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STUDIES ON THE EFFECT OF DRAIN EFFLUENTS ON THE WATER QUALITY OF LAKE MANZALA, EGYPT.

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ABSTRACT

The water quality of Lake Manzala was studied seasonally during the period from autumn 2000 to summer 2001. The results of physical parameters revealed that the values of transparency at the southern region are relatively low and reflect the type of effluents, characterized by high amounts of floating materials, which decrease the water transparency. Moreover, the electrical conductivity at these stations were somewhat high as a result of sewage and industrial wastes at that region. On the other hand, the chemical analysis of water showed high values of chemical oxygen demand (COD) and biological oxygen demand (BOD) but low levels of dissolved oxygen (DO) especially at the southern region opposite to Hadous and Bahr El-Baqar drains, in addition to high levels of trace metals.

INTRODUCTION

Lake Manzala lies at the south-eastern Mediterranean coastal region between Damietta branch to the west and Suez Canal to the east (long 31^{0} 45̀, 32̀ 15̀ E lat 31^{0} 00̀, 31^{0} 00̀, 31^{0}35 N). About 7500 million m^3 of untreated waste water are currently coming from five governorates namely: Port Said, Ismaliya, Dakhliyia, Sharkiya and Damietta, besides seven drains (Abdel-Baky *et al.* 1998; Samir 2000).

Lake Manzala is the most important among all Egyptian Lakes, since it produces about 10 % of the total fish yield in Egypt (Mohamed, 2001). El-Enany (2004) studied the ecological and biological characteristics of Lake Manzala with special reference to its water quality and sediment productivity. He reported that the lake is subjected to continuous steady flow of pollutants through numerous drains that discharge heavy load of organic and inorganic pollutants.

Shakweer (2005) studied the chemistry of Lake Manzala and pointed out that most of chemical parameters are relatively high at the southern areas of the lake, near to the outlets of Bahr El-Baqar and Hadous drains.

Over the last few decades, the lake has undergone dramatic environmental changes (Zyadah, 1995; Shakweer, 2005). Therefore, the present study aimed to give an over view about the impacts of the southern drains effluents on the water quality condition of Lake Manzala.

MATERIALS AND METHODS

The water quality of Lake Manzala was studied during four successive seasons (from autumn 2000 to summer 2001). Eight stations were selected to cover the different regions of the investigation area (Fig. 1), which can be described in the following table.

No.	Station	Location at the lake
1	El-Zarka	At the north western part of the lake
2	Bahr El-Baqar	At the outlet of Bahr El-Baqar drain
3	Hadous – Ramsis outlet	At the outlet of Ramsis and Hadous drain
4	Bahr El-Bashtier	At the outlet of New Bahr El-Baqar drain
5	Bahr El-Genka	At the middle part of the lake
6	Bahr Legan	At the middle part of the lake
7	El-Materiya	At the middle-eastern part of the lake
8	Bahr El-Gamil	At the north-eastern part of the lake

Water samples were collected from sub-surface layer (average lake depth is about 140 cm) by using polyvinyl chloride Van Dorm bottle (1.5 Liter capacity).The water samples were kept in a well stoppered polyethylene plastic bottles until arrival to the laboratory. Temperature and transparency were determined at the field then analyses were undertaken for other physical and chemical parameters according to the standard methods described in APHA (1995).

For trace metals, the samples were acidified with conc. nitric acid (to a pH < 2) and digested by nitric-perchloric acid mixture. The total metal concentrations were determined by Atomic Absorption Spectrophetometer (Model Hitachi 170-30) with a graphite atomizer (GA-Z).

RESULTS AND DISCUSSION

Water temperature

Temperature is one of the most important parameters of water quality (EPA, 1976). Due to the shallowness of the lake and the effect of wind action, there was no sharp differences in the temperature at most stations (16 – 27 ^{0}C) and (20 – 30 ^{0}C) during cold seasons (autumn & winter) and hot seasons (spring & summer) respectively, and the increase or decrease in water temperature may be explained on the basis of climatic effects during the year round.

