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IMPACT OF POLLUTION ON PHYTOPLANKTON COMMUNITY STRUCTURE IN LAKE EDKU, EGYPT.

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Key words: Phytoplankton, Diversity, Habitat structure relationship. Lake Edku.

ABSTRACT

Phytoplankton community structure, diversity index and some hydrographic conditions were investigated seasonally in Lake Edku during the year 2000. Results showed that the studied area is considered to be eutrophic. Levels of nutrients measured are all significantly higher than those found in the same area in the last few years.

A total of 61 species were identified comprising 15 Chlorophyceae which formed 55.3% by number to the total phytoplankton standing crop, 25 Bacillariophyceae (33.7%), 8 Euglenophyceae (8.8%), 11 Cyanobacteria (1.9%) and 2 Dinophyceae (0.3%). The dominant species was the chlorophycean ***Carteria*** sp., (a new record for the lake), which contributed 47.0% by number to the total phytoplankton standing crop, ***Nitzschia*** spp. (14.8%) and ***Cyclotella meneghiniana*** (12.1%).

The phytoplankton standing crop in Lake Edku during the year 2000 showed a remarkable decrease as compared with the previous records (in 1995-1996). Furthermore the present study has indicated high level of eutrophication, accompanying the change in community composition and dominance, as Chlorophyceae became predominant instead of Bacillariophyceae.

Phytoplankton diversity varied widely from 0.24 to 2.85nats, low values were accompanied with stable community states, while higher diversities corresponded to non-steady state periods.

A series of stepwise regression equations describing the dependence of phytoplankton standing crops, its main groups and the most dominant species on the changes of the most abiotic prevailing conditions are given and discussed.

INTRODUCTION

Lake Edku is one of the northern Delta Lakes; it is a shallow brackish coastal lagoon of a depth range of 0.2-1.4 meter connected with the Mediterranean Sea through Boughaz El-Maadiya. The lake is subjected to huge inputs of terrigenous and anthropogenic nutrients from agricultural run off, sewage and drain discharge, these nutritional conditions create rich resource spectrum for algal growth and make the lake biologically productive.

Lake Edku is the third largest coastal water body in the Nile delta ,it is situated west of the Rosetta Nile branch between longitudes 30° 8` 30`` and 30° 23` 00`` E and latitudes 31° 10` 00`` and 31° 18` 00`` N (Fig. 1). The Eastern part of the lake is subjected to the discharge of huge amounts of drainage water, about 83-280x10^3 m^3/day (Shriadah and Tayel, 1992), besides to wastewater from fish farms. The southern part is subjected to drainage water from Barsik Drain, while the western part is directly connected, through Boughaz El-Maadiya to Abu Qir Bay, which is a semicircular shallow basin, which receives wastewater through El-Tabia pumping station with an average of 1850x$10^3$$m^3$/day (Shriadah and Tayel, 1992). In spite of this, tourist Edku beach, 7Km east of Boughaz El-Maadiya had been constructed few years before. Lake Edku was classified previously among oligotrophic lakes (Salah, 1960 and 1961), while nowadays, it becomes eutrophic lake as a result of high inputs of nutrient rich effluents. The latter condition was manifested by extensive growth of the macrophyte ***Phragmites communis*** (L) Tin and ***Typha australis*** Schumt and Thoron (Gharib, 1999). In addition, the introduced sewage may bring high numbers of microorganisms such as the pathogenic coliforms that might threaten aquatic plants and animals and present also a great hazard to public heath

(Siam & Ghobrial, 1999). More than 30% of the lake's area were isolated and converted to fish farms.

