Assessment of some water quality characteristics and determination of some heavy metals in Lake Manzala, Egypt

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ABSTRACT

The concentrations of some heavy metals (Fe, Mn, Zn, Cu, Pb and Cd) in water of the largest Delta wetlands (Lake Manzala; north of Egypt), in relation to some water quality characteristics were investigated. Samples were collected from ten stations covering the whole lake area through twelve successive cruises that commenced in January 2004 and ended in December 2004.

The obtained results declared that, the agricultural and domestic sewage drained into the lake from urban and rural lands have an adverse effects of water quality characteristics of the lake. Nowadays, there are huge amount of treated sewage from Bahr El-Baqr drain discharged into the lake, but the water quality still undergoes a severe deterioration. The most studied parameters; especially nutrient salts and heavy metals varied in wide range, increased in the southern region and decreased towards north eastern part of the lake. Contrarily, salinity, chloride, sulphate and major cations decreased in the south and increased in north eastern part. Heavy metals discharged into the lake create a serious environmental problems, where the levels of iron, manganese, lead and cadmium are exceeded the universal guidelines for water quality established by Environmental Protection Agency.

Key words: physicochemical conditions, heavy metals, nutrient salts, Lake Manzala.

INTRODUCTION

Lake Manzala is the largest of the four brackish coastal lakes fringing the Nile Delta. The lake lies between $31^0 45^\backslash$, $32^0 15^\backslash$ E and $31^0 00^\backslash$, $31^0 35^\backslash$ N. It is bordered by Suez Canal from east, Damietta branch of Nile from west and Mediterranean Sea from north. The lake connected to the Mediterranean Sea via three outlets, permitting exchange the water and biota between the lake and the sea. These outlets are El-Gamil, El-Boughdady and the new El-Gamil (Elewa *et al*., 2007).

Lake Manzala is shrinking in size; the rate of shrinking of the total area from 1922 to 1995 was estimated, being 5.22 km^2/yr. The greater losses of the lake areas were detectable along the western and southern borders of the lake (Frihy *et al*., 1998). In 1900 its area was 1907 km^2, while its area as measured by land sat imagery in 1981 was about 909.85 km^2. As a result of presence of a

large number of islets in the lake, the area of open water is only about 700 km^2 (El-Rakaiby and Youns, 1993).

Lake Manzala receives about 7500 million cubic meters of untreated industrial, domestic and agricultural drainage water, discharged annually into the lake through several drain; Bahr El-Baqer Drains (domestic and industrial sewage), Hadous, Ramsis, El-Serw and Faraskour Drains (agricultural effluents). These amount of water was reduced to about 4000 million cubic meters after construction of El-Salam Canal (Abdel Baky *et al.*, 1998)

Construction of Aswan High Dam accompanied by considerable increase in population and consequently in man's activities constitutes the main cause of pollution in the Nile Delta lakes, mainly eutrophication, as well as occurrence of heavy metals and pesticide contaminants constituted in these lakes problems of increasing concern. Lake Manzala occupies the second polluted level after Lake Mariut (Saad, 2003).

Lake Manzala can be divided into two main regions according to its salinities; the southern region of the lake which characterized by lower values of salinities and high concentration of nutrients and heavy metals as consequence of its receive high volumes of low salinity drainage water through different drains and the second region at the North Eastern area of the lake, near to the lake-sea connection (El-Gamil), which characterized by high salinity values and low nutrient concentration as a result of seawater intrusion through the outlet openings (El-Gawady, 2002; Shakweer, 2005).

The southern part of the lake water maintained the high heavy metals levels which exceed the allowable maximum concentration reported by Word Health Organization, which might cause a public health problem (Abdel-Satar, 2001). These metals affected the survival of fish and accumulated in its different organs especially gills and liver more than edible muscles. El-Naggar *et al.* (2000) found that the levels of Pb, Cd, Ni, Cu, Zn, Cr and Fe were obviously higher in the gills tissue of *Oreochromis niloticus* and *Tilapia zillii* than those in water. Moreover, Abdel Baky (2001) reported that, the southern region of Lake Manzala was highly contaminated by Cu, Pb, Zn and Mn and the concentrations of most studied metals in different organs of *Clarias gariepinus* found in the sequence: liver > kidney > gills > gonad > brain > muscle.

Lake Manzala attracts attention of many scientist because of its important economical aspects. Several investigations have been carried out concerning its ecosystem. These studies dealt with different environmental aspects of the lake including geological aspects, hydrological regime, physicochemical properties, bacterial indices, phytoplankton composition, benthic invertebrates and fishery status (Dowidar and Hamza, 1983; Khalil and El-Awamri, 1988; Khalil and Bayoumi, 1988; Khalil, 1990; El-Ghobashy, 1990; Said, 1992; El-Bokhty, 1996; Frihy *et al.*, 1998; Abdel-Baky and Zyadah, 1998; Abdel-Satar, 2001; Fathi *et al.* 2001; Flower, 2001; Fathi and Abdelzahar, 2003;

Abbassy *et al*., 2003; El-Enani, 2004; Mabrouk, 2004; Gad, 2005; Yacoub *et al*. 2005).

Not only great efforts were needed for recovery of the purity and healthy of this lake, but also an additional informations were needed to provide a data base for optimal fisheries and water quality status that help the proper management of the lake.

The main objectives of this research are: (1) to determine the water quality characteristics of Lake Manzala and (2) to determine the levels of some heavy metals (Fe, Mn, Zn, Cu, Pb and Cd) because of their health implications to human populations consuming fishes from the lake.

MATERIALS AND METHODS

Collection of samples

Ten stations were selected which covered the whole area of the lake (Table 1 and Fig. 1). Water samples were taken monthly from January 2004 till December 2004, using Ruttner Water Sampler bottle with capacity of 2L, the samples were preserved with few drops of chloroform. For heavy metals determination, the samples were collected seasonally in clean plastic bottles and acidified with few drops of concentrated nitric acid.

