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CHEMICAL INDICATORS OF WATER POLLUTION IN LAKE MARIUT (EGYPT)

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ABSTRACT

The polluted basin in Lake Mariut (Lake proper) showed certain chemical features associated with sewage and industrial waste discharges. The Qalaa Drain water which is the main source of water supply to the basin was also highly polluted. On the other hand, the fish farm was nearly free of pollution. The areas subjected to the direct influx of sewage effluents and industrial wastes were mostly depleted of dissolved oxygen which tended to increase gradually away of pollution. The Lake proper sustained high values of dissolved hydrogen sulphide particularly in the polluted areas. The inorganic nitrogen compounds were mainly represented as ammonia. The concentration of both ammonia and reactive phosphate was high indicating increased load of nutrients. This resulted in a heavy bloom of phytoplankton particularly blue-green algae. The average annual values of these components for the whole basin were 4.41 mg O_2/l, 9.0 mg H_2S/l, 4.0 mg N/l and 5.26 PO_4/l.

For the fish farm, the average annual values of both dissolved oxygen and hydrogen-sulphide were 5.29 mg O_2/l and 1.4 mg H_2S/l. The dissolved phosphate and ammonia remained relatively low and they averaged respectively 0.3 mg PO_4/l and 0.8 mg N/L.

The chemical characteristics of the polluted Qalaa Drain water were reflected in complete oxygen depletion and high values of dissolved hydrogen sulphide (average 46.5 mg H_2S/l). The phosphorus and nitrogen loads were also high, reaching an average annual values of 4.1 mg PO_4/l and 6.7 mg N/l.

The water of the Noubaria Canal which borders the eastern margin of the Lake proper was in general more clear. The dissolved oxygen in this Canal averaged 5.78 mg $O2^{/l}$ and the hydrogen sulphide was nearly missing. The dissolved phosphate and ammonia there amounted respectively to 2.07 mg PO_4/l and 1.33 mg N/l.

INTRODUCTION

Lake Mariut is a small shallow basin lying beside Alexandria (Egypt). It has a total area of about 5500 hectars and with an average water depth of 120 cm. As shown in Fig. 1, the Lake is divided by the Umum Drain and Desert Road into four basins, namely; the lake proper (2500 hectars), the fish farm (420 hectars) and the south-east and south west basins (about 2500 hectars). The morphometry and water supply of the Lake were previously given by Samaan and Abdelmoneim (1986). The chemical conditions of the Lake water were also survayed by Abdelmoneim et al. (1987).

The Lake proper which represents the main basin of the Lake is heavily polluted with sewage and industrial wastes. Its main water comes from the Qalaa Drain which flows into the basin through Moharram Bey Bridge. The other sources comprise industrial wastes discarded at its north-eastern corner and two sewers pour raw sewage at the northern margins. The surplus water entering the Lake flows constantly into the Umum Drain and is finally discharged into the sea through El-Max Pumping Station. Some of this water streams also into the Noubaria Canal. The average annual amount of water centering the Lake proper is about 193 million cubic meters of which 171 million m^3 comes from the Qalaa Drain, 8.2 million m^3 from Karmous sewer, 6.2 m^3 from El-Kabbari sewer and 7.6 million m^3 from the industrial waste disposal pipe.

The fish farm receives most of its water from Mariut El-Gedida Hydraulic Pumps and the Umum Drain at its southern margins. It is also connected with the Qalaa Drain at its northern extremity through a movable gate which is usually closed.

The SE and SW basins are totally separated from the Lake by a dyke bordering the Umum Drain. These two basins are extremely shallow and are constantly supplied with the Umum Drain Water.

The present paper deals with the main chemical features associated with water pollution in the Lake proper as compared with that of the fish farm.

MATERIAL AND METHODS

The water samples used for chemical analysis were collected from the different stations with a Ruttner water sampler just below the water surface.

Determination of dissolved oxygen was performed titrimetrically according to Winkler method. Oxygen fixation was carried out directly in the field.

The hydrogen sulphide was determined according to the standard methods of water analysis given by Anon. (1976). The hydrogen sulphide was precipitated as cadmium sulphide. It was then dissolved in acid iodine solution and the excess iodine was titrated against O.1N sodium thiosulphate, using starch solution as indicator.