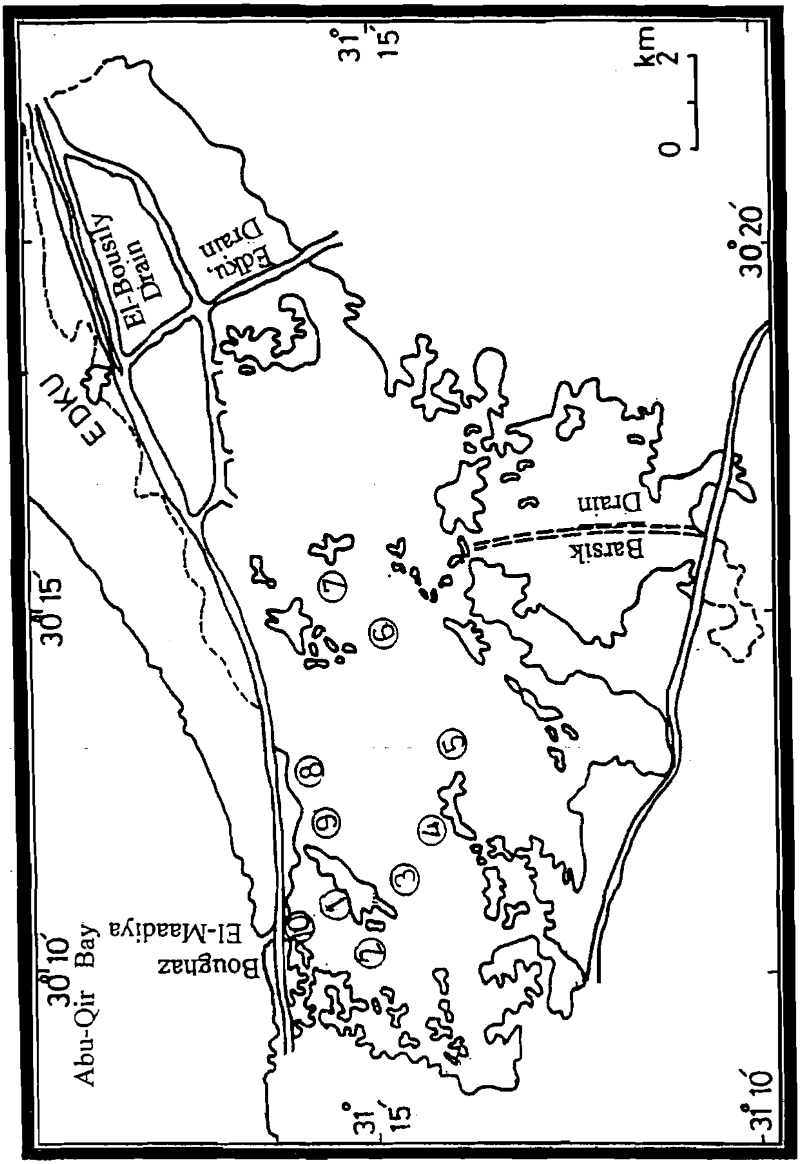

Fig. (1): The location map of sampling stations in Lake Edku.

Many studies have been previously conducted on the hydrograph, chemical and biological characteristics of Lake Edku. El- Sarraf (1994), El- Shenawy (1994), El-Sayed ***et al.*** (1991a & b), Hemeda (1988). Saad (1988), Soliman (1983), Gharib (1983), El-Sabaroti and El-Sokkary (1982). Khalil ***et al*** (1977 a & b), Zazaou (1977), Kinawy (1974), El-Sherif (1973), Ezzat (1972), El-Samra (1973), Gharib & Soliman 1998. Gharib (1999) and Siam & Ghobrial (1999).

The main purpose of the present work is to study the impact of pollutants disposal on population density and species structure of the phytoplankton population of Lake Edku.

The present contribution is a part of environmental investigation of the first phase of the research plan of the fisheries division of National Institute of Oceanography and Fisheries.

MATERIAL AND METHODS

Phytoplankton samples were collected from 10 selected stations detected by the scope of work. Sampling was carried out seasonally for one year during the year 2000 at surface water using Ruttener Sampler with a capacity of two liters.

The environmental conditions: water temperature, hydrogen ion concentration (pH), dissolved oxygen (DO), total dissolved solids (T.D.S.), ammonia, nitrite, phosphate and reactive silicate were studied by Abbas ***et al.***, (in Press). Total bacterial number, enumerated Faecal coliforms, ***E. coli***, ***Streptococcus faecalis*** and ***Vibrio*** sp. were estimated at the sametime of sampling by El-Shenaway ***et al.*** (2000, as well as zooplankton distribution were encountered by Aboul-Ezz and Soliman (2000).

Phytoplankton samples for identification of species and counting were preserved in 4% solution of neutral formalin and few drops of lugol's solution. The phytoplankton standing crop was estimated by sedimentation method (Utermohl, 1936) and expressed in units per litre.

Identification of species follows: El-Nayal (1935 and 1936), Heurck (1896), Huber – Pestalozzi (1938), Peragallo and Peragallo (1897-1908), Cupp (1943), Dodge (1982), Smith (1933), and Lebour (1925). Species diversity index (H) was estimated according to Shannon and Weaver (1963)

as follows: $$H = -\sum_{i=1}^{n} p_i \ln p_i$$

Where Pi = importance probability for each species (n/N is the proportion of i, the n_i species) to the total number of phytoplankton cells [N], the results were expressed as "nats".

Correlation coefficient as well as stepwise multiple regression equations at a confidence limit 95% were evaluated for the whole year (n = 40) to quantize the phytoplankton standing crops, total Chlorophyceae, total Bacillariophyceae and for the dominant Chlorophycean species (***Carteria*** sp.) as well as diversity index in relation to the most correlative environmental factors.

RESULTS AND DISCUSSION

Phytoplankton standing crop:

Community composition:

Phytoplankton standing crop is a good estimate of the current degree of productivity. The occurrence of algal blooms may indicate possible impacts of anthropogenic inputs on the ecosystem. Reduction in the number of dominant species , species diversity and the increase in cell count of one or two algae are some of the changes observed in the phytoplankton populations of polluted environments. In the present study, the average of phytoplankton standing crop and its main different groups are given in table (1) as compared with the previous records in Lake Edku.

The phytoplankton community of Lake Edku included 61 taxa belonging to Bacillariophyceae (25 spp.), Chlorophyceae (15 spp.), Cyanobacteria (11 spp.), Euglenophyceae (8 spp.) and two species of Dinoflagellates. However few of them were responsible for the bulk of the standing stock, particularly the new record chlorophycean species ***Carteria*** sp. (47.0% by number to the total phytoplankton standing crop), ***Nitzschia*** spp (14.8%) ***Cyclotella meneghiniana*** (12.1%), ***Scenedesmus*** spp. (4.9%), ***Phacus*** spp. (4.7%) and ***Euglena*** spp. (3.8%).

