DISTRIBUTION OF PHYTOPLANKTON IN THE SOUTHWESTERN AREA OF ALEXANDRIA (ABU-QIR BAY), EGYPT.

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Abstract

Phytoplankton samples were collected during February, April and June 2004 at fourteen stations. Phytoplankton community represented by 117 species within 66 genus from five groups (Bacillariophyceae; Dinophyceae; Chlorophyceae; Cyanophyceae and Euglenophyceae). There were some fresh, brackish, and marine species. Bacillariophyceae was the most dominant group (71 species) contributing 94.2% of the total phytoplankton counts. The phytoplankton community is generally more productive at stations 1, 2, 3, 4 and 5 that receiving discharge water from El-Tabia pumping station (Stations 1, 2, 3 and 4) and Lake Edku (St. 5). A gradual decrease was seen in phytoplankton density seawards. The major phytoplankton peak was observed at most stations during June (average 5535 x 10^3 unit.L^{-1}). *Skeletonema costatum* was the most dominant species; it was formed 51.3%, 41.3% and 60.4% of the total phytoplankton, respectively during February, April and June. The effect of discharge water was more pronounced at St. 4 in front of El-Tabia pumping station. Species diversity index displayed narrow temporal and spatial variations from 1.02 to 2.85 nats. Throughout the bay, station 3 sustained the lowest diversity index (1.38 nats), while station 14 recorded the highest value (1.95 nats).

Keywords: Chlorophyll-*a*- Diversity- Eutrophication- Phytoplankton- *Skeletonema costatum*.

Introduction

In the Mediterranean Sea, eutrophication appears to be limited mainly to specific coastal and adjacent offshore areas. Several and sometimes severe cases of eutrophication are evident, especially in enclosed or semi-enclosed bays which receive elevated nutrient loads from agricultural, together with direct discharges of untreated or poorly treated domestic and industrial wastewaters (Richardson and Jorgensen, 1996). Abu-Qir Bay is one of the most interesting bays along the Egyptian coast; it is a semicircular basin in the Mediterranean coast of Egypt, lying between longitudes 30° 4′ and 30° 21′ E and latitude 31° 16′ and 31° 30′ N. The Bay is about 360 Km^2 and the water volume is 4.3 Km^3 (Said *et al.*, 1995). It has a shoreline of about 50 Km between Abu-Qir peninsula at the west and the Rosetta branch of the River Nile at the east and maximum depth of about 16m. It receives the effluents of many industrial activities as food processing, refineries, fertilizers, paper mill power station, domestic sewage and agricultural drainage

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(Said, 1991; Tayel, 1992). These wastes are collected and dumped into the bay through El-Tabia Pumping station (TPS) situated at the southern extremity of the bay. The daily discharge of the combined liquid wastes is estimated to be about $2x10^6m^3$. The bay receives also agricultural drainage water from Lake Edku through Boughaz El-Maadiya (Mohamed and El-Maradny, 2001). The discharge water caused continuous changes in the water characteristics, enhancing its fertility. Therefore, the bay as one of the most productive fishery grounds along the Mediterranean Coast of Egypt. Many investigations were done in the bay including hydrographic conditions, pollution problems (El-Deeb, 1977; Anonymous, 1984; Tayel, 1992; El-Rayes *et al.,* 1993; Fahmy, 1997; Mohamed and El-Maradny, 2001; Abdel-Aziz *et al,*. 2001; Aly-Eldeen, 2006). However, a few studies were conducted on phytoplankton in Abu-Qir Bay (Dowidar *et al.*, 1983; Samaan and Mikhail, 1990; El-Sherif and Gharib, 1994; El-Sherif and Mikhail, 2003; Shams-El-Din and Dorgham, 2007). Because of the effluents discharged into the bay causes continuous changes in its ecological characteristics, these changes affect the biological components of the bay's ecosystem. Since 2000, no studies were carried out on phytoplankton community in Abu-Qir Bay. Thus, the objective of this study is to study the dynamics of the phytoplankton in Abu-Qir Bay to analyze the changes in the phytoplankton composition, abundance and biomass, and to establish which of environmental factors determine these dynamics. Comparing the present phytoplankton composition of Abu-Qir Bay with the previous studies will also give.