Transparency

The transparency values were very low at all stations (Table 1), except stations 1 and 8, since both contain less amounts of sewage and industrial wastes, while other stations are strongly affected with drain effluents at the southern region of the Lake.

Electrical Conductivity (EC)

The variations in water conductivity were relatively limited (Table 1), and characteristic for brackish water at most stations, except station 8, which has high EC value, that is related to the Sea-Lake connection through El-Gamil outlet (El-Enany, 2004).

pH

The pH value is a very important factor in the study of water chemistry (APHA 1995). The present work showed that most of the pH values at the lake are at the alkaline side (Table 1). The high recorded values during spring may be attributed to photosynthesis activity, which agrees with Ueda *et al.* (2000), while the lower in pH values recorded during summer could be explained on the basis of organic matter decomposition, which agrees with Fishar (1999).

Dissolved Oxygen (DO)

The values of DO fluctuated between 3.0 – 8.4 mg/l with limited seasonal and regional variation. The highest values were recorded during the cold period (autumn and winter), while the lowest values were observed during the hot period (spring and summer) as a result of temperature elevation (Cole, 1979; APHA, 1995). Generally, the values of DO at most stations were relatively low except stations 1 and 8, where both are far from the effect of drain effluents, which strongly affected the south-eastern region (stations 2 – 7). This is supported by the high values of COD at these stations during the year round (Table 3), which agreed with that obtained by Zyadah (1995).

Biological Oxygen Demand (BOD)

BOD measures the dissolved oxygen consumed by microorganisms present in the studied samples to stabilize any biodegradable organic matter, as well as the quantity of oxygen used in its respiration (APHA, 1995). The BOD values varied between 3.6 – 9.0 mg/l (Table 3). The high BOD values recorded during autumn may be attributed to photosynthesis activity at the surface water and high original DO. This agrees with Ghallab (2000) at Delta Barrage region and Abdo (2002) at Rosetta branch, while the low BOD recorded during winter could be explained on the basis of low activity of microorganisms, as a result of low temperature, which agrees with the data obtained by Zyadah (1995).

Chemical Oxygen Demand (COD)

COD is the total amount of O_2 required to oxidize all organic matter and oxidizable compounds present in the water sample into CO_2 and H_2O (APHA, 1995).The values of COD varied between 5.0 – 19.4 mg/l (Table 3); the high recorded COD values during summer may be due to the high decomposition rate of organic matter as a result of low DO content, which agreed with the results of Zyadah (1995). The low recorded COD values during spring could be attributed to phytoplankton abundance (Visser, 1970; Fishar, 1999).

Heavy Metals

Trace metals play an important role in the geochemical and biological cycle of aquatic environment (Purves, 1988). They have a great ecological significance due to their toxicity and accumulation behaviour and aren't biodegradable and undergo a global ecobiological cycle, in which natural water is the main pathway (Purves, 1988; Pardo *et al.*, 1990). The present study showed that iron levels varied from 0.09 – 6.04 mg/l and the highest value was observed at the southern regions (stations 2 – 5) in front of Bahr El-Baqar and Hadous outlets (Table 4).

A similar trend was observed with other trace metals. For example; Mn (0.024 – 0.395 mg/l) showed high concentrations during hot seasons due to releasing of Mn from sediment under low DO content as mentioned by Yacaub (1999), while the low levels were recorded during cold seasons, due to the oxidation and precipitation on the bottom sediment as mentioned by Cole (1979). Moreover, the high concentration of Mn recorded at stations (3 – 6), as shown in Table (4), could be attributed to domestic wastes discharged from Bahr El-Baqar and Hadous drains, which agreed with Shakweer (2005).

The correlation matrix of Mn showed a negative correlation with pH and DO ($r = -0.56$ and -0.8 respectively), which reveals that Mn precipitates in oxidizing form at high pH values.

