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PHYTOPLANKTON COMMUNITY IN ABU-QIR BAY AS A HOT SPOT ON THE SOUTHEASTERN MEDITERRANEAN COAST.

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ABSTRACT

The phytoplankton community in the stressed part of Abu Qir Bay was studied monthly relative to the prevailing ecological conditions from April 1998 to March 1999 at eight stations. The study recorded a total of 182 species of both fresh and marine origins, belonging to diatoms (89 species), chlorophytes (34 species), dinoflagellates (26 species), cyanophytes (18 species), euglenophytes (12 species), silicoflagellates (2 species), and cryptophyte (one species). Most of the recorded species occurred either seasonally or rarely, while small number of them appeared as persistent. The diversity of the phytoplankton community experienced wide variations on both monthly and spatial scales, accompanied by analogous variations in the diversity index, richness and evenness. The phytoplankton count was low (0.01 x 10^3 - 12.5 x 10^3 unit/L) all the year round, except high density in September (55.6 x 10^3 units/L). In contrast, chlorophyll-*a* attained markedly high values over the year (2.06 – 52.64 g/L). The diatoms *Nitzschia pungens and Asterionella japonica* were the predominant, in addition to *Chaetoceros affinis, Thalassionema nitzschioïdes* and the dinoflagellate *Prorocentrum micans.* The phytoplankton count showed insignificant correlation with the nutrient salts, may be due to the water deterioration, resulting from the acute eutrophication and the increase of pollution stress in the bay. The present study revealed a marked drop in phytoplankton abundance as compared to the earlier records.

1. INTRODUCTION

Abu Qir Bay is a shallow semi-closed basin lying about 20 km east to Alexandria city, between longitudes 30° 03' and 30° 22' E and latitudes 31° 16' and 31° 28' N. It is bordered at the northeastern side by the Rosetta mouth of the Nile and at the southwestern side by Abu Qir head land, which recently was extended further seaward through the construction of Abu Qir Harbor. The bay occupies an area of 500-600 km^2 with average depth of 10-12 m. It represents one of the unique coastal ecosystems that subject to several land-based sources, like freshwater from the Rosetta mouth of the Nile, loaded by nutrients, Lake Edku effluent carried with trace metals, pesticides, humic acids and nutrients, and El-Tabia Pumping Station which pours industrial and domestic wastes. The bay is also exposed to oil pollution from fishing boats, the activities of gas production liquefying and export field, in addition to the activities of Abu Qir Fertilizers Company, and Abu-Qir Electrical Power Station.

The physico-chemical characteristics of the bay have received great attention (Abbas, 1969; El-Samra, 1973; El-Deeb, 1977; Saad, 1979; Said, 1979; Dowidar *et al*., 1983; Anonymous, 1984; Osman and Dorgham, 1987; El-Gindy, 1988; El-Gindy *et al.*, 1988; Mahmoud and Abdel-Hamid, 1991; Tayel, 1992; El-Rayes *et al*., 1993; Nessim and EL-Deek, 1993; Fahmy, 1997, and Abdel-Aziz *et al*., 2001). However, the plankton as an important biological component has attracted little attention, particularly phytoplankton. A few studies were conducted on phytoplankton in Abu Qir Bay (Dowidar *et al*., 1983;

Dorgham and Osman, 1987; Samaan and Mikhail, 1990; El-Sherif and Gharib, 1994 and El-Sherif and Mikhail (2003). Except the last one, all studies on phytoplankton in the bay were based on samples collected either seasonally or once a year.

Since the bay is a dynamic area, the land based effluents cause continuous changes in its ecological characteristics, which are tightly related to the variability (seasonal and/or inter-annual) of the volume and quality of the discharged wastes. These changes undoubtedly affect the biological components of the bay's ecosystem. Therefore, the present study was conducted to trace the monthly dynamics of phytoplankton community relative to the variations of the hydrographic conditions in Abu Qir Bay.

2. MATERIALS AND METHODS

Sampling was performed monthly from April 1998 to March 1999 at 8 stations, representing different ecological conditions in the vicinity of the land based effluents and outside their effect (Fig. 1). Quantitative phytoplankton samples were collected from the surface water, using plastic bottles of 2 liter capacity. The samples were preserved immediately with 4% neutralized formalin. Estimation of the phytoplankton count was carried out by sedimentation method (Ütermohl 1936) and expressed as unit per liter (The unit comprised cells, colonies and filaments). The identification of algal taxa followed Peragallo&Peragallo (1897-1908), Lebour (1925), Cupp (1943), Heurk (1962), Hendey (1964), Sournia (1968, 1986), Dodge (1982), and Mizuno (1990).

The diversity index of the phytoplankton was estimated according to Shannon and Weaver (1963), the equitability (or evenness) according to Heip (1974), and species richness according to Margalef (1968) and Heip (1974). Correlation between phytoplankton count and ecological parameters was calculated and the Brey-Curtis similarity cluster for temporal and spatial phytoplankton community was also done.

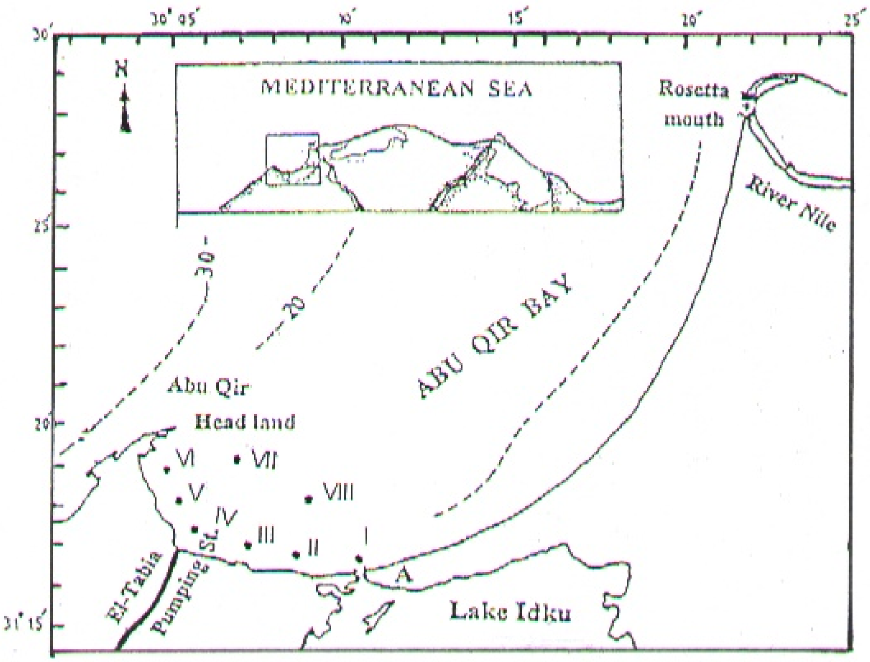

Fig. 1- The positions of sampled stations in Abu Qir Bay.

