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ECOLOGICAL AND FISHERIES MANAGEMENT OF EDKU LAKE

1. HYDRO-CHEMICAL CHARACTERS OF EDKU LAKE

BY

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Key words: Ecology, Lake Edku, Hydro-chemical parameters

ABSTRACT

The present study deals with the chemical composition of Edku lake water. Seasonal samples were collected from 10 sampling stations covering the open water area of the lake during 1999 2000.

The minimum water temperature was recorded as 15.30°C during winter while the maximum was 26.5°C during summer.

The maximum value of total dissolved solids was found as 5.94 gm L at the area near the lake-sea connection, while the minimum was 1.31gm L at the middle of the lake. The values of total dissolved solids varied between 1.5 and 2.5gm L at the most parts of the lake. Such decrease in water salinity enhanced the flourishment of macrophytes to cover wide areas of the lake. The total dissolved solids in the lake water decreased gradually through the last 10 years.

The dissolved oxygen in the lake water attained high values far from the outlets of Bersik and El-Khairy drains and decreased near these outlets.

It is worth mentioning that, Edku lake receives high amounts of nutrient salts (nitrogen salts, phosphates and silicates) through the drainage water of El-Khairy and Bersik drains.

For about 58% of the collected samples, the percentage of nitrate to total inorganic nitrogen exceeded 75%. This indicates that nitrate

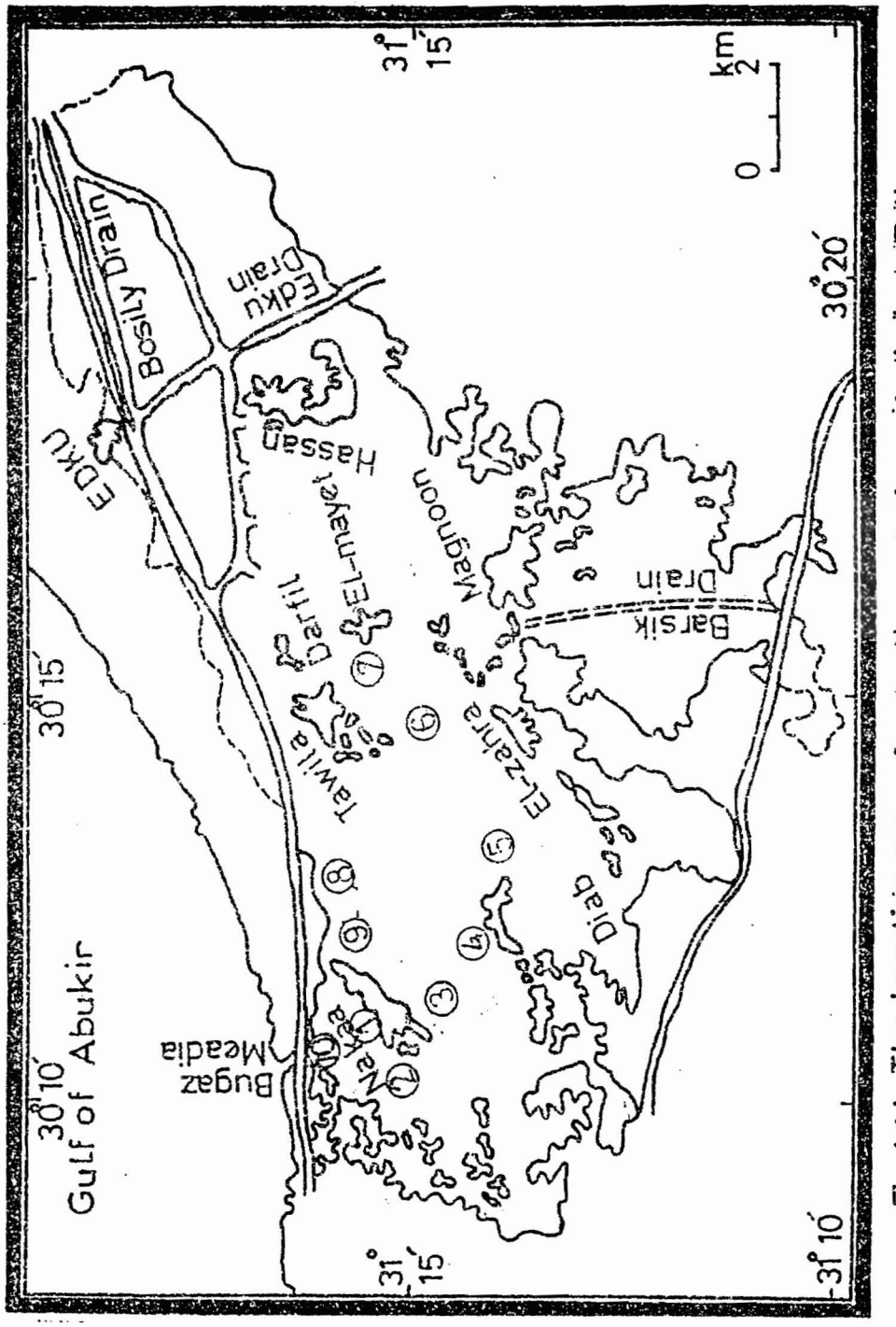

Fig.(1): The location map of sampling stations in Lake Edku.

average depth of about one meter and a surface area of about 17000 feddans. Satellite images taken in 1981 indicated a loss of more than 20% of the lake area through land reclamation since 1923 (Gharib and Soliman, 1998).

The deepest parts of the lake are found at the centre of the lake where it ranges from 90 to 110cm. Most of the area of this lake has a depth ranging between 1.0 and 0.5m. The shallower areas are restricted at the lake margins, around the islands and at Maadiya District.

The bottom of the lake is composed mainly of clay and to a less extent of sand. The percentage of clay increases towards the western section around the lake-sea connection. Plenty of empty shells of Molluscs and calcareous remains as well as barnacles and tubeworms are widely distributed allover the lake bottom (Samaan, 1974).

The lake margin is mostly straight at the northern side while showing plenty of irregularities and boundered by small islands forming sheltered bonds at the western and south-eastern sides. The eastern side of the lake is boardered by a drain which separates a large reclaimed cultivated land which was previously a part of Edku lake.

Due to the shallowness of the lake, the whole area is related to the littoral zone. Thus under favourable conditions, the hydrophytes flourish well and their growth may extend from the margins till the center of the lake (Samaan, 1974).