Table (1): Selected stations, common names and their latitudes and longitude in Manzala Lake

St. No.	Name	Latitude	Longitude	St. No.	Name	Latitude	Longitude
1	Bahr El-Bakr	32°12'16.16"	31°12'10.45"	6	Abwat	31°51'14.75"	31°15'44.97"
2	El-Gamil 1	32°12'30.24"	31°16'43.09"	7	Dishdi	31°56'41.69"	31°15'13.85"
3	El-Gamil 2	32° 9'37.17"	31°17'46.45"	8	El-Mataria	32° 2'51.41"	31°11'40.15"
4	Timsah	32° 3'42.66"	31°17'10.90"	9	El-Genak 1	32° 6'19.00"	31° 7'0.14"
5	El-Zarka	31°54'14.11"	31°21'47.32"	10	El-Genak 2	32°13'39.71"	31° 6'21.82"

Methodology:

The methods described in the American Public Health Association (APHA, 1992) were used for determination of the abiotic parameters unless noted. The pH values were measured during the time of sampling using pH meter model (Jenway 3150) after calibration with buffer solutions of pH 4 and

10. Dissolved oxygen was estimated by using the modified Winkler method. COD was carried out using potassium permanganate method. Water alkalinity was determined immediately after collection of the samples, using phenolphthalein and methyl orange indicators. Chloride was estimated using Mohr's method. Sulphate were determined using turbidimeteric method. Water hardness was determined using compleximetric method by EDTA, while sodium and potassium were determined using flame photometer (Jenway model Felsted Gi Dunmow Essex). Ammonia was determined by phenate method. Nitrite was determined using colorimetric method, while nitrate was determined by reduction method as described by Mullin and Riley (1956). Orthophosphate and total phosphorus were determined by using stannous chloride and acid molybdate method. Silicate was determined by using molybdate method. For heavy metals, water samples were digested by adding 10 ml nitric acid to 500 ml of mixed sample in a beaker. Slow boiling and evaporation on a hot plate were done to reach the lowest volume. Beaker walls were washed carefully with distilled water then the digested samples were transferred to a 100 ml volumetric flask and completed to the mark.

Statistical analysis

Principal component analysis (PCA), a multivariate technique, was used to summarize the general trend and changes in chemical variables using correlation analysis. PCA was performed using CANOCO V. 4.0 (Ter Braak, 1987).

Fig. (1): A map showing the location of Lake Manzala and the selected stations

RESULTS AND DISCUSSION

Electrical conductivity and salinity

Both Electrical conductivity and salinity values are distributed in Lake Manzala in a similar trend. Their values increased in the north eastern area near to boughaz El-Gamil recording the maximal values of (43.8 mS/cm and 22.5 ‰ respectively) at station 1. The lowest values of (2.5 mS/cm and 1.1 ‰ respectively) were recorded at station 4 (Table 2). These results in agreement with those obtained by Khalil and Bayoumi (1988) and Abdel-Satar (2001).

pH Values

The pH values of Lake Manzala were fluctuated between 7.45 - 8.90 with slight regional and seasonal variations. The lowest pH values were mostly recorded in the southern region in front of Bahr El-Baqr Drain due to the fermentation of the organic matter and liberation of hydrogen sulphide and methane gases which lead to lowering pH values (Abdel-Satar, 2001). However, in the western region of lake, the pH values lie in the alkaline side mostly above 8.0. These results in agreement with those obtained by Fathi and Abdelzahar (2003) who reported that the change in pH value was always in the alkaline side and ranged between 7.7 to 9.0.

Dissolved oxygen (DO) and chemical oxygen demand (COD)

Water of Lake Manzala is well oxygenated during different time intervals except the inlet of Bahr El-Baqr region which suffered from complete depletion of dissolved oxygen around the year especially during hot months. Station 1 had the lowest average value during the year as a result of decomposition of organic matter and detrital materials consumed the dissolved oxygen. However, The maximum value of DO (10.2 mg/l) was recorded at station 5 during December due to decreasing of temperature and to the prevailing winds which permit to increase the solubility of atmospheric oxygen (Romairo *et al.,* 1979) (Table 2). On the other hand, Lake Manzala has high values of chemical oxygen demand especially at the region facing the drains inlets. Chemical oxygen demand values fluctuated between 10 - 31.2 mg/l (Table 2). It is noted that, COD values increased during hot months more than cold months due to the increase the rate of organic mater decomposition in addition to fermentation processes (Elewa *et al*., 2007).

Major Anions

Carbonates in Lake Manzala are almost depleted in most stations during cold months as a consequence of its precipitation as $CaCO_3$ onto the overlying sediment or its conversion to bicarbonate, then increased gradually during spring and summer and reached its maximum value of 48 mg/l due to the increase of the amount of dissolved carbon dioxide, which is converted to carbonate in the water environment (Spotte, 1979). Bicarbonate values fluctuated in wide range between 216 - 352 mg/l (Table 2), showing an obvious decrease during March at station 5 in the middle region of the lake due to utilization of dissolved carbon

dioxide that resulted from the chemical reaction of converting calcium bicarbonate to calcium carbonate (Aboul-Kassim 1987). Then, they showed a remarkable increase during hot months at the southern region (stations 9 & 10) which may be attributed to direct impact of the agricultural effluents from Hadous Drain. These results were in agreement with that obtained by Fathi and Abdelzahar (2003) who cited that the total alkalinity of Lake Manzala water reached its minimum in spring (200 mg/l), whereas the maximum value was recorded in summer (300 mg/l) at the southern region.

The distribution pattern of chlorosity and sulphate exhibits an opposite manner to bicarbonate. Their maximum values were recorded in the north eastern area nearby the boughaze outlet as a result of sea water intrusion and then decreased obviously towards southern region. The highest values of chloride and sulphate (13.5 g/l and 1453 mg/l) were recorded at station 3 during August. The lowest chloride and sulphate values (0.54 g/l and 127 mg/l) were recorded at southern region (station 9) during April (Table 2).

Major Cations

Major cations showed their highest levels in the restricted area nearby the boughaz outlet as a result of seawater intrusion into the lake. While in the rest area of the lake the levels showed slight variation among the different stations and time intervals (Table 2). The decrease of calcium levels during hot months were observed, which attributed to the elevation of temperature leads to increase of carbonic acid which enhances precipitation of calcium in carbonate form (Cole, 1979). The lowest calcium value (67 mg/l) was recorded at station 9 during September (Table 2). There are relative variation in magnesium distribution pattern except at boughaz area, which was mainly attributed to high solubility characteristics of its salts, which keep a homogenous distribution and mass balance for magnesium (Wetzel, 1983). The results showed a relative increase of magnesium during summer which is mainly attributed to increase of microbial activity and fermentation processes shared in the increase of magnesium concentration and the elevation of water temperature that enhances the dissolution of magnesium carbonate from underlying sediments or from the rocks containing magnesium salts (Sayyah *et al.*, 1988). Thus, the maximum value of 1344 mg/l was recorded during August at station 3. The minimum value (125 mg/l) was recorded at station 9 during May, which attributed to receiving the freshwater effluents from Hadous drain. In addition to abundance of macrophytes which decreases the magnesium content in the water through adsorption of magnesium salts onto its roots (Diaz *et al*., 1998). More or less, sodium and potassium showed the same behavior, where their minimum values (298 and 26 mg/l) were recorded at station 9 during March, while the highest values (7.8 g/l and 499 mg/l) were recorded at Station 3 during July (Table 2).