3. RESULTS

3.1. Hydrographic conditions:

The measurements of physico-chemical parameters in Abu Qir Bay were carried out parallel to the phytoplankton sampling of the present study and published in a separate paper by Abdel-Aziz *et al*. (2001). As shown in table (1), the water temperature experienced the classical seasonal variations on the Egyptian Mediterranean coast (17°C - 31.5°C). The surface salinity was the most apparently variable parameter (6.42 – 39.05‰) relative to the variability in the volume of the discharged wastes, which caused the occurrence of two distinguished water layers in the inner area of the bay; the low salinity surface layer and the subsurface sea water layer. The mixing of the two layers lead to the existence of three water masses in the bay with different salinities: < 35%o, 35-38.55%o and Mediterranean Sea water (>38.5%o). The dissolved oxygen displayed low values (annual mean: 3.6 mg/l), although it demonstrated wide variation (0.6 – 9.9 mg/L). The water transparency was pronouncedly low (0.3 – 4.0 m). The nutrient salts illustrated high eutrophication level, with clearly wide range of spatial and seasonal variations.

3.2. Community composition:

The study area harbored a diversified phytoplankton community (182 species), that included 97 freshwater and brackish forms and 86 marine forms. Seven algal groups were represented in the bay, namely Bacillariophyceae (89 species), Chlorophyceae (34 species), Dinophyceae (26 species), Cyanophyceae (18 species), Euglenophyceae (12 species), Silicoflagellates (2 species) and Cryptophyceae (one species).

The phytoplankton diversity displayed clear monthly variations, whereas the number of species varied between 26 species during June and 71 species in January. On the spatial scale, stations VI and VIII harbored the most diversified community (87 species) while station I recorded the lowest diversified one (57 species), comprising mainly freshwater forms. As shown in figure 2, the number of freshwater forms showed irregular distribution throughout the Bay while marine species increased with increasing salinity at the offshore stations (VII & VIII). A significant positive correlation ($r = 0.946$ at $p = 0.01$) was reported between the number of marine forms and the salinity throughout the bay.

Regardless of the large number of phytoplankton species in the bay, only 15 species were regarded as perennial (occurring for 9 - 12 months) and 10 species as semi-perennial (6 - 8 months) (Table 2). The rest number of species were observed either for one or two seasons (49 species), or once or twice a year (108 species), usually with very low phytoplankton counts. Twenty seven tychopelagic littoral species were recorded during the present study.

The diatoms were the predominant group, forming numerically about 85.7% of total phytoplankton count, against 8% for dinoflagellates, 3.4% for Chlorophyceae and 2.3% for Euglenophyceae.

The relative abundance of the algal groups varied monthly as well as between stations. On the time scale, diatoms predominated all the year round, except in May, when the dinoflagellates constituted 84.7% of the total count. However, Chlorophyceae was co-dominant with diatoms during June, forming 54.3% of total count (Fig. 3). Throughout the bay, Diatoms were the predominant group from stations II to VI while at stations I and VIII they constituted 47.2% and 53.6% respectively. Chlorophyceae displayed the highest contribution at station I (29.7%) and the lowest one at station VII (0.7%). The role of dinoflagellates varied from 2.3% at both stations III and VI, to 36.2% at station VIII (Fig. 4). The Euglenophyceae recorded its highest percentage (8.8%) at station VIII, and Cyanophyceae (3.2%) at station I (Fig. 4).

Table (1): Minimum, maximum and mean values of different hydrographic parameters in Abu Qir Bay (After Abdel-Aziz *et al*., 2001).

Parameter	Min.	Max.	Mean
Water temperature ^{o}C	17	31.5	23.5
Salinity (ppt)	6.42	39.05	33.4
Transparency (cm)	30	400	124
Dissolved oxygen (mg/L)	0.6	9.9	3.6
NH_4 (µM)/L	ND	338.5	14.1
NO_2 (µM)/L	ND	14.43	2
NO_3 (µM)/L	0.06	51.11	7.17
PO_4 (µM)/L	ND	14.64	1.42
SiO_4 (µM)/L	0.1	99.8	16.75
Chlorophyll- *a* (µg/L)	0.9	90.73	14.9
Zooplankton (orgms./m^3)	11.5	566.2	90.7

Note: ND = not detected

Table (2): Perennial and semi-perennial phytoplankton species in Abu Qir Bay, during 1998-1999.

9-12 months	6-8 months
Asterionella japonica Cleve	*Coscinodiscus radiatus* Ehrenberg
Nitzschia pacifica Cupp	*Cyclotella mengheniana* Kutzing
Nitzschia palea Kutzing	*Gyrosigma acuminatum* Kutzing
Nitzschia pungens Cleve	*Gyrosigma attenuatum* Kutzing
Nitzschia sigma Kutzing	*Navicula cryptocephala* Kutzing
Synedra ulna Nitzsh	*Nitzschia longissima* (Brebisson) Ralfs
Thalassionema nitzcshoïdes Grunow	*Rhizosolenia bergonii* H.Peragallo
Ceratium furca Ehrenberg	*Thalassiothrix frauenfeldii* Grunow
Oxytoxum sceptrum (Stein) Schroder	*Euglena Ehrenbergii* Ehrenberg
Prorocentrum micans Ehrenberg	*Euglena pisciformis* Klebs
Protoperidinium cerasus Paulsen	
Protoperidinium conicum Ostenf. & Schmidt	
Euglena acus Ehrenberg	
Euglena gracilis Klebs	
Ankistrodesmus falcatus Ralfs	

