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ECOLOGICAL AND FISHERIES DEVELOPMENT OF LAKE MANZALAH (EGYPT)
1. HYDROGRAPHY AND CHEMISTRY OF LAKE MANZALAH

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ABSTRACT

Lake Manzalah; the largest delta Lake in Egypt represents a dynamic system that has been undergoing continuous and pronounced changes since long times. In the last year's this Lake faced drastic problems that retarded its environmental and fisheries development; the most serious one is the discharge of waste water. It is attempted in the present study to investigate the chemical characters of Lake Manzalah water during 2001-2002. Water temperature ranged from an average of 12.35°C in January and 29.14°C in July. Dissolved Oxygen, pH and total dissolved solids were found in ranges optimum for the living of marine and freshwater fish species. The average concentrations of nutrients lied in the following ranges:

1.24 to 4.89 µmol PO_4^{-3} l^{-1} , 5.08 to 28.73 µmol SiO_4^{-2} l^{-1} and 1.81 to 17.7 µmol NO_3^{-1} l^{-1}

The concentrations of phosphorus and nitrogen compounds were found to be relatively higher at the southern regions of the Lake near to the outlets of the drains.

INTRODUCTION

The lakes and rivers of the Nile Delta region represent a dynamic system that has been undergoing continuous and pronounced changes since long times.

One of these Lakes is Lake Manzalah which is the largest among them, situated at the North Eastern part of the Nile Delta between the Suez Canal and Damietta Nile branch. The northern border of the Lake is separated from the Mediterranean Sea by a narrow sandy fringe while its Southern side is bordered by fish farms and cultivated land.

At the beginning of the present 20th centaury the surface area of the Lake was about 420.000 feddans. Because of the continuous processes of land reclamation for agriculture, the area has gradually decreased reaching in 1980 to about 200.000 feddans (Macleren, 1981).

To deal with the problems concerned with fisheries development of natural aquatic habitat, it is necessary to investigate the hydrographic and chemical characteristics of the water body.

In fact, Lake Manzalah is affected by various external factors, the most important of which are, the progressive increasing of industrial and agricultural waste water discharge.

The biological domination man exerts over most aquatic environments not only upsets interrelationships of aquatic environments but enters the picture in other ways, most commonly, in water pollution from organic wastes, commercial fertilizers, chemical wastes, pesticides and slit. These pollutants are damaging to aquatic organisms specially fishes. It is doubted that the aquatic environment is capable to absorb the effects of these pollutants without being detrimental to the living resources. The present study aims to study the chemical composition of Lake Manzalah water. This may contribute in understanding to what extent is this water body affected by the waste water discharge into the Lake.

Area of investigation:

Lake Manzalah is almost rectangular in shape with a long axis running from the North West to South East. A characteristic feature of Lake Manzalah is the presence of a large number of islets, of sand or clay mixed with Lamellibranch shells. Malati, (1960) mentioned 1022 islets of a total area 3137 feddans. These islets divide the Lake into about 30 basins. Most of these islets are inhabited by fishermen and farmers.

Lake Manzalah (Fig.1): is connected to the Mediterranean Sea through the main opening at Al-Gameel region, West of Port Said, and it is connected with the Suez Canal through a small canal at Al-Gabouty near Port Said. Highly productive fresh waters of the Nile enrich the Lake through three canals originating from the Damietta Branch; Al-Enania, Al-Rotma and Al-Sufara canals. On the other hand, the Lake is enriched by drainage water transplanted by five main drains which are connected to the Lake at the South and South Eastern Borders. These drains are Al-Serw, Al-Gamaliah, Bahr Hadus, Ramsis and Bahr-Bagar.

The bottom of Lake Manzalah is covered with silty clay and sandy silty clay in the Southern part. The Western and South-Western Regions have bottoms covered with silty clay. The central regions of the Lake are mainly covered with clayed sand (El-Wakeel and Wahby, 1970 b). Further to the North East; the Lake bottom is composed of silty clay. The Lake bottom is contaminated with different accumulations of lamellibranches.

Three regions constituting the bulk of Lake Manzalah were described by El-Wakeel and Wahby (1970,a) as follows:

a- South Eastern region: This region receives its water from Hadus and Bahr El-Bagar drains.

b- Second region extending along the route connecting Mataria to Port Said.

c- Third region occupying the Western Side of the Lake and it receives fresh water from Sufara, Ratma and Enaniya canals. This area is affected also by the water coming from Faraskour Barrage.

MATERIAL AND METHODS

Bimonthly surface water samples were collected from Lake Manzalah during the period from March 2001 to January 2002. Sampling stations are given in Fig. (1). Plastic Ruttner water sampler of 2 liters capacity was used for water sampling.

Water temperature was measured using 0.1˚C graduated thermometer. This thermometer was protected in a metallic case in which the water enters through holes in such case to keep on the constancy of water temperature for a while.

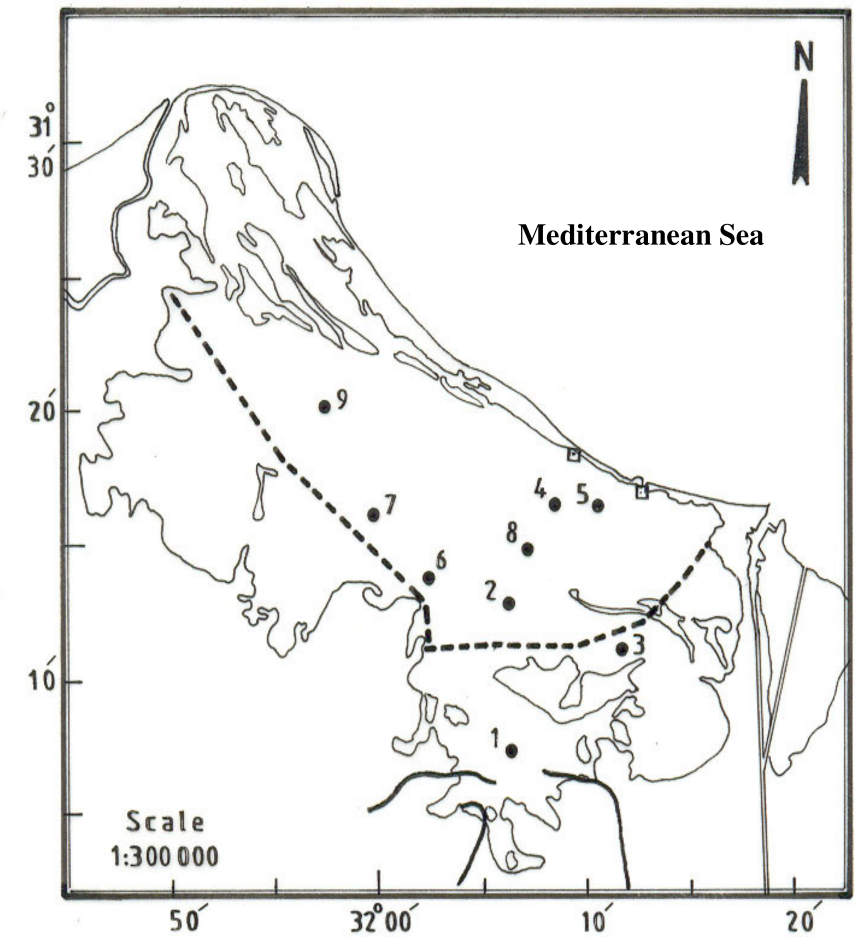
Circular White Secchi Disc 25 cm in diameter was used for determining the turbidity of water.

