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SPATIAL AND TEMPORAL PATTERNS OF PHYTOPLANKTON COMMUNITIES IN MANZALAH LAGOON

By

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Key Words :Manzalah Lagoon, Phytoplankton, Eutrophication, Diversity cycle.

ABSTRACT

During the period from May, 1992 to April ,1993, the species composition and diversity cycle of the phytoplankton community in Manzalah lagoon were investigated monthly at 11 sites . A total of 141 species were identified comprising 64 diatoms, 42 green algae, 24 blue-green algae, 5 dinoflagellates and 6 Euglenophyceae.

A marked variability, in space and time, in phytoplankton standing crop and in community structure was observed in Manzalah lagoon. Diatoms were the most important algae during the winter and spring. Chlorophytes were mainly observed during autumn, while cyanophytes favour summer. The phytoplankton standing crop attained an average of 12.4×10^6 unit. l^{-1} with a remarkable increase as compared with the previous records. The study indicated high level of eutrophication. Phytoplankton diversity varied widely in the areas, neighbouring the outfalls of discharged water and within narrow range far from the effect of drainage water

INTRODUCTION

Although there has been a great interest among limnologists on nutrient-rich lakes during the last decade, the ecology of phytoplankton of these systems is still far from being well understood. Studies on phytoplankton diversity and assemblages from hypertrophic multipolluted lakes are rather limited , since attention has been commonly focussed on the few dominant species which usually overwhelm them (Abdalla *et al.* 1991; Ibrahim 1989; El-Sherif *et al.* 1993; Gharib, 1998).

Much information is available from previous work on the hydrography, chemistry and plankton of Manzalah lagoon (El-Maghraby *et al.* 1963; El-Wakeel and Wahby 1970a,b; Wahby *et al.* 1972; Bishary and Yosef 1977; Guerguess 1978; Shaheen and Youssef 1978, 1979; Halim and Gerguess 1981; Maclaren 1981; Toews and Ishak 1984; Dowidar *et al.* 1984; Abdel-Moati 1985,; Ibrahim 1989; El-Sabrouti 1990; Saad 1990; El-Sherif *et al.* 1993; Siegel *et al.* 1994; Ibrahim *et al.* 1997a,b; Soliman *et al.* 1998 and Samir 2000).

The aim of the present work is to study the spatial and temporal variations in the species composition of phytoplankton as well as the species diversity in the different basins of Manzalah lagoon in order to evaluate the productivity of the lagoon water.

Area Description:

Manzalah lagoon is the largest and most productive of the Egyptian northern Delta lagoons (Manzalah ,Edku and Burollus). It lies on the southeastern Mediterranean coast , between the Damietta branch of the Nile River to the west and the Suez Canal to the east (Long 31° 45`, 32° 15`E, Lat. 31° 00`, 31° 35`N) (Fig.1). The lagoon is shallow (0.6 – 1.0m), roughly rectangular in shape, 65Km in length and 45Km at its greatest width. The actual area of open water is only 699Km^2 due to the presence of a large number of islets (Samir 2000). These islets act as barriers that retard the interchange of water and sediments throughout the lagoon.

Manzalah lagoon is connected to the Mediterranean Sea through a narrow channel known as Boughaz El-Gamil close to Port Said City.