Table (1): The annual average numbers of the different phytoplankton groups, their percentage frequencies and number of species during 1976-1977 (Gharib, 1983 and Soliman, 1983), 1995-1996 (Gharib, 1999) and during the year 2000 in Lake Edku.

Groups	1976-1977			1995-1996			2000		
	Average No.	No. of SPP	%	Average No.	No. of SPP	%	Average No.	No. of SPP	%
Chlorophyceae	1278	28	8.2	863000	39	11.5	2506945	15	55.32
Bacillariophyceae	13713	50	87.6	5213000	40	69.3	1526681	25	33.69
Euglenophyceae	89	6	0.5	547000	17	7.3	398485	8	8.79
Cyanobacteria	447	15	2.9	109000	21	1.5	86858	11	1.92
Dinophyceae	119	1	0.8	786000	2	10.4	12858	2	0.28
Total	15646	100	100	7517000	119	100	4531827	61	100

Chlorophyceae dominated the other phytoplankton components and formed about 55.3% by number to the total phytoplankton, Bacillariophyceae contributed 33.7%, Euglenophyceae constituted 8.79%, Cyanobacteria shared with 1.9% and Dinophyceae was rarely recorded (0.3 %).

The other chlorophycean species were rarely recorded, namely; ***Ankistrodesmus falcatus*** (2.3% by number to the total phytoplankton standing crop), ***Scenedesmus*** (3 species) formed 4.86%, ***Pediastrum boryanum*** (0.08%), while ***Crucigenia*** (2 species), ***Oocystis, Actinastrum, Kirchneriella, Coelastrum, Selenastrum, Closterium*** and ***Oedogonium*** formed all together 1.1%.

Bacillariophyceae was dominated by ***Cyclotella meneghiniana*** (12.1 % by number to the total standing crop all the year round), ***Nitzschia*** (7 species), dominated by ***Nitzschia closterium*** (5.9%), ***Nitzschia microcephala*** (5.2%), ***Nitzschia longissima*** (3.6%). besides to ***Navicula*** (4 species) dominated by ***Navicula cryptocephala*** (3.2%).

The annual average of the phytoplankton standing crop was much higher ($4.5x10^6$ unit.l^{-1}) in 290 folds than that previously recorded at the same region during 1976-77 (Gharib, 1983) as shown in table (1). However, the number of species was decreased and the picture was altered and Chlorophyceae became predominant. On the other hand, the standing crop in the present study was lower than that recorded during 1995-96 ($7.5x10^6$ units.l^{-1}) Gharib (1999), the number of species also decreased as shown in table (1). This may be due to the increased amounts of drainage water and wastewater discharged into the lake.

The annual average of the present phytoplankton standing crop in Lake Edku ($4.5x10^6$ units.l^{-1}) indicated that, the lake is the most productive regions among the Delta Egyptian lakes, which subjected to inland discharge such as Lake Burollus and Lake Manzalah El-Sherif (1993) and Ibrahim (1989) estimated the phytoplankton standing crop in the latter lakes to be $1.04x10^6$ and $2.3x10^6$ units.l^{-1} respectively. Diatoms mostly dominate the Egyptian lakes, while the recent picture in Lake Edku differ.

Phytoplankton Distribution:

The lake water sustained a heavy growth of phytoplankton (Fig. 2) as a result of continuous discharge of allochthonous nutrients and organic load from three main drains, namely; Edku; Bousily and Barsik (Fig.1). These factors induced high standing crop particularly at station 3 (12.7 x 10^6 units l^{-1}) and less so at Stations 1, 2, 4 & 8 as shown in fig. (2). The highest phytoplankton counts of station 3 are due to increase numbers of ***Carteria*** sp. (4.5x10^6 cell.l^{-1}), ***Nitzschia*** spp. (2.3x10^6 cell.l^{-1}), ***Scenedesmus*** spp. (1.3x10^6 cell.l^{-1}) and ***Phacus*** spp. (1.2x10^6 cell.l^{-1}). This associated with the lowest numbers of bacteria; total coliform (9 cell/ml), ***E. coli*** (6 cell/ml), ***St. faecalis*** (30 cell/ml) and ***Vibrio*** sp. (35 cell/ml) as well as moderate values of nutrient salts, NH_4 (2.3µg-at.l^{-1}), NO_2 (1.9µg-at.l^{-1}), PO_4 (5.4µg-at.l^{-1}), SiO_2 (62.1µg-at.l^{-1}), T.D.S. (2088mg.l^{-1}) and DO (10.3ml.l^{-1}). Standing crop values at stations 1, 2 and 4 due to ***Carteria*** sp. (1.9, 4.1 & 4.3x10^3 cell.l^{-1} at the three stations respectively), ***Nitzschia*** spp. (1.3, 0.5 & 0.4x10^6 cell.l^{-1} respectively), ***Euglena*** spp. (0.2, 0.35 & 0.09x10^6 cell.l^{-1} respectively), while at station 8 attributed with the increased numbers of ***Carteria*** sp. (3.9x10^6 cell.l^{-1}), ***Euglena*** spp. (0.5x10^6 cell.l^{-1}) and ***Nitzschia microcephela*** (0.22x10^6 cell.l^{-1}). The lower standing crop values were recorded at stations 6 & 7 as affected directly by Bousily drain, which reflect higher values of all nutrients; NH_4 (3.1 & 13.4 µg at .l^{-1}), NO_2 (4.5 & 15.7 µg at .l^{-1}), PO_4 (11.1 & 16.2 µg at .l^{-1}) and S_iO_2 (172.1 & 90.6µg at .l^{-1}), DO (7.4 & 5.5 ml o_2.l^{-1}) and lower T.D.S values (2410 & 1395 mg.l^{-1}) as well as higher counts of bacteria total coliforms (1293 & 2933 cell.ml^{-1}), ***E. coli*** (1044 & 2173 cell.ml^{-1}), ***St. faecalis*** (480 & 820 cell.ml^{-1}) and ***Vibrio*** sp. (2245 & 2548 cell.ml^{-1}) according to El-Shenawy ***et al***.. (2000).