Material and methods

Abu-Qir Bay lies at the southwestern area of Alexandria and is considered one of the main fishery basins. It is continuously facing pollution problems, however; it receives the effluents from many sources (industrial activities; domestic sewage and agricultural drainage). The western part of Abu-Qir Bay was influenced by the wastewater from El-Tabia pumping station (TPS) and brackish water from Lake-Edku (Fig. 1). This work is a part of the research plan of Marine Environment Division of the National Institute of Oceanography and Fisheries entitled "Effect of land based sources on physical, chemical and biological characteristics of Abu-Qir Bay waters". Sampling was carried out during 2004, including three months (February, April and June) representing three seasons (winter, spring and summer). Fourteen stations were chosen representing different ecological conditions (Figure 1). The data for temperature, salinity and dissolved oxygen were attained from the plan. One liter of water samples were collected by using Ruttener bottle sampler for estimation the phytoplankton abundance. The phytoplankton samples were preserved immediately with 4% neutralized formalin. Estimation of the phytoplankton abundance was carried out by the sedimentation method (Utermöhl, 1958) and the results expressed as unit per liter (the unit-comprised cells, colonies and filaments). For the identification of the phytoplankton species the following works were consulted (Balech, 1948 and 1980; Pankow, 1976; Krammer and Lange-Bertalot, 1986; Heimann, *et al.*, 1995).

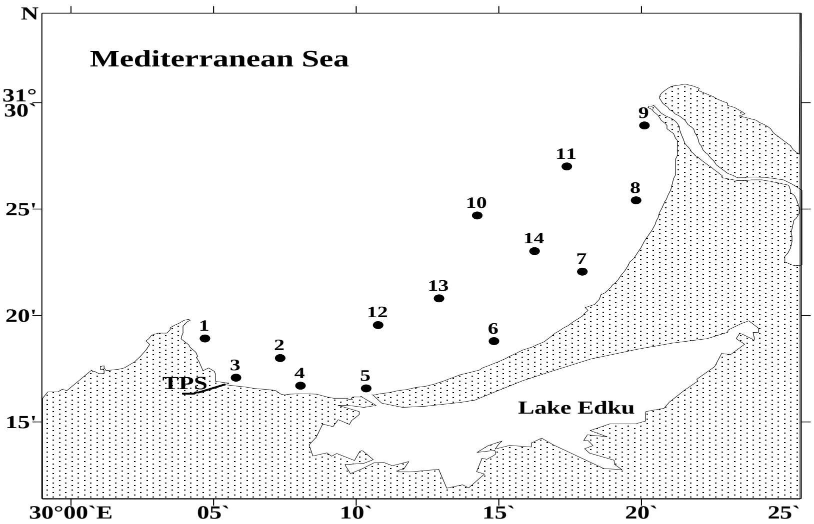

Figure (1): Map of Abu-Qir Bay area and location of the sampling stations

Species diversity index was estimated according to the equation of Shannon and Weaver (1963) the results was expressed as nats.

$$H = -\sum_{i=1}^{n} Pi \, Ln \, Pi$$

Where Pi = importance probability for each species (n/N is the proportional of i, the ni species) to the total number of phytoplankton cells (N).

Correlation coefficient as well as stepwise multiple regression equations by using Minitab program at a confidence limit 95% ($P \leq 0.05$,) were evaluated (n=41) to quantize the phytoplankton abundance in relation to the most correlative parameters.

Results

Changes in temperature at different sampling stations (Sts) in Abu-Qir Bay are shown in Figure (2). The variations of the surface water temperature of the bay are very closely related to those of air temperature. During February, the lowest values of air temperature were observed, the surface water temperature varied from 16.2˚C at Sts. 8 and 9 to 18.3˚C at St. 1. In April, the water temperature increased westward from 19.6˚C at St. 12 to 22.8˚C near TPS (St. 4). During June, the air temperature reached its maximum value throughout the year, while the surface water temperature varied between 26.0˚C at St. 9 and 31.9˚C at

St. 13. Strong positive correlation exists between total phytoplankton and water temperature (r= + 0.61, ≥ 0.05).