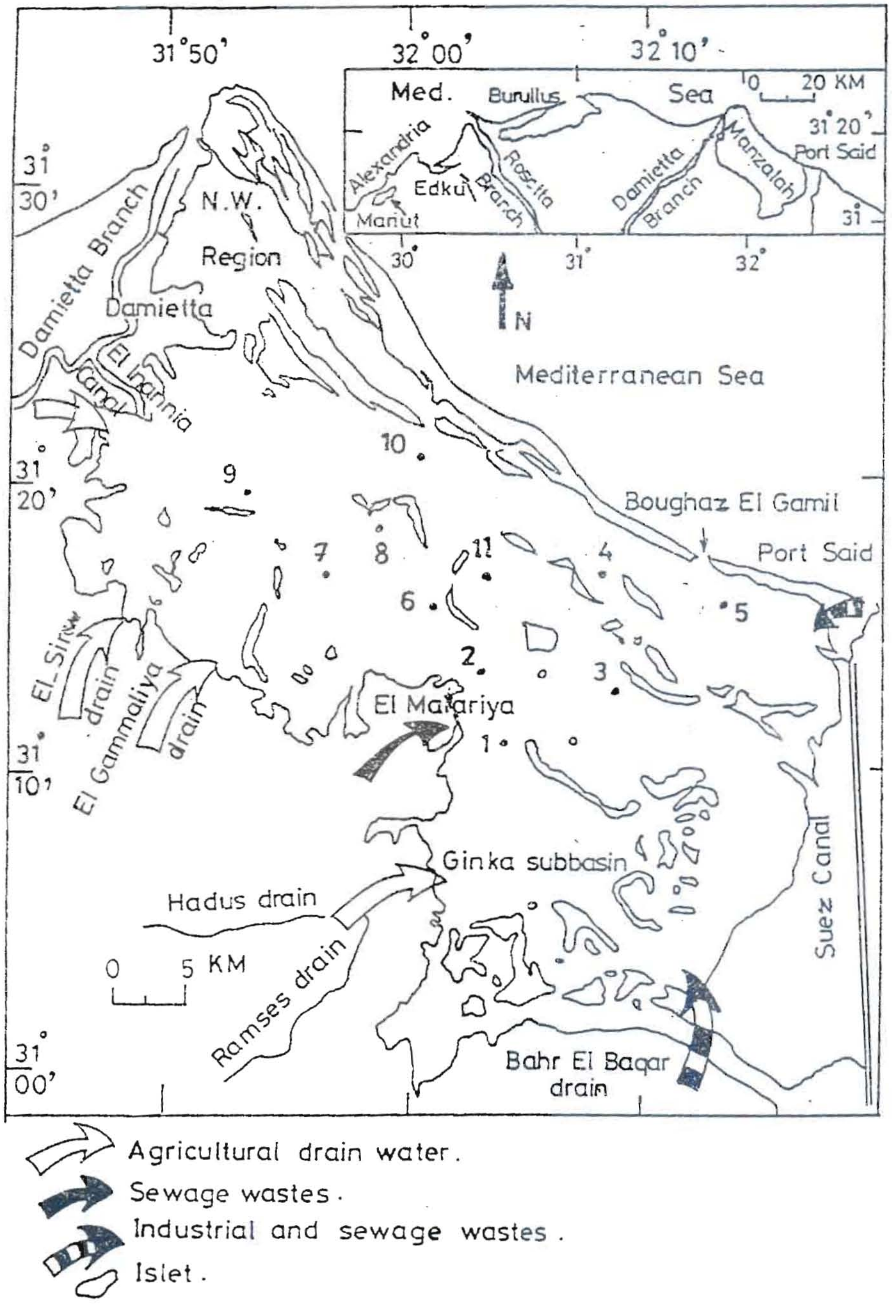

Fig. (1) : Position of stations in Manzalah Lagoon.

A total of about 7500 million cubic meters of untreated industrial, domestic and drainage water, and agrochemicals (fertilizers and biocides) are discharged annually into Manzalah lagoon through four main drains (Hadus-Ramses, Bahr El Baqar, El Sirw and El Gammaliya), El Matariya Pumping Station, El Inaniya and Port Said Canals (Toews and Ishak 1984; Abdel Baky *et al.* 1991).

The borders of the lake receive municipal sewage from the urban centers of Port Said, Damietta, Matariya, Manzalah and El-Gammaliya. The western part receives fresh water with agricultural wastes from the El Inaniya canal; the southern part receives agricultural drainage water with high pesticide content through the Hadus-Ramses drain. About 65% of Cairo's municipal and industrial wastes are discharged through Bahr El Baqar drain into the Ginka subbasin (40 Km^2) at the extreme southeastern corner of the lagoon. The annual total water inflow into the lagoon is about six times the volume of the lagoon (Ibrahim *et al.* 1997a).

MATERIALS AND METHODS

The present study was based on quantitative phytoplankton samples collected at eleven stations, each of which is located in one of the different basins of the lagoon (Figure 1) . The study was conducted during the period from May 1992 to April 1993. The physical and chemical conditions were measured by Abbas (personal communication).

The phytoplankton standing crop was counted according to the Utermohl standard technique (Utermohl 1958) and expressed in units per liter. Identification of species follows: El-Nayal (1935 & 1936) , Edmondson (1959) , Heurck (1896), Huber-Pestalozzi (1938), Peragallo and Peragallo (1897-1908), Cup (1943), Dodge (1982), Smith (1933), Lebour (1925) and Khunnach (1967).

Diversity index (H) was estimated according to Shannon and Weaver (1963) given by the equation:

$$H_n^{i=1} = - \sum Pi \, In \, Pi$$

where Pi= n/N is the proportion of the i^{th} (ni) species to the total number of phytoplankton (N).

The correlation coefficients and the stepwise multiple regression between phytoplankton density and the surrounding environmental parameters were calculated using Number Crunched Statistical System (NCSS) proposed by Hintze (1993) on a computer at a confidence limit of 95% ($P<0.05$).

Also stable community state was considered when more than 80% of phytoplankton numbers was shared by no more than three phytoplankton species (Sommer *et al.*, 1993).

RESULTS AND DISCUSSION

Community structure

The general picture of phytoplankton in Manzalah lagoon during the period of investigation was the presence of large numbers of species (141 species) ranging between 63 species at stations 1 and 9 and 87 species at stations 8 and 10. The low numbers of species at stations 1 and 9 were probably due to high level of water pollution and/or water stagnation.

The great majority of the identified forms (129) were either fresh or brackish water and 12 species were purely marine. Diatoms showed the highest species diversity (64 spp.), while Dinophyceae had the lowest diversity (5 spp.). The fresh water Chlorophyceae, Cyanophyceae and Euglenophyceae were represented by 42, 24 and 6 species, respectively. Only 16 species (2 diatoms, 9 green and 5 blue-green algae) were common to the whole area; these are: *Cyclotella comata* (Ehr.) Kütz.,*Cyclotella meneghiniana* Kütz., *Ankistrodesmus falcatus* var. *acicularis* (A. Braun) G.S. West, *Chlorella vulgaris* Beyerinch. *Crucigenia quadrata* Monren, *Crucigenia tetrapedia* (Kirchn) W.S. West. *Kirchneriella lunaris* (kirchn) Moebius. *Scenedesmus acuminatus* (Lagerh.) Chodat., *Scened. quadricauda* (Turo.) Breb., *Selenastrum gracile* Reinsch., *Tetraedron proteiforme* (Turn.) Brunnthaler, *Chroococcus minutus* (kg.) Naeg., *Merismopedia punctata* Meyer, *Microcystis aeruginosa* Kütz. *Oscillatoria limnetica* Lemn and *Spirulina platensis* (Nordst.) Geitl.