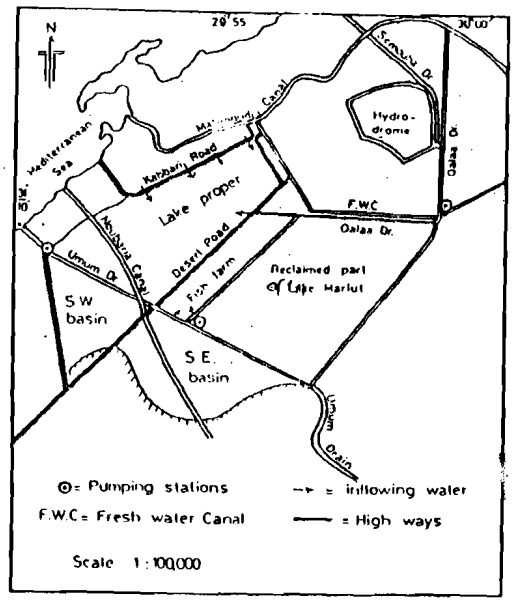

Fig. 1
Morphometry of Lake Mariut

The dissolved nitrite was determined by diazotization with sulphanilamide and coupling with oc-naphthylamine (Strickland and Parasons, 1965). Estimation of nitrate was carried out by reducing it to nitrite by passing through a column of cadmium filling coated with metallic copper and the total nitrite was determined. The nitrate content was calculated by subtracting the original nitrite content from the values obtained after reduction.

The dissolved ammonia was determined by using the modified indophenol blue method given by Koroleff (1969). All reagents used were prepared by demineralized water.

Estimation of reactive phosphate was carried out according to Murphy and Riley (1962).

Fourteen stations were selected as representing the different habitats in the Lake proper as shown in fig. 2. These include the area affected by industrial wastes (St. 1), the area subjected to sewage effluents (Sts. 4, 7 & 10), the area receiving the influx of the Qalaa Drain water (St. 3), and the middle of the eastern Lake (Sts. 2, 5 & 8). The western part of the Lake proper which lies nearby the Noubaria Canal and the Umum Drain and is usually less affected by pollution (Sts. 6, 9, 11, 12, 13 & 14).

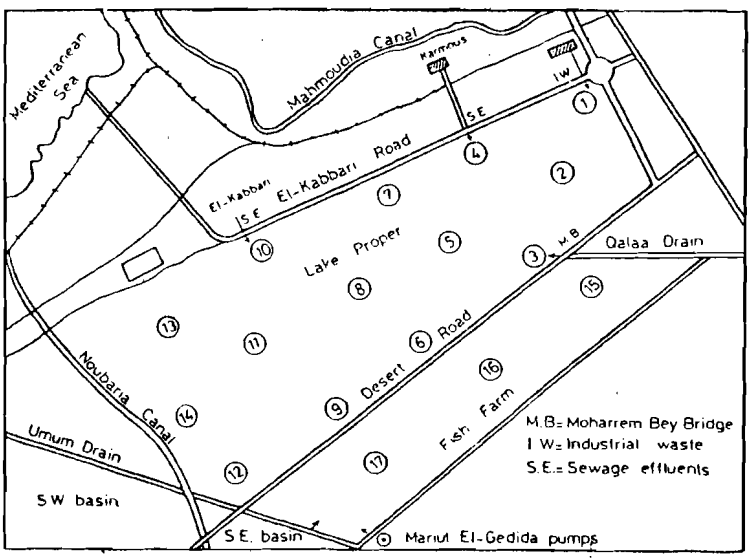

Fig. 2
Position of Stations

Other three stations were chosen in the fish farm (Sts. 15, 16 & 17). Water samples were also taken from the Noubaria Canal and the Qalaa Drain. Collection of the samples was performed monthly from the different stations during the period from August 1975 to July, 1977.

RESULTS AND DISCUSSION

1. Dissolved oxygen :

The amount of dissolved oxygen in the Lake proper was subjected to wide fluctuations between complete depletion and 16.6 mg O_2/L. As shown in Table 1 and Fig. 3, the areas subjected to the direct influx of industrial wastes and sewage effluents sustained lowest values and were mostly depleted of dissolved oxygen while it tended to increase gradually near the middle of the eastern Lak to the flourishing of phytoplankton as well as in the western sector nearby the Noubaria Canal. The average annual value estimated for the whole basin was 4.41 mg O_2/L.

The Qalaa Drain water was nearly depleted of dissolved oxygen throughout most of the investigation period except in April, 1976 and May, 1977 which sustained 4.8 and 5.0 mg O_2/l respectively.