The zooplankton population attained 326.4 x10^3 organism. m^{-3} , it was dominated by Rotifera (76.1%), Copepoda (16.0%),Protozoa (3.4%), Cladocera (2.5%). Ostracoda and other groups were 0.9% for each to the total number of zooplankton community (Aboul –Ezz and Soliman, 2000).

Regarding the regional distribution, the phytoplankton and zooplankton populations showed a direct relationship similar with Makarewicz and Likens (1979) in various eutrophic lakes. Exceptions were observed at stations 1 and 5, where inverse relationship occurred. The highest zooplankton counts were observed at the two stations (580x10^3 and 525x10^3 organism. m^{-3} respectively).The zooplankton community was dominated by small filter feeder species of herbivores rotifers; ***B. calyciflorus*** (106x10^3 and 123x10^3 organism. m^{-3} respectively), ***B. urceolaris*** (51x10^3 and 110x10^3 organism.m^3 respectively), ***B. angularis*** (152x10^3 and 44.5x10^3 organism. m^{-3} respectively) and ***Keratella***

($55x10^3$ organism. m^{-3} for station 1) and ***Monstyla*** ($43x10^3$ organism. m^{-3} for station 5). However, phytoplankton communities harbored a relatively high counts at station 1 ($5.2x10^6$ unit.l^{-1}) dominated by ***Carteria*** sp. ($1.9x10^6$ cell.l^{-1}), ***Nitzschia*** spp. ($1.3x10^6$ cell.l^{-1}). ***Cyclotella*** ($0.9x10^6$ cell.l^{-1})) and ***Euglena*** spp. ($0.2x10^6$ cell.l^{-1}), while at station 5 phytoplankton communities were relatively low ($2.4x10^6$ unit.l^{-1}). Thus, the highest counts of herbivores rotifers and cladocerans, may be responsible for the reduction of phytoplankton density (Champ and Pourist, 1977). Guerguess (1979) examined the stomach contents of ***B. calyciflorus*** in Lake Manzalah and revealed the dominance of ***Cyctotella meneghiniana***, ***Euglena*** spp. and ***Scenedesmus*** spp. The same findings were confirmed by the results of Gharib and Soliman (1998) in Lake Edku and also with the results of this work.

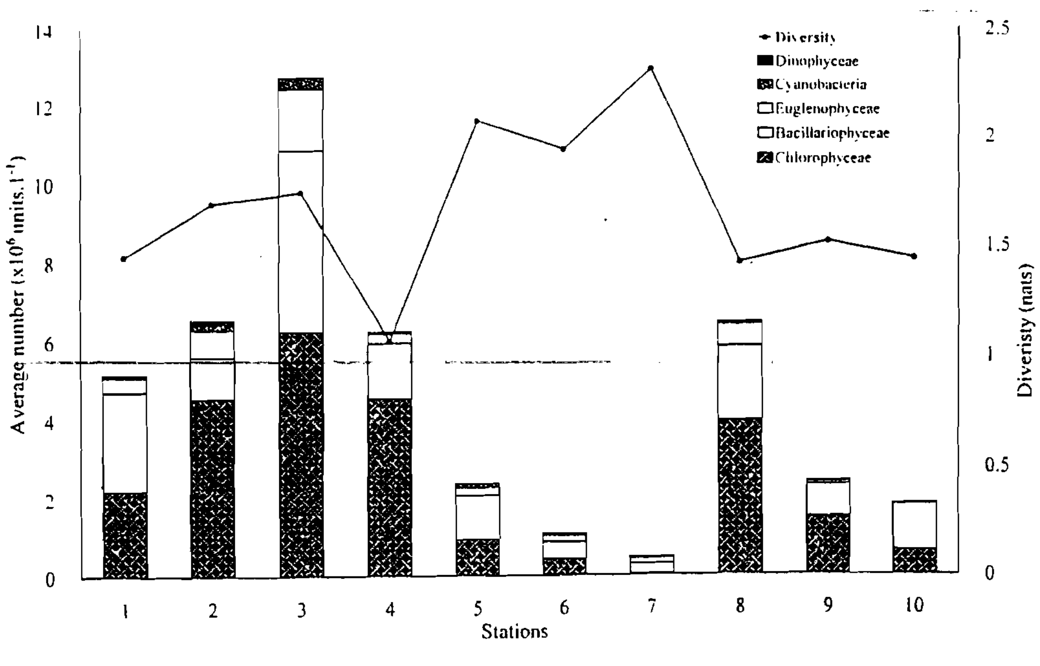

Fig (2): Distribution of total phytoplankton standing crop and its main components ($x10^6$ units.l^{-1}) at different stations and diversity values in Lake Edku during the year 2000.