Table (2) Range and mean average concentration of some chemical variables at different
selected stations in Lake Manzala during 2004

Stations	pH		Sal (‰)		DO (mg/l)		COD (mg/l)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	7.45 - 8.8	8.37	2.4 - 6.3	3.9	0.0 - 4.1	2.4	17.6 - 23.5	21.3
2	7.51 - 8.43	8.11	2.7 - 21.7	12.1	4.8 - 9.6	6.5	16.0 - 24.5	20.6
3	7.89 - 8.36	8.16	6.7 - 22.5	12.8	5.1 - 9.2	7.0	17.2 - 23.8	21.3
4	7.98 - 8.90	8.46	1.1 - 6.9	3.9	4.8 - 9.8	6.8	18.4 - 30.8	25.0
5	7.91 - 8.50	8.21	4.7 - 11.5	7.3	5.4 – 10.2	7.0	18.0 - 26.4	21.9
6	7.85 - 8.40	8.13	1.4 - 4.0	2.7	5.8 - 8.6	7.4	12.0 - 24.3	19.5
7	7.85 - 8.60	8.23	1.2 - 3.9	2.2	4.8 - 8.7	6.7	12.0 - 21.6	19.6
8	7.80 - 8.39	8.13	3.1 - 5.9	4.7	5.2 - 9.4	7.3	19.2 - 26.5	23.6
9	8.15 - 8.9	8.49	1.2 - 3.0	**2.1**	4.9 - 9.4	**7.1**	10.0 - 28.1	**21.8**
10	7.80 - 8.50	8.16	1.9 - 7.0	3.8	5.2 - 8.8	7.2	24.0 - 31.2	28.5

Stations	CO_3^{--} (mg/l)		HCO_3^- (mg/l)		Cl^- (g/l)		SO_4^{--} (mg/l)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	0 - 44	9	235 - 290	250	1.02 - 3.06	1.96	234 - 596	438
2	0 - 12	5	240 - 300	273	1.90 – 12.86	7.76	478 - 1384	1045
3	0 - 40	12	280 - 336	299	3.33 – 13.49	7.22	572 - 1453	1024
4	0 - 40	17	251 - 312	276	0.64 - 4.12	1.99	134 - 865	483
5	0 - 36	6	216 - 304	279	2.36 - 3.83	3.83	537 - 1193	775
6	0 - 8	3	240 - 300	268	0.69 - 2.41	1.33	149 - 507	314
7	0 - 40	12	237 - 300	268	0.64 - 2.34	1.15	134 - 492	280
8	0 - 24	8	280 - 352	313	1.78 - 3.55	2.41	348 - 746	511
9	0 - 48	17	240 - 300	277	0.54 - 1.78	1.09	127 - 375	272
10	0 - 20	4	244 - 320	287	0.77 - 3.55	1.90	224 - 956	463

Table (2): Continue

Stations	Ca^{++} (mg/l)		Mg^{++} (mg/l)		Na$^+$ (g/l)		K$^+$ (mg/l)	
	Range	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**
1	183 - 498	286	210 - 605	316	0.44 - 1.70	1.10	39 - 170	93
2	232 - 648	514	356 - 1344	804	1.08 - 7.09	4.51	59 - 473	257
3	156 - 641	373	440 - 1344	736	1.65 - 7.77	4.37	93 - 267	267
4	75 - 481	282	264 - 607	393	0.38 - 2.47	1.08	36 - 247	100
5	123 - 488	293	340 - 756	553	1.14 - 4.49	2.48	61 - 449	178
6	88 - 352	212	149 - 506	308	0.39 - 1.45	0.73	31 - 145	71
7	93 - 340	194	135 - 514	247	0.36 - 1.41	0.67	27 - 141	62
8	112 - 359	173	326 - 652	426	1.03 - 2.13	1.47	46 - 213	115
9	67 - 138	109	125 - 355	230	0.30 - 1.07	0.64	26 - 107	56
10	128 - 351	263	165 - 704	348	0.50 - 1.89	1.11	35 - 173	79

Nutrient salts

The distribution dynamic of dissolved nutrients in Lake Manzala is governed by several factors; the major of which are; 1) the heavily polluted water drained into the lake through Bahr El-Baqr and Hadous Drains, and 2) its removal through uptake by macrophytes assimilation processes. The mixing of lake water with the seawater at the lake-sea connection, absorption on suspended particles and subsequent sedimentation to the overlying sediment also play a role in determining the concentrations and distribution of nutrients in lake water.

Although, the construction of great treatment ponds to treat about 30,000 cubic meter per day of the organic sewage from Bahr El-Baqr, but the effect of this treatment not clearly obvious till now. The south and south eastern regions still undergoes a severe pollution case represented in high nutrients and heavy metals loading from different effluents inflow into the lake. Except this area, the distribution of nutrients in the rest of the lake showed irregular narrow variations (Figs. 2 – 7).

The present study showed that, the nitrite values increase during cold months and decrease during hot months and ranged between 3.2 - 221.6 µg/l (Fig. 2). It is clear obviously that the concentration of nitrite at station 1 (facing Bahr El-Baqr Drain) exceeds much more than other parts in the lake which mainly attributed to different sewage effluents discharges into this area. Nitrate showed its minimum value (26.7 µg/l) during December at station 5, while the maximum value (661 µg/l) was recorded during July at station 1(Fig. 3). It is

clear that, the increase of nitrate concentration attributed to the oxidation of ammonia yielding nitrate especially in abundant of dissolved oxygen according to equations:

$$NH_4^+ + 1½ O_2 \longrightarrow NO_2^- + 2H^+ + H_2O$$
$$NO_2^- + ½ O_2 \longrightarrow NO_3^- \text{ (Cooper, 1990)}$$
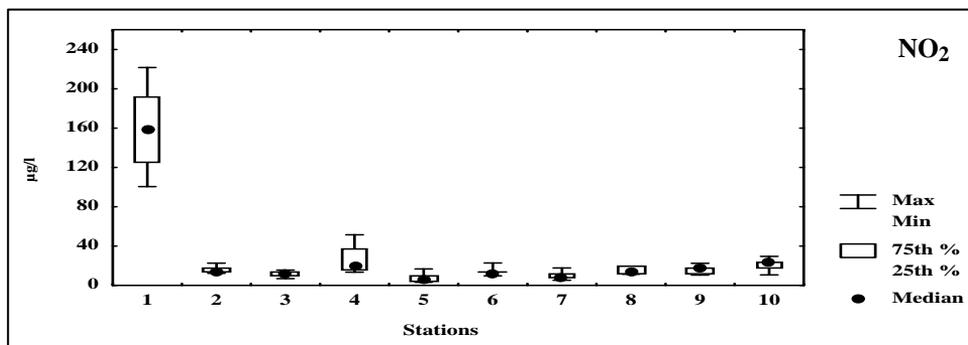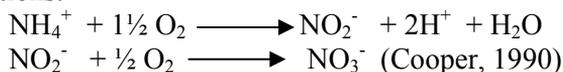
Fig.(2): Monthly variation of nitrite concentration (µg/l) in Lake Manzala during 2004
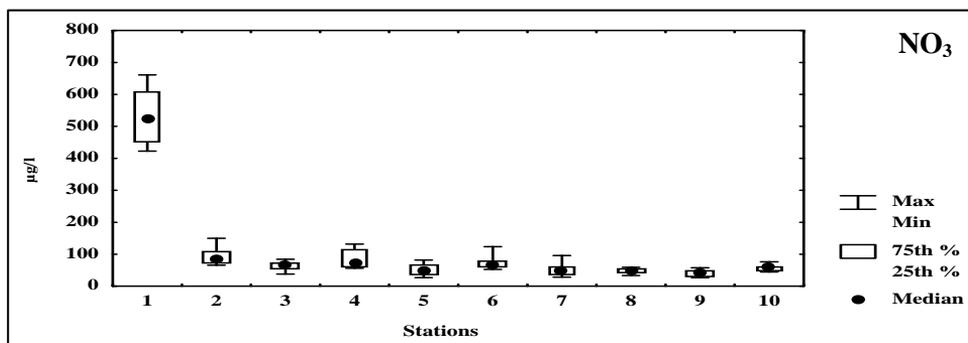
Fig.(3):Monthly variation of nitrate concentration (µg/l) in Lake Manzala during 2004