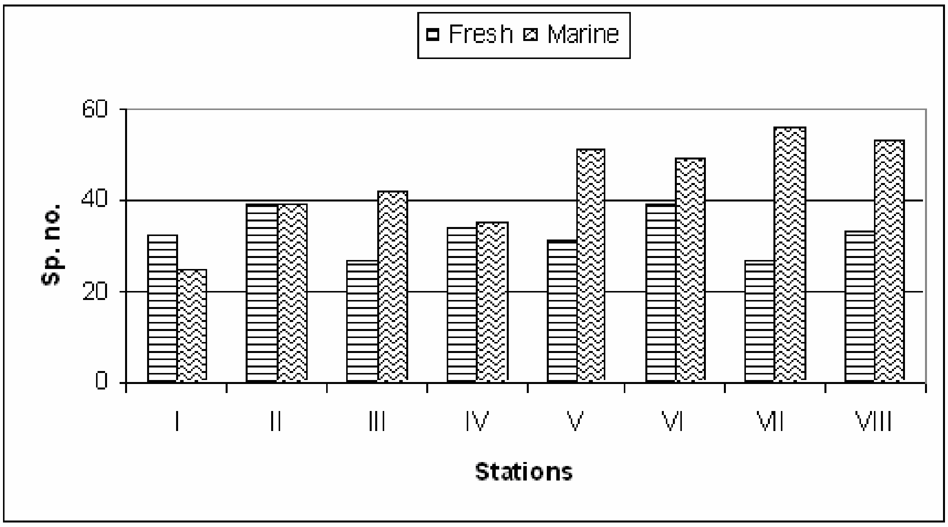

Fig. (2): Number of fresh and marine species at different stations in Abu Qir Bay during 1998-1999.

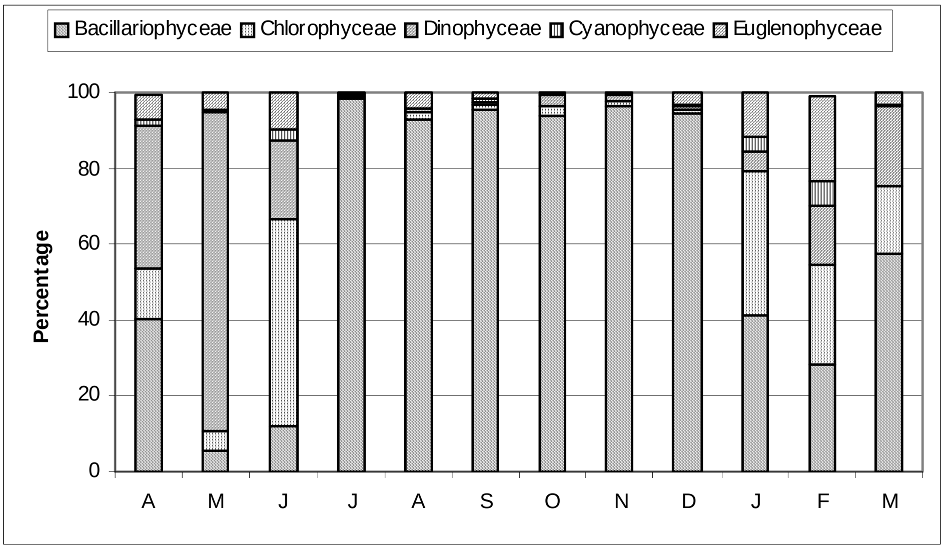

Fig. (3): Monthly relative abundance (%) of different phytoplankton groups in Abu Qir Bay 1998-199.

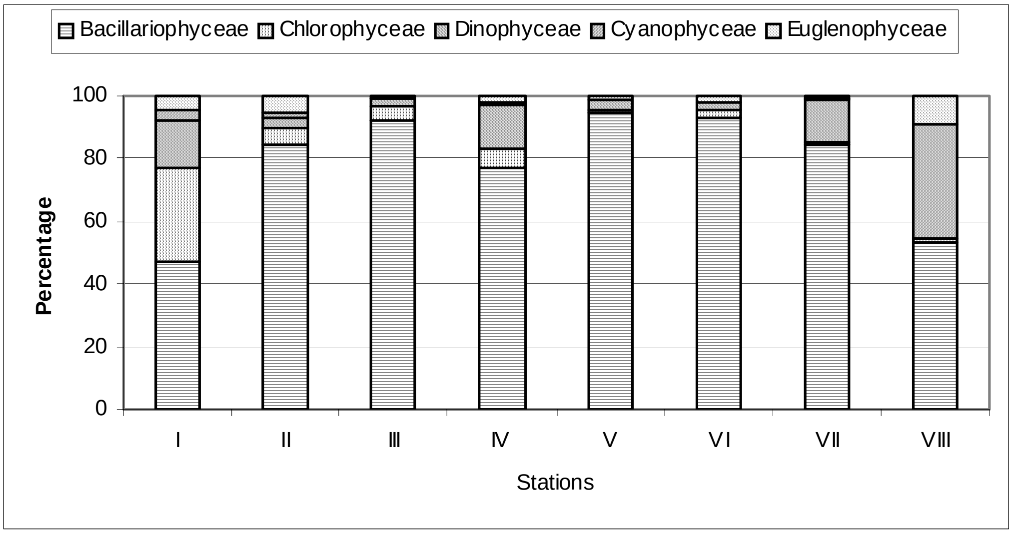

Fig. (4): Spatial distribution of relative abundance (%) of different phytoplankton groups in Abu Qir Bay during 1998-199.

3.3. Standing crop:

The phytoplankton count was generally low in Abu Qir Bay, whereas it was mostly less than 12.5 x 10^3 unit/L over the year, except in September when the count reached to 55.6 x 10^3 unit/L. Stations I and VIII sustained the lowest count (0.75 x10^3 and 2.24 x10^3 unit/L respectively), followed by stations II, III & IV which harbored comparatively high and approximately close counts (5 x10^3 -5.6 x10^3 unit/L). The highest counts were recorded at stations V, VI (8x10^3 unit/L, each) and VII (7x10^3 unit/L). Different patterns of monthly variation were observed at the different stations; one distinguished peak occurred in September at stations II, IV, V, VI & VIII, and one peak also in July at station III. Two peaks appeared at station VII in August and October, while no peaks were observed at station I (Fig. 5). The September peak was due to the blooming of the diatom *Nitzschia pungens*, contributing 86.6% - 99.9% to the total count at the different stations, while the peak of July was due to *Asterionella japonica* (98.5%). The peaks at station VII were caused by *Chaetoceros affinis* (64.2%) and *Asterionella japonica* (25.2%) in August and *Asterionella japonica* (60.6%) and *Chaetoceros didymus* (21.2%) in October. The dinoflagellate *Prorocentrum micans* showed significantly high count during May over the whole bay, forming 64.1% and 71% of the total phytoplankton count at stations VII and VIII respectively. *Thalassionema nitzschioïdes* constituted 77.5% and 33% at stations V and VI respectively in October, and *Asterionella japonica* displayed high counts over the whole bay in December, contributing up to 81% to the total count at station III. Throughout the bay, the phytoplankton count sustained the highest value (annual average: 8 x 10^3 unit/L) at station VI and the lowest value (0.75 x10^3 unit/L) at station I.