The bulk of the phytoplankton density was caused mainly by few species while the total number of species at the different stations (63-87 spp.) reflected low similarity of phytoplankton composition in most parts of the lagoon.

Standing crop and Successional sequence:

The phytoplankton density varied widely during the study period between 0.44×10^6 and 57.9×10^6 unit.l^{-1}. The mean densities at the different stations indicated pronounced variations; stations 3 and 10 harboured the maximum density, while station 9 sustained the lowest density.

In Manzalah lagoon ,the monthly changes of the relative abundance of the major phytoplankton groups showed pronounced variations with no distinct pattern (Fig. 2). The maximum phytoplankton production was found in spring (average 21×10^6 unit.l^{-1}), and a secondary peak appeared in summer (average 14×10^6 unit.l^{-1}). Such pattern revealed that spring is still the season of the highest phytoplankton production in Manzalah lagoon as well as in the other Egyptian Delta lagoons.The minimum standing crop was recorded in autumn (average 5×10^6 unit.l^{-1}), mostly in September. On spatial scale stations 3 and 10 harboured highest phytoplankton count ,with annual average density 20×10^6 unit.l^{-1}.

Comparing the present study with the previous records ,it was observed that phytoplankton crop in Manzalah lagoon showed continuous increase during the period from 1986 to 1993 .Such increase was associated with parallel decrease in the number of species . They increased from 2.3×10^6 unit.l^{-1}, during 1986-1987 (Ibrahim 1989) to 3.9×10^6 unit.l^{-1}, during 1990 (El-Sherif *et al* 1993) to reach 12.3×10^6 unit.l^{-1}, during 1992-1993 in the present study, but the number of species decreased, respectively from 170 to 140 , the latter is nearly the same as recorded (141 species). This may be due to the increased amount of water discharged in the lagoon .The abnormal bloom of phytoplankton acts as an evidence of eutrophication. Thus, Manzalah lagoon is more productive than other Egyptian lagoons which are subjected to inland discharge such as Edku and Burollus lagoons. Gharib (1998) and El-Sherif (1993) estimated the phytoplankton standing crop in the latter lagoons to be 7.5×10^6 and 1.04×10^6 unit.l^{-1}, respectively. However, Manzalah lagoon is still less productive than Lake Mariut which harboured an average of 56×10^6 unit.l^{-1} (Abdalla *et al*, 1991) .As the other Egyptian lagoons, Manzalah lagoon is mostly dominated by diatoms, while in south Africa lagoons, cyanobacteria is the dominant group, usually *Microcystis* (Talling 1986).

Since there are ecological differences between the sampling stations, chiefly with regard to salinity, amount of nutrients and quality of waters (Table 1), the