Ammonia concentration in Lake Manzala showed an abrupt increase at station 1 due to the direct impact of domestic sewage inflow from Bahr EL-Baqr Drain into this region. Thus, the rate of ammonification process increases converting the organic matter to ammonia especially at high temperature, therefore the maximum ammonia value (7232 µg/l) was recorded during May. The other parts of the lake showed a homogeneous distribution with narrow horizontal fluctuations. The minimum value of 196 µg/l was recorded at station 8 during April (Fig. 4).
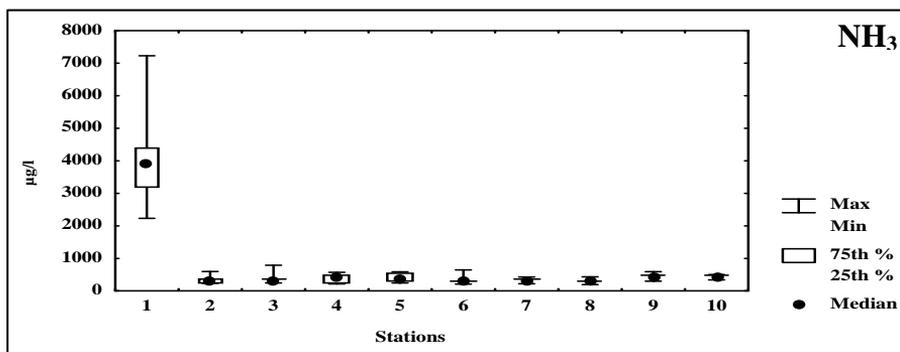
Fig.(4): Monthly variation of ammonia concentration (µg/l) in Lake Manzala during 2004

The orthophosphate contents in Lake Manzala showed a slight increase during spring and summer more than in other seasons. The maximum orthophosphate value of 980 µg/l was recorded at station 1 during August, while the minimum (101 µg/l) was recorded at station 3 during April (Fig. 5). The orthophosphate values showed a remarkable decrease at boughaz area due to high salinity of seawater than the lake water. Thus, phosphorus forms chemically tight compounds with major cations, these tight forms especially noted with magnesium in the form of $MgPO_4^-$ $MgHPO_4$ and MgH_2PO_4 and calcium in the form of $CaPO_4$; $CaHPO_4$ and CaH_2PO_4 (Pulmmer *et al*., 1984).
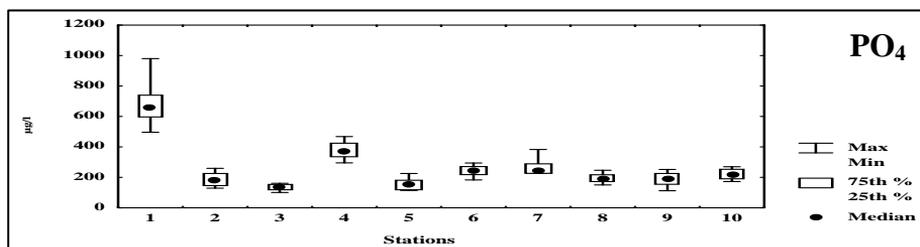
Fig. (5): Monthly variation of orthophosphate concentration (µg/l) in Lake Manzala during 2004

Total phosphorus values exhibited similar distribution trend as orthophosphate. However, its values increase during summer more than other seasons. The highest values of TP (3475 µg/l) was recorded at station I during August, which attributed to phosphorus loading from Bahr El-Baqr Drain, in addition to the mineralization of phosphorus throughout the decomposition of organic matter and also, its release from the sediment under oxic conditions (Sanchez-Pérez and Trémoliéres, 1997), while the lowest TP values (313 µg/l) was recorded at station 5 during April (Fig. 6).
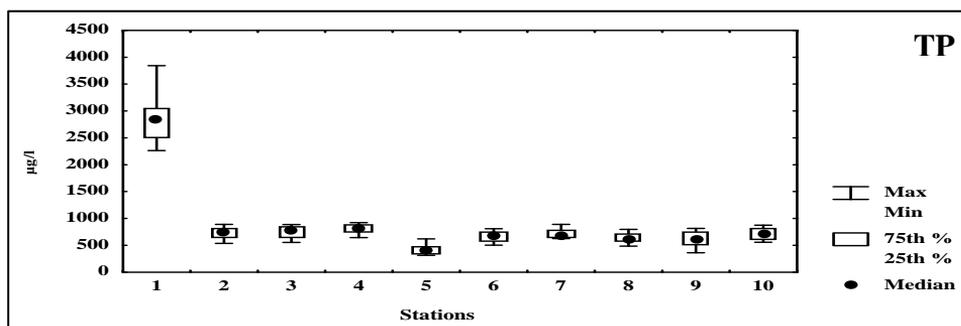
Fig. (6): Monthly variation of total phosphorus concentration (μg/l) in Lake Manzala during 2004