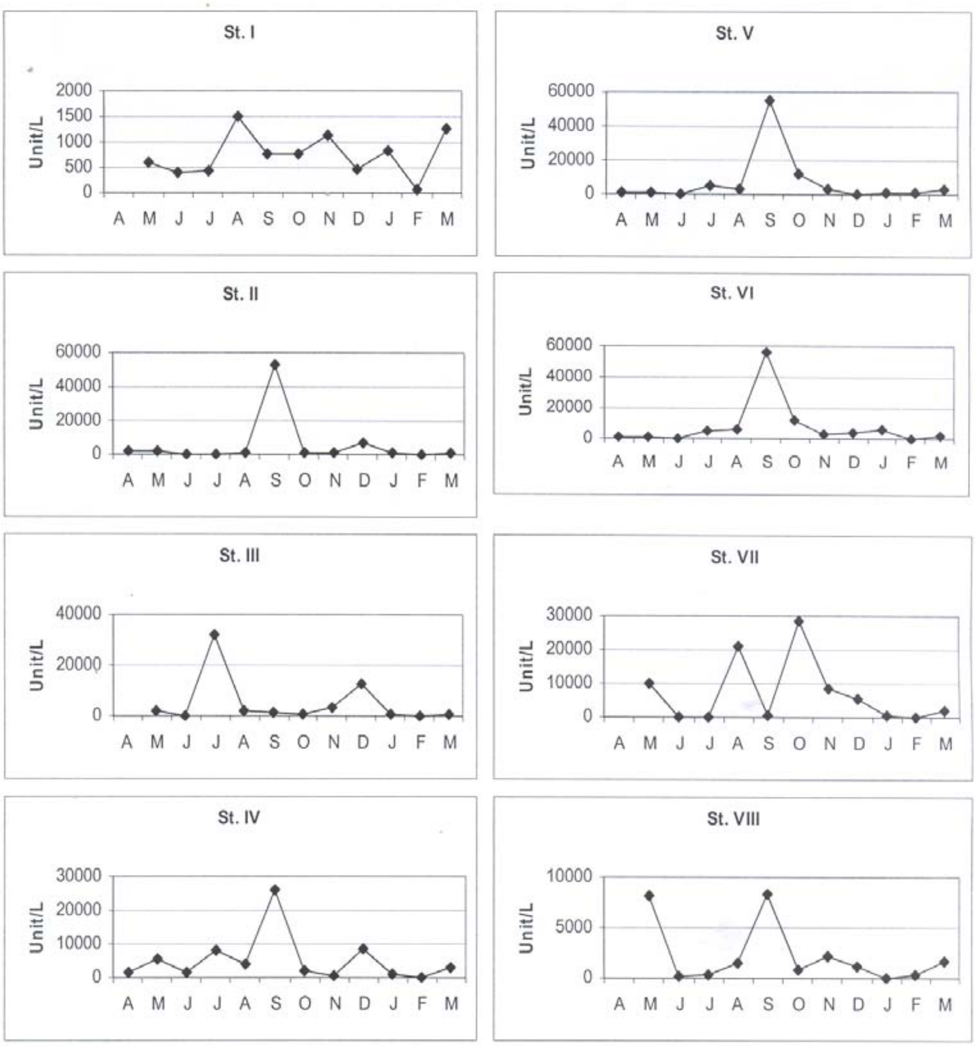

Fig. 5- Monthly variation of phytoplankton count at different stations in Abu Qir Bay (April 1998-March 1999).

In contrast to the low phytoplankton count chlorophyll-*a* attained extremely high concentrations all the year round, but with mostly different seasonal distributional pattern. Stations I, II, III & IV which lie near the outfalls of the land based effluents were characterized by pronouncedly higher concentrations of chlorophyll- *a* (19.44, 24.78, 15.36 & 17.4 µg/L, respectively) than the Stations V, VI, VII & VIII found relatively away from the effluent effect (13.85, 12.07, 8.68 & 7.58 µg/L, respectively). The main peaks of chlorophyll-*a*, were recorded in April, September and March (Fig. 6). The chlorophyll peak of April coincided with the maximum abundance of several species each of which showed dominance at certain stations such as *Asterionella japonica, Pediastrum clathratum, Nitzschia pungens, Euglena acus, Protoperidinium cerasus, Oxytoxum sceptrum and Prorocentrum micans*. During September 1998, the chlorophyll peak coincided with very low count at some stations (0.352 - 1.442 x 10^3 unit/L), while *Nitzschia pungens, Nitzschia sigma and Nitzschia pacifica* were dominant at other stations. During March, phytoplankton count was markedly low over the whole bay (0.363 - 2.75 x 10^3 unit/L).

The absolute values of diversity index displayed wide temporal and spatial variations from 0.01to 3.12 nats. The monthly average reported the lowest value (0.83) in September and the highest (1.98 nats) in March (Fig 7). Throughout the bay, station III sustained the lowest diversity index (1.17 nats), while stations II and VII recorded the highest value (1.56 nats).

The richness showed also wide range of variations (0.17– 4.57), with the lowest monthly average (0.85) in June, and the highest (2.78) in December (Fig. 7). On the other hand, station I recorded the minimum richness (1.25) and station VIII sustained the maximum (2.07).

The evenness varied between 0.01 and 0.85, the monthly average attained the lowest value (0.28) during September and the highest value (0.74) in February (Fig. 7). On spatial scale, the evenness was the minimum (0.42) at station V and the maximum (0.55) at station I.

The cluster analysis of phytoplankton count on the monthly basis showed several subclusters; the first one includes October, November and December, the second includes January, February, March, April and June, while May, July, August and September appeared as independent months (Fig. 8). On the other hand, the cluster of spatial variations of phytoplankton count demonstrated the following groups; stations I & VIII, stations III & VII, stations II, V & VI (Fig. 9). The numerically important species were also treated by Bray-Curtis similarity test (Fig. 10), whereas clear associations were reported between different species. These associations are summarized in Table 3, which indicates that these associations were mainly related to the variable ecological conditions over the year since each association occurred within a certain period or month that is characterized by environmental conditions differ from those in other months. However, the most dominant species *N. pungens*, *A. japonica* and *Euglena acus* each showed independent cluster.