Two drains namely El-Khairy and Barsik discharge a huge amount of drainage water to the lake. El-Khairy drain is in fact joined to three sources of drainage water coming from El-Bosely, Edku and Damanhour subdrains which transport domestic, agricultural and industrial waste water as well as the drainage water of more than 300 fish farms. Barsik drain transports mainly agricultural drainage water to the lake. This drainage water creates in most times water movement through the lake from both the west and south to the north.

The configuration, hydrography and chemical characteristics of Edku lake have been investigated by many authors: Ezzat (1972), El-Samra (1973), Samaan (1974), Khalil ***et al*** (1977a,b), El-Sabaroti and El-Sokkary (1982),

Soliman (1983), Gharib and Soliman (1988), Hamada (1988), Abou El-Nagah (1991), and Gharib (1998).

MATERIAL AND METHODS

Surface water samples were seasonally collected from 10 stations (Fig.1) representing the whole open area of Edku lake. These samples were collected during 1999-2000 using plastic Ruttner water sampler of 2 liters capacity.

The limit of visibility of the lake water was measured using a white enamelled Secchi disc of 30cm in diameter. Secchi disc measurements were usually carried out on the shaded side of the boat.

Water temperature was measured by using a simple thermometer graduated to 0.1°C. The thermometer was protected in metallic case in which the water enters through it and is trapped when taking the reading of the thermometer.

The pH values were measured using a portable glass electrode pH meter (Lutron Research model 206). Dissolved oxygen was measured by the Azide modification of Winkler method according to APHA (1985).

Dissolved solids were measured as total dissolved solids expressed in 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 nitrate, nitrite, ammonia, dissolved inorganic phosphate, and silicate, were determined spectrophotometrically according to Grasshoff (1976). A shimadzue double beem spectrophotometer UV-150-02 was used for measurements.

RESULTS AND DISCUSSION

Water Temperature:

The water temperature in such shallow lake were recorded at the 10 sampling stations during winter, spring, summer and autumn are given in tables 1-4 and graphically represented in Fig. 2a. The average amplitudes of these

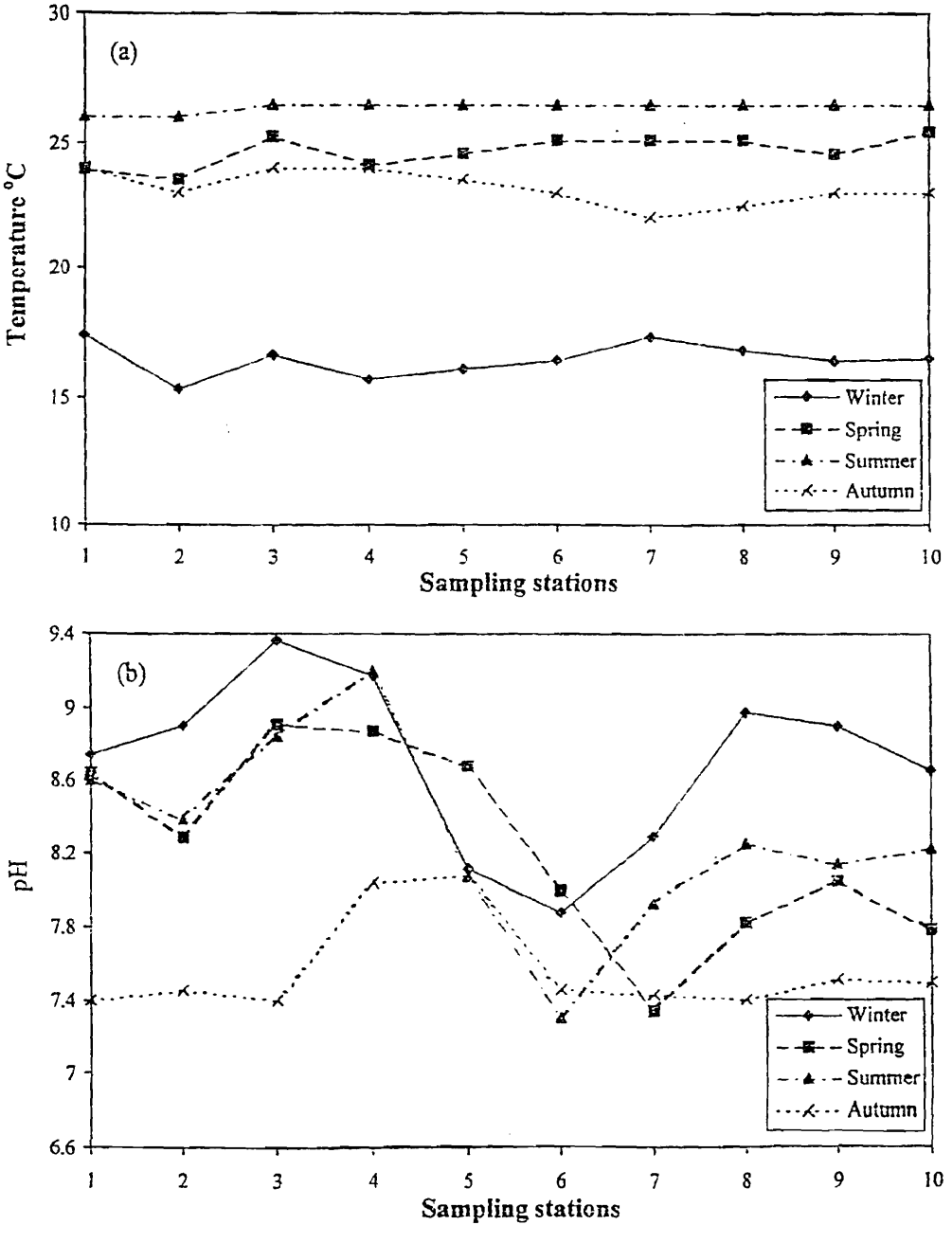

Fig. (2): Seasonal variations of Temperature (a) and pH (b) at different stations of Lake Edku.