It is obvious that the distribution pattern of silicate in the lake exhibits a dissimilar trend comparing with other nutrients. Their highest values were not restricted in the southern area but it showed irregular fluctuation into the whole lake (Fig. 7). The heterogeneous distribution of silica in Lake Manzala indicates that, the source of silica is not allachothonus from the drains but its main source is autochothonus through the production of biogenic silica from diatoms, which caused preservation in silica content distribution (Verschuren *et al.*, 1998). Also, the uptake of dissolved silica by the aquatic microorganism especially diatoms, flagellate microalgae, macrophytes and zoobenthos causes silica preservation (Cole, 1979).The reactive silicate contents in Lake Manzala increased during hot months than other months, the maximum silicate value of 7.0 mg/l was recorded at station 8 during June, while the minimum (2.1 mg/l) was recorded at station 9 during December (Fig. 7).
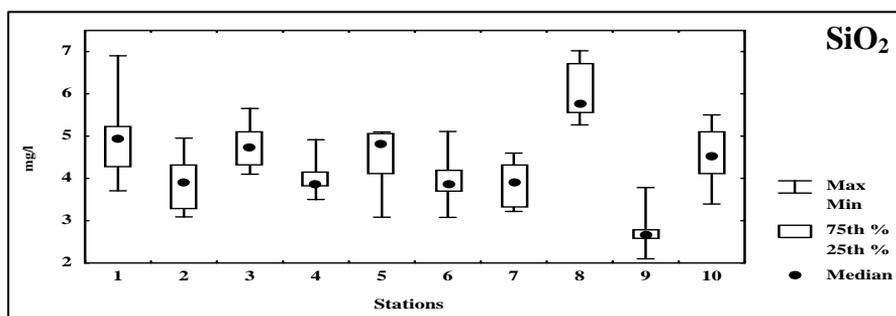
Fig. (7): Monthly variation of reactive silica concentration (mg/l) in Lake Manzala during 2004

Heavy Metals

Heavy metals are the most dangerous contaminants since they are persistent and accumulate in water, sediments and in tissues of the living organisms, through two mechanisms, namely 'bio-concentration' (uptake from

the ambient environment and 'bio-magnification' (uptake through the food chain) (Chaphekar, 1991). Fish are able to uptake and retain heavy metals dissolved in water via active or passive processes (Ay *et al.*, 1999). Toxic effects of metals occur when excretory, metabolic, storage and detoxification mechanisms are no longer able to match with uptake rates (Roesijadi and Robinson, 1994).

In general, the heavy metals contents in Lake Manzala showed their maximal values at El-Genka region including the inlets of El-Mataryia pumping station at station 8, Hadous drain at stations 9 & 10 and Bahr El-Baqr Drain at station 1. On the other hand, the lowest values recorded at the middle sector of the lake (stations 5, 6 and 7).

Iron contents in the lake fluctuated in a relatively wide range (Fig. 8). Furthermore, the results showed slight increase of Fe during spring and summer than other seasons due to the elevation of temperature, which decreases the assimilation rate of Fe by aquatic organisms especially macrophytes (Berg *et al.*, 1995). Iron values increased at station 8, which is facing El-Mataryia pumping station recording the maximum value (1212 µg/l), the values decreased progressively while moving away from the drains recording the minimum value (477 µg/l) at station 5 during autumn (Fig. 8). On the other hand, manganese values exhibited a similar distribution trend as iron, where its values increase during hot seasons than cold seasons, which was mainly attributed to the mobilization of manganese from the sediment to the overlaying water due to the decomposition of organic debris by microbial activity (Sung and Morgan, 1981). Its values fluctuated between highest value of 925 µg/l recorded during spring at station 9, and the lowest value of 334 µg/l recorded during autumn at station 7 (Fig. 9).
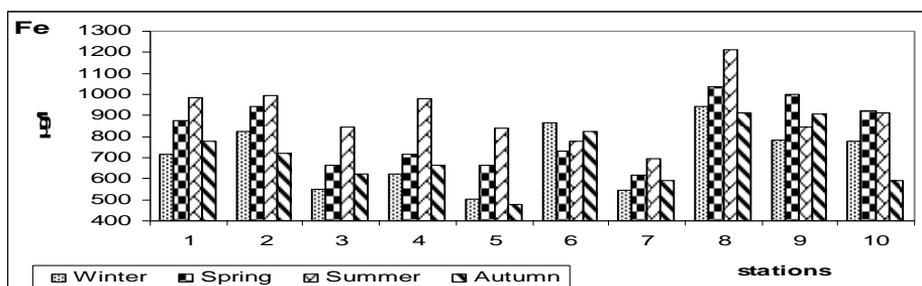
Fig. (8): Seasonal variation of iron concentration (µg/l) in Lake Manzala during 2004
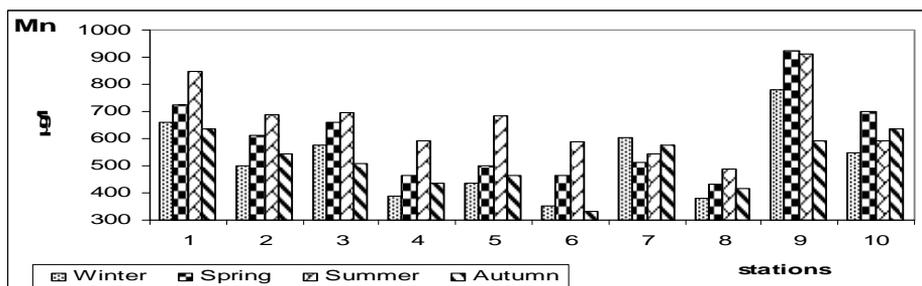
Fig. (9): Seasonal variation of manganese concentration (µg/l) in Lake Manzala during 2004

The obtained results of zinc showed slight increase during cold seasons (winter and autumn) more than hot ones (summer and spring). The decrease of zinc during summer and spring is due to its uptake by macrophytes, and its adsorption into the clayey particles and then sedimentation to the underlying sediments (Ali and Fishar, 2005). The highest value of zinc (93 µg/l) was recorded at station 1 during winter and the lowest value (36.6 µg/l) was recorded during summer at station 7 (Fig. 10). On contrast to the results of Fe and Mn, the levels of copper showed a similar trend as Zn, where its values increased during autumn and winter more than spring and summer, which was mainly attributed to the precipitation of copper to the sediment as CuS under elevation of temperature (Hutchinson, 1957). The highest value (11 µg/l) was recorded during winter at station 8, while the minimum (4.3 µg/l) was recorded during summer at station 3 (Fig. 11).
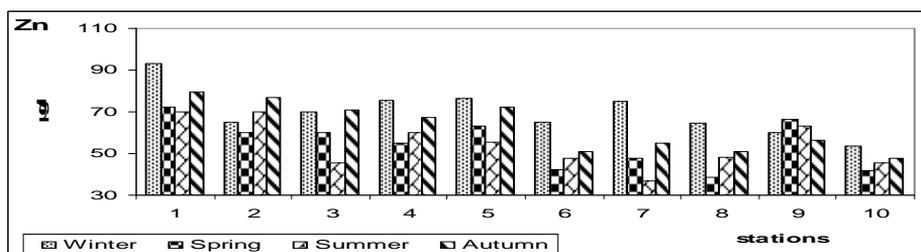
Fig. (10): Seasonal variation of zinc concentration (µg/l) in Lake Manzala during 2004
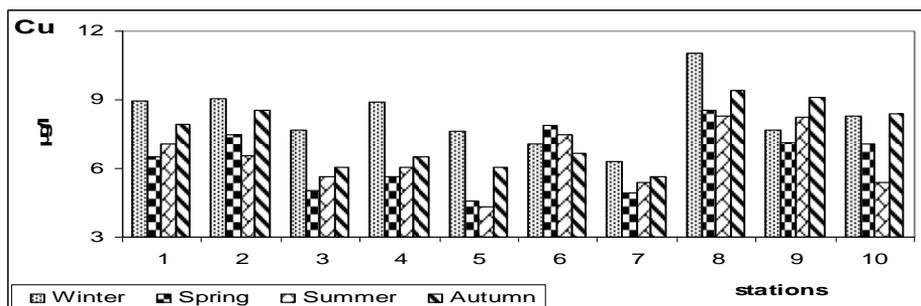
Fig. (11): Seasonal variation of copper concentration (µg/l) in Lake Manzala during 2004