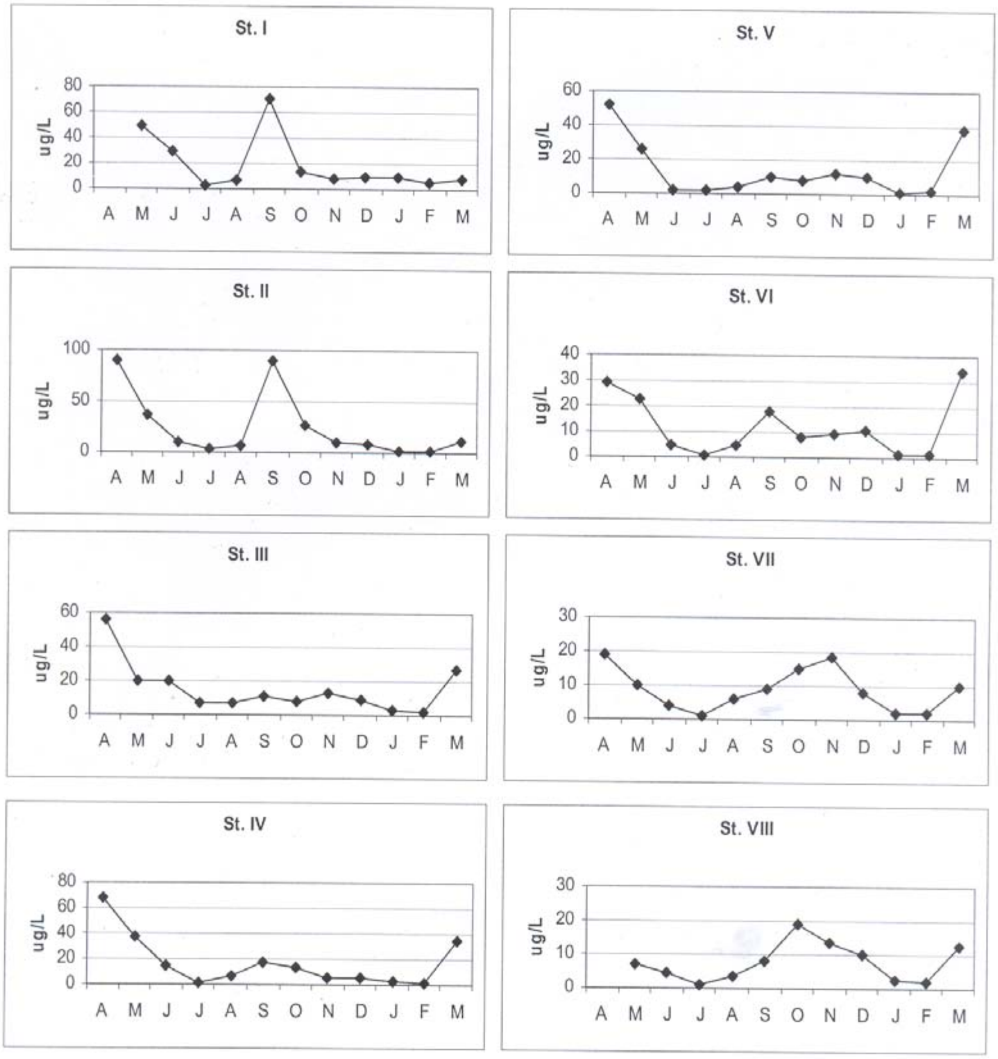

Fig. (6): Monthly variation of chlorophyll-*a* at different stations in Abu Qir Bay (April 1998-March 1999).

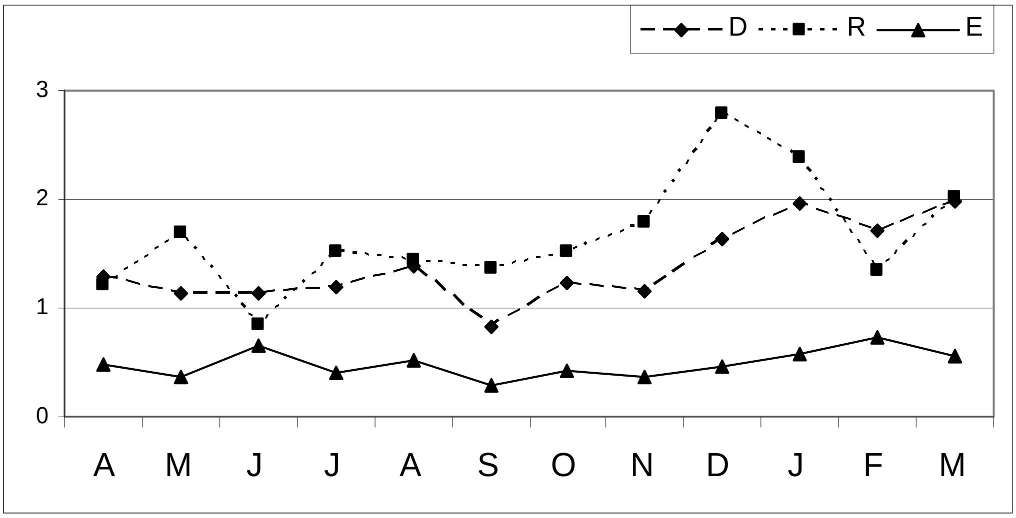

Fig. (7): Monthly variations of diversity index (D), evenness (E), and richness ® in Abu-Qir Bay (April 1998 – March 1999).