The pH values were measured by using a portable glass electrode pH meter (Lutron Research model 206).

Dissolved oxygen was determined by the Azide modification of Winkler method according to APHA (1985).

Total dissolved solids were measured as grammes dissolved in one liter of water. These measurements were carried out by the use of pH/ conductivity/ TDS/ meter EXTECH model "Oyster".

Nutrient Salts, nitrates, nitrites, ammonia, dissolved inorganic phosphorus and silicate were determined spectrophotometrically according to Grasshof (1976). A Shimadzue double beam spectrophotometer UV-150-02 was used for measurements.



Lake Manzalah

Fig. 1: Map of Lake Manzalah showing the main drains and location of the sampling stations.

The main basins are:

1. Bahr Genka	**2. Bahr Lagan**	**3. Bahr Bashtir**
4. Bahr Kassab	**5. Bahr El-Gainil**	**6. Bahr Deshdee**
7. Bahr Abwat	**8. Bahr Kurumulls**	**9. Bahr El-Zarka**

RESULTS AND DISCUSSION

a- Physical Parameters:

1. Winds:

The wind plays an important role in the limnological properties of the North Delta Lakes of Egypt. It has a mixing action reducing any chemical- physical stratification due to the shallowness of the Lake. It affects the Lake also by agitation of the bottom sediments. This process may help in librating the absorbed and regenerated nutrient salts from the bottom. Wind action assist also in dissolving atmospheric Oxygen required for the metabolic activities of various organisms.

The strong northern winds blowing steadily from March to September pile up the sea water along the coast resulting in rising the sea level and may contribute in transporting the sea water into the Lake.

The directions and speeds of winds blowing on Lake Manzalah during the whole year can be briefly indicated as follows:

During winter season the winds at Port Said blow mostly from NE, NW and SW, with velocities from 1 to 21 knots, mostly from 4-10 knots

During spring season the winds blow mostly from NW, less from SE and S with velocities ranging from 1 to 21 knots, moderately from 4 to 6 knots.

The summer season is characterized by calm winds (NW), with velocities from 1-16 knots, moderately from 1-3 knots NW winds.

During autumn the winds blow mostly from NW and NE, with velocities ranging from 1 to 16 knots, and moderately from 4 to 6 knots.

2- Temperature:

Due to the shallowness of Lake Manzalah together with the common mixing of water by wind, the thermal stratification was difficult to be established in the water body of the Lake. (Wahby *et al*, 1972).

The recorded water temperature at the various sampling stations are given in tables (1 to 6) and graphically shown in Fig (2).

It can be observed from the data given that:

a- The minimum water temperature was recorded during January when water temperature ranged from 11.0˚C to 13.0˚C , this agrees with El-Arabi, (1990).

b- The maximum water temperature was recorded during July ranging between 27.0˚C and 30.0˚C with an average of 29.0˚C, as recorded by El-Araby, (1990)

c- The water temperature started to increase gradually from February to reach the maximum in July where it began to decrease gradually reaching its minimum in January.

d- The difference in water temperature did not exhibit large values from one station to another.

Beside temperature effect on the chemical and physical characteristics of the environment, it has a great effect on the vital activities of the living organisms. Temperature influences the total standing crop of phytoplankton where it decreases during winter and regains its maximum during spring and summer. Dissolved oxygen as well is influenced by temperature, since reverse correlation has been existed between dissolved oxygen and temperature Saad, (1987). Prepas and Trew, (1983) found that temperature influences on phosphorus release where it increases in summer. In addition, it is well known that fish is sensitive to temperature variations.

3- Transparency:

Transparency can be considered as an indicator for the penetration of the light passing through the water. It is known that the water transparency is generally low at the North Delta Lakes of Egypt. This attributed to their shallowness and the continuous disturbance of the mud bottom by wind action.

The recorded Sechi depth readings throughout the period of the present investigation at the various sampling stations are shown in table (1 to 6).

The data given in these tables indicate that:

a- The lowest Sechi-depth 40.0 cm to 120.0cm were recorded during January, such recorded low transparency may be attributed to the stormy wind which usually blow upon the Lake during this month. This leads to agitation of the bottom sediments and rise the turbidity of water.

b- The low transparency recorded during May, can be attributed to the continuous blooming of phytoplankton. Guerguess, (1979) pointed out that the phytoplankton community is flourished at Lake Manzalah during February and April.

c- Station (8) located in the area near the Lake sea connection was found to be the most transparent station at the Lake where its transparency ranged from 130 cm and 200 cm during the whole period of the present study. The high transparency of this area may have resulted from its high depth in comparison with the other areas of the Lake.

As for the effect of turbidity on the aquatic environment, it was found that turbidity directly affect fish as the turbid water reduces the natural food availability as well as reducing their growth rates (hepher and Pruginin, 1981).

Welch, (1952) pointed to both the favorable and unfavorable influences of light reduction caused by turbidity. He indicated that its favorable effect appears in the protection of aquatic biota against excess light while the most drastic unfavorable effect is its inhibition of the photosynthetic activity (winter, 1975).

b- Chemical Parameters

1. Hydrogen ion concentration:

The Hydrogen ion plays an important role in many of the life processes and living organisms in the aquatic environment. Measurement of pH in the aquatic habitat is essential as it reflects the biological activity and changes in the water as well as the extent of water pollution.

In general the pH is a result of interaction of numerous substances dissolved in water. The importance of such factor arises from the fact that the marine organisms are usually adopted to an average pH value and do not withstand sudden changes.

Ness, (1949) indicated that fish are able to be alive in water having pH range from 5.0 to 10.0 where at pH 5.5 fish develop hypersensitivity to bacterial infections and usually die within short time if the pH is low as or lower than 4.50. Moreover, very hard waters are sometimes toxic to fish.

The pH values recorded at the different stations of Lake Manzalah are indicated in tables (1-6) and illustrated in Fig. (3).

The data given indicated that:

1- Station (1) El-Genka exhibited mostly lower pH values in comparison with the other sampling areas of the Lake. Guerguess, (1979) found in Lake Manzalah that the minimum pH values were recorded at this area where it varied between 7.0 to 7.80 with an average of 7.46. He attributed the decrease of pH values at this area to the high rates of waste water discharge from three drains at this polluted region.

The present data are in support with the results given by El-Shebly (1994), Sabbak *et al* (1987), Ibrahim *et al* (1987), and El-Hehyawi (1977) who found that the pH was low at El-Genka area as a result of the discharge of drains. They attributed such pH decrease to the decomposition of organic matter on the bottom of such area.