TABLE (1)

Range and mean values of dissolved oxygen in mg O_2/l recorded in the different localities of the lake during the two successive years of investigation.

LOCALITY	August,75 - July,76		August,76-July,77	
	range	mean	range	mean
1. Lake proper				
Area receiving industrial wastes (St.1)	0.00- 6.58	1.83	0.00- 5.33	1.01
Area receiving sewage effluents (St. 4,7 & 10)	0.00-16.60	2.22	0.00-16.30	2.36
Area receiving Qalaa Drain water (St. 3)	0.00- 3.62	0.36	0.00- 5.00	0.46
Middle of the eastern lake (St. 2,5 & 8)	0.00-14.00	6.06	0.00-15.26	6.38
Western sector (St. 6,9,11,12,13 & 14)	0.00-13.40	5.38	0.00-16.43	6.07
2. Fish farm	0.00-18.30	6.32	1.57-11.60	4.85
3. Qalaa Drain	0.00- 4.82	0.40	0.00- 5.00	0.42
4. Noubaria Canal	2.64-14.46	6.06	2.01- 9.50	5.50

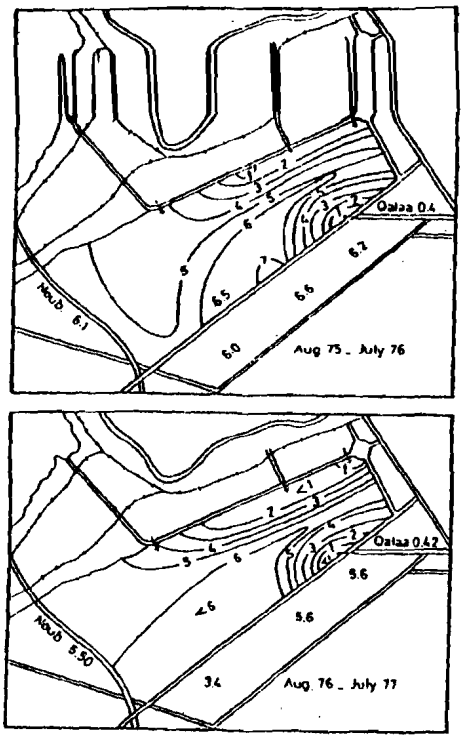

Fig. 3
Distribution od dissolved oxygen mg O_2/l during two successive years of investigation

The dissolved oxygen in the Noubaria Canal and fish farm remained high during the whole investigation period and it averaged respectively 6.06 and 6.32 mg O_2/l during the first year of investigation and decreased to 5.50 and 4.85 mg O_2/l in the second one.

Regarding the seasonal variations, the amount of dissolved oxygen in the Lake proper tended to increase in early winter as a result of stirring up of water by the strong wind prevailing that season as well as in the summer, parallel to the increased photosynthetic rate of phytoplankton (Fig. 4). In the fish farm, the peaks appeared mostly in winter. The dissolved oxygen was subjected to irregular monthly fluctuations in the Noubaria Canal with a tendency of a marked increase in the spring (April-May) and in late summer (September).

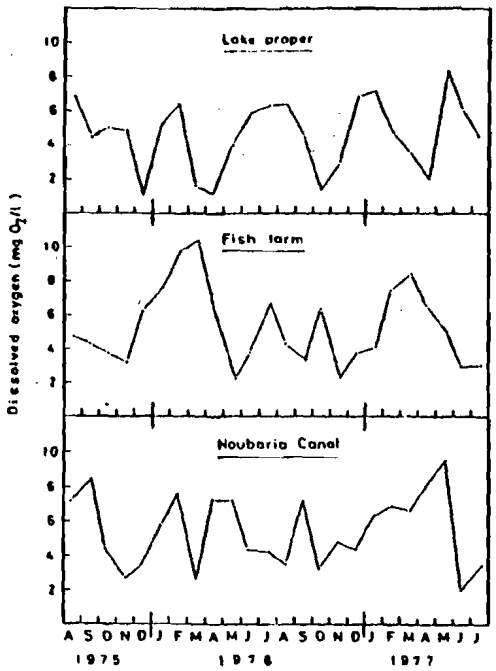

Fig. 4
Seasonal variations of dissolved oxygen in mg O_2/l

2. Hydrogen sulphide :

The dissolved hydrogen sulphide in the Lake water is mostly produced through the anaerobic decomposition of organic matter accompanied with sewage effluents and industrial wastes, in addition to that produced autogenetically in the Lake itself. Such a process is mainly carried out in the upper layer of bottom sediments. In water, the hydrogen sulphide produced reacts rapidly with dissolved oxygen forming sulphide ions and it may on certain occasions cause oxygen depletion.