Table (1): Hydro-chemical parameters at Edku lake during the winter (1999)

Stat. N^{o}	O_2 mg/L	T°C	Total Dissolved Solids gm/L	pH	µmol/l NH_4^+-N	µmol/l NO_2^--N	µmol/l NO_3^--N	µmol/l PO_4^{3-}-P	µmol/l SiO_4^{2-}-Si
1	11.71	17.40	5.94	8.74	3.18	0.35	1.83	1.19	23.46
2	8.71	15.30	2.31	8.90	1.57	3.00	38.55	9.52	40.78
3	12.14	16.60	2.27	9.36	4.29	0.08	3.09	4.00	3.44
4	13.43	15.70	2.44	9.17	3.09	0.14	0	2.47	12.85
5	10.71	16.10	3.28	8.11	1.71	3.24	16.14	9.76	65.64
6	5.99	16.40	3.24	7.87	4.29	2.58	40.51	17.74	45.53
7	4.71	17.30	1.58	8.28	17.48	8.96	88.92	16.42	51.68
8	10.71	16.80	2.16	8.97	1.47	0.81	8.11	7.71	7.45
9	8.57	16.40	2.73	8.90	0.83	0.75	6.05	6.80	43.02
10	7.71	16.50	2.40	8.65	3.23	1.66	22.99	9.38	40.78
Mean	9.44	16.45	2.84	8.70	4.11	2.16	22.62	8.50	33.46
Standard deviation	±2.65	±0.62	±1.14	±0.45	±4.60	±2.53	±26.12	±5.15	±19.53
El-Khayry drain	1.39	15.70	1.52	7.65	36.18	2.96	87.11	16.37	149.40
Bersik drain	2.70	16.60	2.36	7.94	3.74	1.22	122.04	9.53	154.45

Table (2): Hydro-chemical parameters at Edku lake during the spring (2000)

Stat. Nº	O_2 mg/L	T°C	Total Dissolved Solids gm/L	pH	µmol/l NH_4^+-N	µmol/l NO_2^--N	µmol/l NO_3^--N	µmol/l PO_4^{3-}-P	µmol/l SiO_4^{2-}-Si
1	8.98	23.90	2.58	8.64	3.78	0.0	0.74	6.20	101.78
2	4.74	23.50	1.81	8.28	2.47	0.55	15.79	12.31	127.57
3	11.27	25.20	1.75	8.91	2.99	0.0	[illegible]	12.90	99.24
4	12.89	24.10	1.85	8.87	1.26	0.0	0.47	3.89	85.42
5	9.14	24.60	1.92	8.68	4.88	0.00	0.27	8.71	87.12
6	4.25	25.10	1.52	7.99	2.73	0.55	1.22	17.62	94.87
7	5.22	25.10	1.32	7.33	13.75	1.81	34.11	32.98	49.05
8	7.35	25.10	1.31	7.82	20.57	4.86	56.50	13.78	122.64
9	4.89	24.60	1.40	8.04	9.81	2.41	35.54	8.27	136.88
10	5.22	25.40	1.53	7.78	4.35	0.23	27.82	11.52	157.46
Mean	7.40	24.56	1.70	8.23	6.66	1.04	17.30	12.82	106.20
Standard deviation	±2.89	±0.61	±0.36	±0.50	±5.88	±1.50	±19.11	±7.70	±29.25
El-Khayry drain	1.95	25.70	1.33	7.49	24.04	18.06	87.05	7.49	112.13
Bersik drain	1.90	25.60	2.30	8.09	9.18	8.73	135.15	6.59	146.13

Table (3): Hydrochemical parameters at Edku lake during the summer (2000)

Stat. N^{o}	O_2 mg/L	T°C	Total Dissolved Solids gm/L	pH	µmol/l NH_4^+-N	µmol/l NO_2^--N	µmol/l NO_3^--N	µmol/l PO_4^{3-}-P	µmol/l SiO_4^{2-}-Si
1	8.33	26	1.99	8.60	0.64	0.16	0.01	5.64	80.30
2	6.04	26	1.70	8.38	1.89	4.11	46.57	8.46	145.40
3	12.29	26.5	1.75	8.84	0.48	4.29	11.60	3.06	98.38
4	15.63	26.5	1.72	9.20	0.84	0.25	0.65	2.14	27.49
5	14.53	26.5	2.49	8.06	0.364	0.11	0.38	4.37	200.38
6	12.25	26.5	2.64	7.30	0.614	3.44	46.81	6.80	508.55
7	6.37	26.5	1.47	7.92	7.74	17.10	36.85	7.00	159.87
8	7.18	26.5	1.53	8.25	5.14	17.35	28.28	7.14	206.17
9	6.37	26.5	1.68	8.14	2.25	3.73	148.95	8.31	152.64
10	5.88	26.5	4.29	8.22	0.82	0.58	24.09	7.10	96.21
Mean	9.49	26.40	2.13	8.29	2.08	5.11	34.42	6.00	167.54
Standard deviation	±3.60	±0.20	±0.81	±0.49	±2.33	±6.27	±41.92	±2.05	±123.19

Table (4): Hydro-chemical parameters at Edku lake during the autumn (2000)

Stat. N^{o}	O_2 mg/L	T°C	Total Dissolved Solids gm/L	pH	µmol/l NH_4^+-N	µmol/l NO_2^--N	µmol/l NO_3^--N	µmol/l PO_4^{3-}-P	µmol/l SiO_4^{2-}-Si	Sechi depth (cm)
1	7.08	24.0	1.84	7.40	2.52	5.18	250.33	1.65	135.66	30
2	6.82	23.0	2.12	7.45	5.69	10.26	314.20	4.65	76.73	40
3	5.45	24.0	2.58	7.40	1.47	3.23	216.55	1.71	47.37	60
4	7.63	24.0	2.12	8.04	1.94	12.14	212.30	1.04	85.51	30
5	8.72	23.5	2.36	8.07	1.84	7.13	237.88	2.20	123.87	48
6	7.08	23.0	2.24	7.45	4.93	11.34	178.35	2.20	39.59	50
7	5.86	22.0	1.21	7.42	14.61	35.00	444.80	8.56	101.86	25
8	7.09	22.5	1.50	7.40	8.42	23.81	322.30	7.09	36.02	45
9	5.73	23.0	1.84	7.51	5.14	13.32	169.50	4.22	142.11	35
10	5.73	23.0	1.85	7.49	4.49	9.47	172.10	3.49	46.70	35
Mean	6.72	23.20	2.57	7.56	5.11	13.08	248.83	3.68	83.54	39.80
Standard deviation	±0.98	±0.64	±1.80	10.25	±3.78	±9.03	±85.66	±2.37	±38.75	10.31

temperatures were 16.45, 24.66, 26 35 and 23.2°C during the four seasons respectively. It can be indicated therefore that the water temperature had its minimum values during winter while the maximum were in summer. Following the classification given by Forel and modified by Wimpple (1927) Edku lake may be considered as a tropical lake

Samaan (1974) in his study on primary production in Edku lake found that the average daily water temperature varied between the average maximum and minimum air temperature. He indicated also that in the very shallow areas of the lake located at the margins the water temperature may attain a slightly higher values than that recorded for the air during the day time.