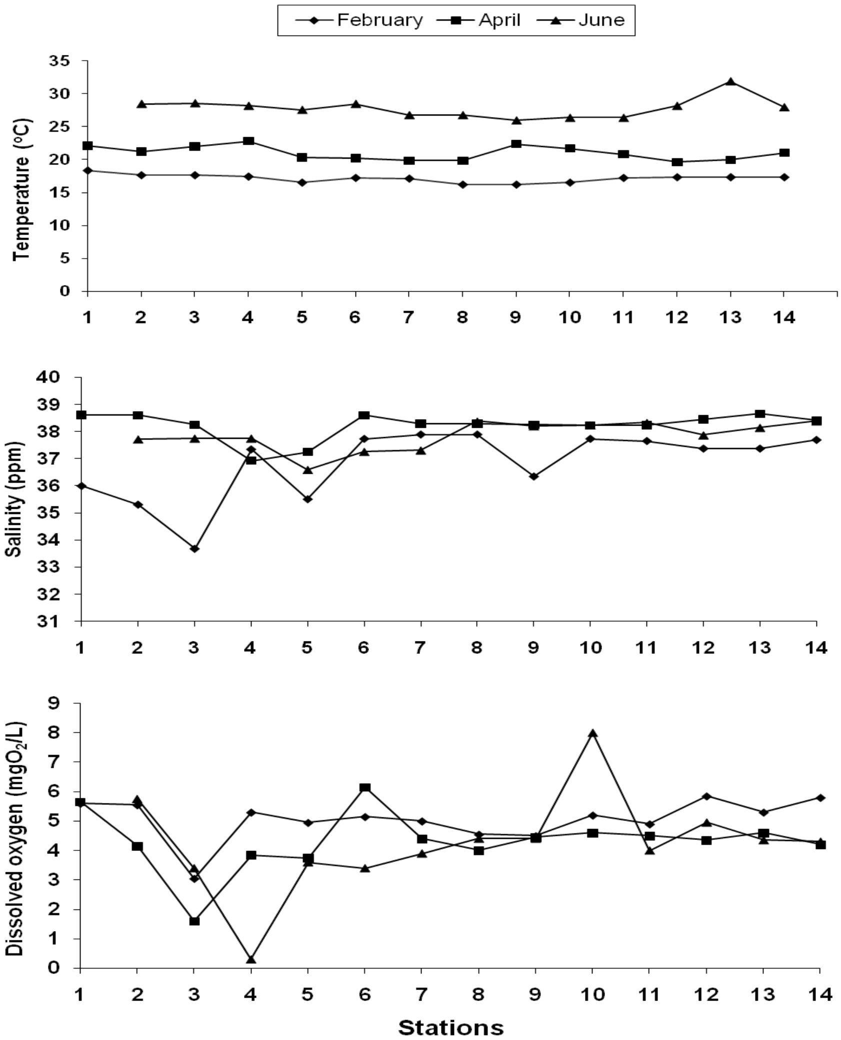

Figure (2): Surface water temperature, salinity and dissolved oxygen at different sampling stations at Abu-Qir Bay during February, April and June 2004

The surface water salinity in Abu-Qir Bay (Figure 2) varied locally within a wide range. During February, the minimum water salinity 33.67 ppt was recorded at TPS (St. 3), due to the influence of the brackish water from TPS. The salinity values of less than 37.00 ppt were found in the western part of Abu-Qir Bay. In April, due to a decrease in the amount of fresh water discharged from the river as compared to winter month, the surface salinity increased from 36.92 ppt at St. 4 to 38.65 ppt at St. 13. During June, the surface salinity varied between 36.58 ppt at St. 5 and 38.38 ppt at St. 14. It was due to the effect of the brackish water from Lake Idku and the waste water from TPS.

Regarding with dissolved oxygen (DO) concentrations (Figure 2), the values in February ranged between 3.05 $mgO_2.L^{-1}$ (St. 3) and 5.85 $mgO_2.L^{-1}$ (St. 12). In April, between 1.60 mg $O_2.L^{-1}$ at TPS and 6.15 mg $O_2.L^{-1}$ at St. 12, while during June, it ranged from 0.30 mg $O_2.L^{-1}$ near TPS (St. 4) to 5.75 mg $O_2.L^{-1}$ (St. 2), station 4 sustained the lowest values throughout the year.

The phytoplankton community in Abu-Qir Bay comprised 117 species within 66 genera (Table 1). Most of the recorded species are eurythermal, appeared during the study period, also euryhaline tolerate a wide range of salinity, but low numbers exist at high salinity. Five algal groups were represented at the study area, namely, Bacillariophyceae (71 species); Dinophyceae (18 species); Chlorophyceae (12 species); Cyanophyceae (12 species) and Euglenophyceae (4 species). As it is usually found in semi-enclosed regions affected by discharged freshwater; Bacillariophyceae appeared to be the most dominant group qualitatively and quantitatively. Qualitatively, it represented by 71 species with 41 genera, while quantitatively was formed with average of 94.2 % of the total phytoplankton count (Table 2). Dinophyceae showed only in 9 genera (Table 1). The other fresh water groups showed remarkable by low numbers of genera with low counts and its occurrence may be coming from Lake Edku. They were represented by 6 genera for Chlorophyceae, 9 for Cyanophyceae and one genus for Euglenophyceae (Table 1).

The appearance of different species revealed that, 117 species were observed throughout the whole area (Table 1). During February, the higher species number were represented at St. 14 (72 species), while the lowest number (40 species) were observed at St. 7. On the other hand, during April, the higher species number (78 species) was recorded at St. 4, while the lower numbers (40 species) were observed at St 14. During June, the higher species number (76 species) were recorded at St. 5, but the lowest one (49 species) were observed at St. 4.