Seasonal variations:

The phytoplankton standing crop showed a high-pronounced peak in winter and spring seasons (Fig. 3). Its magnitude and variability were governed by significant input of nutrient rich effluent into the lake, which induces ecosystem modification on the level of community structure and species abundance. It comprised mainly Chlorophyceae, showing maximum persistence in spring season. The most dominant chlorophycean species was ***Carteria*** sp. (80.1% by number to the total phytoplankton standing crop during this season). It flourished at stations 3 and 8 (Fig. 4), attained 11.9 x 10^6 and 15.0 x 10^6 cell.l^{-1} respectively. This may be due to higher values of PO_4 (12.9 & 13.78µg at .l^{-1}), S_iO_2 (99.24 & 122.64µg at .l^{-1}), NH_4 (3.0 and 20.57 µg at .l^{1}) and DO (11.3 & 7.4ml o_2.l^{-1}) as well as lower values of T.D.S (1750 & 1310 mg .l^{-1}). Also it flourished at stations 2, 3 and 4 during winter (Fig.4), since it reached 14.4, 5.5 and 7.6 x 10^6 cell.l^{-1} respectively. This is accompanied with higher values of DO (8.7, 12.1 & 13.4ml o_2.l^{-1}). Bacillariophyceae attained its highest counts during winter particularly at stations 3 and 8 (Fig. 4), this is mainly due to the higher counts of ***Cyclotella meneghiniana*** (6.8 and 5.1 x 10^6 cell.l^{-1} respectively), and attributed with higher values of pH (9.4 and 9.0 respectively) DO (12.1 & 10.7ml O_2.l^{-1}), lower values of NH_4 (4.3 and 1.5µg at .l^{-1}), PO_4 (4.0 and 7.7µg at .l^{-1}) S_iO_2 (3.44 and 7.45 µg at .l^{-1}) and T.D.S (2270 and 2160 mg.l^{-1} respectively). this outstanding peak consumed nutrient salts. Also high counts were recorded during summer season especially at stations 1 and 4, which were dominated by ***Nitzschia*** spp. (3.4 x 10^6 cell.l^{-1}) and ***Melosira varians*** (1.9 x 10^6 cell.l^{-1}), respectively. The increase at St. 4 was accompanied with the highest values of DO (15.6 mlo_2.l^{-1}) and low values of T.D.S (1990 mg .l^{-1}), NH_4 (0.64µg at .l^{-1}), NO_2 (0.16µg at .l^{-1}), PO_4 (5.64µg at .l^{-1}) and S_iO_2 (80.3µg at .l^{-1}) as consumed by Bacillariophycean species.

On the other hand, the lowest phytoplankton standing crop were recorded during both summer and autumn seasons, this is may be attributed to grazing of zooplankton and most common fish ***Tilapia*** spp. which are common in the lake and omnivorous fish reported to be (Al-Kholy and Abdel Malek, 1972).

Seasonally, phyto-zooplankton relationship showed a direct correlation. Outstanding peaks recorded during winter season for both phytoplankton and zooplankton communities, phytoplankton standing crop represented by Chlorophycean species ***Carteria*** (3.4x10^6 cell.l^{-1}), ***Ankistrodesmus*** (0.34x10^6

cell.l^{-1}) and Bacillariophyceae *Cyclotella* ($2.0x10^6$ cell.l^{-1}), ***Nitzschia*** spp. ($0.6x10^6$ cell.l^{-1}) and ***Navicula*** spp. ($0.5x10^6$ cell.l^{-1}), while zooplankton were dominated by rotifers, ***Brachionus calyciflorus*** ($129x10^3$ organism.m-^{3}), ***B. angularis*** ($76x10^3$ organism.m^{-3}) and ***B. urceolaris*** ($68x10^3$ organism. m^{-3}).

Generally, the dominant zooplankton species, ***B. calyciflorus*** (21.5% by number to the total zooplankton population), ***B. angularis*** (14.8%), ***B. urceolaris*** (9.5%) and ***Keratella*** (4.0%), play an important role for determine the relation between phytoplankton and zooplankton communities.