During the present investigation, it is obvious that the water temperature differ significantly from one season to the other. Such variations are attributed to the differences in air temperature. On the other hand it was difficult to detect significant variations in water temperature from one area to another in such lake during the same season.

The homogeneity of the surface water temperature through the whole area of the lake may be resulting from the more or less continuous movement of the drainage water from the south and east sides of the lake towards the lake Sea connection at the north western part of this lake. Such movement helps in mixing up the whole water mass of the lake.

Hydrogen ion Concentration (pH):

The pH values of Edku lake water as recorded at the different sampling areas during the course of the present study are given in tables 1- 4 and graphically represented in Fig.2b.

The average values of pH were found to be 8.70, 8.23, 8.29 and 7.56 during winter, spring, summer and autumn respectively.

It can be indicated therefore that the pH of the water seemed to be of slightly alkaline. Small variations were also observed.

According to Samaan (1974), the changes in pH are mainly due to photosynthesis activities of phytoplankton and aquatic plants, and respiration of both animals and plants as well as variations in temperature.

Generally the areas of the lake near to the outlets of the two drains had lower pH values in comparison with the other areas.

The observed results are in good agreement with those of Gharib and Soliman (1998), as they found that the lowest values of pH were recorded in the drains sector of Edku lake. They attributed the decrease of pH at such areas to the great amount of agricultural water discharged and also to the decomposition of phytoplankton and organic matter.

Preliminary experiments were made by Samaan (1974) on the effect of changes of pH on the primary production. His results indicated that the primary production shows a linear increase as the pH increases between 8.7 and 9.2. Inhibition of phytoplankton takes place when the pH exceeds 9.2. Thus it is expected that increase of pH above 9.2 may reduce the rate of photosynthesis of phytoplankton. Records of Hydrogen ion concentrations in Edku lake, however indicate that the pH values of the water scarcely exceed this last figure.

Total Dissolved Solids (TDS):

The dissolved solids in the lake water were determined in the present study as total dissolved solids in one litre of the lake water. It was found that TDS ranged from 1.58 to 5.94, 1.32 to 2.58, 1.47 to 4.29, and 1.21 to 2.58 gm/L during winter, spring, summer, and autumn respectively (Table 1- 4).

This indicates that total dissolved solids do not differ significantly from one area to another in the lake, and it was more or less the same as that of Bersik and El-Khairy drains which supply the lake with the drain water. Otherwise it increases slightly when the Sea water rarely invades the lake during the windy and stormy weather through winter season. It was found that the total dissolved solids gradually decreased towards the east as we approach El-Khairy drain at station (7) (Fig. 3a).

Samaan (1974) pointed out that the chlorosity values near the lake Sea connection ranged between 0.47 and 10.2 gm Cl/L. The highest values were recorded during October 1969 as well as the period from February - May 1970 due to the invasion of the area by Sea water. Under such conditions, two layers of water of different chlorisity were formed namely: surface water of lower chlorosity and bottom water of higher salinity. Such

temperatures were 16.45, 24.66, 26.35 and 23.2°C during the four seasons respectively. It can be indicated therefore that the water temperature had its minimum values during winter while the maximum were in summer. Following the classification given by Forel and modified by Wimpple (1927) Edku lake may be considered as a tropical lake

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During the present investigation, it is obvious that the water temperature differ significantly from one season to the other. Such variations are attributed to the differences in air temperature. On the other hand it was difficult to detect significant variations in water temperature from one area to another in such lake during the same season.

The homogeneity of the surface water temperature through the whole area of the lake may be resulting from the more or less continuous movement of the drainage water from the south and east sides of the lake towards the lake Sea connection at the north western part of this lake. Such movement helps in mixing up the whole water mass of the lake.

Hydrogen ion Concentration (pH):

The pH values of Edku lake water as recorded at the different sampling areas during the course of the present study are given in tables 1- 4 and graphically represented in Fig.2b. .

The average values of pH were found to be 8.70, 8.23, 8.29 and 7.56 during winter, spring, summer and autumn respectively.

It can be indicated therefore that the pH of the water seemed to be of slightly alkaline. Small variations were also observed.

According to Samaan (1974), the changes in pH are mainly due to photosynthesis activities of phytoplankton and aquatic plants, and respiration of both animals and plants as well as variations in temperature.

stratification would be quickly diminished as a result of the constant flow of the drain water from the lake into the Sea.

If the TDS values recorded in the present study are compared with those recorded by Samaan 1974, it can be pointed out that the TDS water of the Edku lake is generally decrease with time due to the gradual raising up in the bottom of the lake as a result of the accumulation of the decayed plants and detritus as well as the increase of the rates of drainage water. Such condition makes it more difficult for the Sea water to invade the lake through the lake Sea connection. This contributes significantly in the increase and enhancement of macrophytes in the lake.

Dissolved Oxygen:

The dissolved oxygen concentrations in the surface water of the lake during the four seasons are shown in tables (1-4) and graphically represented in Fig. 3b. The averages of these concentrations were found to be 9.44, 7.40, 9.49 and 6.72 mg O_2/L during winter, spring, summer and autumn respectively. Concentrations of dissolved oxygen were low at the stations near to the outlets of El-Khairy and Barsik drains. This can be attributed to the effect of drainage water poor in oxygen as shown in (tables 1 and 2). The dissolved oxygen concentrations in such drainage water varied between 1.39 and 2.7 mg/L during winter, at El-Khairy and Barsik drains, and between 1.95 and 1.90 mg/L during spring at the two drains respectively.

It can be concluded that the dissolved oxygen concentrations in the drainage water were very low comparing with those in the lake water. The depletion of such concentrations in the drainage water of the two drains can be attributed to the consumption of oxygen with high rates through the oxidation of the organic materials. The transportation of organic materials to the lake water played an important role in the consumption of dissolved oxygen in the whole area near to the outlets of the two drains.