Regarding with the number of species during different months (Table 1), February showed the higher species number (112 species), while April attained the lower number of species (99 species), on the other hand, June have 104 species.

Also, according to the total phytoplankton counts distribution, the western part was the most productive stations (Sts.1, 2, 3, 4 and 5) in the bay (Table 3). On the other hand, the other stations showed pronounced low averages. The predominant species which showed strongly distribution during the study period along the sampled stations were *Skeletonema costatum; Nitzchia spp; Rhizosolenia delecatula;* and *Asterionella spp.*

Table (1): The recorded phytoplankton species at Abu-Qir Bay during February, April and June 2004.

Season	February														April														June												
Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	1	2	3	4	5	6	7	8	9	10	11	12	13	14	2	3	4	5	6	7	8	9	10	11	12	13	14
Bacillariophyceae																																									
Achanthus sp.	x								x					x	x			x	x	x	x		x		x	x		x	x			x		x			x			x	
Amphora turgida Grég.		x				x					x		x			x	x		x		x	x		x	x	x	x	x			x	x		x		x		x			x
Amphora grevilleana var. Contracta Clevé.	x							x							x	x			x	x			x		x		x		x	x		x			x				x		x
Amphiprora gigantea (O Meara) Clevé	x		x				x	x									x	x	x		x		x	x		x		x		x						x				x	
Asterionella glacialis Castracane.	x	x	x	x	x	x	x	x	x	x					x	x	x	x	x			x			x				x		x	x			x		x		x		x
Asterionella sp.	x	x	x	x																									x	x		x	x			x		x			
Bacteriastrum sp.								x				x				x		x		x		x		x		x		x		x	x			x			x				x
Bellerochia malleus (Brightwell) Van Heurick.	x		x		x			x	x								x	x											x		x	x	x		x		x		x		
Biddulphia mobiliensis Bail.	x		x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x		x		x		x		x	
Bidulphia obtusa Kütz	x	x	x																																						
Biddulphia auriata (Lyng.) Breb.								x			x																														
Bidulphia sp.																		x											x	x		x		x		x		x		x	x
Cerataulina bergonii H.Pergallo												x	x	x	x	x		x	x					x		x				x				x			x				
Chaetoceros borealis Bail		x			x	x			x		x	x	x																x	x	x	x	x	x	x	x	x	x	x	x	x
Chaetoceros socials Lauder				x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x		x	x		x	x	x	x
Chaetoceros didymus Ehr.					x	x			x		x	x	x	x	x	x	x			x		x		x	x		x			x		x		x	x		x	x	x	x	x
Chaetoceros curvisetus Cleve	x		x		x			x		x		x	x	x		x	x	x	x	x		x	x		x		x		x	x	x	x	x	x		x	x		x		x
Chaetoceros affinis Lauder	x	x	x	x	x			x	x	x	x	x			x		x	x		x		x	x	x	x	x	x	x			x	x	x	x	x		x		x		x
Chaetoceros decipience Cleve	x	x	x						x			x							x		x								x	x		x	x		x		x	x		x	x
Cocconeis scutellum Ehr.		x						x	x		x		x	x		x	x	x			x		x		x	x		x				x		x			x				
Coscinodiscus excentricus Ehr.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x		x	x		x				x		x		x	x		x		x		x
Coscinodiscus granii Gough	x		x				x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x				x	x		x		x		x			x		x
Cyclotella meneghiniana Kütz	x	x	x	x	x	x			x	x	x		x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x	x	x		x		x	
Cyclotella nana Hustedt	x	x	x	x		x		x				x	x	x															x	x				x	x	x		x			
Cyclotella kutzingiana Thw.	x	x	x	x	x	x		x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x		x			x	x	x		x	x	x		x		x		
Diploneis bombus (Ehr.) Clevé.		x		x	x				x			x		x	x	x	x	x	x		x	x	x	x	x	x				x		x		x		x	x	x		x	x
Diploneis smithii (Bréb.) Clevé.		x		x				x			x		x	x															x		x			x		x		x		x	x
Epithemia sp.						x			x	x		x			x		x	x	x		x		x	x	x	x		x	x	x		x		x			x		x	x	
Grammatophora angulosa Ehr.	x		x					x																									x				x				x
Grammatophora marina (Lyng.) Kütz	x		x												x	x	x	x	x	x	x	x		x	x	x	x					x	x		x		x		x	x	
Grammatophora sp	x		x	x	x		x					x		x			x				x																				
Gyrosigma attenuatum Ehr.	x		x			x	x	x		x	x		x	x	x			x	x			x	x		x	x	x		x			x	x	x	x		x		x		x
Hemiaulus sp.		x			x		x					x				x		x	x	x		x		x		x	x	x		x	x	x			x		x				
Hyalodiscus laevis Ehrenb.		x					x		x			x	x	x		x			x	x	x			x	x				x				x				x				
Lauderia borealis Gran.						x	x	x		x	x	x		x		x	x	x	x		x	x		x	x	x		x		x		x	x		x		x		x		x
Leptocylindrus danicus Cleve	x		x	x	x	x	x		x	x	x			x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Licmophora sp.							x				x			x																		x									
Licmophora paradoxa Lyngb.				x		x							x	x		x	x	x	x	x	x	x	x	x	x		x	x				x		x			x			x	
Lithodesmium undulatum Ehrenberg		x			x			x	x	x		x	x	x	x			x	x	x	x		x	x	x		x		x	x		x	x		x		x		x	x	x
Mastogloia smithii Thw.	x		x							x					x	x	x	x			x		x	x		x				x											
Melosira granulata var. angustissima Műller.	x	x	x	x	x	x		x	x		x					x	x	x	x		x	x	x		x		x		x	x	x	x	x	x	x	x	x	x	x	x	x