        The values of lead and cadmium exhibit a similar distribution pattern, and showed a slight increase during spring and summer more than that recorded during autumn and winter; the elevation of temperature enhanced the mobilization of lead from the underling sediment then liberate to the overlaying water (Berg *et al*., 1995). The highest values (71.5 and 5.6 µg/l) of lead and cadmium were recorded during summer at station 1, while their minimum values (29.7 and 2.2 µg/l) were recorded at station 7 during winter and autumn respectively (Figs. 12 & 13).
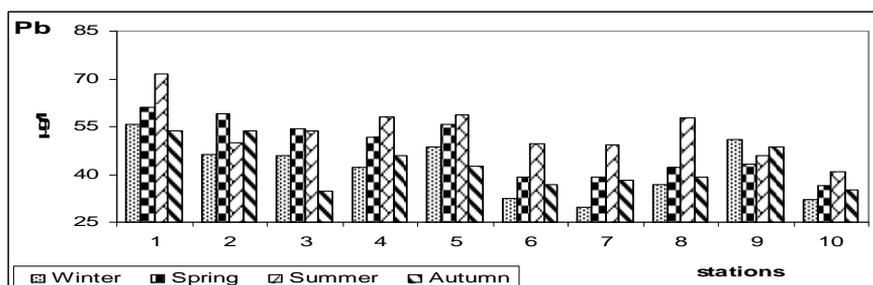
Fig. (12): Seasonal variation of lead concentration (µg/l) in Lake Manzala during 2004
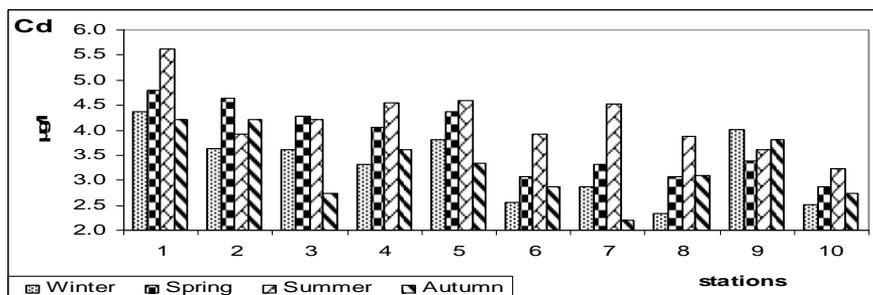
Fig.(13): Seasonal variation of cadmium concentration (µg/l) in Lake Manzala during 2004

        The present study showed that, the annual mean values of Fe, Mn, Pb and Cd (787, 575, 50 and 4µg/l respectively) are higher than standard permissible levels (500, 50, 50 and 3 µg/l) which cited by World Health Organization (WHO) and European Economic Community (EEC) (WHO 1992). On the other hand, the annual mean values of Zn and Cu in the present study (60.4 and 7.2 µg/l) are lower than the corresponding permissible limits (5000 and 50 µg/l) for the same metals respectively.

Statistical analysis

        Principal component analysis (PCA) indicated that, the heavy polluted water was represented on the X axis, while Y axis resemble the sea water, which enters the lake through the inlets (Fig. 14). Site 1 displayed farthest on the right