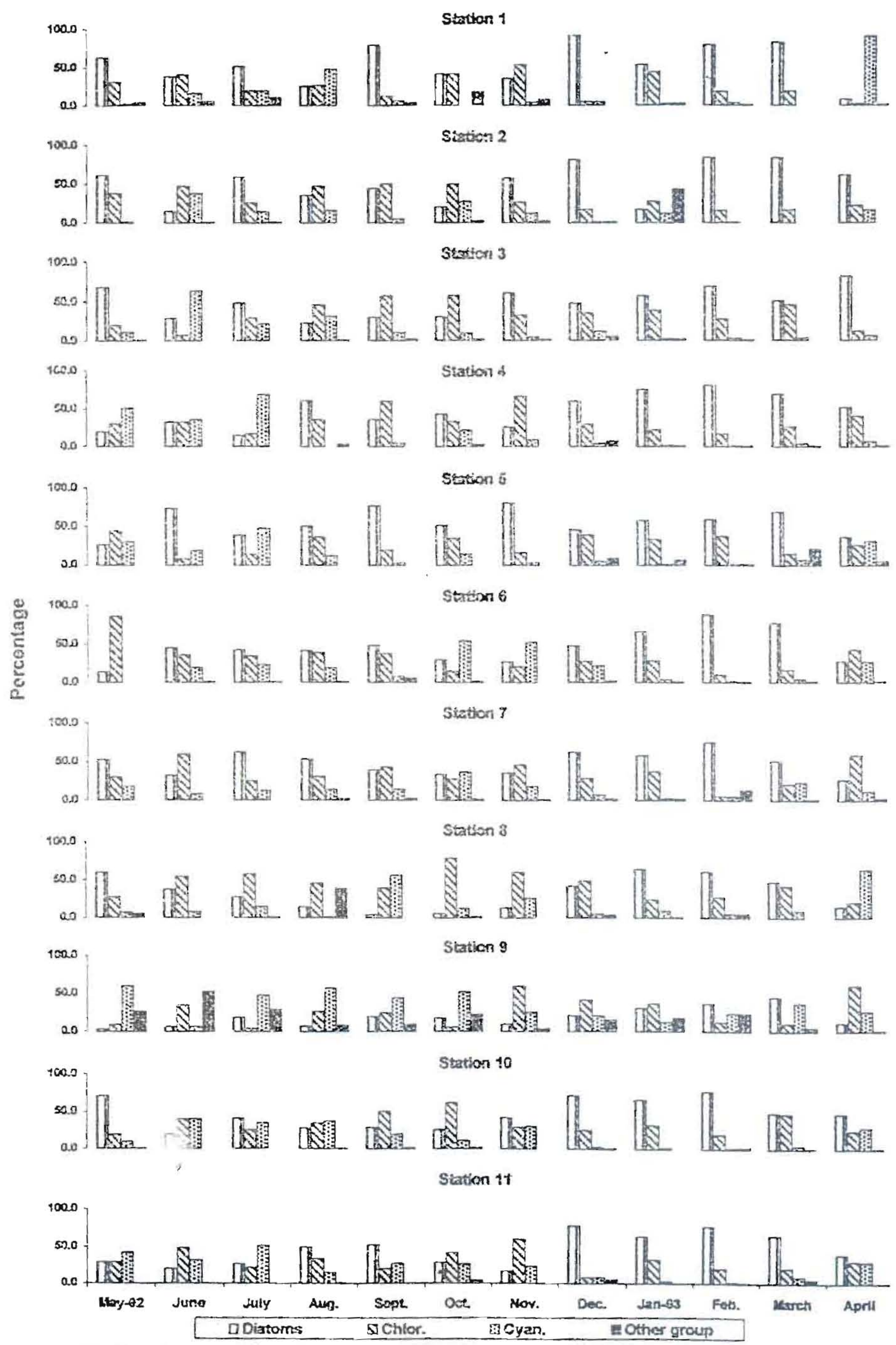

Fig (2): Monthly variations of relative abundance of major phytoplankton groups in Manzalah Lagoon at the different stations during the study period.

Table (1): Ranges of annual variations and average values of physico-chemical parameters at different stations in Manzalah lagoon during the period May 1992 – April 1993 (Abass, personal communication).

Parameter	Station	1	2	3	4	5	6	7	8	9	10	11
PH	Range	7.0-7.9	7.7-8.5	7.5-8.9	7.9-9.0	7.4-8.8	7.8-8.6	7.9-8.8	8.0-9.0	8.4-9.4	7.5-8.8	7.5-8.9
Chlorides Gm Cl.l^{-1}	Range	0.4-2.1	0.7-2.7	0.8-4.0	1.1-7.4	2.3-20.5	0.9-2.1	0.5-1.2	0.9-1.9	0.5-1.1	0.8-3.5	0.9-3.5
	Mean	1.1	1.3	1.8	2.5	7.5	1.2	1.0	1.2	0.7	1.6	1.4
Dissolved O_2 mg.l^{-1}	Range	0.3-7.8	1.7-13.5	1.4-12.6	1.5-12.2	1.2-9.9	1.2-10.5	1.1-7.7	1.0-6.8	1.1-6.7	1.5-11.8	1.5-11.9
	Mean	3.5	7.1	6.5	6.2	5.1	5.4	4.6	4.4	4.5	6.0	6.5
Phosphate µmol. l^{-1}	Range	0.2-21.0	0.5-24.4	0.5-18.5	0.1-6.5	0.1-4.7	0.2-16.8	0.0-4.3	0.2-0.6	0.0-0.6	0.2-6.5	0.2-12.1
	Mean	6.8	7.7	6.3	1.9	1.4	3.5	0.7	0.4	0.2	1.6	3.2
Silicate µmol. l^{-1}	Range	1.4-128.9	5.0-110.5	2.5-119.0	2.4-127.2	1.2-134.6	2.1-103.4	4.6-53.1	1.2-67.0	5.7-89.0	3.5-79.3	5.1-111.1
	Mean	48.3	48.0	41.1	33.1	38.3	28.8	26.2	29.0	30.8	32.0	45.1
Nitrite µmol. l^{-1}	Range	0.4-35.6	0.4-41.1	0.3-18.6	0.2-12.6	0.1-22.0	0.3-5.1	0.1-10.6	0.1-0.6	0.0-1.0	0.3-12.1	0.3-12.1
	Mean	6.1	10.0	3.1	3.2	5.0	1.8	1.5	0.4	0.3	2.9	3.6
Ammonia µmol. l^{-1}	Range	0.1-84.6	0.6-19.1	0.4-37.3	0.8-9.4	0.4-5.1	0.6-60.5	0.6-4.2	0.6-14.9	0.6-17.4	0.9-41.4	0.9-25.1
	Mean	14.0	4.8	7.3	3.5	2.7	9.4	1.8	3.4	4.1	6.0	6.6

Table (2): Correlation coefficients between phytoplankton abundance and mean values of physico-chemical parameters.

Parameter	r	Parameter	r
Water temperature	0.37	Dissolved Oxygen	0.81
Depth	0.05	Dissolved phosphate	0.41
Transparency	-0.67	Reactive silicate	0.98
PH	0.84	Ammonia	0.05
Chlorides	-0.01	Nitrite	0.69

phytoplankton community showed marked spatial variations (figs. 2 & 3) which are discussed in the following part.