2- The pH values recorded in the Lake throughout the period of the present study showed optimum condition for the living of various fish species.

Table (1): Hydro-chemical parameters at Lake Manzalah during March 2001.

Station No.	Water temp. °C	Depth (cm)	Sechi depth (cm)	pH	Dissolved O_2 (mgl^{-1})	T.D.S. gl^{-1}	NH_4^{+1} μml^{-1}	NO_2^{-1} μml^{-1}	NO_3^{-1} μml^{-1}	SiO_4^{-2} μml^{-1}	PO_4^{-3} μml^{-1}
1	16.40	150.0	50.0	8.61	7.3	2.54	7.69	12.16	17.154	7.329	11.868
2	16.30	120.0	30.0	8.32	7.9	5.60	1.55	0.85	11.846	9.844	4.343
3	18.20	150.0	70.0	8.68	8.5	2.17	1.08	0.79	1.826	2.472	6.423
4	18.10	150.0	70.0	8.54	8.5	2.11	0.58	0.26	1.826	3.793	1.770
5	17.30	170.0	70.0	8.61	8.5	2.70	0.92	0.41	0.807	6.733	0.979
6	17.40	120.0	30.0	8.45	8.2	3.55	1.31	0.82	5.562	5.710	4.282
7	17.30	170.0	70.0	8.72	8.0	2.44	0.73	0.21	2.929	4.432	3.119
8	16.20	190.0	160.0	8.07	8.3	1.68	0.42	0.00	1.613	2.088	7.769
9	16.10	150.0	60.0	8.19	7.5	13.60	0.94	0.36	1.444	3.281	3.426
Average	17.03	152.22	67.78	8.47	8.08	4.04	1.69	1.76	5.00	5.08	4.89
S.D. ±	0.81	22.79	38.33	0.23	0.44	3.77	2.28	3.91	5.71	2.55	3.36

Table (2): Hydro-chemical parameters at Lake Manzalah during May 2001.

Station No.	Water temp. °C	Depth (cm)	Sechi depth (cm)	pH	Dissolved O_2 (mgl^{-1})	T.D.S. gl^{-1}	NH_4^{+1} μml^{-1}	NO_2^{-1} μml^{-1}	NO_3^{-1} μml^{-1}	SiO_4^{-2} μml^{-1}	PO_4^{-3} μml^{-1}
1	24.70	150.0	50.0	7.70	6.99	2.96	0.603	1.771	4.883	6.989	3.854
2	24.40	150.0	60.0	8.70	6.27	5.50	1.154	3.695	1.911	7.969	5.873
3	24.60	200.0	70.0	8.70	10.20	3.75	0.446	1.668	1.911	5.455	0.795
4	26.30	150.0	60.0	7.90	9.30	2.65	0.262	2.129	2.972	5.625	1.224
5	26.40	170.0	50.0	7.90	6.85	4.68	0.866	2.823	3.078	6.946	3.793
6	25.20	120.0	50.0	8.80	8.31	5.07	0.787	1.796	1.911	6.861	1.713
7	25.30	170.0	40.0	8.40	6.56	2.84	0.446	2.412	2.759	6.608	2.141
8	26.20	200.0	200.0	8.30	8.60	2.00	0.446	1.617	2.017	8.395	0.856
9	24.10	120.0	50.0	8.40	7.29	9.76	0.787	2.643	2.866	7.884	3.119
Average	25.24	158.89	70.00	8.31	7.82	4.36	0.64	2.28	2.70	6.97	2.60
S.D. ±	0.87	29.34	49.50	0.40	1.35	2.35	0.28	0.69	0.96	1.01	1.70

Table (3): Hydro-chemical parameters at Lake Manzalah during July 2001.

Station No.	Water temp. °C	Depth (cm)	Sechi depth (cm)	pH	Dissolved O_2 (mgl^{-1})	T.D.S. gl^{-1}	NH_4^{+1} μml^{-1}	NO_2^{-1} μml^{-1}	NO_3^{-1} μml^{-1}	SiO_4^{-2} μml^{-1}	PO_4^{-3} μml^{-1}
1	27.02	150.0	80.0	7.90	7.143	1.97	0.000	9.186	10.275	0.742	2.997
2	28.03	120.0	30.0	8.10	9.184	2.79	0.918	0.154	1.677	8.924	2.079
3	30.05	120.0	50.0	8.10	6.268	2.08	0.000	0.154	0.509	9.221	0.612
4	29.04	150.0	60.0	8.30	6.850	1.91	0.000	0.703	1.146	15.785	0.734
5	30.01	120.0	60.0	8.20	9.038	2.64	0.105	0.128	9.256	34.322	1.285
6	29.05	150.0	100.0	8.50	8.892	2.84	0.000	0.077	6.539	74.934	0.428
7	30.04	150.0	70.0	8.20	7.289	2.77	2.098	0.103	4.756	31.731	1.346
8	30.03	130.0	130.0	8.30	9.475	2.39	0.656	0.000	5.647	70.587	1.346
9	29.01	120.0	50.0	8.50	10.787	4.64	2.544	0.103	8.365	12.290	0.306
Average	29.14	134.44	70.00	8.23	8.33	2.67	0.70	1.18	5.35	28.73	1.24
S.D. ±	1.06	15.09	30.00	0.19	1.49	0.82	0.98	3.01	3.62	27.21	0.87

Table (4): Hydro-chemical parameters at Lake Manzalah during September 2001.

Station No.	Water temp. °C	Depth (cm)	Sechi depth (cm)	pH	Dissolved O_2 (mgl^{-1})	T.D.S. gl^{-1}	NH_4^{+1} μml^{-1}	NO_2^{-1} μml^{-1}	NO_3^{-1} μml^{-1}	SiO_4^{-2} μml^{-1}	PO_4^{-3} μml^{-1}
1	26.01	170.0	50.0	8.10	7.88	2.15	0.734	3.239	3.269	5.625	2.599
2	27.02	140.0	-	8.50	7.88	1.95	1.705	1.732	1.868	4.773	2.520
3	26.01	150.0	60.0	8.50	7.60	1.55	0.052	0.416	0.934	15.363	1.606
4	27.03	180.0	70.0	8.60	8.16	1.87	0.105	0.609	1.783	7.628	1.147
5	26.12	160.0	60.0	8.60	8.10	2.10	0.085	-	1.415	-	2.115
6	28.14	170.0	70.0	8.60	7.60	2.78	0.000	0.321	0.934	8.267	1.529
7	27.14	160.0	70.0	8.80	7.04	1.99	0.000	0.160	1.444	10.782	0.382
8	28.02	180.0	160.0	8.30	8.20	2.10	0.350	-	1.234	-	1.215
9	27.03	140.0	50.0	8.50	7.32	3.30	5.115	3.368	3.439	3.644	2.294
Average	26.95	161.11	73.75	8.50	7.75	2.20	0.91	1.41	1.81	8.01	1.71
S.D. ±	0.80	15.37	35.83	0.20	0.40	0.53	1.67	1.39	0.93	4.02	0.73

Table (5): Hydro-chemical parameters at Lake Manzalah during November 2001.