of the X axis, with combination of highest nutrient and heavy metals (Mn, Zn, Pb and Fe) associated with highest polluted zones (Fig. 15). The other sites that confirming a gradient of decreasing eutrophication appear in the left side of this axis near to zero point. Group 1 (sites 2 and 3) which lie in the north east part of the lake, presented up in the Y axis and characterized by highest levels of different cations, conductivity and salinity. In contrast, groups 2 and 3, which distributed in the middle part of the lake, presented down on Y axis. Group 2 is characterized by highest COD and HCO_3, while group 3, which is located in the south west area of the lake, was completely contradict with Gr. 1; it was characterized by least levels of different cations, conductivity and salinity. Fig. 15 shows a well correlated variables with nutrient characteristics (NO_2, NO_3, NH_3, PO_4 and TP), contribute to the construction of X axis, as well as heavy metals which is rather characteristic of highly polluted ecosystems. Analysis of data shows that these variables are linked to allochthonous inputs due to urban pollution at site 1. The positive values on X axis correspond to important inputs (at site 1), and the negative values (at left side of X axis) to low inputs. On the other side, major cations, conductivity and salinity were highly contribute to the construction of Y axis, which is rather characteristic of sea water intrusion into the lake.
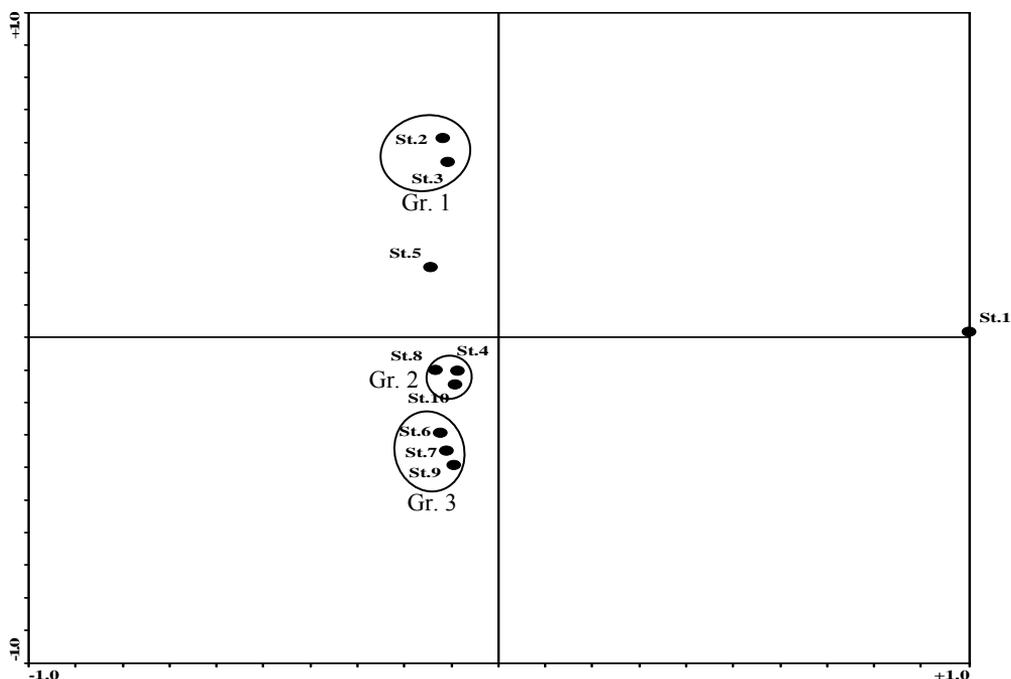
Fig. (14): Principal component analysis (PCA) ordination of sampling stations based on sampling locations
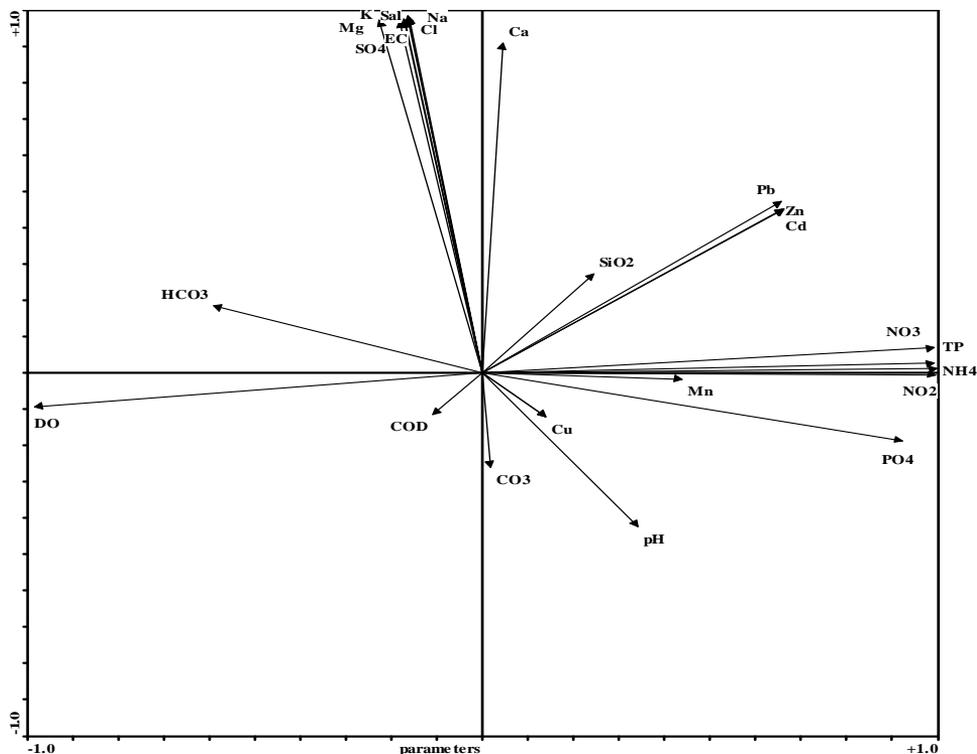
Fig. (15): Principal component analysis (PCA) ordination of sampling stations based on studied parameters

REFERENCES

Abbassy M.S.; Ibrahim H.Z. and Abdel-Kader H.M. (2003). Persistent Organochlorine Pollutants in the Aquatic Ecosystem of Lake Manzala, Egypt, Bull. Environ. Contam. Toxicol., 70: 1158–1164.

Abdel Baky, T. E. (2001). Heavy metals concentrations in the cat fish Claries gariepinus from River Nile, El-Salam Canal and Lake Manzala and their impact on cortisol and thyroid hormones, Egypt. J. Aqua. Biol. & fish., 5 (1): 79 – 98.

Abdel Baky, T. E. and Zyadah, M. A. (1998). Effect of accumulation of copper, cadmium and zinc on some biological parameters of some marine fishes

from the northern region of Lake Manzala, Egypt. J. Egypt. Ger. Soc. Zool. 27(B): 1-19.

Abdel Baky, T. E.; Hagras, A. E.; Hassan, S. H. and Zyadah, M. A.(1998). Environmental impact assessment of pollution in Lake Manzala. 1-Distribution of some heavy metals in water and sediment. J. Egypt. Ger. Soc. Zool., 26 (B): 25-38.

Abdel Satar, A. M. (2001). Environmental studies on the impact of the drains effluent upon the southern sector of Lake Manzala, Egypt, Egypt. J. Aquat. Biol. & Fish., 5(3): 17- 30.

Aboul–Kassim, T. A. (1987). Cycles of carbon, nitrogen and phosphorus in the marine environment in Alexandria region. M. Sc. Thesis. Fac. Sci. Alex. Univ., 233pp.

Ali, M. H. H and Fishar, M. R. (2005). Accumulation of trace metals in some benthic invertebrate and fish species relevant to their concentration in water and sediment of Lake Qarun, Egypt. Egypt. J. Aquat. Res., 31: 289 – 302.

American Public Health Association (APHA) (1992). Standard methods of the examination of water and waste water. 17th edition, AWWA, WPCF, 1015P.

Ay, O.; Kalay, M.; Tamer, L. and Canli, M. (1999). Copper and lead accumulation in tissues of a freshwater fish *Tilapia zillii* and its effects on the branchial Na,K-ATPase activity, Bull. Environ. Contam. Toxicol, 62: 160-168.

Berg, H.; Kiibus, M. and Kautsky, N. (1995). Heavy Metals in Tropical Lake Kariba, Zimbabwe. Wat., Air, & Soil Poll., 83 (3/4): 237-252

Chaphekar, S. B. (1991). An overview on bioindicators, J. Environ. Biol., 12: 163-168.

Cole, G. A. (1979). Text book of limnology. 2nd Edition, St. Louis, Toronto, London, C.V. Mosby Company

Cooper, A.B. (1990). Nitrate depletion in the riparian zone and stream channel of a small headwater catchment. Hydrobiol., 202: 13-26.

Diaz, P.; Guerrero, M. C.; Alcorlo, P.; Baltanas, A.; Florin, M. and Montes, C. (1998). Anthropogenic perturbations to the trophic structure in a permanent hypersaline shallow lake. La Salada de Chiprana (North-Eastern Spain). International Journal of Salt Lake Research, 7: 187-210.

Dowidar, A. A. and Hamza, R. W. (1983). Primary productivity and biomass of Lake Manzala. Rapp. Comm. Int. Mer. Medit., 28: 6-12.

El-Bokhty, E. E. B. (1996). Distribution of bottom fauna in Lake Manzala in relation to prevailing environmental conditions. M. Sc. Thesis, Fac. Sci. Tanta Univ., Egypt, 124pp.

El-Enani, H. R. (2004). Ecological and biological studies on Lake El-Manzala with special reference to their water quality and sediment productivity. M. Sc. Thesis, Fac. Sci., Al Azhar Univ., 358 pp.