Station 1 is located near the outlet of Bahr El Baqar drain and represents the area receiving the major source of waste water discharged into the lagoon. The phytoplankton community comprized 63 species with annual average count amounting to 8.6 x 10^6 unit.l^{-1}, and two peaks, in April and August. Cyanophyceae was represented by 10 species , the count of which formed 45.8% of total crop . They showed a conspicuous bloom in April mainly due to *Chroococcus minutus* (90.0% of the total crop). The dense blue-green algal bloom at station 1 was accompanied by high concentrations of nutrient salts (Table 1). This is in agreement with Smith (1985, 1986); Sommer *et al* (1986); Trimbee and Prepas (1987),who pointed out that cyanophytes favour in water rich in nutrient salts .

Diatoms were the second in importance (34.3%) comprising 17 species, but their standing crop showed clear temporal variation , varying monthly between 8.1% and 90.6% of the total crop. *Cyclotella meneghiniana* was the dominant species over the year, with a peak in February (76.4% to the total counts).

Chlorophceae (17.9%, 29 species) varied widely from 1.7 to 53.0% of the total phytoplankton in different months, with maximum in June and August due to *Chlorella vulgaris* and *Ankistrodesmus falcatus*.

Euglenophyceae and Dinophyceae formed collectively 2.0% of the total counts.

Station 2 is located near the outfall of domestic wastes from El-Matariya .Atotal of 78 species were recorded at this station amounting totally to 15.8 x 10^6 unit.l^{-1}. Two peaks were recorded in February and April. Diatoms (25 spp.) constituted the main bulk of the community (57.4%) showing variable monthly contribution (14.6% - 83.9%) . The February peak was caused by *Cyclotella meneghiniana* (80% to the total crop), which is usually found in low salinity waters (Smith and White 1985) , in eutrophic waters (Werner 1977) and is halophilic species that appear to be stimulated by higher ionic concentrations (Earle *et al.* 1987).

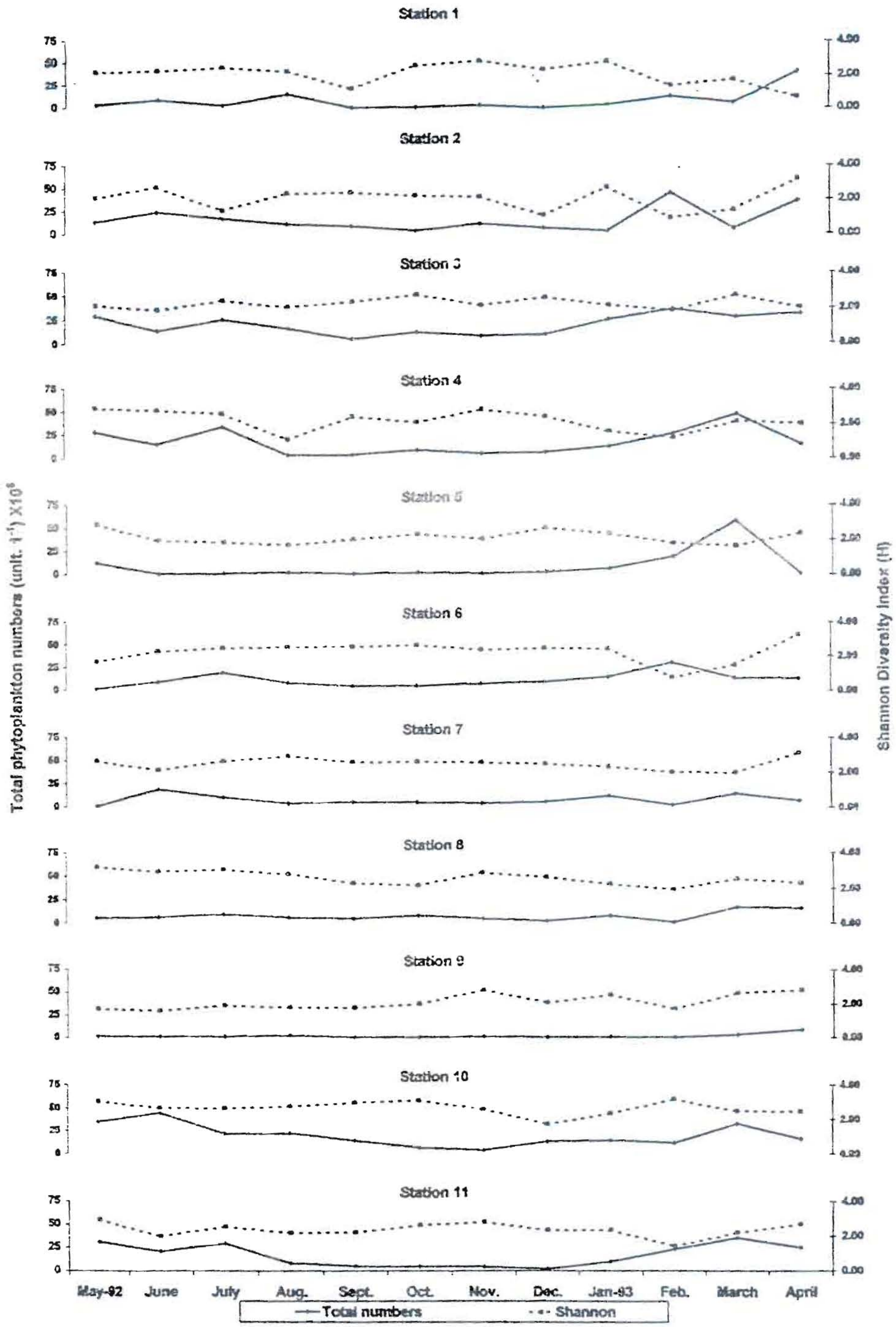

Fig (3): Monthly variations of phytoplankton standing crop and Shannon - Weaver Index (H) at the different stations.