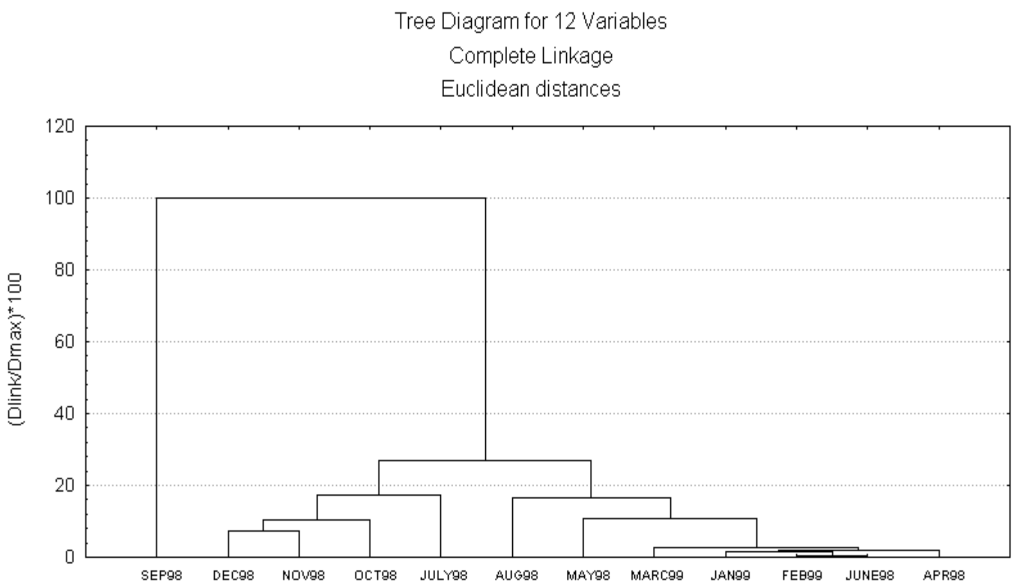

Fig. (8): Cluster analysis of phytoplankton count on monthly basis in Abu Qir Bay (April 1998 – March 1999).

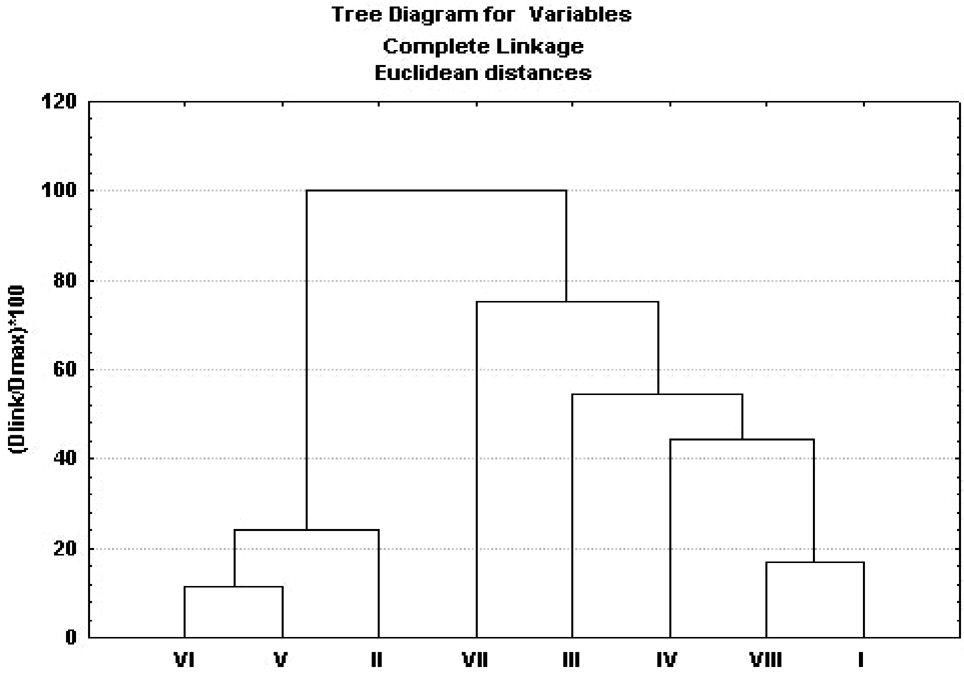

Fig. (9): Cluster analysis of phytoplankton count on spatial scale in Abu Qir Bay.

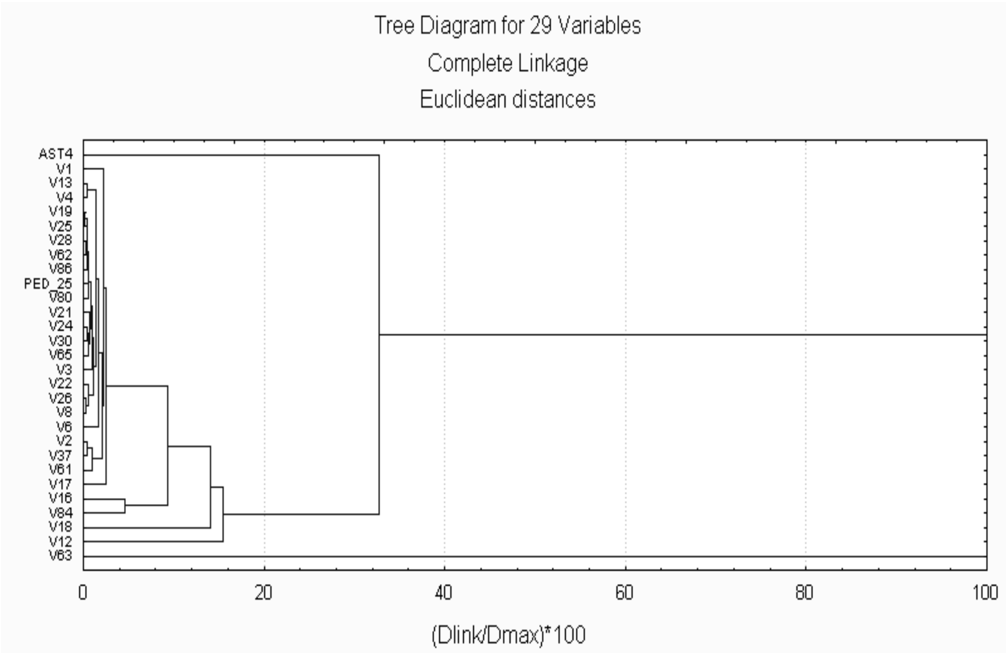

Fig. (10): Cluster analysis of dominant phytoplankton species among months in Abu Qir Bay.

4. DISCUSSION

The area of Abu Qir Bay, particularly that found in the vicinity of discharged wastes is heavily polluted and referred as a hot spot. The high levels of nutrient salts and abnormal high concentration of chlorophyll-*a* indicate an acute eutrophication in the bay. In addition, the low concentrations of dissolved oxygen (3.6 mg/L) reflect the deterioration of water quality in the bay. These conditions altogether appeared to have pronounced impact on the qualitative and quantitative structure of phytoplankton community in the bay. The salinity could be considered as keynote of the volume variability of the discharged wastes and consequently reflects the changes in the nutrient salts and the phytoplankton community throughout the bay.

