture use are 0.01, 0.20 and 5.0 mg L^{-1} respectively.

The permissible limits of Cd, Ni and Pb in human drinking water as recommended by **WHO (2006)** should not exceed 0.01, 0.07 and 0.01 mg L^{-1} respectively.

Because of the toxicity of nitrate to both plants, humans and animals, FAO, WHO and other attributes allover the world recommended critical limits for NO_3 concentrations in both irrigation and drinking waters.Permissible limits of nitrate in irrigation water ranges between 5to 30mg/l **(FAO, 1985)**. **Trodore (1994)** reported that the permissible concentration of Nitrate in drinking water supplies in New Jersey is 10 mg NO_3 L^{-1}.

According to **WHO (2006) the** maximum Contaminant Level (MCL) of Nitrate (as Nitrogen) that is allowed in drinking water is 10ppm.

According to United States Public Health Service **(USPHS, 1996)** the permissible limit of nitrate in drinking water for livestock and poultry is 45 ppm. **Donald and Charles, (2001)** reported that the permissible limit of nitrate in drinking water for livestock and poultry is 10 ppm.

2-MATERIALS AND METHODS

Fifty water samples were collected to examine the quality of water resources of Fayoum Governorate in winter and summer seasons. Water resources included: canals Nile water (14 samples), drains water (14 samples), canals Nile water mixed with drainage water at six water mixing stations distributed allover the Governorate (12 samples), Qaroun lake(4 samples): 2 in the vicinity of the beach at Ellsan area and 2 at a distance of 100m from the beach, Wadi El-Rayan lake (4 samples): 2 were taken at the mouth of the lake (end of tunnel) and 2 at a distance of 100 m from the coast, in addition to 2 samples from Fayoum city tap water. Samples were collected in December, 2004 and August2005. Locations of the studied sites were recorded using a "GPS" as shown in (figure 1).

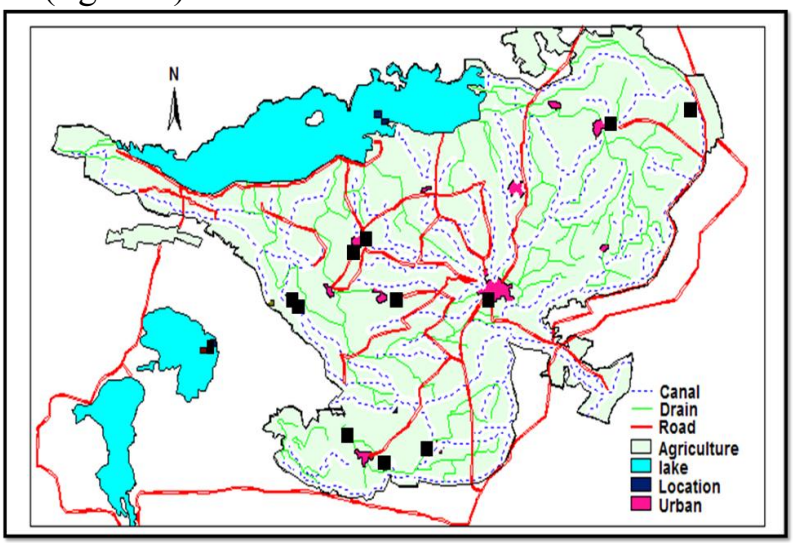

Fig. (1) Locations of collected water samples, Fayoum Governorate

Water samples were filtered through whatman filter paper No. 42 and stored in clean dry plastic bottles in a refrigerator. Two blank samples were prepared in two plastic bottles using redistilled water. Quality of water samples were identified through the determination of Cd, Ni, Pb,NO_3, EC and pH using the following methods:

Cadmium (Cd), Nickel (Ni) and Lead (Pb) concentrations were analyzed using atomic absorption spectrophotometer.

Nitrate (NO_3) was determined colorimetrically with Brucine (10, 11 dimethoxystrychnine $C_{23}H_{26}N_2O_4$) using a spectrophotometer according to **APHA-AWWA-WPCF, (1980)**.

Electrical Conductivity (EC) and pH were determined according to **U.S. Salinity Lab. Staff (1969).**

3. RESULTS AND DISCUSSION

3.1. Levels of Heavy Metals in Fayoum Water Resources.

3.1.1. Cadmium

Data presented in table 1 show the levels of cadmium in the different water resources of Fayoum Governorate in December, 2004 and August, 2005.