In this concern Gharib and Soliman (1998) pointed out that the drains sector at Edku lake was considerably affected by the drainage and irrigation water, which is poor in oxygen.

Samaan (1969) found that the oxygen content in the polluted area of Maruit lake ranged between 0-8.21mg/L. He attributed the depletion of oxygen content to its consumption through the oxidation of organic matter in the water and on the bottom of the lake. This agrees to a large extent with the data obtained in

the present study, which indicate that the oxygen content in the water of Edku lake attained its minimum values at the parts near to the outlets of El-Khairy and Barsik drains.

Nutrient Salts:

Ammonia:

Ammonia is the nitrogenous end product of the bacterial decomposition of natural organic matter containing N, and is an important excretory product of animals in aquatic systems. It is also discharged into water bodies by industrial processes and as a component of municipal or community wastes as well as the use of ammonia-containing fertilizer such as ammonium sulphate, ammonium nitrate, urea and ammonia itself.

Ammonium ion, present in water or in soil as a result of ammonification. Thus most of organic matter contains nitrogen in different amounts. When organic matter decomposes in water and soil, the nitrogen is first released in a reduced form as ammonium ions or ammonia, depending on the ambient pH (Vanloon and Duffy; 2000).

During the period of study, the level of ammonia (tables1-4) varied between a minimum value of 0.36 µmol/l at station (5) during summer to a maximum of 20.57µmol/l at station (8) during spring.

According to Wahby ***et al***; 1978, natural water always contains a small amount of ammonia (0.05 - 0.4 mgl^{-1}), as a result of natural biological process.

Concerning spatial variation, based on the average values, the higher values of 13.39 and 8.9 µmol/l were recorded at stations (7) and (8) respectively. Station (7) receives drainage water from El-Khairy drain. The levels of ammonia in this drain were 36.18 and 24.04 µmol/l during winter and spring respectively.

Except for stations (2), (8) and (9), lower values of ammonia were detected during summer. According to Hutchinson; 1957, a decrease of ammonia concentration accompanies an increase in plankton population. Harvey; 1974, stated that most species of phytoplankton utilize ammonium ions in preference to other inorganic nitrogen species. This might explain the decrease of ammonia during summer.

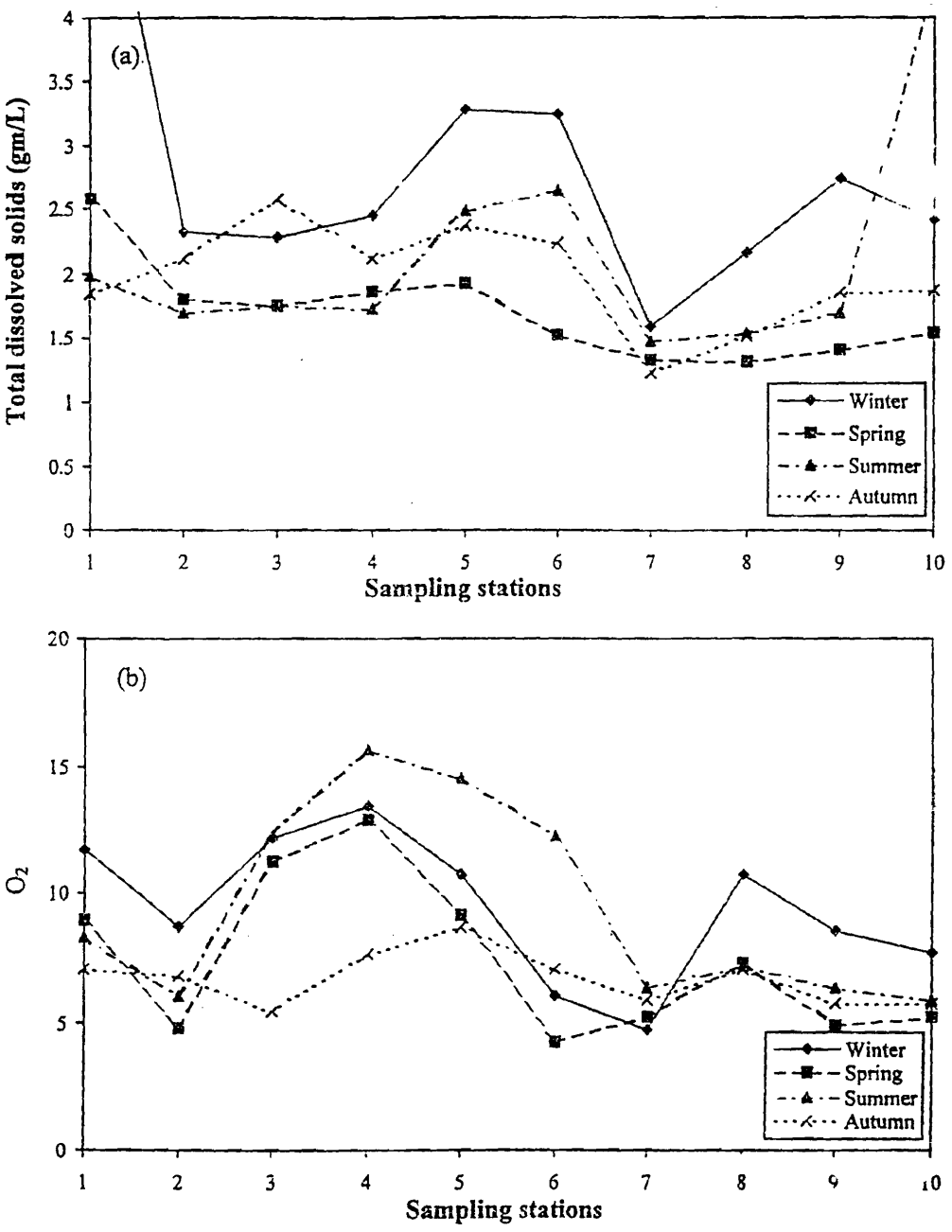


Fig. (3): Seasonal variations of Total dissolved solids (a) and Dissolved oxygen (b) at different stations of Lake Edku.

Nitrite:

Nitrite is an intermediate oxidation state between the low oxidant state (ammonia) and the higher oxidant state (nitrate).