Since the study area has similar characteristics of estuarine areas, the phytoplankton community in Abu Qir Bay appeared to be highly diversified (182 species), with pronounced occurrence of freshwater forms. The species number demonstrated pronounced monthly variation, which usually associated with the change in the direction of the current through Boughaz El-Maadiya. Abdel-Aziz *et al.*, (2001) stated that the current regime seems to be one of the main factors controlling the structure and abundance of plankton community in Abu Qir Bay. Mohamed, 1981 stated that during spring and summer, the current is mostly seawards, while in winter it shows lake-wards direction. As compared to earlier records, the community structure experienced serious changes, particularly the increase in the number of freshwater assemblages, like those of Chlorophyceae, Cyanophyceae and Euglenophyceae in addition to fresh water diatoms. This indicates the increase of freshwater discharge to the bay and the adaptation of more freshwater species to live in such area. The present findings are in agreement with Stirn (1988) and Sarojini (1994) who observed that Chlorophyceae and Cyanophyceae are usually favored by increased nutrients and dissolved organic material characterizing areas subjected to freshwater discharge. However, it is to be noticed that, the differences in the community structure between the present study and the earlier records in the bay are attributed mainly to the fact that the present study based on monthly sampling for a complete year, while the earlier studies based on sample collected in three months only during the year.

Despite of the pronouncedly high concentrations of nutrient salts over the year in Abu Qir Bay (Abdel-Aziz *et al*., 2001), the phytoplankton count during the present study was markedly low, and showed insignificant correlation with nutrient salts. But the peak of phytoplankton in September coincided with the lowest concentrations of both ammonia and nitrate. The count (annual average: $5x10^3$ unit/L) during the present study was markedly lower than those (0.363 and 36.4 $x10^3$ unit/L, respectively) reported by Samaan and Mikhail (1990) and El-Sherif and Gharib (1994). Such great drop may be attributed to more deterioration in the water quality in the bay during the past two decades with the increase of the land based effluents and the pollution stress resulted from Abu Qir Harbor and activities of the gas field in the bay, as indicated from the abnormal variations of both N/P and Si/P ratios and comparatively low content of dissolved oxygen contents. Welch (1980) stated that N/P varies with trophic state and decreases with increased eutrophication. This is in agreement with present values of N/P ratio, which regardless of its wide fluctuation in the bay were mostly lower than that reported in the open sea (15:1, Redfield, 1934)**.** Phosphorous is the factor limiting for the development of algae in most freshwater ecosystems (Mur *et al.,* 1977) and is the key nutrient controlling eutrophication (Schindler & Fee 1974; Schindler 1975, 1977). These observations support the present findings, whereas the highest phytoplankton count at stations V, VI and VII accompanied the lowest phosphate concentration over the whole bay (0.54 – 0.64 µM/L). However, at the stations I, II, III & IV affected directly by the land based effluents both relatively high and markedly low phytoplankton counts were associated with high phosphate concentrations (1.03 – 4.09 µM/L). The latter situation may indicates the minor role of phosphate as controlling factor of phytoplankton count in Abu Qir Bay, compared to other environmental factors. The rapid variability of salinity and the expected high concentrations of different pollutants in the vicinity of the outfalls of the discharged wastes may be considered the most affecting factors on phytoplankton count. On the other hand, the high chlorophyll- *a* concentrations at Stations I, II, III & IV may reflect the effective contribution of the great numbers of picoplankton cells (which were difficult to be counted by normal research microscope) to the phytoplankton biomass, since the phytoplankton counts could not produce such high values of chlorophyll- *a* in the Bay. The role of picoplankton in phytoplankton biomass was reported in the Western Harbor (Gharib and Dorgham, 2006) and Dekhaila Harbor (Dorgham, Unpublished data) of Alexandria. The grazing stress by high zooplankton count in the bay (Abdel-Aziz, 2001) may also be regarded as another factor causing marked decrease in the phytoplankton count. As general, the phytoplankton count in Abu Qir Bay during the present Although the seasonal cycle of phytoplankton abundance in the bay was unimodal at most stations and bimodal at some stations, chlorophyll *a* displayed trimodal cycle. This is attributed to the spatial variability of the environmental conditions throughout the bay which in turn affect the seasonality of the phytoplankton abundance as well as chlorophyll *a* content at each station.

The main bulk of phytoplankton count in Abu Qir Bay was caused by few species, namely *Nitzschia pungens, Asterionella japonica* followed by *Chaetoceros affinis* and *Thalassionema nitzchïodes* and *Prorocentrum micans.* The dominant species *Nitzschia pungens* has never been recorded earlier in the bay (Samaan and Mikhail, 1990; El-Sherif and Gharib, 1994). *Prorocentrum micans* is a neritic euryhaline form, well known to the Egyptian Mediterranean waters (Gergis, 1983; Dowidar *et al*., 1983; Dorgham and Osman, 1987; Samaan & Mickhail 1990; El-Sherif and Gharib 1994; Ismael , 1993; Ismael and Dorgham, 2003; Gharib and Dorgham, 2006). It is considered as indicator of eutrophication and pollution (Dorgham *et al.,* 1987).

As compared to the earlier studies (March, June and October, 1980 by Samaan and Mikhail, 1990) and (May, September and November, 1990 by El-Sherif and Gharib, 1994), the present study reported pronouncedly different patterns of species dominance in the Bay. For example, the present study recorded the dominance of *P. micans in* May, *N. pungens* in September and *A. japonica* and *Th. nitzschioides* in November, while El-Sherif and Gharib observed the dominance of *Pediastrum clathratum, Pediastrum duplex,* and *Th. nitzscioïdes* in May, *Nitzschia longissima* and *A. japonica* in September, and the later two species extended their dominance with *Chaetoceros* sp., *Leptocylindrus danicus* in November. On the other hand, all dominant species reported in March and June by Samaan and Mikhail (1990) were completely absent from the bay during the present study. However, the dominant species during October of the present study were mostly similar to those of Samaan & Mikhail (1990), being *A. japonica, Chaetoceros sp.*and *Th. Nitzschoïdes.* Furthermore**,** in 1997, Gharib and Dorgham (2000) reported high count of the fresh and brackish water forms *Cyclotella meneghiniana, Scenedesmus quadricauda, Scenedesmus bijugatus, Nitzschia palea, Nitzschia microcephala, Cyclotella glomerata* inside the bay, in front of Boughaz EL-Maadiya. None of these species appeared among the dominant species at the same area or at any other part of the bay during the present study. Also, *Skeletonema costatum* was occasionally found as abundant species by Gharib & Dorgham (2000), but it was missed in the present study. *Cyclotella meneghiniana i*s considered as eutrophic indicators (Caroppo and Cadrellicchio, 1995, Dorgham, 1997, Gharib and Dorgham, 2000). On the other hand, the results of the present study appeared to be different to a large extent from those of EL-Sherif and Mikhail (2003) although the latter study based on samples collected for nine months during the period from December 1999 to November 2000. The present study reported 182 phytoplankton species with an annual average count of $5X10^3$ unit/L and the main peak in September. EL-Sherif and Mikhail (2003) identified 241 species, attaining an annual average of $780x10^3$ cell/L and the main peak in May. In addition, the variation ranges and as well as the values of all nutrient salts and chlorophyll-*a* in the present study were extremely wider and greater than those given by El-Sherif and Mikhail (2003).