Chlorophyceae (28.9%, 30 species) constituted from 15.4% to 50.3% to the total algal counts, having the maximum in summer due to the dominance of *Coelastrum microporum* and *Scenedesmus* spp.

Cyanophyceae (12.4%, 17 species) were absent in March, while their maximum persistence appeared in June, dominated by *Anabaena variabilis*.

Euglenoids (5 species) were occasionally abundant in January (40% of total count) depending more on inorganic sources of nitrogen and phosphorus. The leading species were *Euglena acus* and *E. granulata*.

The genus *Euglena*. tops a list of sixty most tolerant genera to pollution (Palmer 1969) and is generally considered as a biological indicator for organic pollution (Munawar 1972).

Station 3 is located at the eastern sector of the lagoon. It was characterized by dense phytoplankton population (average 20.2 x 10^6 unit.l^{-1}) with 83 species. A pronounced increase was recorded in May and from February to April. Diatoms were represented by 31 species, constituting 22.1% - 82.1% of the total crop. The genera *Cyclotella* (3 species) and *Nitzschia* (7 species) were the main assemblages . In May, the bloom was predominated by *Nitzschia longissima* (44.1% to the total crop), while in the period from February to April the blooms were mainly due to *Cyclotella meneghiniana* and *C. comata*.

Chlorophyceae (31%, 28 species) constituted from 7.5% to 57.7% of the total crop, with maximum persistence in spring (March). Dominance was shared by several genera, *Scenedesmus* (4 species), *Pediastrum*(3 species), *Chlorella* and *Ankistrodesmus* .

Cyanophyceae (12.7%, 18 species) showed a very irregular production, constituting from 2.1% to 63.2% of the total alga. They attained their peak during summer. *Spirulina platensis*. *Anabaena spiroides* and *Oscillatoria limnetica* were leading.

Station 4 is located near El Gamil area. As the preceding station, dense phytoplankton blooms occurred with annual average 17.5 x 10^6 unit.l^{-1}, comprising 83 species. An outstanding peak was observed in March and less one in July. Bacillariophyceae (47.8%, 32 species) constituted from 14.7% to

80.8% of the total populations. *Cyclotella meneghiniana* formed 76.8% of the total crop in February and *Nitzschia longissima* formed 54.7% in April.

Chlorophyceae (27.5%, 25 species) formed 16.6% to 66.2% of the total crop, with the dominance of *Crucigenia* (2 species) and *Kirchneriella* (3 species).

Cyanophyceae (23.8%, 20 species), reached its maximum in July (68.6%) coupled with high concentration of ammonia, mainly represented by *Anabaena* and *Oscillatoria*. Cyanophyceae usually prefer the warm waters (Tilman and Kiesling 1984; Komarkova and Hejzlar 1996) and they are more characteristic to eutrophic waters than oligotrophic (Lund, 1969; Wetzel 1975; Trimbee and Prepas 1987).

Station 5 is located at El Gamil area and is affected with sea water from Boughaz El-Gamil. The annual average phytoplankton amounted to 9.2 x 10^6 unit.l^{-1}, with 74 species. Dense phytoplankton was observed in March and others less in May and February. Bacillariophyceae (52.6%, 35 species) constituted 26 to 80% of the total community. Their maximum crop was observed in March resulting from *Nitzschia longissima* (58.6%). High chlorides (> 20g.l^{-1}) coupled with low concentration of nutrients during November and April were associated with the presence of brackish and marine forms notably, *Rhizosolenia* spp., *chaetoceros* spp. and *Thalassiosira rotula*.

Chlorophyceae (25.3%, 19 species) ranged between 7.7% and 43.8% of the total community. A pronounced increase in chlorophycean numbers were recorded during February-March. Dominance was shared by several genera. *Ankistrodesmus. Crucigenia. Selenastrum* and *Chlorella*.

Cyanophyceae (9.8%, 13 species) showed a great irregularity, ranged from 1.1% to 47.2% of the total crop. Their maximum was recorded in May and March due to the increased numbers of *Oscillatoria limnetica*. Dinophyceae were only recorded in winter and early spring with high persistence in March. The most representative species are *Gymnodinium* sp. and *Peridinium trochoideum*. Pollingher (1990) observed that, the dinoflagellates are represented in large lagoons at temperate latitude by *Gymnodinium*.

Station 6 is located at the southern sector of the lagoon. The total average standing crop amounted 11.1 x 10^6 unit.l^{-1}, comprising 76 species. Two peaks were recorded in February and July. Bacillariales (56.7%, 32 species) were always well represented, constituting from 13.6% to 87.8% of the total population. Their maximum crop was observed in February, when *Cyclotella meneghiniana* achieved dominance (85.5%).

Chlorophyceae (26.2%, 23 species), ranged between 10% and 86.4% of the total crop with maximum occurrence in July due to the flourishing of *Ankistrodesmus falcatus*.