It could be observed from the obtained data the concentrations of Cd in agriculture irrigation water (canal mixed and non-mixed waters were generally greater in August (2005) than those of December (2004).

In order to assess the quality of the different water resources of Fayoum Governorate with respect to their Cd content, the recorded concentrations were compared with the maximum permissible limits recommended by several international organizations. **Alloway (1995)** reported that the maximum permissible Cd concentration in irrigation water as recommended by **FAO (1985)** are 0.01 mgL^{-1} under conditions of continuous use in soils of pH 6-8.5 and 0.005 mgL^{-1} for intermittent use in heavy soils. According to the European commission, Cd concentration in irrigation water should not exceed 0.005 mgL^{-1} **(Alloway, 1995)**. Australian guidelines contaminant concentrations of Cd as recommended by the National Water Quality Management Strategy Water Quality Criteria **(NWQMSWQC)** for agricultural short-term use (less than 20 years) is 0.05 mgL^{-1} and 0.01 mgL^{-1} for long-term use (not more than 100 years) **(McLaughlin *et al*. 2001)**. The maximum permissible limit recommended by the **National Academy of Science (1972)** is 0.01 mgL^{-1}. Data obtained (table 1) indicated that cadmium concentrations in irrigation, drainage, lakes waters and even in tap water of Fayoum are greater than the maximum permissible limits listed by all the above mentioned organizations. On basis of these findings, it could be concluded that all water resources of Fayoum Governorate are considered contaminated with Cd.

It is worthy to mention in this respect that Cd concentration which is of health significance in human drinking water as recommended by **WHO, (2006)** is 0.003 mg L^{-1} and should not exceed 0.01 mg L^{-1}. Data illustrated in table (1) showed that Cd concentration in tap water of Fayoum city is 0.06 mg L^{-1} during all (winter and summer).

Table 1. Cadmium concentrations in water resources of Fayoum Governorate.

Water resource	Name	Location	Cd Concentration mg/liter		General mean
			Dec. (2004)	August (2005)	
Canals (Nile water before mixing with drainage water)	Bahr Ehreet	Ehreet	0.050	0.070	
	Bahr El-Nazla	Elhamoly	0.090	0.100	
	Bahr El-Nazla	Etsa	0.100	0.080	
	Bahr El-Banat	Iz. Elwady	0.040	0.120	
	Bahr El-Bashawat	Menshat Abd Elmagid	0.020	0.130	
	Bahr El-Gharak	El-Gharak	0.070	0.140	
	Bahr Wahby	Tamia	0.020	0.180	
	Mean		0.056	0.120	0.088
Canals (Nile water mixed with drainage water)	Bahr El-Nazla	Elhamoly	0.060	0.080	
	Bahr El-Nazla	Etsa	0.080	0.110	
	Bahr El-Banat	Iz. Elwady	0.040	0.130	
	Bahr El-Bashawat	Menshat Abd El-Magid	0.090	0.140	
	Bahr El-Gharak	Elgharak	0.040	0.150	
	Bahr Wahby	Tamia	0.200	0.180	
	Mean		0.085	0.130	0.110
Drainage water	Abo Denkash Drain	Ehreet	0.030	0.060	
	Open Canal Drain	Elhamoly	0.090	0.080	
	Open Canal Drain	Iz. Elwady	0.090	0.100	
	El-Tagen Drain	Etsa	0.090	0.120	
	El-Gharak Drain	Menshat Abd Elmagid	0.050	0.130	
	Zefita Drain	Elgharak	0.060	0.140	
	El-Bats Drain	Tamia	0.070	0.170	
	Mean		0.070	0.110	0.090
Lakes water	Qaroun Lake	Near coast (at Ellsan)	0.110	0.210	
		100m from coast	0.140	0.220	
	Mean		0.215	0.215	0.170
	Wadi El-Rayan Lake	Near coast (End Of tunnel)	0.070	0.110	
		100m from coast	0.090	0.120	
	Mean		0.080	0.120	0.100
Tap water			0.060	0.060	0.060

3.1.2. Nickel (Ni).

Data given in table 2 show the concentrations of Ni in the studied water resources of Fayoum Governorate.

Table 2. Nickel concentrations in water resources of Fayoum Governorate.