The Lake proper sustained high values of dissolved hydrogen sulphide which fluctuated between 78.9 mg H_2S/l and complete depletion. The highest records appeared in areas subjected to the direct discharge of sewage effluents and industrial wastes as well as at station 3 which receives the influx of Qalaa Drain (Table 2 and Fig. 5).

The amount of dissolved H_2S in the Qalaa Drain exceeded in most cases 20 mg H_2S/L and it reached a peak of 73.6 mg H_2S/l in October, 1976.

TABLE (2)

Range and mean values of dissolved hydrogen sulphide in mg H_2S/l recorded in the different localities on the lake during the two seccessive years of investigation.

LOCALITY	August,75-July,76		August,76-July,76	
	range	mean	range	mean
1. Lake proper				
Area receiving industrial wastes (St. 1)	1.0-78.9	16.2	2.1-51.8	20.8
Area receiving sewage effluents (St. 4,7, & 10)	0.6-64.2	22.3	0.2-70.0	13.4
Area receiving Qalaa Drain water (St. 3)	0.0-61.0	28.3	10.0-50.4	25.4
Middle of the eastern lake (St. 2,5 & 8)	0.00-39.8	3.8	0.0-21.5	3.6
Western sector (St. 6,9,11,12,13 & 14)	0.0- 9.2	1.8	0.0-14.1	1.6
2. Fish farm	0.0-10.1	2.7	0.0- 2.3	0.1
3. Qalaa Drain	0.0-52.2	29.9	7.7-73.6	31.2
4. Noubaria Canal	0.0- 3.0	1.1	0.0- 0.0	0.0

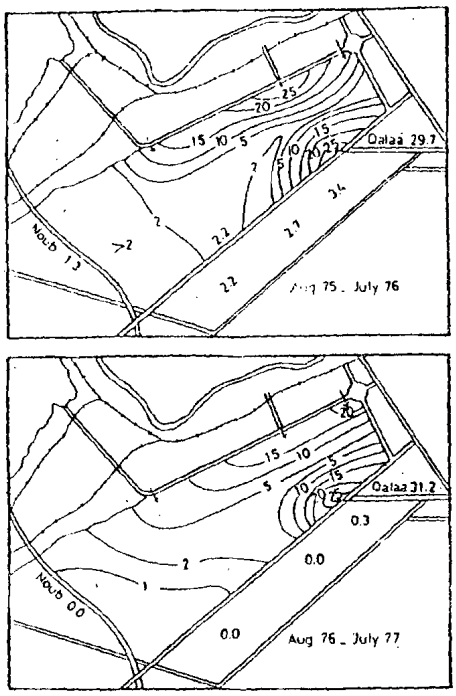

Fig. 5
Distribution of dissolved hydrogen sulphide in mg H_2S/l during the two successive years of investigation

The fish farm and Noubaria Canal sustained low concentrations of hydrogen sulphide during the first year of investigation and were nearly depleted in the second one. This indicates seepage of small amounts of Qalaa Drain water into the fish farm during the former year.

As shown in Fig. 6, the monthly fluctuations of dissolved hydrogen sulphide in the investigated areas were irregular, with no piculiar seasonal cycle. These fluctuations appear to be controlled by the prevailing physical conditions such as wind action as well as the quality of water introduced into the Lake.

The average annual values of dissolved H_2S amounted to 9.0 mg H_2S/l in the Lake proper and 30.6 mg H_2S/l for the Qalaa Drain, decreased to 1.4 and 0.6 mg H_2S/l in the fish farm and Noubaria Canal respectively.