Cyanophyceae (61.1%, 16 species), showed their maximum occurrence in July. *Oscillatoria limnetica* was the most representative species.

Station 7 is located at the southern sector of the lagoon. It is not directly affected by neither the saline water from Boughaz El-Gamil nor by Bahr El-Baqar drain and was devoid of hydrophytes or at most with scattered patches of *Potamogeton*. The total average standing crop amounted 7.7 x 10^6 unit.l^{-1}, with 86 species. Two peaks were observed in June and March. Bacillariales (46.7%, 35 species) were the dominant group (27.3% - 75.7%), showing a great abundance in January and March. *Cyclotella meneghiniana* was the leading.

Chlorophyceae (38.1%, 24 species) showed an irregular production (5.4% - 59.8%) with pronounced increase in June. Small coccoid green algae as *Scenedesmus* (3 species) and *Chlorella vulgaris* were mainly represented.

Cyanophyceae (2.7% - 36.7%, 18 species) showed their maximum crop in March due to the increased numbers of *Chroococcus minutus*.

Station 8 is located at the north western sector of the lagoon and is not directly affected by sea water or drainage water. The annual average phytoplankton amounted to 7.7 x 10^6 unit.l^{-1}, comprising 87 species. Two peaks were recorded in March and April. Bacillariales showed irregular production (3.9% - 64.6%, 33 species) with maximum crop in March. *Cyclotella meneghiniana* was the dominant.

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Chlorophyceae were always well represented (20.8% - 79.2%, 28 species) with maximum persistence in October. The cosmopolitan species *Chlorella vulgaris* (Tremel ,1996) was the dominant species.

The blue-green algae (1.1% - 63.5%, 17 species), occupied a dominant position in April, mainly due to *Chroococc*ᵏ *minutus*.

Euglenophyceae and Dinophyceae were diversified forming respectively 5 and 4 species, constituted collectively 3.8% of the total crop.

Station 9 represents the western sector of the lagoon receiving drain waters from El-Inaniya area. This station is differ from other stations, having low concentrations of nutrient salts, low chlorides and less suspended matter load (Table 1). It also showed low standing stack (average 2.2 x 10^6 unit.l^{-1}) and smaller number of species (63 species). This may be attributed to the dense vegetation that causes water stagnation and accelerating the precipitation of suspended particles; and hence depriving the water from its nutrients. This process results in suppressing the phytoplankton growth (Abdel Baky and El-Ghobashy 1990) and decreasing also zooplankton and zoobenthos in the area (Ibrahim *et al* 1997b). Hamza (1999) illustrated that the low phytoplankton density could be the result of a direct competition between the macrophytes (especially the submerged populations), and the phytoplankton. A pronounced increase in phytoplankton counts was observed in April.

Green algae (36.2%, 23 species) were well represented constituting from 3.7% to 60.7% of the total counts. Their maximum stock was observed in April resulting from the increased numbers of several genera, notably; *Scenedesmus*, *Crucigenia*, *Chlorella*, *Pediastrum* and *Coelastrum*.

Cyanophyceae was second (34.3%), flourish well in April. *Oscillatoria limnetica* and *Merismopedia punctata* were leading.

Dinophyceae (12.6%) were always present and predominated in June (52%) due to the increased numbers of *Goniaulax apiculata* and *Exuviella apora*.

Station 10 is located at the north sector of the lagoon and is not directly affected with sea water or drainage water. The station sustained high densities of phytoplankton most of the year (average 19.8 x 10^6 unit.l^{-1}) and high number of species (87 species). Diatoms (45.5%, 32 species) mainly represented by the genera *Cyclotella* and *Nitzschia*.

Green algae occupied the second (33.7%, 30 species), represented mainly by *Scenedesmus* spp. and *Chlorella vulgaris* followed by blue-green algae (20.4%, 18 species) which were well represented during summer. *Oscillatoria* and *Anabaena* were the leading genera.

Station 11 harboured an annual average phytoplankton counts of 16.5 x 10^6 unit.l^{-1}, with 85 species. Dense phytoplankton blooms occurred during May-July and February-April with maximum persistence in March. Bacillariales (44.3%, 31 species) constituted from 16.5% to 78.4% of the total crop with high counts in March. *Nitzschia longissima* and *Cyclotella comata* were the leading species and formed collectively 61% of the total counts.

Chlorophyceae (28.4%, 28 species) constituted from 8.1% to 60% with high occurrence in June. *Chlorella vulgaris* and *Crucigenia quadrata* were the most dominant species.

Cyanophyceae (25.8%, 20 species) showed a great irregularity (1.9% - 51.7%) with high occurrence in July. *Oscillatoria limnetica* and *Anabaena flos-aquae* were the leading.

Data analysis

a. Diversity of phytoplankton:

A Shannon-Weaver function was used to measure phytoplankton diversity. All through the sampling period, diversity index (H) in Manzalah lagoon showed irregular pattern. We can identify an annual steady-state period, during which more than 80% of the total phytoplankton counts was shared by no more than three phytoplankton species (Sommer *et al* 1993).