For Cu, its concentration varied from 0.004 – 0.28 mg/l. The decrease in Cu concentration during cold period may be due to formation of CuO, that rapidly changed to $Cu(OH)_2$ and precipitates at the bottom sediment, which agreed with Masoud *et al.* (1994). The correlation matrix of copper showed a negative correlation with temperature and DO ($r = -0.56$ and -0.33 respectively), which means that copper may precipitate in oxidized form at high temperature.

Zinc concentration fluctuated between 0.007 – 0.057 mg/l, and the high Zn concentration was observed during the cold period, which could be attributed to the decrease in sorption of zinc at organic matter with drops with temperature. This agrees with that reported by Warner and Zimmerman (1994). The decrease in Zn concentration at stations (1, 6, 8) during spring may be due to the reaction of Zn with high concentration of H_2S to from insoluble ZnS under anoxic condition, as reported by Birch *et al.* (1996).

Zn showed a positive correlation with BOD and COD ($r = 0.79$ and 0.81 respectively) which explains that most of zinc compounds are biologically and chemically degradable, while a negative correlation was observed with DO ($r = -0.78$).

For cadmium, its concentration varied between 0.010 – 0.034 mg/l, and the high concentrations were recorded during the cold period, which could be explained on the basis of mobilizing of cadmium from sediment under low temperature (El-Shebly, 1996).

For lead, its concentration fluctuated from 0.020 – 0.057 mg/l and the low concentrations were recorded during cold period, which may be attributed to its precipitation in the form of sulphide and carbonate, which agreed with that reported by Zyadah (1995).

It can be concluded that the southern drains play an important role in causing a severe pollution in Lake Manzala, especially at the south-eastern regions which receive a great quantities of effluents from Bahr El-Baqar, Hadous and Ramsis drains. These severe polluted effluents reflect the high levels of most chemical parameters. The studied heavy metals showed that Fe, Cd and Pb concentrations exceed the maximum permissible limits according to the Egyptian Chemical Standards (ECS) (1994), while other elements concentrations exceed the maximum permissible limits according to other international criteria (Table 5).

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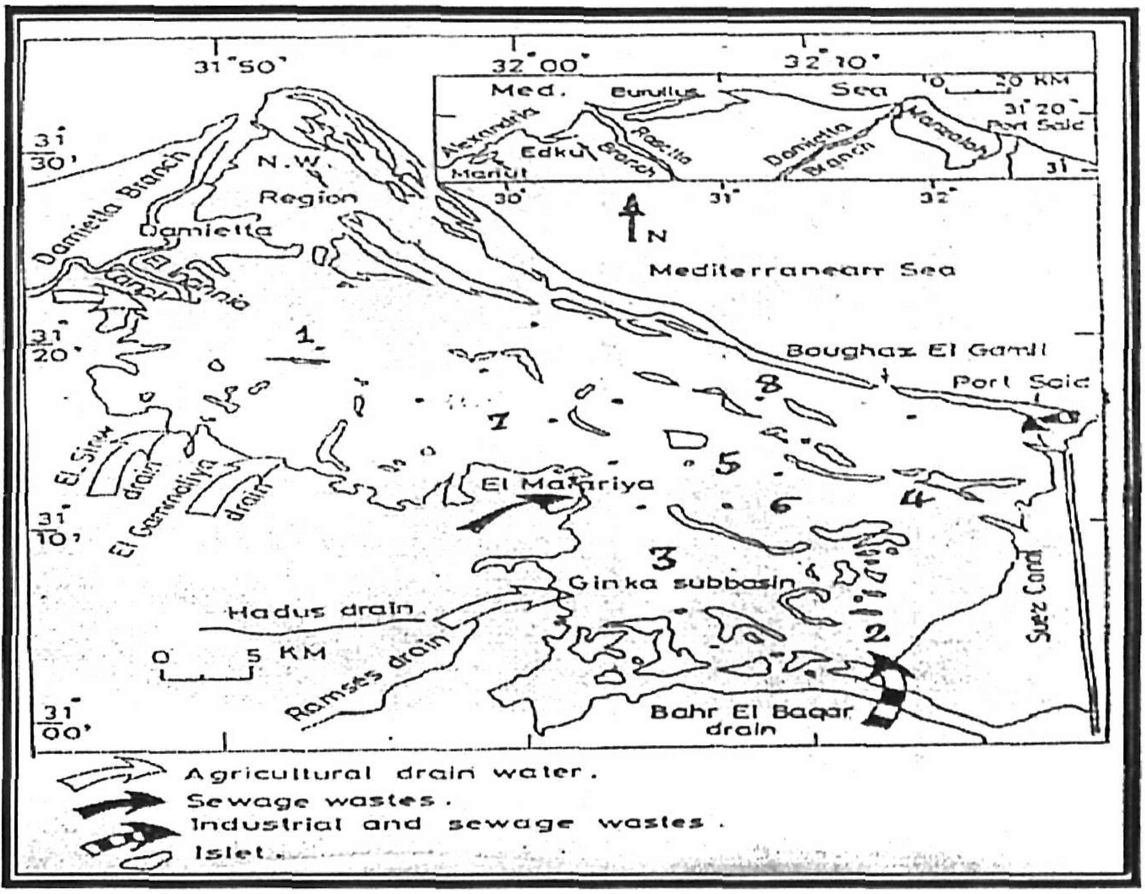