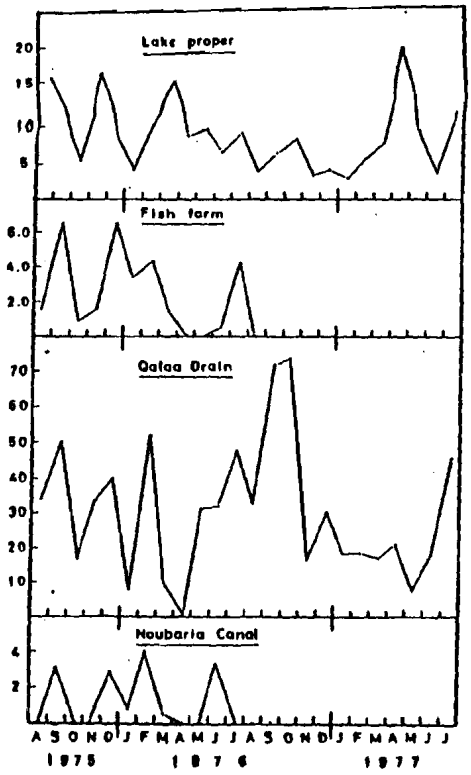

Fig. 6
Seasonal variations of dissolved hydrogen sulphide in mg H_2S/l

3. Inorganic nitrogen compounds.

The dissolved inorganic nitrogen compounds in the Lake water comprise nitrate, nitrite and ammonia. The estimation of these constituents was carried out monthly from July, 1974 till June, 1975 and the results are summerized in Table 3. The data indicate that ammonia was by far the most dominant constituent as it formed over 99 % of the total inorganic nitrogen compounds. This is attributed to the high level of water pollution.

Further estimations were confined to dissolved ammonia as being the main inorganic nitrogen compound. As shown in Table 4 and Fig. 7 its highest concentration appeared at the northern margin of the Lake proper as produced by the influx of sewage and industrial wastes as well as at station 3, decreasing gradually westwards.

The fish farm sustained low values which averaged 0.90 and 0.69 mg N/l during the two successive years. Realtively high concentrations of ammonia were occasionally met with in the fish farm near to the movable gate of the Qalaa Drain.

TABLE (3)

Range and mean annual values of the different inorganic nitrogen compounds (mg N/l) recorded in the investigated area during the period July, 1974-June, 1975.

Location	Nitrogen Compound	mg N/l	
		Range	Mean
Lake Proper	Ammonia	4.24 - 15.18	9.75
	Nitrite	0.01 - 0.36	0.08
	Nitrate	0.01 - 0.15	0.03
Fish Farm	Ammonia	0.25 - 6.43	2.73
	Nitrite	0.00 - 0.27	0.04
	Nitrate	0.00 - 0.07	0.02
Qalaa Drain	Ammonia	4.97 - 19.56	11.11
	Nitrite	0.00 - 0.63	0.06
	Nitrate	0.00 - 0.12	0.01

The concentration of dissolved ammonia in the Qalaa Drain remained high and it fluctuated between 1.64 and 10.44 mg N/l. In the Noubaria Canal it dropped to values ranging from 3.18 mg N/l to complete depletion.

The monthly fluctuations of dissolved ammonia in the Lake proper showed highest values in August and December, 1975 as well as in May, 1976, otherwise it fluctuated within a narrow range throughout the rest of the investigation period (Fig. 3). In the fish farm, the higher values were recorded between May and August, 1976 with a peak in July. The dissolved ammonia showed irregular monthly fluctuations in the Qalaa Drain and Noubaria Canal.

The average annual values of dissolved ammonia amounted to 4.00 mg N/l in the Lake proper, 0.80 mg N/l in the fish farm, 6.06 mg N/l in the Qalaa Drain and 1.33 mg N/l in the Noubaria Canal.

TABLE (4)

Range and mean values of dissolved ammonia in mg N/l recorded in the different localities of the lake during the two successive years of investigation.

LOCALITY	August,75-JUly,76		August,76-July,76	
	range	mean	range	mean
1. Lake proper				
Area receiving industrial wastes (St. 1)	2.63-10.70	7.29	3.16-8.30	5.58
Area receiving sewage effluents (St. 4,7 & 10)	1.19-12.50	6.13	0.36-12.43	4.62
Area receiving Qalaa Drain water (St. 3)	2.49-11.83	7.74	1.83-9.44	5.08
Middle eastern lae (St. 2,5 & 8)	0.75-9.05	4.41	1.69-5.30	3.02
Western sector (St. 6,9,11,12,13 & 14)	0.38-8.40	3.04	0.01-3.96	2.29
2. Fish farm	0.13-2.10	0.90	0.04-1.60	0.69
3. Qalaa Drain	1.99-10-40	7.10	1.64-10.44	5.05
4. Noubaria Canal	0.00-3.18	1.19	0.60-2.80	1.46