Water resource	Name	Location	Ni Concentration mg/liter		General mean
			Dec. (2004)	August (2005)	
Canals (Nile water before mixing with drainage water)	Bahr Ehreet	Ehreet	0.150	0.561	
	Bahr El-Nazla	Elhamoly	0.150	0.650	
	Bahr El-Nazla	Etsa	0.100	0.770	
	Bahr El-Banat	Iz. Elwady	0.150	0.380	
	Bahr El-Bashawat	Menshat abd El-Magid	0.160	0.690	
	Bahr El-Gharak	Elgharak	0.040	0.730	
	Bahr Wahby	Tamia	0.230	0.330	
	Mean		0.140	0.587	0.364
Canals (Nile water mixed with drainage water)	Bahr El-Nazla	Elhamoly	0.120	0.780	
	Bahr El-Nazla	Etsa	0.130	0.610	
	Bahr El-Banat	Iz. Elwady	0.150	0.770	
	Bahr El-Bashawat	Menshat Abd Elmagid	0.170	0.320	
	Bahr El-Gharak	Elgharak	0.190	0.330	
	Bahr Wahby	Tamia	0.120	0.690	
	Mean		0.147	0.583	0.365
Drainage water	Abo Denkash Drain	Ehreet	0.200	0.720	
	Open Canal Drain	Elhamoly	0.090	0.590	
	Open Canal Drain	Iz. Elwady	0.130	0.770	
	El-Tagen Drain	Etsa	0.180	0.620	
	El-Gharak Drain	Menshat abd El-Magid	0.270	0.790	
	Zefita Drain	Elgharak	0.190	0.770	
	El-Bats Drain	Tamia	0.170	0.660	
	Mean		0.176	0.703	0.439
Lakes water	Qaroun Lake	Near coast (at Ellsan)	0.600	0.590	
		100m from coast	0.630	0.780	
	Mean		0.615	0.685	0.650
	Wady El-Rayan Lake	Near coast (End of tunnel)	0.160	0.770	
		100m from coast	0.140	0.480	
	Mean		0.150	0.625	0.388
Tap water			0.080	0.080	0.080

The general mean values of Ni concentrations in water resources of Fayoum Governorate Showed the following order: Qaroun lake> drainage water> Wady El-Rayan lake> canals mixed water > canals non mixed water> tap water. The concentrations of Ni in agriculture irrigation waters (canals mixed and nonmixed water were generally greater in August (2005) than December (2004).

Recorded Ni concentrations in the different water resources were compared with the maximum permissible limits recommended by international organizations. **Alloway (1995)** reported that the maximum permissible limit of Ni concentration in irrigation water as recommended by **National Academy of Science (1972)** and **FAO (1985)** is 0.2 mgL^{-1}. Australian guidelines contaminant concentrations of Ni in irrigation water are 2.0 mgL^{-1} for short-term use (20 years) and 0.2 mg L^{-1} for long-term (100 years) use **(McLaughlin *et al*. 2001)**.

Data obtained (table 2) indicated that nickel concentrations in all irrigation waters of Fayoum Governorate in August exceeded the allowable limits of Ni listed by the above mentioned organizations. Nickel concentrations in winter (December, 2004) were almost below the critical limits in mixed and non-mixed water. The mean concentration of Ni in Qaroun lake(0.650ppm) was about twice that of wady El-Rayan lake (0.388ppm).

Data presented in table 2 also show that Ni concentration in Fayoum tap water was 0.08 mg L^{-1} in both summer, and winter. According to World Health Organization "WHO" guidelines for human drinking water quality, Ni concentration should not exceed 0.07 mgL^{-1}**(WHO, 2006)**. Drinking water recommended limit for livestock is 1.0 mgL^{-1} **(University of Arkansas, Cooperative Extension, 1987).**

3.1.3. Lead (Pb).

Data illustrated in table (3) show the values of recorded lead concentrations canals nonmixed and mixed water, drains, lakes and tap water.

The obtained lead concentrations were compared with the maximum permissible limits of Pb as recommended by several international organizations. The maximum permissible Pb concentrations in irrigation water as recommended by **FAO (1985)** are 5.0 mgL^{-1} for continuous irrigation and 10 mgL^{-1} under intermittent irrigation **(Alloway, 1995)**. Critical limit of Pb listed by **National Academy of Science (1972)** is 5.0 mgL^{-1}. **McLaughlin *et al*. (2001)** reported that recommended Australian limits of Pb in irrigation water are 5.0 mgL^{-1} for short-term use (20 years) and 2.0 mgL^{-1} for long-term use (100 years).

The concentrations of Pb in all water resources of Fayoum Governorate including lakes are below the maximum critical levels listed by the above mentioned organizations for irrigation water.