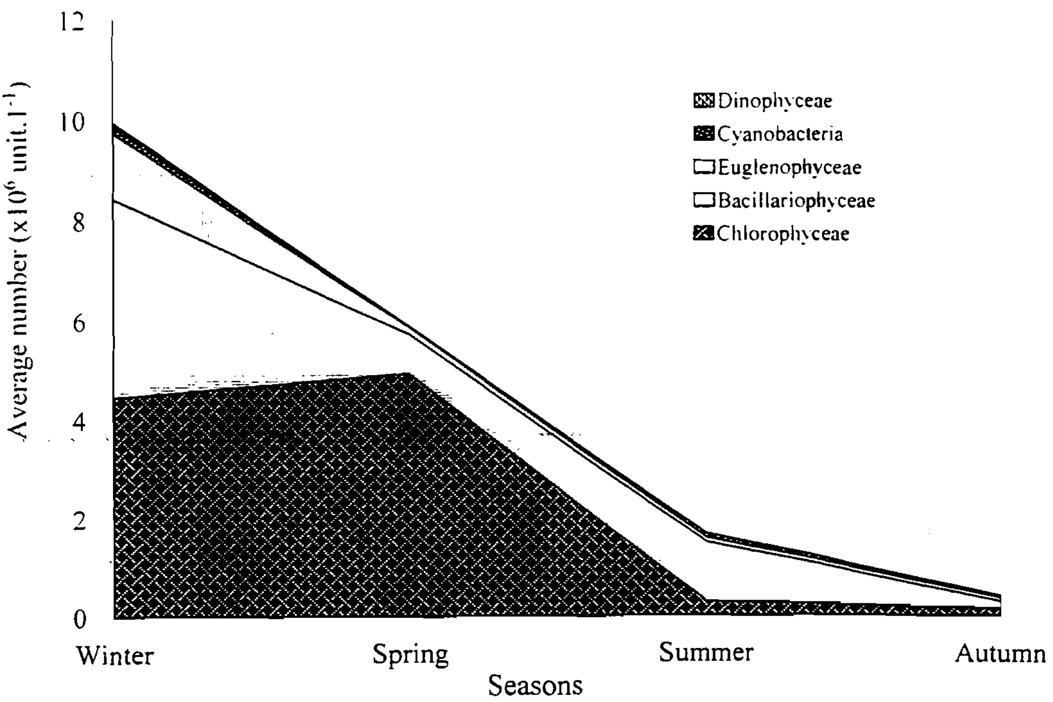

Fig. (3): Seasonal average variations of total phytoplankton standing crop and its main components (x10^6 unit.l^{-1}) in Lake Edku during the year 2000.

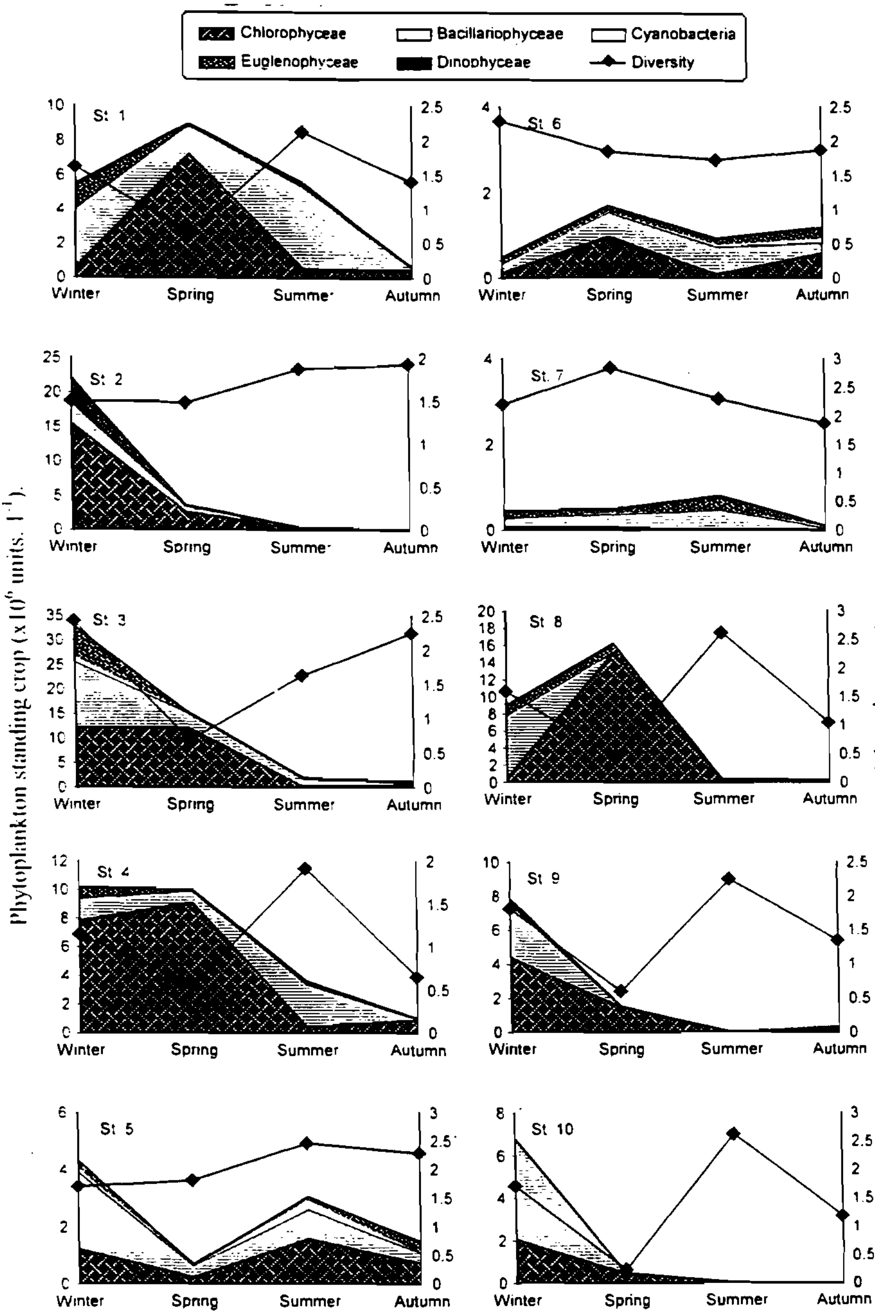

Fig. (4): Seasonal variations of phytoplankton standing crop, its main components ($x10^6$ units. l^{-1}) and diversity values at the different stations in Lake Edku during the year 2000.