Nitrite appears in the water mainly as a result of biochemical oxidation of ammonia (nitrification) or the reduction of nitrate (denitrification) (Abdel-Moneim; 1977).

During the present study, Depletion of nitrite (tables 1-4) was observed during spring at stations (1), (3), (4) and (5). For all locations, except for location (3), the higher levels of nitrite were recorded during autumn and reached a maximum value of 35 µmol/l at station (7).

Nitrate:

Nitrate is the most stable form of inorganic nitrogen in oxygenated water. It is the end product of nitrification process in natural water.

During the period of study, the levels of nitrate fluctuated considerably within the same station during different seasons (tables1-4, Fig. 4). During winter and autumn, the higher levels of nitrate 88.92µmol/l and 444.80 µmol/l respectively were recorded at station (7). However, during spring and summer, the maximum of 54.55µmol/l and 138.24 µmol/l were recorded at locations (8) and (9) respectively. During autumn, the concentrations of nitrate were remarkably higher than those in the other seasons (Fig. 4). Edku lake receives drainage water through different drains from the agricultural land of the Behera province.

Vanloon and Duffy (2000) mentioned that the use of ammonium-containing fertilizer (ammonium sulphate, ammonium nitrate, urea and ammonia itself) is a source of ammonium ion in water. In an aerobic environment, nitrification takes place in two steps:

$$2NH_4^+(aq) + 3O_2 + 2H_2O \xrightarrow{Nitrosomonas} 2NO_2^-(aq) + 4H_3O^+(aq)$$

$$2NO_2^-(aq) + O_2 + H_2O \xrightarrow{Nitrobacter} 2NO_3^-(aq)$$

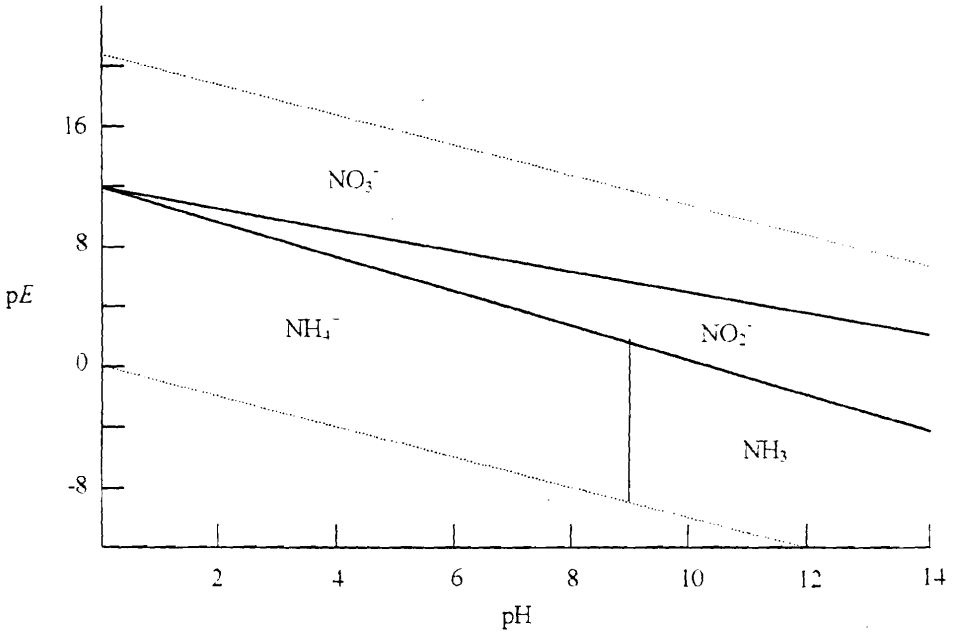
The overall reaction is

$$NH_4^+(aq) + 2O_2 + H_2O \longrightarrow NO_3^-(aq) + 2H_3O^+(aq)$$

The optimum environmental pH for nitrification lies between 6.5 and 8, and the reaction rate decreases significantly when the pH falls below 6.

Different rates of oxidation (nitrification) may be account for the irregular distribution of nitrate in Edku lake.

Nitrate, Nitrite and Ammonia Percentages:



The pE/pH diagram for nitrogen species
after Vanloon and Duffy, 2000

pE*/pH diagram for aqueous inorganic species (nitrate, nitrite and ammonia) shows that under aerobic conditions, nitrate is the stable species in water A low

*pE is defined as the negative logarithm of the electron activity ($pE=-\log a_e$)

pE state leads to reduction from nitrate through nitrite to ammonia in its protonated and unprotonated forms (Vanloon and Duffy, 2000).

During the course of study (tables5-7), about 58% of the samples have the percentage of nitrate to total inorganic nitrogen species exceeds 75%. However, for 20% of the samples, ammonia represents more than 57% of the total inorganic nitrogen species. This indicates that nitrate is the dominant species of the total inorganic nitrogen content of Edku lake and the lake is highly oxygenated environment. This was supported by the high levels of dissolved oxygen .

For about 58% of the samples, nitrite exhibited the lowest percentages of the total inorganic nitrogen species. Vanloon and Duffy; 2000 mentioned that intermediate pE values are uncommon in water and nitrite is usually a transient species measured only in small concentrations.

Reactive Silicate:

Silicon is the second most abundant element in the earth's crust. There are innumerable mineral sources of silica for natural waters, but most are quite resistant to chemical processes (Faust and Aly 1981).

The concentrations of reactive silicate ranged between a minimum value of 3.44µmol/l at station (3) during winter to a maximum one of 508.55µmol/l at station (6) during summer. Such range was accepted in natural water. Faust and Aly: (1981) stated that silicon concentrations of 35-107µmol/l are most frequently encountered in natural waters.

For both spatial and seasonal variations of reactive silicate, irregular distributions were observed (tables1-4, Fig. 5a). Concentrations of reactive silicate were considerably increased from winter to spring. During summer, the concentration of reactive silicate reached a maximum 508.55µmol/l at station (6). During autumn, reactive silicate fluctuated between 36.02 and 142.11µmol/l.

Actually, Edku lake receives water with a relatively high load of reactive silicate. For example, during winter, the maximum concentrations of 154.43 and 149.40 µmol/l were recorded at Barzik and El-Khairy drains respectively.

Irregular distribution of reactive silicate might be related to the biological activity of diatoms in the lake water. According to Hutchinson; (1957), the main mechanism of silica from lake waters is its utilization by diatoms.