The obtained results (table 3) also show that Pb concentrations in Fayoum tap water was 0.12 mgL^{-1} in winter and summer water samples. According to **"WHO"** guidelines **(2006)** for human drinking water Pb concentration should not exceed 0.01 mgL^{-1}.

Recommended limit, of Pb concentration for livestock and paultry drinking water is 0.05 mgL^{-1} **(US Public Health Service, 1996) and University of Missouri Extension Guidelines (2001).** Recommended limit for beef cattle is 0.1 mg/l **(University of Arkansas, Cooperative Extension Service (1987)**.

Table 3. Lead concentrations in water resources of Fayoum Governorate.

Water resource	Name	Location	Pb Concentration mg/liter		General mean
			Dec. (2004)	August (2005)	
	Mean		1.190	1.190	
Canals (Nile water before mixing with drainage water)	Bahr Ehreet	Ehreet	0.400	0.350	
	Bahr El-Nazla	Elhamoly	0.330	0.720	
	Bahr El-Nazla	Etsa	0.810	0.73	
	Bahr El-Banat	Iz. Elwady	0.63	0.880	
	Bahr El-Bashawat	Menshat Abd Elmagid	0.540	1.190	
	Bahr El-Gharak	Elgharak	0.770	1.160	
	Bahr Wahby	Tamia	0.540	1.120	
	Mean		0.574	0.878	0.726
Canals (Nile water mixed with drainage water)	Bahr El-Nazla	Elhamoly	0.860	0.580	
	Bahr El-Nazla	Etsa	0.480	0.590	
	Bahr El-Banat	Iz. Elwady	0.690	1.060	
	Bahr El-Bashawat	Menshat Abd Elmagid	0.320	0.970	
	Bahr El-Gharak	Elgharak	0.590	0.260	
	Bahr Wahby	Tamia	0.750	1.200	
	Mean		0.615	0.777	0.696
Drainage water	Abo Denkash Drain	Ehreet	0.740	0.770	
	Open Canal Drain	Elhamoly	0.450	0.670	
	Open Canal Drain	Iz. Elwady	0.710	0.270	
	El-Tagen Drain	Etsa	0.450	1.020	
	El-Gharak Drain	Menshat Abd Elmagid	0.840	1.220	
	Zefita Drain	Elgharak	0.820	1.330	
	El-Bats Drain	Tamia	0.260	1.220	
	Mean		0.610	0.929	0.769
Lakes water	Qaroun Lake	Near coast (at Ellsan)	1.130	1.790	
		100m from coast	0.950	1.820	
	Mean		1.040	1.805	1.423
	Wady El-Rayan Lake	Near coast (End of tunnel)	0.840	0.940	
		100m from coast	0.490	0.500	
	Mean		0.665	0.720	0.693
Tap water			0.120	0.120	0.120

3.2. Nitrate Concentrations in Fayoum Water Resources.

Data presented in table (4) show that nitrate concentrations in canals water in December, 2004 (Winter Season) ranged between 0.04 and 0.31 with an average value of 0.18 mg NO_3-N L^{-1}. In August, 2005 (Summer Season) nitrate contents ranged between 0.09 and 0.22 with an average of 0.17 mg NO_3-N L^{-1}.

Concentrations of nitrate in canals water after mixing with drainage water in December 2004 (Winter Season) ranged between 0.18 and 0.59 with the average of 0.31 mg NO_3-N L^{-1}. In August 2005 nitrate contents ranged between 0.09 and 0.18 with an average of 0.14 mg NO_3-N L^{-1}.

Nitrate contents in drainage waters in December 2004 ranged between 0.09 and 0.46 with the average of 0.32 mg NO_3-N L^{-1}. In August 2005 nitrate concentrations ranged between 0.04 and 0.22 with an average of 0.15 mg NO_3-N L^{-1}. Data in table 4 also indicated that nitrate concentrations were generally greater in water of Wady El-Rayan lake than Qaroun lake in both summer and winter seasons. Levels of NO_3-N in all water resources of Fayoum Governorate were below the maximum permissible limit of irrigation water recommended by **FAO (1985), National Academy of Scince (1972)** and Australian guidelines **(Mclaughlin *et al.*,2001)**. The concentrations of NO_3-N in Fayoum tap water was below the maximum permissible limit of WHO for human drinking water.