Phytoplankton structure and environmental conditions:

The correlation coefficient of phytoplankton standing crop. its main groups and dominant species with some physico-chemical parameters are given in table (2).

Table (2): Significant correlation coefficient at $P \leq 0.05$ of Biological factors with some physico-chemical environmental factors in Lake Edku during 2000.

Parameters Groups	pH	Temperature	Dissolved oxygen	Ammonia	Nitrite	Silicate
Phytoplankton	0.62	- 0.44	0.42		- 0.34	- 0.29
Chlorophyceae	0.38		0.26		- 0.26	
Bacillariophycea	0.65	- 0.48	0.46	- 0.24	- 0.34	- 0.35
Cyanobacteria	0.34	- 0.29	0.33			
Euglenophyceae	0.44	- 0.47	0.29			- 0.27
Dinophceae	-	- 0.30				
Carteria sp.	0.44	- 0.57				- 0.27
Cyclotella spp.	0.33		0.27	0.24	- 0.26	
Nitzschia spp.	0.53	- 0.34	0.39		- 0.31	- 0.22

Thus, all of the biological factors are positively significant correlated with pH values and dissolved oxygen, and negatively correlated with water temperature, nitrite and silicate content and this explained high outstanding peak in winter season as shown in figure (3).

Stepwise multiple regression models showed the dependence of phytoplankton standing crop (St. crop); Bacillariophyceae, Chlorophyceae and its dominant species (***Carteria***) on the most correlative environmental factors are as follows.

St. crop = - 44667 x 10^3 + 6963390 pH - 403879 Temperature + 279945 Ammonia (r = 0.68, R^2 = 0.42).

Bacillariophyceae = - 13029 x 10^3 + 2312641 pH - 194372 Temperature. (r=0.70, R^2 = 0.47).

Chlorophyceae = - 20871x10^3 + 2723619pH + 321381NH_4 – 121436NO_2 (r = 0.51, R2 = 0.19)

Carteria sp. = 4481369 – 414367 Temperature – 973988pH – 783 T.D.S. - 104750 NH_4 (r = 0.67, R^2 = 0.38).

Diversity Index:

The average phytoplankton diversity ranged from 1.12 nats (spring) to 2.16 nats (summer), with an annual average of 1.67 nats as shown is figure (5). The highest average values were recorded during winter and summer 1.8 and 2.16 nats respectively. Although the phytoplankton density in winter (10×10^6 unit.l^{-1}) was much higher than that in summer (1.7×10^6 unit.l^{-1}) and the species richness were 34 & 47 respectively. Such high diversity values are attributed to the dominance of several species as shown in figure (5). On the other hand, the lowest average diversity values were obtained in spring and autumn (1.12 & 1.59 nats respectively). Although the standing crop in spring (5.9×10^6 unit.l^{-1}) was higher than in autumn (0.6×10^6 unit .l^{-1}), and the species richness were nearly similar 43 and 49 species respectively. The community was dominated by only one species, ***Carteria*** sp. (80.1% and 46.2% to the total phytoplankton standing crop for the two seasons respectively) as shown in figure (5). This is confirmed with the significant inverse relation between diversity values and the degree of dominance ($r = -0.87$).

The absolute value of species diversity ranged between 0.24 nats (St. 10, Spring) to 2.85 nats (St. 7, Spring), the lowest value was attributed to the dominance of only one species: ***Carteria*** sp., constituting about 96% by number to the total standing crop at station 10 as well as lowest counts of phytoplankton (0.5×10^6 unit .l^{-1}), species number reached 15. While the highest species diversity was recorded at station 7 during spring was accompanied with high number of species (30) and low dominance was shared by more than one species namely; ***N. microcephala*** (14.7%), ***N. closterium*** (10.7%), ***N. paradoxa*** (8.04%), ***Melosira granulata*** var. ***angistissima*** (8.04%), ***Navicula cryptocephala*** (7.7%), ***Synedra ulna*** (7.0%), ***Closterium acutum*** (5.3%), ***Phacus longicauda*** (5.3%) and ***Euglena acus*** (6.4%).

Regarding the regional variation of diversity index as shown in figure (2). The values ranged from 1.07 nats (St. 4) to 2.3 nats (St.7). The lowest diversity value at Station 4, coincided with higher phytoplankton standing crop (6.2×10^6 unit.l^{-1}) and number of species than that recorded at Station 7 (0.5×10^6 unit.l^{-1}) while the species richness (39 & 38 species) was comparable at both stations. A condition which may confirm the inverse relationship between diversity index and standing stock of phytoplankton.