Station No.	Water temp. °C	Depth (cm)	Sechi depth (cm)	pH	Dissolved O_2 (mgl^{-1})	T.D.S. gl^{-1}	NH_4^{+1} μml^{-1}	NO_2^{-1} μml^{-1}	NO_3^{-1} μml^{-1}	SiO_4^{-2} μml^{-1}	PO_4^{-3} μml^{-1}
1	16.01	120.0	50.0	8.20	9.913	0.545	24.734	7.621	9.554	6.669	7.035
2	16.02	180.0	70.0	8.60	10.787	1.180	26.255	6.030	6.070	6.925	9.604
3	16.04	140.0	40.0	8.50	9.913	1.080	8.262	5.543	9.934	5.519	6.423
4	16.01	170.0	60.0	8.60	8.163	0.558	0.472	0.103	1.741	3.686	1.591
5	15.02	150.0	50.0	8.60	9.038	0.908	0.341	2.438	8.874	5.518	5.506
6	15.03	150.0	70.0	8.50	8.746	1.640	8.236	11.521	11.677	6.392	6.301
7	16.04	170.0	90.0	8.70	11.370	1.050	0.892	0.231	2.887	3.089	1.346
8	16.01	220.0	200.0	8.80	8.455	1.460	0.682	0.051	4.204	6.371	1.285
9	15.02	120.0	50.0	8.40	7.871	4.750	23.895	7.980	28.873	7.671	3.119
Average	15.69	157.78	75.56	8.54	9.36	1.46	10.42	4.61	9.31	5.76	4.69
S.D. ±	0.50	31.53	49.02	0.17	1.21	1.28	11.36	4.12	8.09	1.51	2.97

Table (6): Hydro-chemical parameters at Lake Manzalah during January 2002.

Station No.	Water temp. °C	Depth (cm)	Sechi depth (cm)	pH	Dissolved O_2 (mgl^{-1})	T.D.S. gl^{-1}	NH_4^{+1} μml^{-1}	NO_2^{-1} μml^{-1}	NO_3^{-1} μml^{-1}	SiO_4^{-2} μml^{-1}	PO_4^{-3} μml^{-1}
1	10.99	130.0	50.0	8.30	8.163	1.44	18.911	7.672	44.243	7.585	2.202
2	12.01	150.0	40.0	8.40	7.580	2.41	49.154	6.466	19.871	10.441	7.096
3	12.03	150.0	40.0	8.70	9.329	1.80	1.626	8.314	41.480	4.773	2.596
4	13.02	150.0	50.0	8.60	9.329	1.76	0.839	0.590	6.114	10.099	0.795
5	12.01	150.0	50.0	8.50	8.455	2.11	0.970	1.771	17.281	3.196	3.976
6	13.04	150.0	40.0	8.60	7.580	1.23	0.970	0.795	5.349	6.222	2.018
7	12.03	150.0	40.0	8.60	8.455	1.97	0.551	0.590	3.057	7.671	0.917
8	13.01	200.0	160.0	8.80	8.163	1.31	1.651	0.385	4.119	5.242	0.184
9	13.02	120.0	40.0	8.60	8.163	1.91	20.799	7.287	18.408	6.648	4.772
Average	12.35	150.00	56.67	8.57	8.36	1.77	10.61	3.76	17.77	6.88	2.73
S.D. ±	0.72	21.79	39.05	0.15	0.64	0.39	16.59	3.54	15.66	2.38	2.21

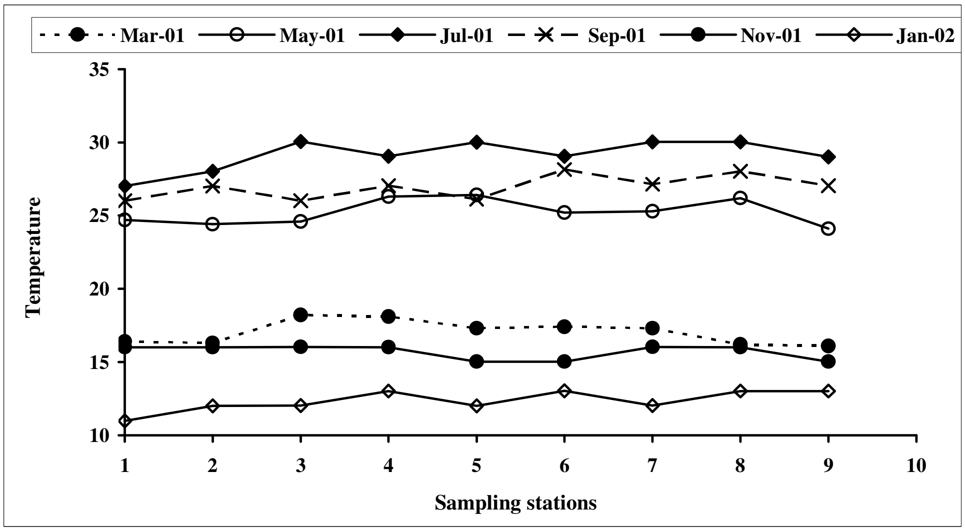


Fig. (2): Monthly variations of temperature at different stations of Lake Manzalah.

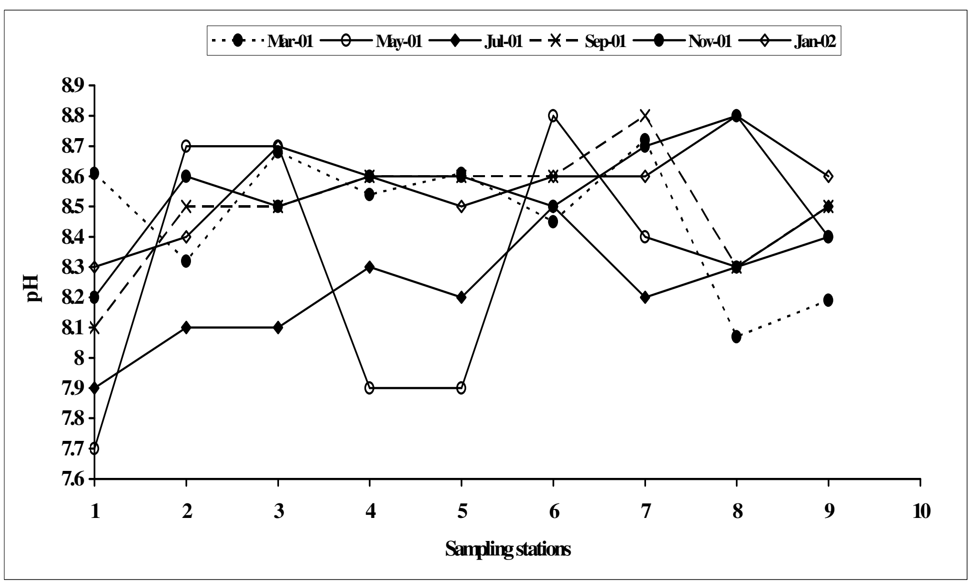


Fig. (3): Monthly variations of pH at different stations of Lake Manzalah.