Table 4. Nitrate Concentrations in the different water resources of Fayoum Governorate

Water resource	Name	Location	(Dec. (2004)	August (2005)	General mean
			NO_3-N (mg/L)		
Canals (Nile water before mixing with drainage water)	Bahr Ehreet	Ehreet	0.19	0.18	
	Bahr El-Nazla	Elhamoly	0.19	0.22	
	Bahr El-Nazla	Etsa	0.04	0.09	
	Bahr El-Banat	Iz. Elwady	0.20	0.18	
	Bahr El-Bashawat	Menshat Abd Elmagid	0.31	0.18	
	Bahr El-Gharak	Elgharak	0.23	0.13	
	Bahr Wahby	Tamia	0.12	0.18	
	Mean		0.18	0.17	0.17
Canals (Nile water mixed with drainage water)	Bahr El-Nazla	Elhamoly	0.19	0.18	
	Bahr El-Nazla	Etsa	0.28	0.13	
	Bahr El-Banat	Iz. Elwady	0.36	0.09	
	Bahr El-Bashawat	Menshat Abd Elmagid	0.18	0.18	
	Bahr El-Gharak	ElGharak	0.25	0.13	
	Bahr Wahby	Tamia	0.59	0.13	
	Mean		0.31	0.14	0.22
Drainage water	Abo Denkash Drain	Ehreet	0.09	0.04	
	Open Canal Drain	Elhamoly	0.32	0.13	
	Open Canal Drain	Iz. Elwady	0.46	0.13	
	El-Tagen Drain	Etsa	0.36	0.22	
	El-Gharak Drain	Menshat Abd Elmagid	0.30	0.09	
	Zefita Drain	Elgharak	0.26	0.13	
	El-Bats Drain	Tamia	0.46	0.22	
	Mean		0.32	0.14	0.23
Lakes water	Qaroun Lake	Near coast (at Ellsan)	0.09	0.09	
		100m from coast	0.19	0.18	
	Mean		0.14	0.14	0.14
	Wady El-Rayan Lake	Near coast (End Of tunnel)	0.37	0.27	
		100m from coast	0.09	0.13	
	Mean		0.23	0.20	0.22
Tap water			0.22	0.22	0.22

3.3. Water Salinity.

Data of water salinity as expressed in terms of electrical conductivity values are given in table 5.

EC values of nonmixed canals water in December 2004 (Winter Season) ranged between 0.68 (Bahr El-Gharak at El-Gharak) and 1.84 (Bahr El-Nazla at El-Hamouly) with an average of 0.92 dS/m, however in August 2005 (Summer Season) EC values ranged between 0.53 (Bahr Wahby at Tamia) and 1.24 (Bahr El-Bashawat at Manshat Abd Elmagid).

Table 5. Electrical conductivity of water resources of Fayoum Governorate

Water resource	Name	Location	Dec. (2004)	August (2005)	General mean
			EC (dS/m)		
Canals (Nile water before mixing with drainage water)	Bahr Ehreet	Ehreet	0.79	0.59	
	Bahr El-Nazla	Elhamoly	1.84	0.77	
	Bahr El-Nazla	Etsa	0.74	0.99	
	Bahr El-Banat	Iz. Elwady	0.86	0.54	
	Bahr El-Bashawat	Menshat Abd Elmagid	0.82	1.24	
	Bahr El-Gharak	El-Gharak	0.68	0.78	
	Bahr Wahby	Tamia	0.69	0.53	
	Mean		0.92	0.78	0.85
Canals (Nile water mixed with drainage water)	Bahr El-Nazla	Elhamoly	1.60	1.29	
	Bahr El-Nazla	Etsa	0.94	1.11	
	Bahr El-Banat	Iz. Elwady	1.01	0.95	
	Bahr El-Bashawat	Menshat Abd Elmagid	2.06	0.99	
	Bahr El-Gharak	El-Gharak	0.72	1.18	
	Bahr Wahby	Tamia	1.02	1.59	
	Mean		1.23	1.01	1.12
Drainage water	Abo Denkash Drain	Ehreet	1.50	1.96	
	Open Canal Drain	Elhamoly	1.38	1.45	
	Open Canal Drain	Iz. Elwady	1.31	1.39	
	El-Tagen Drain	Etsa	1.18	1.23	
	El-Gharak Drain	Menshat Abd El-magid	2.21	2.71	
	Zefita Drain	El-Gharak	0.97	1.78	
	El-Bats Drain	Tamia	1.64	2.01	
	Mean		1.47	1.78	1.62
Lakes water	Qaroun Lake	Near coast (at Ellsan)	29.40	35.40	
		100m from coast	29.70	35.60	
	Mean		29.55	35.5	32.53
	Wady El-Rayan Lake	Near coast (End of tunnel)	1.39	1.47	
		100m from coast	1.35	1.98	
	Mean		1.37	1.72	1.55
Tap water			0.49	0.49	0.49