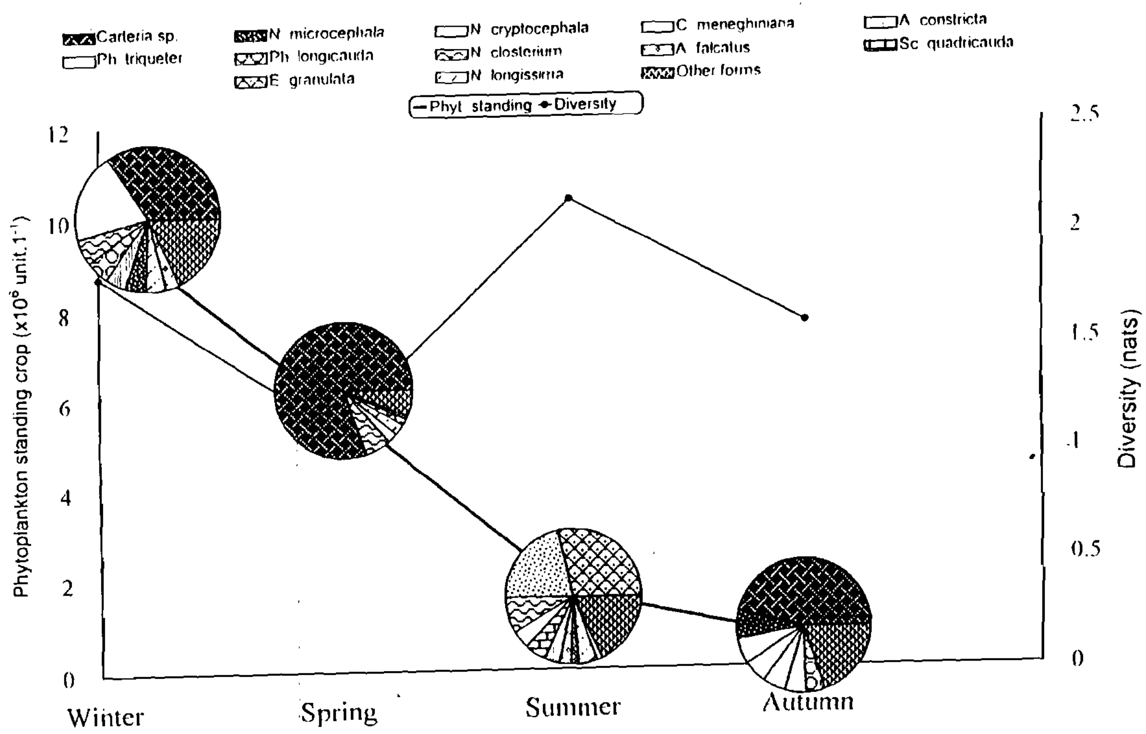

Fig. (5): Average number of total phytoplankton standing crop, its main components and diversity values in Lake during the year 2000.

Diversity and habitat structure relationship:

The number of species occurring in a particular phytoplankton community depends on the interaction between several ecological factors (Hallegraff & Reid, 1986; Abdalla *et al.*, 1992; Zaghloul, 1994 and 1995). The availability of resources is one of the most important ecological factors affecting species diversity. This effect was emphasized by numerous workers who have reported correlation between species diversity and some aspects of habitat structure (Borowitzka, 1972; Margalef, 1978; Cosser, 1988 and Samaan *et al.*, 1996).

According to Abbas *et al.*. (in Press). Lake Edku is characterized by high nutrient concentrations with annual averages of 5.35μg at NO_2-N.l^{-1}, 4.49μg at NH_4-N.l^{-1}, 7.75 μg at PO_4-P.l^{-1} and 97.70μg at S_iO_2 - Si.l^{-1} as well as high dissolved oxygen (8.3ml O_2.l^{-1}). Such values are higher than that previously recorded from the lake during the last ten years (Gharib and Soliman, 1998) and are mostly attributed to the huge amounts of both drainage and wastewater discharged into the lake. The increased concentrations of nutrient salts in the lake create eutrophication at times particularly during spring and summer seasons.

A stepwise regression model showing the dependence of diversity on the most correlative environmental factors were developed. The equation being :

$$\text{Diversity} = 0.870837 + 0.00021 \text{ Total dissolved Solids} + 0.052107 \text{ Phosphate} + 0.03343 \text{ Nitrite} - 0.053673 \text{ Ammonia}. \quad (r = 0.43,\ R^2 = 0.2)$$

From this model, it is clear that diversity mainly reflects the eutrophication phenomena in Lake Edku. Logically, eutrophication reflects the excess of nitrite, ammonia and phosphate, which are introduced by the huge amounts of drainage water, characterized by high dissolved solids, which in turn stimulate photosynthesis of phytoplankton.

CONCLUSION

The investigated area received huge amounts of drainage water enriched with agricultural fertilizers in addition to domestic industrial effluents and farms fisher wastes. These conditions affected directly and/or indirectly the water quality of the lake, causing eutrophication state and lowering the diversity values of phytoplankton population and have also affected the species composition ,relative abundance and dominance of the major components of the phytoplankton community .This companied by certain preference on the dominance of some species considered as indicators of water pollution such as ***Euglena*** spp. and ***Phacus*** spp., and altering the community composition from Bacillariophycea to Chlorophyceae. The estimated correlation coefficient showed a linear relationship between the phytoplankton standing crop and zooplankton population (r=0.64), which reflects eutrophic state in the lake during this work. Such situation provides a warning alarm against the increased pollution in the lake .It is recommended to control discharge of drainage and sewage water into the lake or at least minimize the usage of fertilizers in agricultural lands. Secondary treatment for sewage water essential to accelerates its recovery and improving water quality of the lake.

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