Table (1): continue																																									
Navicula dicephala Nm. Sm.	x					x		x				x		x	x	x	x	x	x	x		x	x		x		x	x	x		x		x	x	x		x	x	x		x
Navicula gracilis Cleve		x				x	x	x	x		x	x			x	x	x	x	x	x	x	x	x	x	x	x	x		x		x	x	x	x	x	x	x		x		x
Navicula lyra Her			x				x	x	x	x		x	x	x																x		x		x			x		x		x
Nitzschia longissima (Brebisson in KŸtzing) Ralf.	x	x	x	x				x		x	x	x			x	x	x	x		x		x		x				x	x			x	x		x		x		x		x
Nitzschia closterium (Ehr.) W. Smith	x	x	x			x	x	x		x	x	x	x			x		x	x	x	x	x		x	x	x		x	x		x	x		x		x			x	x	x
Nitzschia microcephala Grunow	x	x	x			x	x	x	x	x		x		x	x	x		x	x		x		x						x	x		x		x		x		x		x	
Nitzschia paradoxa (Gmelin) Grun.		x	x		x	x			x	x	x	x	x																	x		x			x			x		x	x
Nitzschia sigma (KŸtzing) W. Smith	x	x	x	x	x		x	x	x	x		x	x			x	x	x	x		x		x		x		x		x		x	x			x		x		x		
Nitzschia serriata Clevé.	x	x	x	x		x			x			x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Plagiogramma vanheurckii Grunow		x			x	x			x		x		x	x				x	x		x				x																
Pleurosigma decorum Smith.	x		x		x		x	x		x		x	x	x		x	x	x			x		x			x		x			x		x				x				
Pleurosigma elongatum W.Smith	x		x	x		x			x			x			x	x			x			x									x								x		x
Pseudonitzschia delicatissima (Cleve) Heiden.	x				x	x		x	x	x	x	x		x	x	x	x		x	x		x	x				x		x	x	x		x		x		x	x		x	x
Rhizosolenia alata f. gracillima (Cleve) Grun	x	x			x			x			x		x					x	x	x	x	x		x		x			x	x	x	x		x	x	x	x	x	x	x	x
Rhisosolenia delicatula Clevé.	x		x	x	x	x	x	x		x			x		x		x	x	x		x	x		x		x			x	x	x	x	x	x	x	x	x	x	x	x	x
Rhisosolenia fragilissima Bergon.	x	x	x	x	x	x		x	x	x	x		x	x	x	x		x	x							x															
Rhisosolenia hepatata Bail. – Grun.	x		x			x			x	x	x	x	x			x			x		x		x		x	x															
Rhisosolenia stalterfothii H.Peragallo	x	x	x		x	x	x		x		x	x	x	x	x	x		x		x		x		x		x						x	x	x	x	x		x		x	x
Skeletonema costatum (Greville) Cleve	x	x	x	x	x	x	x	x	x	x			x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Stauroneis membranaceae (Cleve).		x					x	x		x	x			x		x			x				x			x				x				x	x	x	x	x			x
Streptotheca thamenses Shrubsole.							x	x		x		x	x	x		x		x		x		x		x		x		x	x	x			x		x			x		x	
Surirella ovata Kütz	x		x																x		x		x		x				x	x						x		x		x	x
Synedra ulna (Nitzsch) Ehrenberg	x		x			x				x		x	x	x	x	x	x		x		x		x	x	x		x		x		x		x	x			x	x		x	x