2- Total dissolved solids:

The total dissolved solids in the water of Lake Manzalah is obviously affected by various factors, the most important of which are the continuous discharge of drainage water and the frequent inrush of seawater through the lake-sea connection. The evaporation accelerated by the high summer temperature as well as the rain water are other factors influencing the total dissolved solids in the lake.

The total dissolved solids (T.D.S.) in the Lake water during the period of the present investigation are given in tables (1 to 6) and graphically represented in Fig. (4). The date given show that in most cases, the South Eastern region of the Lake was characterized by lower values of total dissolved solids if compared with the other regions of the Lake. In fact this region is characterized by receiving high rates of drainage water through Bahr El-Bagar, Ramsis and Hadus drains. The T.D.S. ranged at this area from 0.545 to 2.96 gl^{-1} with an average value of 1.93 gl^{-1}.

Comparatively higher values of T.D.S. were found at the North Eastern area of the Lake, near to the Lake- sea connection (El-Gamil) and (El-Gaboaty openings) where the average value was 6.33 gl^{-1}.

The effect of increasing human activities, mainly industrial, agricultural and mariculture carried out at the areas adjacent to Lake Manzalah, on the Salinity of N.E. area, was observed. The values of salinity, and T.D.S. during 1967 (Youssef, 1967 and 1975, El-Arabi 1990), and 2001 (present study) are given in table (7). Due to the waste water discharge discharge it. It can be emphasized from the data given in this table (7) that El-Gamil area exhibits steady decrease of water salinity where its average value decreased from 17.24% to 5.37% in 1975 and to 2.53 gl^{-1} in 2001. This region while was characterized by high rates of primary and fish production is suffering now from drastic water pollution and decreased rates of fish production.

3. Dissolved Oxygen:

Dissolved oxygen is considered as one of the important factors controlling the biota in the aquatic habitat. Oxygen content can be used as an indicator of organic loading, nutrient input and biological activity (Red field, 1942). Huet, (1979) pointed out that if the decomposing matter is in too great proportion, it will absorb much of the dissolved oxygen in water. The content of dissolved oxygen could then fall below the minimum level acceptable to fish. This threats are particularly great in warm water. The oxygen contents of Lake Manzalah water during the period of study are given in tables (1 to 6) and graphically represented in Fig (5). It is noted from the data given for dissolved oxygen in the various season that:

1- The average values of dissolved oxygen attained the highest figure as 9.36mgl^{-1}in November. The minimum average was found to be 7.75 mgl^{-1} in September. However, it can be observed that the average water temperature was low (15.69^{o}C) during November while it was relatively high (26.95^{o}C) during September. This may indicate that the relative increase in water temperature may contribute in decreasing the dissolved oxygen in the lake water. In this concern El-Shebly, (1994) studied the ecological conditions at Lake Manzalah and found a reverse correlation between dissolved oxygen and temperature.

2- The minimum recorded value of dissolved oxygen in Lake Manzalah was found to be 6.27 mgl^{-1} while the maximum recorded value was 10.78 mg/L. It can be pointed out therefore that the dissolved oxygen in Lake Manzalah water is optimum for the living of fish in the Lake.

3- It is observed that the dissolved oxygen in the water of El-Genka area was in most cases lower than the average values of dissolved oxygen in the whole area of the Lake. This low concentration can be attributed to the high rate of waste water discharge in this area.

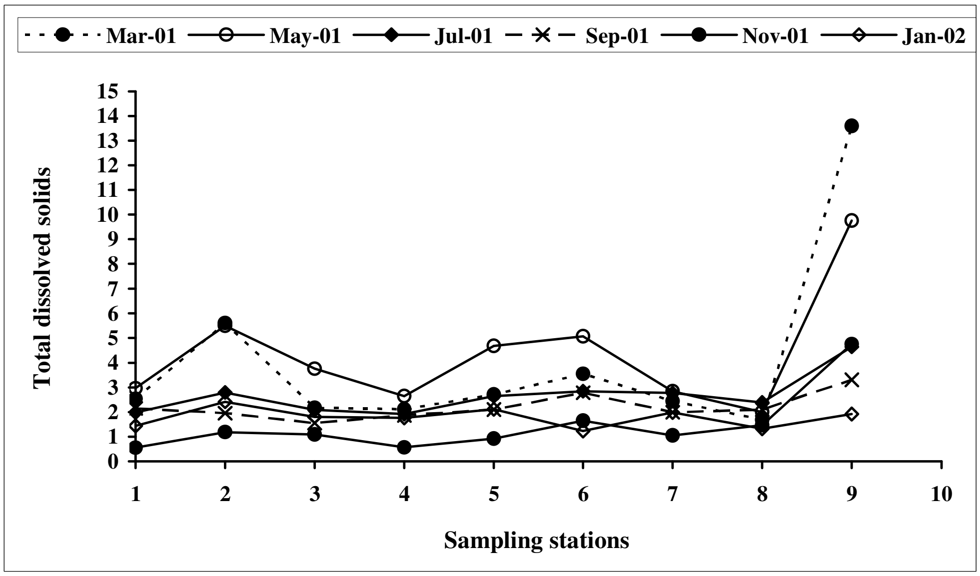


Fig. (4): Monthly variations of total dissolved solids at different stations of Lake Manzalah.

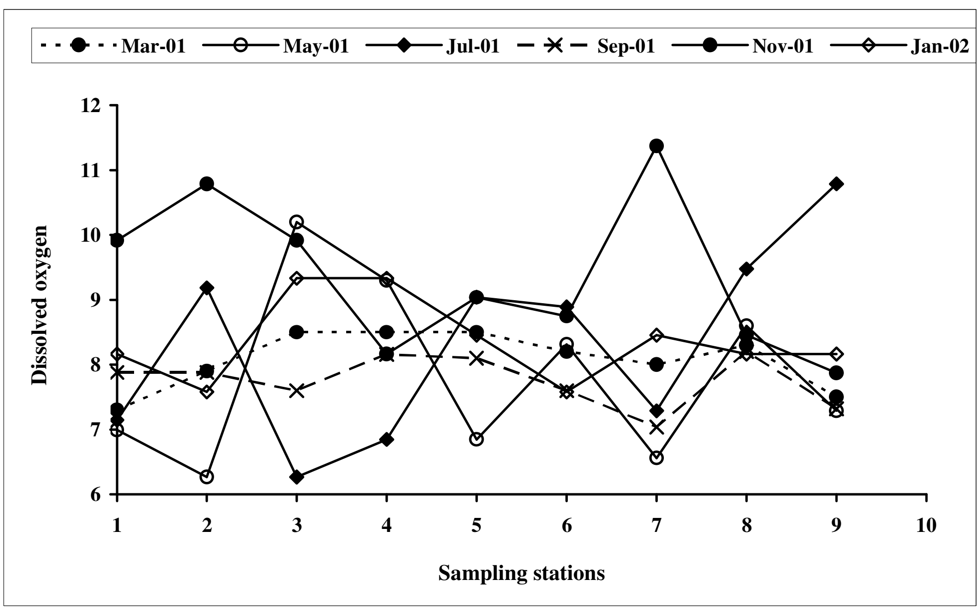


Fig. (5): Monthly variations of dissolved oxygen at different stations of Lake Manzalah.