Data also showed that EC values of Nile canals water mixed with drainage water in December 2004 (Winter Season) ranged between 0.72 (Bahr El-Gharak canal at El-Gharak) and 2.06 (Bahr El-Bashawat at Manshat Abd Elmagid) with an average of 1.23 dS/m. In August 2005 (Summer Season) EC

values ranged between 0.95 (Bahr El-Gharak at El-Gharak) and 1.59 (Bahr Wahby canal at Tamia) with an average of 1.18 dS/m.

The general EC mean values of canals water before and after mixing with drainage water were 0.85 and 1.12 dS/m respectively. The mean EC values of Wady El-Rayan lake water was 1.55 dS/m. According to FAO guidelines irrigation waters that have 0.7-3.0 dS/m are considered of slight to moderate restriction for use in agriculture and their use in irrigation will cause increasing problems.

EC values of drainage waters in December 2004 (Winter Season) ranged between 0.97 (Zefita drain at El-Gharak) and 2.21 (El-Gharak drain at menshat abd El-magid) with the average of 1.46 dS/m. In August 2005 (Summer Season) EC values ranged between 1.23 (El-Tagen drain at Etsa) and 2.71 (El-Gharak drain at menshat abd El-magid) with an average of 1.77 dS/m.

The mean values of EC in Qaroun lake were 29.55 in winter and 35.5 dS/m in summer. Corresponding values for Wady El-Rayan lake were 1.37 and 1.72 dS/m respectively.

It could be observed from data that the general EC mean values of canals water either mixed or nonmixed with drains water were greater in winter than in summer, however the opposite was found with drains and lakes water. This could be attributed to the renewal of canal in the flooding season (August) and the greater evaporation from drains and the closed lakes waters in summer

3.4. Water pH.

Results illustrated in table (6) show that the pH values of canals (nonmixed Nile water) in December 2004 ranged between 8.09 (Bahr El-Bashwat at menshat abd El-magid) and 8.46 (Bahr El-Nazla at El-Hamouly) with an overall average of 8.27. In August 2005 pH values ranged between 8.38 (Bahr El-Ghark at El-Ghark) and 8.98 (Bahr El-Nazla at Etsa) with an average of 8.65. The pH values of Bahr Yousef were 8.79 in both summer and winter, while they were 8.31 in Baher Yousef at Fayoum city, with a general mean value of 8.55.

These results indicate that water of Bahr Yousef at Lahoon is more alkaline than both those of Bahr Yousef at Fayoum city and those of other canals and drains. These findings could be due to the nearness of collected water samples from houses, roads, anthropogenic activities at the studied sites in Bahr Yousef.

Data also showed that the pH values of canals water mixed with drainage water in December 2004 ranged between 8.06 (Bahr Wahby at Tamia) and 8.34 (Bahr El-Nazla at El-Hamouly) with an average of 8.22. In August 2005 pH values ranged between 8.48 (Bahr El-Nazla at Etsa) and 8.67 (Bahr El-Ghark at El-Ghark) with an average value of 8.59. pH values of drains waters in December 2004 ranged between 7.93 (El-Bats drain at Tamia) and 8.30 (Open canal drain at Iz. El-wady) with an overall average of 8.14. In August 2005 pH