Fig. (1): Diagrammatic map for Lake Manzala showing the water sampling stations

Table (1): Seasonal variations of water temperature (°C), EC (µmohs/m) and transparency (cm) in Lake Manzala water during 2000 – 2001.

Station	Autumn			Winter			Spring			Summer		
	Temp.	EC	Trans.	Temp.	EC	Trans.	Temp.	EC	Trans.	Temp.	EC	Trans.
1	21	2955	50	18	3230	60	21	3455	55	25	2200	65
2	22	3700	20	17	4345	25	20	4570	15	28	3190	20
3	24	1965	30	16	2355	30	20	2480	20	30	2645	25
4	25	5780	20	16	5480	25	21	4525	20	27	5460	25
5	24	3100	35	16	2820	30	21	2950	25	27	3240	30
6	27	2875	40	17	2780	30	20	3055	25	28	4400	30
7	27	2545	45	17	2660	35	21	2440	40	28	2635	50
8	20	23.800	55	18	19.550	45	23	11.870	50	28	31.440	70

Table (2): Seasonal variations of pH and DO concentrations (mg/l) in Lake Manzala water during 2000 – 2001.

Station	Autumn		Winter		Spring		Summer	
	DO	pH	DO	pH	DO	pH	DO	pH
1	7.80	8.22	10.00	7.50	7.60	8.31	5.00	8.64
2	4.20	7.44	5.00	7.47	4.60	7.60	3.20	7.35
3	3.60	7.78	4.40	7.56	4.00	7.39	3.00	7.29
4	4.40	7.91	5.20	8.09	4.80	7.43	3.40	7.18
5	4.20	7.31	4.80	7.41	3.80	7.54	3.00	7.58
6	3.80	8.10	5.20	7.68	4.40	7.33	3.60	7.53
7	4.40	7.21	5.00	7.82	4.20	7.37	4.00	7.39
8	8.40	8.20	8.20	7.68	6.80	8.30	5.80	7.81

Table (3): Seasonal variations of BOD and COD concentrations (mg/l) in Lake Manzala water during 2000 – 2001.