S. tabulata (C. Agardh) Kütz.		x								x	x				x			x	x	x		x		x		x			x		x			x			x	x			
Striatella unipunctata (Lyngbye) Agardh												x			x		x	x						x																	
Stephanodiscus sp.		x		x					x						x	x	x	x		x	x		x	x	x		x		x		x			x	x			x			
Thalassiosira rotula Meunier.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x		x	x	x		x	x	x	x	x	x	x		x	x	x		x	x
Thalassiothrix fraunfeldii Grunow	x	x	x	x					x	x		x	x			x		x	x	x	x			x	x		x	x	x	x	x		x		x		x	x	x	x	x
*Thalassionema nitzschioides (*Grunow) Mereschkosy	x	x	x		x			x				x		x	x		x		x	x	x	x		x		x	x		x		x		x			x			x		x
Triceratium alternans (Bail.) Grunow.		x		x		x	x	x	x	x	x	x	x	x	x	x		x	x	x	x		x		x		x			x		x			x			x			
Number of species	**43**	**73**	**40**	**25**	**29**	**32**	**25**	**39**	**36**	**34**	**32**	**41**	**35**	**36**	**36**	**44**	**37**	**48**	**46**	**33**	**39**	**33**	**34**	**36**	**35**	**35**	**26**	**23**	**41**	**39**	**31**	**42**	**30**	**38**	**35**	**27**	**41**	**32**	**31**	**31**	**40**
Dinophyceae																																									
Alexandrium minutum Halim.		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x		x	x	x	x	x
Ceratium furca Ehr. (Clap.) & Lachm.		x	x		x	x	x		x				x		x	x		x	x		x	x	x	x	x	x	x	x		x		x		x	x			x		x	
C. fusus Ehr.			x					x		x	x			x																		x		x							
Dinophysis sp.											x	x	x	x		x	x	x				x		x		x			x				x								
Prorocentrum cordatum (Oustenf.) Apé	x					x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
P. micans Ehr.		x		x		x	x	x	x	x	x	x	x	x		x	x	x	x		x	x	x		x	x	x	x	x		x	x	x	x	x	x	x		x		x
P. triastinum Schiller.	x		x	x	x		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x		x		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Protoperidinium breve Paulsen.		x			x			x						x	x			x		x		x		x		x	x	x		x											
P.curvipes (Ous.) Balech	x				x			x						x		x	x				x		x		x		x		x		x			x	x		x		x		x
P. depressum (Bailey) Balech	x					x		x	x	x	x		x	x		x			x											x	x	x		x	x		x		x		x
P. minutum (Kofoid) Balech.	x	x	x	x		x		x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x		x	x	x	x
P. steinii (Jšrgensen) Balech		x	x	x						x				x	x	x	x	x			x		x		x							x	x		x	x		x	x		x
Gonyaulax polyedra Stein.																x			x	x	x		x	x	x		x			x		x			x			x		x	