Table 6. pH values of water resources of Fayoum Governorate

Water resource	Name	Location	(Dec. (2004)	August (2005)	General mean
Canals (Nile water before mixing with drainage water)	Bahr Ehreet	Ehreet	8.28	8.72	
	Bahr El-Nazla	Elhamoly	8.46	8.72	
	Bahr El-Nazla	Etsa	8.12	8.98	
	Bahr El-Banat	Iz. Elwady	8.28	8.77	
	Bahr El-Bashawat	Menshat abd El-magid	8.09	8.54	
	Bahr El-Gharak	El-Gharak	8.32	8.38	
	Bahr Wahby	Tamia	8.34	8.46	
	Mean		8.27	8.65	8.46
Canals (Nile water mixed with drainage water)	Bahr El-Nazla	Elhamoly	8.34	8.50	
	Bahr El-Nazla	Etsa	8.24	8.48	
	Bahr El-Banat	Iz. Elwady	8.30	8.63	
	Bahr El-Bashawat	Menshat Abd Elmagid	8.21	8.64	
	Bahr El-Gharak	El-Gharak	8.14	8.67	
	Bahr Wahby	Tamia	8.06	8.64	
	Mean		8.22	8.59	8.41
Drainage water	Abo Denkash Drain	Ehreet	7.95	8.85	
	Open Canal Drain	Elhamoly	8.13	8.64	
	Open Canal Drain	Iz. Elwady	8.30	8.59	
	El-Tagen Drain	Etsa	8.24	8.77	
	El-Gharak Drain	Menshat Abd Elmagid	8.25	8.59	
	Zefita Drain	El-Gharak	8.21	8.76	
	El-Bats Drain	Tamia	7.93	8.77	
	Mean		8.14	8.71	8.43
Lakes water	Qaroun Lake	Near coast (at Ellsan)	8.08	8.29	
		100m from coast	8.00	8.38	
	Mean		8.04	8.34	8.19
	Wady El-Rayan Lake	Near coast (End of tunnel)	8.31	8.38	
		100m from coast	8.24	8.76	
	Mean		8.28	8.57	8.41
Tap water			7.89	7.89	7.89

values ranged between 8.59 (El-Gharak drain at menshat abd El-magid) and 8.85 (Abo Denkash drain at Ehreet) with an average of 8.71. Qaroun Lake water pH values in December 2004 ranged between 8.00 (Qaroun Lake at a distance of 100 m from coast) and 8.08 near coast (at El-lsan) with the average value 8.04. In August 2005 pH values were greater and ranged from 8.29 near coast (at El-lsan) to 8.38 at a distance of 100m from coast) with a mean of 8.34. pH values of Wady El-Rayan lake water in December 2004 ranged between 8.24 at a distance of 100m from coast and 8.31 near coast with the average 8.28. In August 2005 pH values ranged from 8.38 near coast to 8.76 at a distance of 100m from coast with an average value of 8.57. it is clear from data that Qaroun

lake water had the lowest ph values among all other Fayoum water resources. This could be due to the fact that Qaroun lake water contains more greater amounts of natural salts.

The normal range of pH values in irrigation water as recommended by FAO (1985) is 6.5-8 **(Alloway, 1995)**.

The pH values of irrigation waters of Fayoum Governorate exceeded the maximum limit of normal pH range in both winter and summer seasons.

It could be concluded from the obtained results that canals water, canals water after mixing with drainage water, drainage and lakes water of Fayoum Governorate are contaminated with cadmium. Nickel concentrations in all these resources exceeded the maximum permissible limit only in summer, however they were within the permissible range in winter. pH values of all irrigation waters exceeded the normal range in both winter and summer seasons. According to FAO guidelines (1985), canals water before and after mixing with drainage water are considered of slight to moderate restriction for use in irrigation with respect to their salinity. The levels of Cd, Ni and pH were generally greater in summer in comparison with winter. Lead and nitrate concentrations were generally below the maximum permissible limits for Agriculture irrigation. Concentrations of Ni in Fayoum city tap water in both summer and winter were slightly greater whilst Cd and Pb greatly exceeded the maximum permissible limits recommended by **WHO (2006).** Results of the present investigation emphasizes the necessity of accurate long term monitoring for heavy metals and salinity in Fayoum water resources. More serious precautions and solutions should be started in order to face the increasing problems of water salinity and contamination with heavy metals.

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الملخص العربي

أجريت هذه الدراسة بغرض تقدير درجة جودة مصادر المياه المختلفة في محافظة الفيوم، على أساس محتواها من عناصر الكادميوم والنيكل والرصاص والنترات وتركيز الأملاح والرقم الهيدروجيني pH لها، ولتحقيق هذا الهدف جُمِعت ٢٧ عينة مياه لتَمْثل مصادرِ المياه المختلفةِ في محافظةِ الفيوم كالتّالي:

٢١ عينةِ تَمْثل: (ترع ماء الري النيلي (٧ عيناتِ)، مياه الصرف الزراعي (٧ عيناتِ) ومياه النيلِ المخَلوطةَ بمياهِ الصرفِ بعد خلطها في ٧ محطاتَ لخلط المياه)، وأخذت عينتان مِنْ بحر يوسف: الأولى عند المصب في اللاهون والثانية عند مدينةِ الفيوم بجوار قصرِ الثقافةَ، كما أخذت عينتان مِنْ بحيرةِ قارون: الأولى بجوارِ الشاطئِ في منطقةِ اللسان والثانية على مسافةِ ١٠٠ متر مِنْ الشاطئِ في نفس المنطقة ، كذلك تم أخذ عينتين مِنْ بحيراتِ وادي الريان: الأولى بجوار الشاطئ بعد مصبِ مصرف الوادي مباشرة في البحيرة والثانية على مسافةِ ١٠٠ متر مِنْ الشاطئِ، هذا بالإضافة إلى عيّنة واحدة مِنْ مياه الشرب بمدينة الفيوم.

جُمِعتْ عينات المياه خلال فصلين هما: فصل **الشتاءِ** (ديسمبر/ ٢٠٠٤) وفصل **الصيفِ** (أغسطس ٢٠٠٥).

وقد بينت نتائج هذه الدراسة ما يلي: تَجاوز تركيز الكادميوم في كُلّ من مياهِ الرَيَّ المخلوطة وغير المخلوطة بمياه الصرفَ في محافظةِ الفيوم الحدودَ القصوى المسموح بها في مياه الري، كذلك تجاوز تركيز النيكل الحد المسموح به في مياه الري فقط في فصل الصيف (أغسطس ٢٠٠٥)، أما تركيز الرصاص فكان بشكل عام أقل من الحدِّ الأقصى المسموح به الذي حددته منظمة الأغذية والزراعة "FAO" (١٩٨٥)، وأكاديمية العِلْوم الوطنية (١٩٧٢) والمعايير الاسترالية لمياه الري، وكان متوسط تركيزات الكادميوم والنيكل والرصاص والرقم الهيدروجيني "pH" في كل مصادر المياه بمحافظةِ الفيوم أعلى في فصل الصيفِ (أغسطس) عنها في فصل الشتاءِ (ديسمبر).

وقد وجد ان تركيز النتراتِ في كُلّ مصادرِ مياه محافظةِ الفيوم كَانتْ أقل من الحدودِ الحرجةِ القصوى التي أوصتْ بها منظمة الأغذية والزراعة "FAO" (١٩٨٥) في مياه الري.

وقد تبين أن المتوسط العام لقِيَمِ الرقم الهيدروجيني "pH" (متوسط عيناتِ الصيف والشتاءِ) في مياهِ الترع غيرِ المُخْلوَطةِ والمُخْلوَطةِ بمياهِ الصرفِ وفي مياه بحيره وادي الريان تَجاوزت الحدَّ الأعلى للمدى الموصّى بهِ لمياهِ الرَيِّ من قبل منظمة الأغذية والزراعة "FAO" (١٩٨٥)، وقد وجد أن المتوسط العامّ لقِيَمِ التوصيل الكهربي "EC" ٠,٤٣ في مياه بحر يوسف، ٠,٨٥ في مياهِ الترع الغير مخلوطة، ١,٢١ في مياه الترع المخَلوطَة بمياه الصرفِ ١,٦١ في مياه المصارف، ١,٥٥ في بحيرة وادي الريان و٣٢,٥٣ ديسيسيمنز/متر في مياهِ بحيرةِ قارون.

وطبقا لمعايير منظمة الأغذية والزراعة (١٩٨٥) فإن تركيز الأملاح بمياه الترع في الفيوم قبل وبعد خلطها بمياه الصرف وفي مياه بحيرة وادي الريان يقع في المدى الذي يسبب مشاكل متزايدة حيث تزداد مشاكل استخدامه في الري كلما زادت قيمة توصيله الكهربي عن ٠,٧ ديسيسمنز/متر

وبينت هذه اتلدراسة أيضا أن محتوى مياه الشرب في مدينة الفيوم (ماء الصنبور) من عنصر النيكل يزيد قليلا عن الحد المسموح به، أما تركيز عنصري الكادميوم والرصاص فتزيد كثيرا عن الحدود المسموح بها طبقا لمعايير منظمة الصحة العالمية (WHO, 2006).

وقد أكدت نتائج هذه الدراسة ضرورة إجراء تحليلات دورية دقيقة على المدى البعيد لمحتوى مصادر المياه من العناصر الثقيلة والأملاح الكلية الذائبة وضرورة إجراء المزيد من البحوث وتنفيذ الخطط اللازمة لمواجهة مخاطر تلوث مياه الري والشرب في الفيوم.