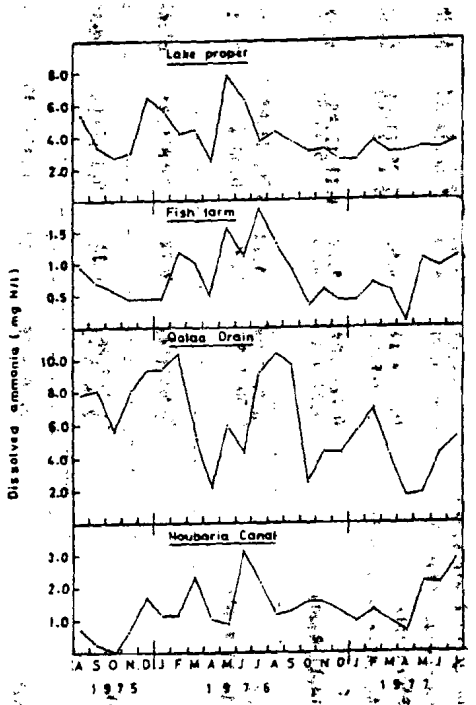

Fig.8
Seasonal variations of dissolved ammonia in mg N/l.

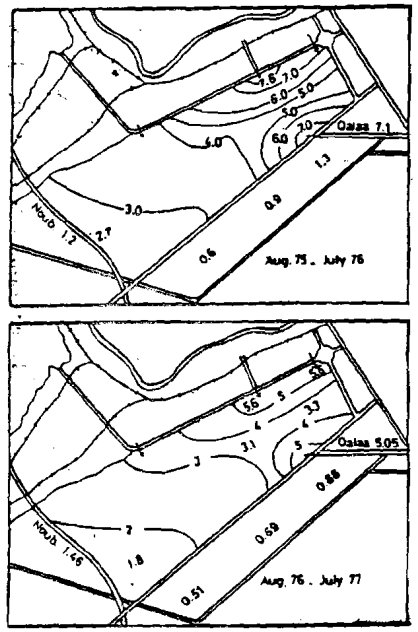

Fig. 7
Distribution of dissolved ammonia in mg N/l during the two successive years of investigation

4. Reactive Phosphate :

The amount of dissolved phosphate in the Lake proper fluctuated between 14.8 mg PO_4/l and complete depletion. The highest concentration appeared along the northern margin which is subjected to the direct influx of sewage and industrial wastes. It decreased gradually towards the southwest (Table 5 and Fig. 9). The concentration of reactive phosphate in the fish farm remained low and it did not exceed 1.78 mg PO_4/l.

The Qalaa Drain water sustained relatively high values which ranged from 2.30 to 6.67 mg PO_4/l, but still remained lower than the records of the polluted areas of the basin. The concentration of dissolved

TABLE (5)

Range and mean values of dissolved phosphate in mg PO_4/l recorded in the defferent localities of the lake during the two seccessive years of investigation.

LOCALITY	August,75-JUly,76		August,76-July,77	
	range	mean	range	mean
1. Lake proper				
Area receiving industrial wastes (St. 1)	3.18-10.20	6.86	0.00-12.73	7.73
Area receiving sewage effluents (St. 4,7 & 10)	0.00-19.30	6.99	0.00-14.80	0.06
Area receiving Qalaa Drain water (St. 3)	2.52-6.67	4.02	2.59-12.53	5.36
Middle of eastern lake (St. 2,5 & 8)	0.22-9.19	4.82	1.25-11.41	5.37
Western sector (St. 6,9,11,12,13 & 14)	0.22-9.04	4.24	1.11-11.84	4.32
2. Fish farm	0.00-1.48	0.38	0.00-1.78	0.21
3. Qalaa Drain	2.30-6.67	3.93	2.98-5.33	4.16
4. Mouberia Canal	0.00-3.26	1.17	0.17-7.40	2.97

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Area receiving Qalaa Drain water (St. 3)	2.52-6.67	4.02	2.59-12.53	5.36
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Western sector (St. 6,9,11,12,13 & 14)	0.22-9.04	4.24	1.11-11.84	4.32
2. Fish farm	0.00-1.48	0.38	0.00-1.78	0.21
3. Qalaa Drain	2.30-6.67	3.93	2.98-5.33	4.16
4. Noubaria Canal	0.00-3.26	1.17	0.17-7.40	2.97