El-Hehyawi, (1977) and El-Ghobashy, (1990), indicated that the lower values of dissolved oxygen in El-Genka area were due to the consumption of high rate of oxygen in the decomposition of organic matter discharged in this area.

4- Nutrients:

The concentrations of dissolved nutrients in the Lake and their variations are governed by a variety of factors, the most of which are the drainage water input and removal by plant assimilation. The concentrations and distribution of nutrients are also affected by the mixing of lake water through the lake-sea connection. Absorption on suspended particles and subsequent sedimentation may also play an important role in determining the concentrations of nutrients in the Lake water. According to Gureguess, (1979) the total volume of waste water discharged during the period from June to Dec. 1971 was 2.285 x10^9 m^3. In 1972 and 1973 the total input was 4.683 and 4.548-x109 m^3 respectively. Nutrients budgets loading to Lake Manzalah from its different sources as indicated by Towse and Ishak, (1984) are illustrated in table (8). It can be found from the data given that the highest amounts of nitrates and phosphates are discharged to the Lake from Bahr El-Bager.

Inspite of discharging 49% of the total water reaching Lake Manzalah through Hadus drain, it's contributing in the budget of nutrients reaching the Lake was less than that of the first mentioned drain. This means that the concentrations of phosphates and nitrates in Hadus drain are expected to be less than their concentrations in the water of Bahr El-Bagar. The other drains contribute with comparatively less amounts of the nutrient salts. The water discharging mainly from Bahr El-Bagar and Hadus drains affect principally the water of the South Eastern Region of the Lake (El-Genka).

a. Phosphates:

The concentrations of phosphates at the various areas of Lake Manzalah are given in tables (1 to 6) and illustrated by Fig. (6). In general it can be observed that the average phosphate distribution in the Lake reflects the pattern of drainage water to the Lake. Higher concentrations of phosphates ranging from 2.202 to 11.868 μml^{-1} were found at station (1). This station is located at the southern zone of the Lake, near to the out let of Bahr El-Bager.

It can be observed that the concentrations of such nutrient salt decrease gradually away from this area; in other words away from Bahr El-Bagar and Hadus drains. Such decrease results from adsorption, and sedimentation by plant assimilation. Guergeuss, (1979) who pointed out that Bahr El-Bagar drain is the main source of phosphate to the Lake. Near to the outlet of the drain, phosphate concentrations showed high values, where it ranged from 4.01 to 61.44 μml^{-1} with an average of 17.2 μml^{-1}.

However it can be indicated from the data given in the present investigation that the drain water is rapidly diluted as it spread into the Lake. It may be worth to mention that the environmental importance of phosphate at Lake Manzalah arises from its role as a major nutrient for both plants and micro-organisms and it can be considered as a limiting factor.

On the other hand Vanloon and Duffy, (2000) mentioned that the contribution of nutrients in eutrophication are most commonly, the limiting one is phosphorous.

Therefore monitoring and controlling of phosphorous compounds in Lake Manzalah is important due to its vital role in the euotrophication of this Lake.

b. Inorganic nitrogen (Ammonia, Nitrites, and Nitrates):

Inorganic nitrogen compounds exist commonly in the water bodies in three forms namely Ammonia, Nitrites and Nitrates. Vanloon and Duffy, (2000) pointed out that, under aerobic conditions, nitrate is the stable species in water. A low pH state leads to the reduction from Nitrate through nitrite to ammonia in its protonated and unprotonated forms. The concentrations of these three forms depends therefore, mainly on the oxygenation conditions of the water.

Table (7): Average values of salinity and T. D. S. during 1967, 2001 at El-Gamil area of Lake Manzalah

Month	Salinity during 1967 (Youssef, 1973)	Salinity during 1975 (El-Araby, 1990)	T. D. S. 2001 Present study
January	8.11	2.65	2.11
February	16.16	3.82	-
March	15.68	9.97	2.70
April	15.82	7.95	-
May	17.72	4.64	4.68
June	24.75	8.86	-
July	27.13	9.67	2.64
August	25.74	6.43	-
September	16.74	2.28	2.10
October	7.04	3.10	-
November	18.34	2.13	0.95
December	13.70	2.91	-
Average	17.24‰	5.37‰	2.53 ‰

Table (8): Water and nutrients budgets loading to Lake Manzalah according to Towes and Ishak, (1984).

Source	Flow $m^3/10^6$ (Year)	% Of total flow	Nitrogen load (T/Y)	Phosphate. Load (T/Y)	Nutrient load (T/Y)
Bahr El-bagar	1678	25 %	6180	1700	7880
Hadus	3276	49 %	2391	629	3020
Ramsis	252	4 %	160	36	196
Serw	847	13 %	969	153	1222
Mataria	154	2 %	59	28	87
Faraskour	292	4 %	131	40	171
Port Said	40	1 %	596	165	761
El-Enanya canal	156	2 %	-	-	-
Total	6695	100	10486	2751	13237

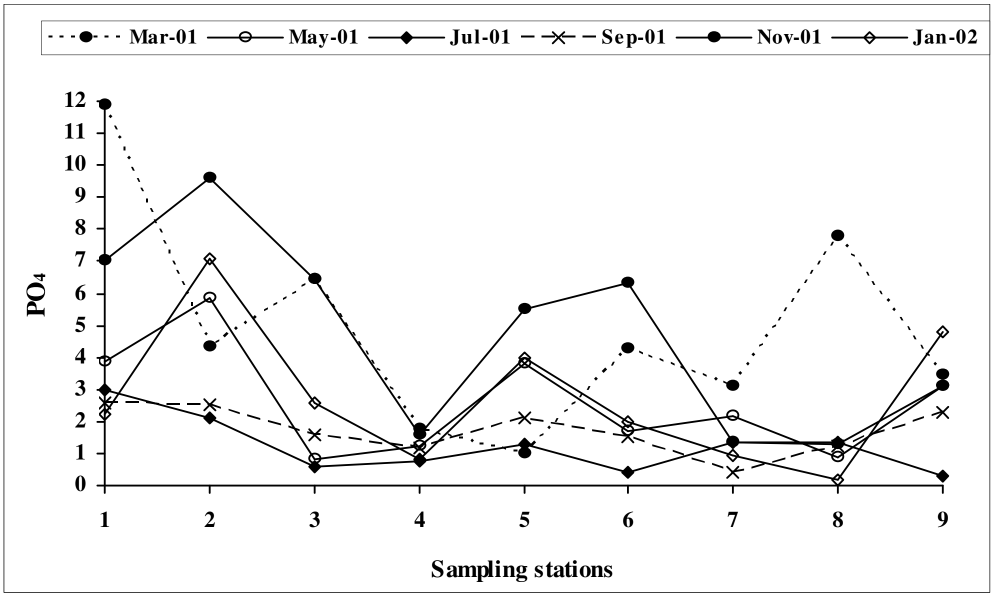


Fig. (6): Monthly variations of total phosphate at different stations of Lake Manzalah.