Dissolved Inorganic Phosphate:

The environmental significance of phosphorus arises out of its role as a major nutrient for both plants and micro-organisms (Vanloon and Duffy; 2000). The authors mentioned that, of the nutrients that contribute to eutrophication, most commonly the limiting one is phosphorus. Phosphate can be considered as a pollutant if it is present at a concentration higher than normal (Saad, 1973).

During the period of study, the concentration of dissolved inorganic phosphate ranged from 1.04 - 32.98 µmol/l (Tables 1-4, Fig. 5b).

According to Faust and Aly; 1981, it is somewhat difficult to establish a range of concentrations for phosphate in natural waters because the inputs from many sources are quite variable. Commercial fertilizers, domestic and industrial waste water, and to a lesser extent, decomposition of organic phosphorus compounds in biological systems are the most pollution sources for phosphate.

Spatial distribution of dissolved inorganic phosphate (Fig. 5b) showed a characteristic pattern which is more or less related to the sources of drainage water of Edku lake. Generally, based on the average values, the higher values of 16.24 and 11.09 µmol/l PO_4^{3-}-P were recorded at stations (7) and (6) respectively, due to the effect of El-Khairy drain. The level of dissolved inorganic phosphate at the outlet of ElKhiry drain were 16.37 and 7.49 µmol/l during winter and spring respectively.

The low values of dissolved inorganic phosphate that recorded at station (1) during winter and at station (4), during the four seasons, may be due to either or both of (A) excessive growth of macrophytic species (B) the availability of calcium in the lake water. Vanloon and Duffy, (2000) and Faust and Aly, (1981) mentioned that, under alkaline condition, phosphorus solubility in water is controlled by the availability of calcium which forms insoluble phosphate. Indeed, the minimum concentration of phosphate (1.19 µmol/l) at station (1) that observed in winter was accompanied by a maximum value of total dissolved solids (table 1).

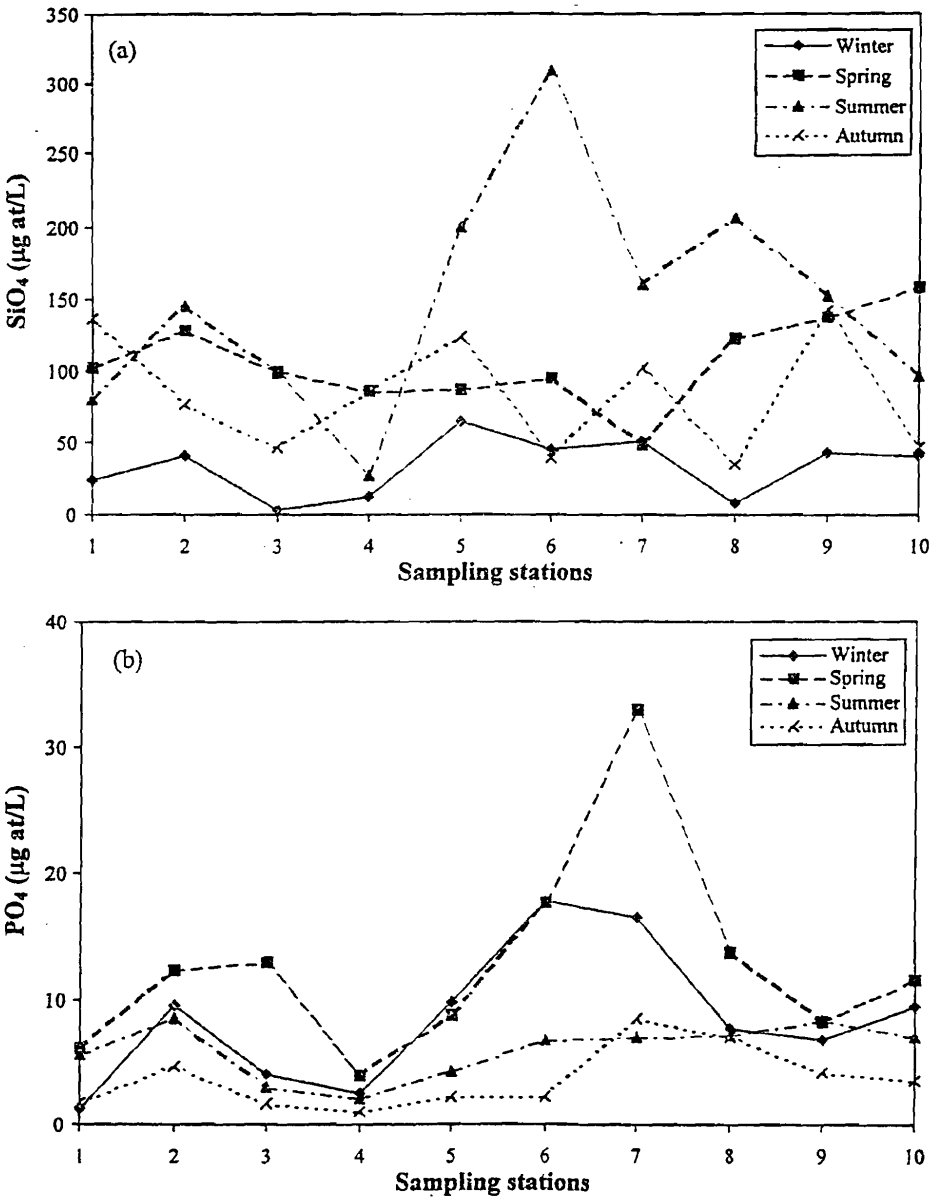


Fig. (5): Seasonal variations of Silicates and Phosphates at different stations of Lake Edku.