Lowest values of diversity were recorded at stations 1, 2 and 6 -which are to some extent affected by drains water . These stations showed also a wider range of variations in diversity index (Fig. 3). Minimal values of 0.63, 0.93 and 0.76 were observed between February and April at stations 1, 2 and 6, respectively. By February, *Cyclotella meneghiniana* formed more than 80% of the total community at stations 2 and 6, while in April lowest diversity took place at station 1 due to dominance of *Chroococcus minutus* which formed 89% of the total count. The high standing crop of phytoplankton, single species community structure is probably the ultimate manifestation of hypertrophy as observed in Boughaz El Maadiya region (Gharib 1998).

For most of the year, high phytoplankton diversities ocurred in October and November. During both months, stable community states based on a few coexisting species were ended, and the number of species increased paralleling to diversity. When water stability is re-established by February-March, phytoplankton moved again to a new steady-state phase, the number of species and diversities were much reduced.

Maximal diversity (>3.0) was recorded at station 10 (May, September, October and February), at station 8 (May and July) and at stations 6 and 7 in April. As was expected diversity and total abundance of phytoplankton varied simultaneously. At most stations, maximum abundance of algae was brought about by different species. At station 10, *Cyclotella meneghiniana* was the leading species followed by *Nitzschia longissima, Ankistrodesmus* spp. and *Crucigenia quadrata.*

At station 8 , high diversity value cannot be attributed to any particular species but was shared almost equally by (*Merismopedia punctata, Scenedesmus quadricauda, Selenastrum gracile, Cyclotella comata* and *Nitzschia closterium*). At station 6, the dominancy was also shared by larger number of species, particularly; *Nitzschia closterium, N. longissima, Grucigenia quadrata, Scenedesmus* spp. and *Oscillatoria limnetica.*

The lowest phytoplankton density at station 9 was not accompanied by a decrease of diversity values because there were low numbers of units only distributed among various species. The low diversity recorded at station 5 may be due to sharp fluctuation in salinity, this is agree with the observation of Gharib (1998) at Boughaz El-Maadiya region and contrary to the observation obtained by Margalef (1960) who pointed out that the diversity index would be higher when two different communities mix together.

Generally, the results of Diversity Index and species composition virtually confirm that the most southern area is polluted. The water pollution decreases north and westwards.

b. Correlation coefficient analysis:

Statistical analysis of correlation coefficient has been performed on the phytoplankton abundance to the different physico-chemical parameters of Manzalah lagoon (Table 1). The phytoplankton abundance was correlated significantly to the reactive silicate (= 0.98). This may be related to the dominance of diatoms most of the year . Phytoplankton counts showed also significant correlation with pH (r = 0.84) and dissolved oxygen (r =0.81) , reflecting the effect of photosynthetic activity of dense phytoplankton population . A negative correlation was found between phytoplankton standing crop and transparency (r = -0.67, P = 0.05), indicating the role of dense phytoplankton bloom in reducing water transparency .

c. Stepwise multiple regression analysis:

The stepwise multiple regression analysis revealed that phytoplankton abundance in the studying area was highly correlated with dissolved phosphate, dissolved oxygen and chlorides (r = 0.8108, n = 12 at $P < 0.05$).

The regression model is described as follows:

Total phytoplankton abundance= 7912.13+2402.3 PO_4-1100.73 O_2+1531.92 Cl.

Comparison of observed and calculated values (Fig. 4), showed an average error due to the interference of other factors not incorporated in the model equation.

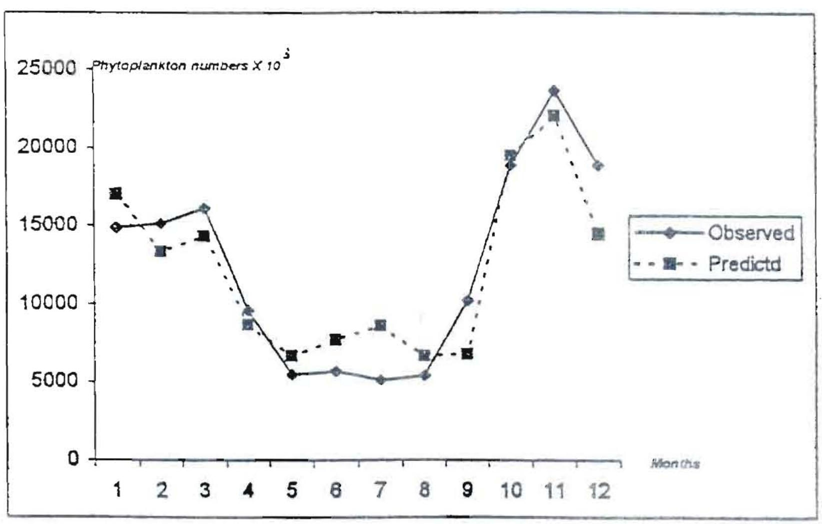

Fig.(4). Comparison of the observed average phytoplankton numbers and the predicated values according to the multiple regression equation in Manzalah lagoon .

CONCLUSION

Manzalah lagoon is a highly dynamic aquatic system. The data of the physical and chemical parameters beside the phytoplankton standing crop showed marked variations relevant to the site of the station and time of sampling. The results lead to a conclusion that the discharged pollutants and drainage water rich in nutrient salts, mainly from Bahr El-Baqar drain must be curtailed or treated in order to improve water quality and to avoid toxic algal blooms or eutrophication in the future which can't be brought under lasting control.

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