Ammonia:

The presence of ammonia in the aquatic system may result from the bacterial decomposition of organic matter containing nitrogen. It is also an important excretory product of animals in such systems. The bimonthly concentrations of ammonia as well as its spatial distribution at Lake Manzalah during the period of the present investigation are given in tables (1-6) and graphically represented in Fig (7). It is obvious from the data given that the concentrations of Ammonia were relatively high at the Southern areas of the Lake near to the outlets specially Bahr El-Bagar and El-Serw drains.

The average concentrations of ammonia at the whole area of the Lake ranged from 0.64 μml^{-1} in May to 10.61 μml^{-1} in January. The maximum concentration of ammonia was found to be 49.154 μml^{-1} at station (2) very near to the outlet of Bahr El-Bager drain during January 2002. On the other hand ammonia was not detected of the middle regions of Lake Manzalah during July and September of the year 2001, it can be observed also that the concentrations of ammonia were low during the summer season where its average concentrations were 0.70 μml^{-1} and 0.91μml^{-1} during July and September respectively. These decreased concentrations can be attributed to the utilization of this nitrogen compound by the flourished community of phytoplankton at the Lake. In agreement with that, Abass *et al* (2001) recorded decreasing of ammonia concentrations at Lake Edku during the summer season of the year 2000. In this concern, Hutchinson, (1957) pointed out that the decrease of ammonia concentrations is accompanied with an increasing in plankton population. Harvy, (1974) stated that most species of phytoplankton utilize ammonia ion in preference to other inorganic nitrogen species.

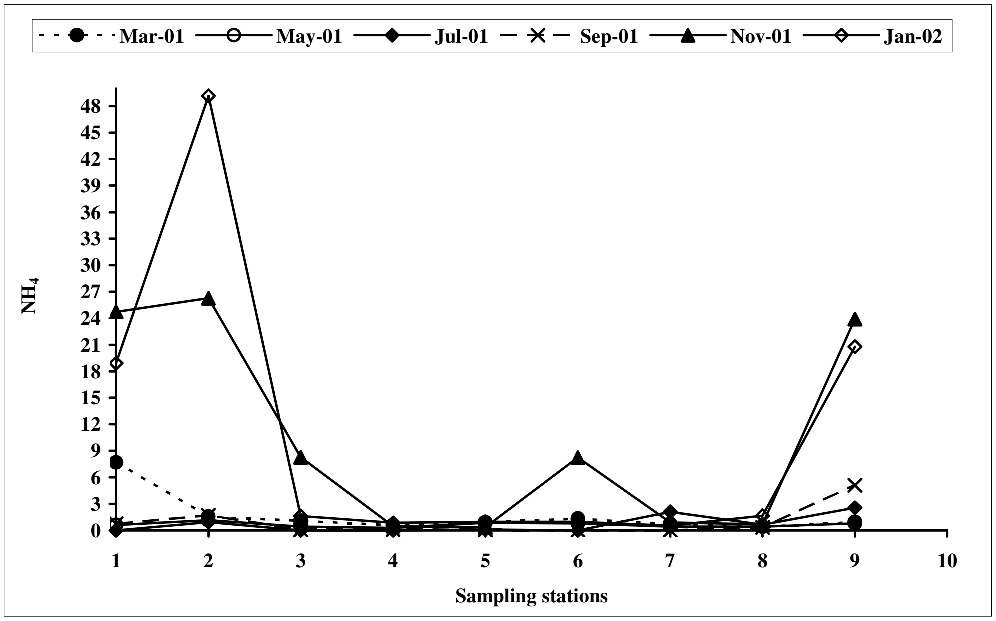


Fig. (7): Monthly variations of total Ammonia at different stations of Lake Manzalah.

Nitrite:

The concentrations of Nitrite ion during the different months of the period of study at Lake Manzalah are given in tables (1-6). An illustration of these concentrations is given in Fig (8). It can be pointed out from the data given that:

1- The average concentrations of nitrite at the whole area of investigation ranged from 1.18µml^{-1} during July to 4.61 µml^{-1} during Nov. of the same year.

2- Higher concentrations of nitrite were recorded in most months at station (1) and (9) near to the outlets of drains at the Southern region of Lake Manzalah.

3- Higher values of nitrite were found during November and January in comparison with the other months of the year. These average concentrations were found to be 4.61 µml^{-1} in November 2001 and 3.67 µml^{-1} in January 2002.

Nitrate:

It is a matter of fact that the Egyptian delta Lakes are characterized by the rapid regeneration of nutrient salts and specially nitrates. The increased discharge of drainage water enriches Lake Manzalah with nitrates. However production of nitrite in the lake is firmly correlated with reduction of nitrates. Vanloon and Duffy, (2000) mentioned that the use of ammonia containing fertilizer (ammonium sulphate, ammonium nitrate and urea) is a good source of ammonium ion in water. In an aerobic condition in the aquatic habitat nitrification takes place converting ammonia and nitrite to nitrate. The concentrations of nitrates at Lake Manzalah during the period of the present investigation are given in tables (1-6) and Fig (9). The data given shows that the concentrations of nitrates were relatively higher at the stations located near to the outlets of the drains specially at stations 1, 2, 3 and 9. The concentrations of nitrates at these stations attained their maximum values during January where these concentrations were 44.243, 19.871, 41.480 and 18.408µml^{-1} respectively.

The average concentrations of nitrates were found to range between 1.81 in September and 17.77 μml^{-1} in January.

c. Silicates:

Diatoms play an important role in influencing the Silicate concentrations in the aquatic habitat. These compounds are utilized by diatoms. The concentrations of silicate in the water of lake Manzalah are given in tables (1-6) and Fig (10). Opposite to the case of other nutrients where their concentrations were higher at the areas near to the outlets of drains, the concentration of silicate did not exhibit significant variations from one station to another with the exception of January. 2002. Higher concentrations appeared at stations 5,6,7 and 8. These stations are located at the middle area of Lake Manzalah along the route connecting Mataria to Port Said.

The following points can be concluded from the present investigation:

(1) The direction and speed of blowing winds as well as the chemical properties of wastes discharged into the Lake are the most important factors affecting the chemistry of Lake Manzalah waters.

(2) The minimum water temperature was recorded with an average of 12.35^oC in January while the maximum was 29.14^oC in July.

(3) The stormy winds that blow up in January increased the turbidity of the Lake water where the average Secchi depth ranged from 40.0 and 160.0 cm with an average of 56.70 cm. On the other hand the most transparent area was found near the Lake-sea connection where the average Secchi depth ranged from 130.0 and 200.0 cm during the whole period of study.