Station	Autumn		Winter		Spring		Summer	
	BOD	COD	BOD	COD	BOD	COD	BOD	COD
1	5.00	7.60	4.00	7.00	2.60	6.40	5.40	8.00
2	8.20	14.20	5.80	10.20	4.00	9.00	6.20	13.40
3	6.80	12.60	4.60	8.80	3.60	10.40	5.60	11.80
4	9.00	14.00	7.00	15.20	6.40	16.80	8.40	19.40
5	6.40	12.80	4.00	7.40	3.00	9.60	7.20	14.60
6	6.00	10.40	4.80	10.60	5.20	8.00	7.00	13.80
7	5.80	12.00	3.60	9.20	4.00	7.40	6.00	10.00
8	3.60	6.20	3.00	6.80	2.80	5.00	4.20	8.40

Table (4): Seasonal variations of heavy metals concentrations mg/l (Fe, Mn, Cu, Zn, Pb and Cd) in Lake Manzala water during 2000 – 2001.

Station	Autumn						Winter						Spring						Summer					
	Fe	Mn	Cu	Zn	Pb	Cd	Fe	Mn	Cu	Zn	Pb	Cd	Fe	Mn	Cu	Zn	Pb	Cd	Fe	Mn	Cu	Zn	Pb	Cd
1	0.85	0.079	0.006	0.021	0.019	0.013	1.94	0.024	0.004	*	*	0.022	0.91	0.074	0.017	0.008	0.023	0.011	0.84	0.028	0.013	0.013	0.028	0.01
2	2.01	0.085	0.009	0.03	0.034	0.024	3.01	0.122	0.008	0.019	0.039	0.031	1.02	0.067	0.013	0.028	0.048	0.023	0.14	0.127	0.016	0.021	0.045	0.018
3	3.10	0.170	0.008	0.024	0.03	0.019	4.80	0.16	0.01	0.027	0.047	0.026	6.04	0.191	0.019	0.011	0.053	0.02	0.09	0.152	0.012	0.02	0.039	0.016
4	2.61	0.281	0.016	0.057	0.041	0.03	2.09	0.179	0.02	0.02	0.05	0.034	1.12	0.209	0.028	0.023	0.051	0.027	0.13	0.395	0.022	0.027	0.057	0.025
5	1.00	0.146	0.012	0.038	0.033	0.023	1.02	0.164	0.01	0.019	0.045	0.029	2.00	0.133	0.018	0.018	0.049	0.021	0.11	0.147	0.013	0.021	0.047	0.02
6	2.50	0.130	0.013	0.035	*	0.026	3.80	0.1	0.016	0.013	0.031	0.028	1.02	0.099	0.014	0.009	0.039	0.024	0.11	0.142	0.011	0.024	0.051	0.02
7	2.10	0.125	0.01	0.039	0.03	0.018	0.95	0.08	0.01	0.018	0.027	0.023	0.80	0.111	0.019	0.011	*	0.017	0.12	0.153	0.014	0.019	0.034	0.014
8	0.88	0.089	0.011	0.017	0.02	0.015	0.71	0.07	0.009	0.023	0.03	0.019	0.11	0.091	0.018	0.007	0.022	0.012	0.13	0.265	0.012	0.01	0.028	0.013

* not detected

Table (5): Standard limits (maximum permissible limits) of drinking water parameters according to different criteria.

Parameters	**Units**	**WHO Standards**	**USEPA Standards**	**ESS Standards**	**ECS Standards**	**Present study**
pH		6.5 – 8.5	6.5 – 8.5	6.5 – 8.5	6.0 – 9.0	6.88 – 8.31
Temperature	°C	-	-	-	35	16 - 30
Color		NO	NO	NO	NO	NO
BOD	mg/l	-	-	-	20	2.6 – 9.0
COD	mg/l	-	-	-	30	5.0 – 19.4
Fe	mg/l	0.3	0.3	0.3	1	0.09 – 6.04
Mn	mg/l	0.05	0.05	0.05	0.5	0.024 – 0.411
Cu	mg/l	1	1	0.1	1	0.003 – 0.055
Zn	mg/l	5	5	0.1	5	0.007 – 0.057
Cd	mg/l	0.005	0.01	0.005	0.01	0.007 – 0.920
Pb	mg/l	0.05	0.005	0.05	0.05	0.013 – 0.062

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