Table (1): continue																																									
Gonyaulax turbynei Murr. and Whitt.	x	x	x		x	x	x	x	x	x	x	x	x	x	x			x	x											x		x			x		x			x	
Gymnodinium catenatum Graham.			x	x	x					x				x	x	x	x	x	x		x	x	x	x	x	x		x	x	x					x		x				x
Gyrodenium fusiform Kof. and Swezy.	x		x	x				x		x	x		x	x																		x	x			x			x		x
Gyrodenium sp.	x						x		x	x		x	x	x			x	x			x			x																	
Oxytoxium constrictum (Stain) Butschli		x				x		x		x	x		x	x	x	x	x	x	x	x	x		x		x		x					x	x			x		x			
Number of species	**8**	**8**	**9**	**7**	**7**	**8**	**6**	**11**	**9**	**12**	**11**	**8**	**12**	**16**	**10**	**13**	**11**	**13**	**11**	**7**	**12**	**9**	**10**	**10**	**10**	**9**	**9**	**8**	**8**	**9**	**6**	**13**	**9**	**8**	**12**	**7**	**8**	**8**	**9**	**7**	**10**
Chlorophyceae																																									
Ankistrodismus falcatus (Corda) Ralfs.			x	x	x	x		x	x		x	x	x	x	x	x	x		x	x	x	x	x	x	x	x		x	x	x	x	x		x	x	x	x	x		x	x
Crucigenia quadrata Morren.		x				x		x	x	x		x	x	x	x	x		x	x			x			x	x	x	x	x	x		x	x		x	x		x	x		x
C. rectangularis (A. Brawn) Gay.		x	x	x			x				x		x																	x	x	x	x	x	x		x	x	x	x	x
C. tetrapedia (Kirchn.) W and G. S. West.	x	x	x			x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x
Oedognium sp.	x	x	x		x					x			x																x	x				x					x		
Oocystis borgei Snow.	x			x		x			x		x	x	x	x	x			x		x	x				x		x	x		x		x	x			x		x		x	
Pediastrum duplex Meyen.		x											x			x	x	x	x				x	x																	
P. simplex Meyen.	x						x	x		x				x			x					x			x	x			x	x	x		x		x	x		x	x	x	
Scenedesmus dimorphus Turp.	x		x	x		x					x	x		x	x	x			x	x	x		x				x			x		x			x	x	x				x
S.quadricauda (Turp.) Breb.		x		x	x			x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x		x	x		x	x		x	x	x	
S. obliqus Kutz.						x		x	x		x	x		x															x	x					x	x			x		x
S. bijuga (Turpin) Lagerh.			x		x	x	x			x			x	x		x								x																	
Number of species	**5**	**6**	**6**	**5**	**4**	**7**	**3**	**6**	**6**	**6**	**7**	**6**	**9**	**9**	**6**	**7**	**5**	**5**	**6**	**5**	**5**	**5**	**4**	**5**	**6**	**5**	**5**	**5**	**6**	**9**	**3**	**7**	**6**	**4**	**8**	**8**	**4**	**7**	**7**	**6**	**6**
Cyanophyceae																																									
Anabaena sp.	x		x	x	x	x		x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Anabaenopsis sp	x									x	x		x			x	x					x			x														x		
Chroococcus turgidus (Kg.) Naeg.	x				x		x	x			x	x	x	x	x			x	x		x		x	x						x		x			x	x		x	x	x	
Chroococcus dispersus (Keissl.) Lemm	x		x	x		x		x	x	x		x													x														x		
Gomphosphaera oponina Kg.	x				x		x				x		x	x	x	x	x	x		x	x			x		x						x	x		x		x	x	x	x	
Lyngbya limnetica Lemm.					x	x		x	x	x	x	x	x	x															x	x		x	x		x	x	x		x	x	x
Lyngbya sp.															x		x	x	x		x		x	x		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Merismopedia punctata Meyen.			x	x			x	x		x		x	x	x	x	x		x	x		x	x	x		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Microcystis aeraginosa Kütz.	x			x	x			x	x	x	x		x	x		x			x	x		x		x						x	x	x	x	x	x	x	x	x	x	x	x
Oscillatoria sp.			x				x	x			x	x	x	x	x		x	x			x	x			x					x		x	x		x		x	x	x	x	x
Spirulina platensis (Nordst.) Geitter.	x				x	x		x		x	x	x	x	x	x	x	x	x			x		x				x		x	x	x	x		x		x		x	x	x	x
Spirulina sp.		x	x	x					x				x		x		x	x	x		x		x		x				x	x	x	x	x	x	x	x	x	x	x	x	x
Number of species	**7**	**1**	**5**	**5**	**6**	**4**	**4**	**8**	**5**	**7**	**8**	**7**	**10**	**8**	**8**	**5**	**6**	**8**	**6**	**3**	**8**	**5**	**6**	**5**	**6**	**3**	**3**	**3**	**6**	**9**	**6**	**10**	**8**	**6**	**9**	**8**	**8**	**9**	**12**	**10**	**8**
Euglenophyceae																																									
Euglena acus Ehr.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
E. codata Hübner	x	x	x		x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x			x	x	x	x	x	x	x	x	x	x	x	x	x
E. gracils (Klebs)		x	x	x	x	x	x	x	x	x	x	x		x	x		x	x		x		x		x					x	x	x	x	x		x	x		x		x	
E. granulata (Klebs.)															x	x	x	x		x	x		x	x						x		x			x		x		x		x
Number of species	2	3	3	2	3	3	2	3	3	3	3	3	2	3	4	3	4	4	2	4	3	3	3	3	2	1	1	1	3	4	3	4	3	2	4	3	3	3	3	3	3
Total number of species	**65**	**55**	**63**	**44**	**49**	**54**	**40**	**67**	**60**	**62**	**61**	**65**	**68**	**72**	**64**	**72**	**63**	**78**	**71**	**52**	**67**	**55**	**57**	**59**	**59**	**53**	**44**	**40**	**64**	**70**	**49**	**76**	**56**	**58**	**68**	**53**	**64**	**59**	**62**	**57**	**67**