(4) Lower pH values were recorded at El-Genka area which is located to the south of the lake. Decrease of pH values was attributed to the high rates of organic matters decomposition at this area.

(5) The minimum recorded value of dissolved oxygen in Lake Manzalah was found to be 6.27 mgl^{-1} while the maximum was 10.78 mgl^{-1}. this means that the whole water body of the Lake is well oxygenated.

(6) Lower values of total dissolved solids were recorded at the Southern area of the Lake. Where the T.D.S ranged from 0.545 to 2.96 with an average value of 1.93 gl^{-1}. The average value of T.D.S at the northern area was found to be 6.33 gl^{-1}.

(7) The average concentrations of nitrogen, phosphorus and silicon compounds were found to be as follows:

1.24 to 4.89 μml^{-1} for PO_4^{-2}, 5.08 to 28.73 μml^{-1} for NH_4^{+1} 0.64 to 10.61 μml^{-1} for NO_2^{-1}. And 1.81 to 17.77 μml^{-1} for NO_3^{-1}.

Higher concentrations of phosphorus and nitrogen compounds were found at the southern area of Lake Manzalah while relatively higher concentrations of SiO4 occurred at the middle areas of the Lake.

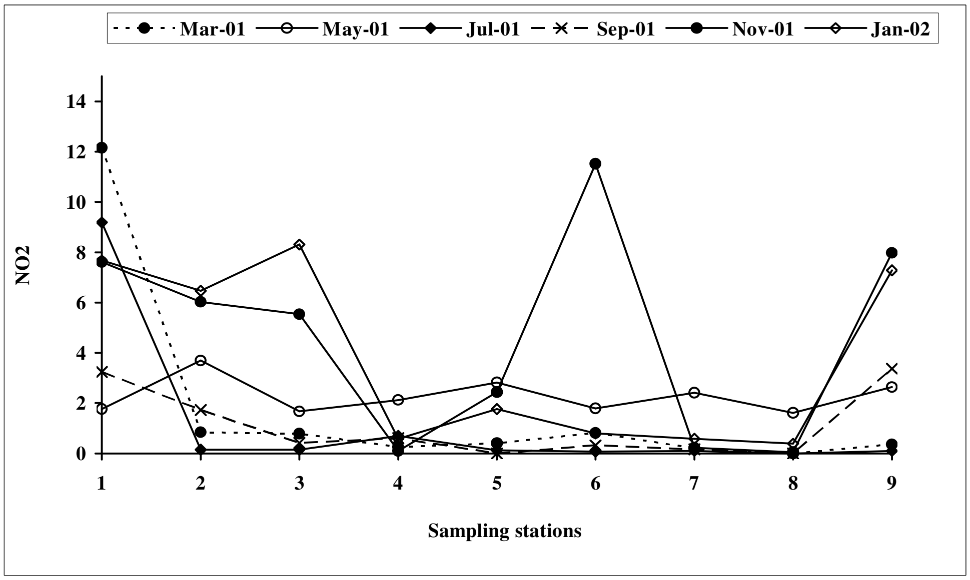


Fig. (8): Monthly variations of total Nitrites at different stations of Lake Manzalah.

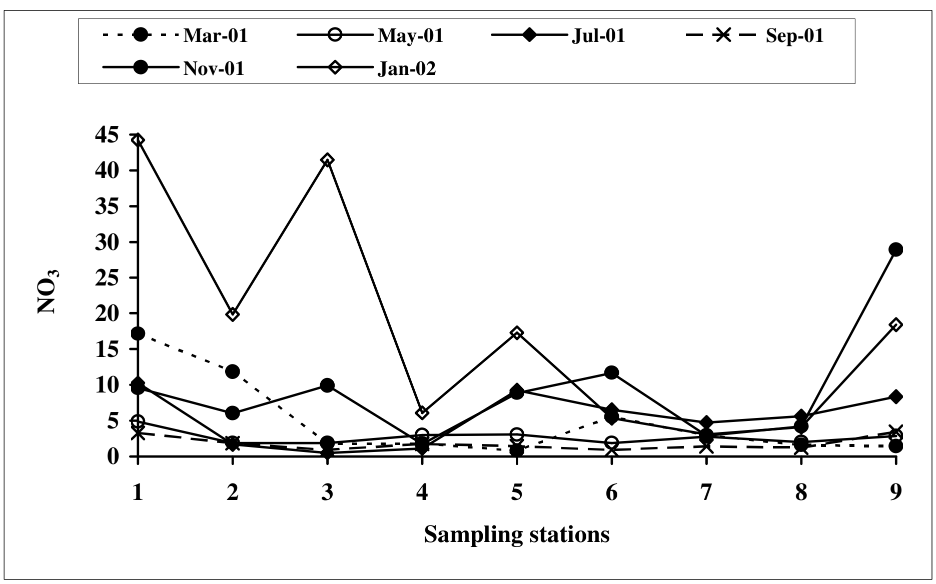


Fig. (9): Monthly variations of total Nitrates at different stations of Lake Manzalah.

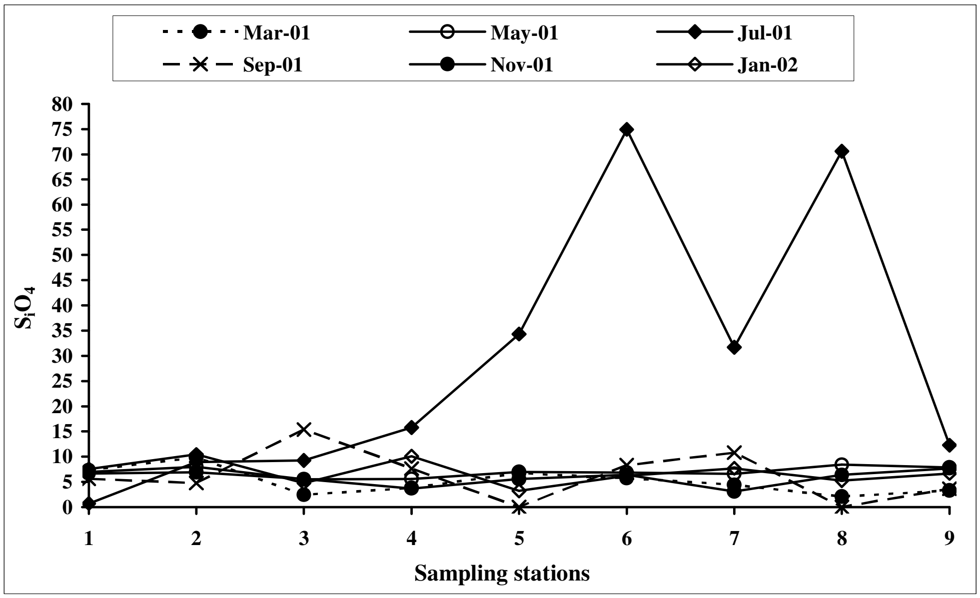


Fig. (10): Monthly variations of total Silicates at different stations of Lake Manzalah.

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