Table (5): Percentages of nitrate to total inorganic nitrogen

Station No	Winter	Spring	Summer	Autumn
1	34.20	16.37	1.23	97.01
2	89.40	83.94	88.59	95.17
3	41.42	15.30	70.86	97.87
4	0	27.17	37.36	93.78
5	76.53	5.53	44.50	96.37
6	85.52	27.0	92.03	91.64
7	77.08	68.68	59.73	89.96
8	78.05	68.96	55.70	90.91
9	79.29	74.41	96.14	90.18
10	82.46	85.86	94.51	92.50

Table (6): Percentages of nitrite to total inorganic nitrogen

Station No	Winter	Spring	Summer	Autumn
1	6.35	0	19.75	2.01
2	6.96	2.92	7.82	3.11
3	1.07	0	26.21	1.46
4	4.33	0	14.37	5.36
5	15.36	0	12.88	2.89
6	5.42	12.22	6.76	5.83
7	7.77	3.64	27.72	7.08
8	7.79	5.93	34.17	6.71
9	9.83	5.04	2.41	7.09
10	5.95	0.71	2.28	5.09

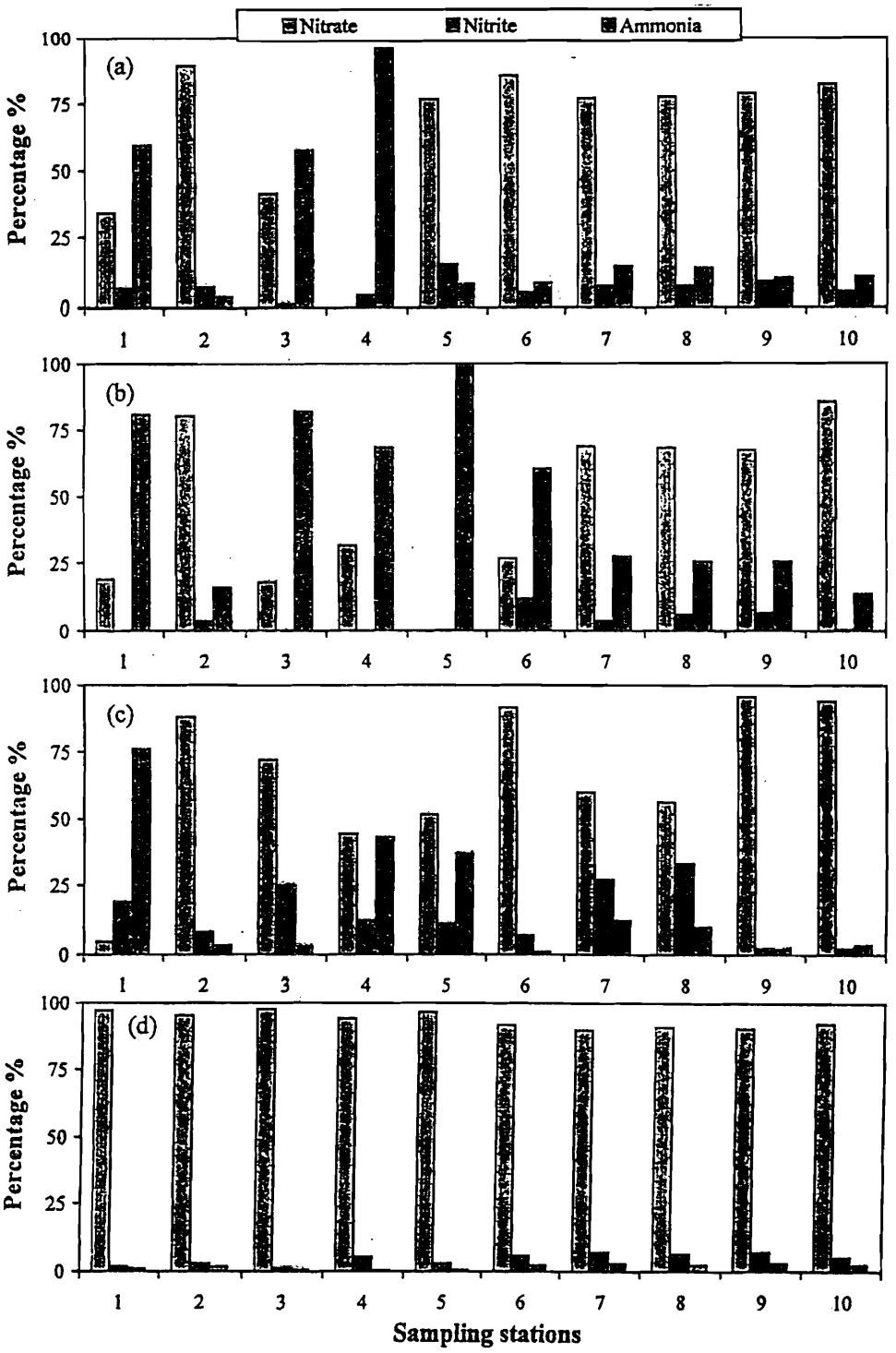


Fig. (6): Inorganic nitrogen species in the water of Lake Edku in (a) winter, (b) spring, (c) summer, and (d) autumn.

SUMMARY AND CONCLUSIONS

It can be concluded from the present investigation that:

1- The lake receives most of its water from El-Khairy and Bersik drains at the northern and southern sides of the eastern part of the lake. The lake in turn discharges the excess water into Abukir Bay through the lake Sea connection at the north western extremity.

2- The water temperature of the lake follows that of the air. The minimum water temperatures were recorded during winter ranging from 15.30 to 17.40°C and the maximum temperatures were recorded in summer ranging between 26.0 and 26.5°C.

3- The total dissolved solids in the lake water is greatly affected by the water discharged from the drains where their values were near to that of the drainage water. Salinity of the lake water decreased significantly during the last 10 years as a result of the very rare Sea water invasion to the lake through the lake Sea connection. Such salinity decrease enhanced macrophytes flourishment in wide areas of the lake. On the other hand these conditions inversely affect the abundance of marine fishes in the lake.

4- The pH of the lake water fluctuated with a narrow range near the outlet of El-Khairy drain of about 7.7 on the average to higher average value of about 8.0 near the lake Sea connection.

5- The dissolved oxygen attained its lowest values at the localities near to the outlets and attained the highest values at the areas near the lake Sea connection.

6- For about 58% of the samples nitrites exhibited the lowest percentages of the total inorganic nitrogen species, on the other hand the percentage of nitrate to total inorganic nitrogen species exceeded 75% for such samples. This indicates that nitrate is the dominant species of the total inorganic nitrogen which means that the lake is well oxygenated.

7- Lake Edku receives water with relatively high concentrations of reactive silicate. The distribution of such silicate was characterized by irregularity which can be attributed to the biological activities of diatoms in the lake water.

8- Commercial fertilizers, domestic and industrial wastes discharged in Edku lake as well as the decomposition of organic phosphorus compounds in the biological systems played the most important role in determining the range of phosphates concentrations in the lake water.

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