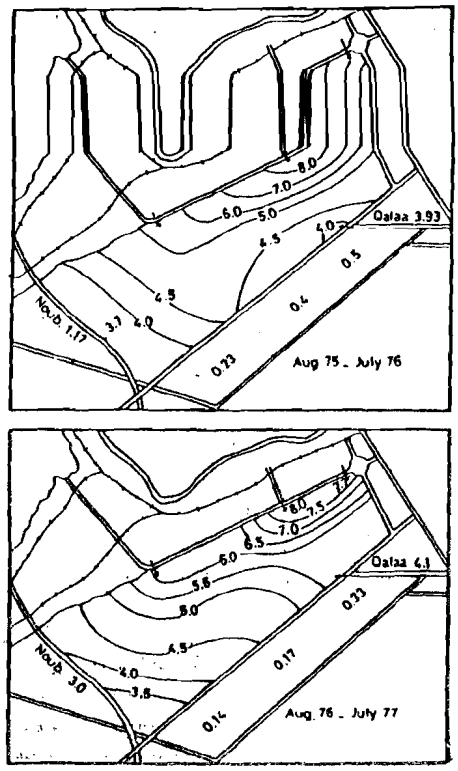

Fig. 9
Distribution of reactive phosphate in mg PO_4/l during the two successive years of investigation

phosphate in the NoubariaCanal was mostly low and fluctuated between 7.40 mg PO_4/l and complete depletion.

As regards to the seasonal variations, the higher values of dissolved phosphate appeared in the Lake proper during the spring and summer as a result of the higher turnover rate associated with increasing water temperature (Fig. 10).

In the fish farm, this was mainly observed in winter and late summer, when the growth of the hydrophyte **Potamogeton pectinatus** was at minimum.

The dissolved phosphate in the Qalaa Drain water showed irregular monthly fluctuations within narrow range except of a peak recorded in February, 1976.

In the Noubaria Canal, the dissolved phosphate remained low till January, 1977. This was followed by a rapid increase between February and July, 1977, indicating increased flow of the Lake water into the Canal.

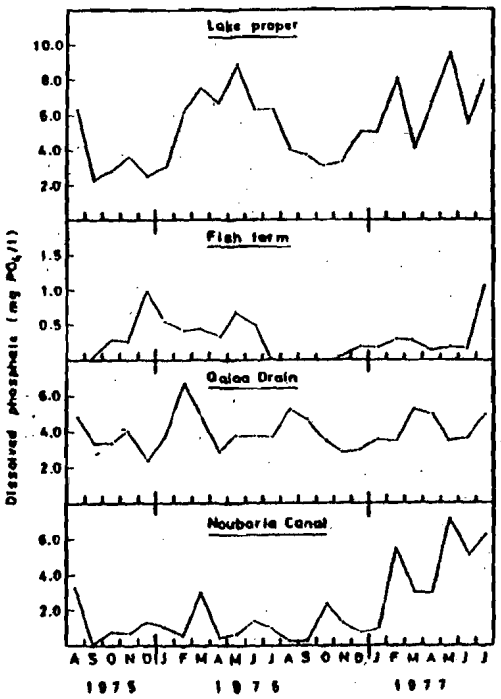

Fig. 10
Seasonal variations of reactive phosphate in mg PO_4/l

The average annual values of dissolved phosphate amounted to 5.26 and 4.00 mg PO_4/l in the Lake proper and the Qalaa Drain respectively. This values decreased to 0.30 mg PO_4/l in the fish farm and 2.07 mg PO_4/l in the Noubaria Canal.

CONCLUSION

The growing population in Alexandria City and the expanding industries around Lake Mariut were accompanied with increased quantities of raw sewage and industrial wastes discharged into the Lake proper. The water quality in this basin was highly deteriorated, resulting in complete oxygen depletion in areas subjected to the direct influx of inland discharges. This was also accompanied with a considerable increase in the amount of dissolved hydrogen sulphide which is highly poisonous to aquatic biota. The inorganic nitrogen compounds were mainly represented as ammonia.

The high input of nutrients through sewage and industrial wastes has considerably increased the phosphorus and nitrogen load in the Lake proper. This resulted in a high degree of water eutrophication accampanied with a heavy bloom of phytoplankton, particularly blue green algae. According to the nutrient concept given by Vollenweider and Dillon (1974), the expected improvement of the Lake water should take several years after treatment of all inland discharges flowing into the Lake.

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