Elewa, A. A.; Saad, E. A.; Shehata, M. B. and Ghallab, M. H. (2007). Studies on the effect of drain effluents on the water quality of Lake Manzala, Egypt. J. Aquat. Biol. & Fish., 11(2): 65 – 78.

El-Gawady, M. (2002). Study on microbial pollution types in Manzala Lake. M.Sc. Thesis, Fac. Agri. Mans. Univ.

El-Ghobashy, A. E. (1990). Bilological studies on the Western region of Lake Manzala Ph.D. Thesis. Fac. Sci. Mans. Univ. 279 pp.

El-Naggar, M. M.; Hagras, A. E.; Ogawa, K.; Hussein, A. B. and El-Naggar, A. M. (2000). A correlation between heavy metals in water and gills of *Oreochromis niloticus* and *Tilapia zillii* and the intensity of their parasitic monogeneans at Manzala Lake and the River Nile in Egypt. J. Egypt. J. Egypt. Ger. Soc. Zool., 32(D): 189- 204.

El-Rakaiby M. L. and Youns H. A. (1993). Morphological and temporal studies of Manzala Lake area and Damietta-Port Said Coast, Egypt using remote sensing Technology. Egypt J. Remote Sensing, (1): 55-66.

Fathi, A. A. and Abdelzahar, H. M. A. (2003). Limnological studies on the wetland Lake El-Manzala, Egypt, Bull. Fac. Sci. Assiut. Univ., 32(2-D): 215-233.

Fathi, A. A.; Abdelzahar, H. M. A.; Flower, R. J.; Ramdani, M. and Kraiem, M. (2001). Phytoplankton communities in North African wetland Lakes: the CASSARINA Project. Aquatic Ecology, 35 (3-4): 303-318.

Flower, R. J. (2001). Change, stress, sustainability and aquatic ecosystem resilience in North African wetland lakes during the 20th century: an introduction to integrated biodiversity studies within the CASSARINA Project. Aquatic Ecology, 35(3-4): 261-280.

Frihy, O.; Dewidar K.; Nasr S. and El Raey, M. (1998). Change detection of the northern Nile delta of Egypt: shoreline changes, Spit evolution, margin changes of Manzala lagoon and its islands. Int. J. Remote Sensing, 19: 1901–1912.

Gad, N. S. (2005). Impact of environmental pollution in the southern region of Lake Manzala Egypt on some biochemical parameters of *Tilapia zillii*, J. Egypt Ger. Soc. Zool. comparative physiology, 48(A): 279- 298.

Hutchinson, G. E. (1957). A treatise on limnology. 1. Geography, Physics and Chemistry. John Wiley and sons,. New York, V.I.P.XIV+1015 pp.

Khalil, M. T. (1990). The physical and chemical environment of Lake Manzala, Egypt. Hydrobiol., 196: 193- 199.

Khalil, M. T. and Bayoumi, A. R. (1988). Fishery assessment survey of Lake Manzala, Egypt, Bull. Nat. Inst. Oceanogr. & Fish., ARE, 14(3): 139-154.

Khalil, M. T. and El-Awamri A. A. (1988). Plankton organisms as bio indicators for organic pollution at the southern area (El-Genka) of lake Manzala, Egypt. The First National Conference on Environmental Studies and Research- June 1988 Cairo, Egypt.

Mabrouk, D. B. M. (2004). Aspects of Manzala Lake pollution on Mugil species. Ph. D. Thesis, Zool. Dep., Girl's College. Ain Shams Univ.

Mullin, J. B. and Riely, J. P. (1956). The spectrophotometric determination of nitrate in natural waters, with particular references to see water; Bull. Analytica, chemica ACTA, 12 : 479- 480.

Pulmmer, J.; Jones, B. and Truesdell, A. (1984). WATEQ-A FORTRAN IV version of WATEQ, a computer program for calculating chemical equilibrium of natural waters. Water Resources Investigations U.S. Geological Survey, 76: 31.

Roesijadi G. and Robinson, W. E. (1994). Metal regulation in aquatic animals: Mechanisms of uptake, accumulation and release. In: Aquatic Toxicology; Molcular biochemical and cellular perspectives (ed. Malins D. C.; Ostrander G. K.), Lewis Publishers, London, pp.539pp.

Romairo, R. P.; Boyd, C. E. and Collins, W. J. (1978). Predicting nighttime dissolved oxygen decline in ponds used for Tilapia culture. Trans. m. Fish. Soc., 107: 804 – 808.

Saad, M. A. H. (2003). Impact of diffuse pollution on the Socio-economic development opportunities in the coastal Nile Delta Lakes, Diffuse Pollution Conference Dublin 2003.

Said, M. A. (1992). Detailed variations in mean temperature and heat content of some Egyptian lakes. Bull. Nat. Inst. Ocean.& Fish., Egypt., 18: 11-23.

Sanchez-Pérez, J. M. and Trémolières, M. (1997). Variation in nutrient levels of the groundwater in the Upper Rhine alluvial forests as a consequence of hydrological regime and soil texture. Global Ecology and Biogeoraphy Letters., 6: 211 – 217.

Sayyah, S. M.; Elewa, A. A..; Latif, A. F. A. and Touffek, A. F. (1988). The major anions and cations in Lake Nasser- River Nile water at Aswan, Egypt. bull. Inst. Oceanogr. & Fish., ARE, 14(3): 213-226.

Shakweer, L. (2005). Ecological and fisheries development of Lake Manzala (Egypt). 1- Hydrography and chemistry of Lake Manzala. Bull. Nat. Inst. Oceanogr. & Fish., 31(1): (251-270).

Spotte, S. (1979). Seawater aquarium: the captive environment. John Wiley and Sons, N. Y., 413 pp.

Sung, W. and Morgan, J.J. (1981). Geochem. Cosmochim. Acta, 45: 2377-238.

Ter Braak, C. F. (1987). CANOCO – a FORTRAN program for canonical community ordination by partial detrended canonical correspondence analysis, principle component analysis and redundancy analysis (Version 3.1) Agriculture Mathematics Group, Wageningen.

Verschuren, D.; Edgington, D. N.; Kling, H. J. and Johnson, T. C. (1998). Silica depletion in Lake Victoria: Sedimentary signals at offshore stations. J. Great Lakes Res., 241: 118 – 130.

Wetzel, R. G. (1983). Limnology. Saunders College Publishing. 2nd Edition. 767 pp.

WHO (1992). World Health Organization for inorganic constituents of health significance and European Economic Community Standards for parameters Water Quality Standards and Goalls, New York, 1271 pp.

Yacoub, A. M.; Siliem, T. A.; Kadry, S. M. and Mabrouk, D. B. (2005). Effect of drainage water on the chemical characteristics of Lake Manzala waters, Egypt. J. Egypt. Acad. Soc. Environ. Develop., (D- Environmental Studies). 6(1): 133-152.