Furthermore, the dominance of species in the two studies was mostly different (Table 5). Such differences could be attributed to several reasons. The first reason is the difference in the number of sampled months and stations, the location of each station, and the day and daytime of sampling during each month. The second reason is the volume and dispersion patterns of the discharged wastes, which are controlled by the temporal variations of the water circulation system inside the bay. The third reason is the different units of estimation of the phytoplankton count (Unit/L or Cell/L). The fourth reason is the rate of exchange between the open sea and the bay. The fifth reason is the degree of accuracy of identification of the phytoplankton species. However, most of the differences mentioned above could be related to the rapid variability in the water quality in Abu Qir Bay, which are subsequently reflected on the dynamics of the phytoplankton community.

Table (3): Monthly association between different phytoplankton species in Abu Qir Bay during 1998-1999.

	Species	Similarity
Cluster 1	*Ceratium furca* (V2) *Leptocylindricus danicus* (V37) *Nitzschia pacifica* (V61)	The highest count in March
Cluster 2	*Pediastrum duplex* (V22) *Protoperidinium steinii* (V26) *Dinophysis sacculus* (V8)	The highest count in May
Cluster 3	*Pediastrum simplex* (V24) *Scenedesmus quadricauda* (V30) *Nitzschia sigma* (V65)	The highest count in September
Cluster 4	*Chaetoceros didymus* (V16) *Thalassionema nitzcshioïdes* (V84)	The highest count in July
Cluster 5	*Chaetoceros compressus* (V13) *Euglena Ehrenbergii* (V4)	The highest count in August
Cluster 6	*Scenedesmus dimorphus* (V28) *Nitzschia palea* (V62)	The highest count in January and March

Table (4): Species number, annual average count of phytoplankton and chlorophyll-*a* in different eutrophic areas on Egyptian Mediterranean Coast.

Area	Sp. No.	Count (x 10^3 unit/L)	Chl. *a* (μg/L)	Reference
Mex Bay	209	42.8	----	Dorgham *et al*., (1987)
Mex Bay	----	848	---	Soliman and Gharib (1998)
Dekhaila Harbor	107	15382.9	107.49	Ismael & Dorgham (2003)
Western Harbor	107	980.4	33.82	Gharib and Dorgham (2006)
Eastern Harbor	76	820	1.61	Tawfik (2001)
Abu Qir Bay	183	5	15.7	Present study

Table (5): The dominant species during two successive years in Abu Qir Bay.

Present study	El-Sherif and Mikhail (2003)
April 1998-March 1999	**December 1999-November 2000**
Nitzschia pungens Cleve	*Asterionella glacialis*
Asterionella japonica Cleve	*Skeletonema costatum*
Thalassionema nitzschioïdes Grunow	*Rhizosolenia fragilissima*
Chaetoceros affinis Lauder	*Leptocylindrus minimus*
Chaetoceros didymus Ehrenberg	*Chaetoceros affinis*
Chaetoceros sp.	*Nitzschia longissima*
Nitzschia pacifica Cupp	*Nitzschia seriata*
Prorocentrum micans Ehrenberg	*Cyclotella meneghiniana*
Euglena acus Ehrenberg	*Cyclotella nana*
	Prorocentrum triestinum
	Scrippsiella trochoidea
	Carteria cordiformis

The wide fluctuations (0.01 - 3.12 nats) of the diversity index of phytoplankton in Abu Qir Bay indicate the instability of the area due to the effect of the discharged wastes. The smallest value of diversity index was attributed to the occurrence of one species only at station VIII during January. However, the variation range is clearly wider than that (1-2.5 nats) recorded by Margalef (1964 and 1978) for the actively growing coastal populations and eutrophic lakes, and other eutrophic areas on Alexandria coast, like the Dekhaila Harbour (Ismael & Dorgham, 2003), the Western Harbor (Gharib and Dorgham, 2006).

The diversity index is a suitable indication for water quality (Balloch, *et al.,* 1976; Gharib and Dorgham, 2006). It has clear relation with the degree of dominance, species richness and total standing crop (Gharib and Dorgham, 2006). In contrast, the values of diversity index are related to evenness, while they are not affected by the (richness) species number (Reed, 19678; Ismael & Dorgham, 2003). In the present study, diversity index exhibited significant positive correlation with evenness ($r = 0.59$ at $p = 0.05$), richness ($r = 0.63$ at $p = 0.05$) and negative correlation with phytoplankton count ($r = -0.56$ at $p = 0.01$), while the evenness showed strongly significant correlation with species number ($r = 0.90$ at $p = 0.001$). It is obvious that the variation of diversity index in Abu Qir Bay were related to spatial and seasonal variations in the number of species. MC Cormick and Cairns (1997) stated that Species richness may increase or decrease in response to modest changes in water quality depending upon whether those changes represent a subsidy or stress to the organisms but highly impacted sites typically have very few species compared to references sites. Furthermore, Rao & Mohanchand (1988) stated that reduction in the number of dominant species and species diversity and the increase in cell count of one or two resistant algae were some of the changes observed in the phytoplankton populations in domestic and industrially polluted environments.

Comparing with other eutrophic areas on the Egyptian Mediterranean coast (Table 4), the phytoplankton community in Abu Qir Bay seems to be the most diversified, but it was the poorest with regards to the population density and among the lowest in terms of chlorophyll- *a*. This may support the more inhibiting effect of various pollutants in the bay on the phytoplankton growth. However, the extent of pollution problem in the bay is not clearly defined, particularly from the chemical point of view, since the chemical structure of the industrial wastes is not well known (Abdel-Aziz *et al*., 2001)

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