There were strong positive correlation between *Skeletonema costatum* and water temperature(r= 0.54, ≥ 0.05), while negative correlation for *Asterionella spp* (r= -0. 40, ≥ 0.05).

Abu-Qir Bay showed a marked variability of phytoplankton abundance in space and time as well as in community structure. The phytoplankton density (Figure 3) varied widely during the study period between 1737 x10^3 unit.L^{-1} at St. 14 and 6616 x10^3 unit.L^{-1} near TPS (Table 3) with an average of 3595 x10^3unit.L^{-1} (Table 2).

Table (2): Average numbers of the different phytoplankton groups (x10^3 Unit.L^{-1} ± standard deviation) and their percentage frequencies in Abu-Qir Bay during February, April and June 2004.

Season / Groups	February		April		June		Average	%
	No.	%	No.	%	No.	%		
Bacillario.	**2365±1942**	**90.86**	**2595±1022**	**95.26**	**5269±1905**	**95.18**	**3387±1827**	**94.2**
Dino.	**104±43**	**4.00**	**58±14**	**2.13**	**124±72**	**2.24**	**93±50**	**2.6**
Chloro.	**35±17**	**1.34**	**28±7**	**1.03**	**37±18**	**0.67**	**33±12**	**0.9**
Cyano.	**52±27**	**2.00**	**21±5**	**0.77**	**67±38**	**1.21**	**47±30**	**1.3**
Eugleno.	**47±26**	**1.80**	**22±12**	**0.81**	**39±20**	**0.70**	**36±19**	**1.0**
Total	**2603±1928**	**100**	**2724±1032**	**100**	**5536±2033**	**100**	**3595±1862**	**100**

During February, the phytoplankton counts showed the lowest density (Figure 3), they fluctuated between 934 x10^3 unit/L (St. 14) and 6768 x10^3 unit.L^{-1} (St.3) with an average of 2603 x10^3 unit.L^{-1} (Tab. 2). As represented in table (1, 2), the community included 112 species, diatoms were the main bulk (90.86 % of the total phytoplankton count) with 69 species and predominated by *Skeletonema costatum* (51.3 %) and less extend *Asterionella spp* (8.7 %). The highest counts were recorded at the western part of the bay especially Sts. 1, 2 and 3 (Figure 4). On the other hand, diatoms *Nitzchia spp.* (1.7 %)*; Cyclotella spp.* (2.7 %); *Leptocylindrus danicus* (2.1); *Rhisosolenia delicatula* (4.2 %) and *Thalassiosera rotulla* (2.2 %) were rarely recorded, in addition to dinophycean *Prorocentrum spp*. (1.9 %) and *Protoperidenium spp.*, (1.6 %). Freshwater forms were represented mainly by Cyanobacterium *Merismopedia punctata* which formed 0.8 % of the total phytoplankton especially at Sts. 1, 4, 8, 13 and 14. *Euglena spp.* was recorded at all stations with a percentage of 0.9 % of the total phytoplankton (Figure 4).

During April, the highest phytoplankton density appeared near TPS and the counts of total phytoplankton decreased seaward (Figure 5). They fluctuated between 1172 x 10^3 unit.L^{-1} at St. 14 and 4073 x 10^3 unit.L^{-1} at St. 3 with an average 2724 x 10^3 unit.L^{-1} (Fig. 5 and Tab. 2). The community included 99 species (Table1), in which diatoms contributed 95.26 % (Table 2) of the total phytoplankton count (60 species) and represented mainly by *Skeletonema* *costatum* (41.3 %) and *Nitzchia serriata* (46.5 %). The two latter species formed a peak near TPS (Figure 5).

Table (3): Average counts of different phytoplankton groups (x10^3 Unit. L^{-1} ± standard deviation) at different stations in Abu-Qir Bay during the study period.

Group	Stations													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Bacillario.	4316 ± 1745	5118 ± 840	6312 ± 2267	4058 ± 2104	4549 ± 3323	3114 ± 1707	2494 ± 1871	3956 ± 2970	2958 ± 1283	2819 ± 1033	2215 ± 1019	2130 ± 870	1813 ± 1356	1565 ± 1188
Dino.	37 ± 0	72 ± 34	144 ± 108	118 ± 44	137 ± 110	79 ± 33	93 ± 31	116 ± 78	91 ± 20	78 ± 14	69 ± 11	107 ± 78	81 ± 40	81 ± 48
Chloro.	22 ± 1	49 ± 26	37 ± 21	28 ± 8	44 ± 35	37 ± 18	18 ± 3	41 ± 8	29 ± 10	32 ± 5	35 ± 7	27 ± 3	32 ± 16	29 ± 7
Cyano.	56 ± 32	29 ± 24	70 ± 54	33 ± 14	71 ± 78	35 ± 15	39 ± 23	63 ± 41	35 ± 8	38 ± 14	41 ± 17	37 ± 25	63 ± 53	43 ± 21
Eugleno.	38 ± 25	42 ± 29	53 ± 32	39 ± 10	70 ± 47	34 ± 20	20 ± 11	37 ± 18	35 ± 26	30 ± 4	29 ± 15	20 ± 6	24 ± 12	18 ± 11
Total	4469 ± 1752	5310 ± 1905	6616 ± 2469	4277 ± 2120	4871 ± 3530	3299 ± 1652	2664 ± 1883	4213 ± 3069	3148 ± 1241	2997 ± 1051	2389 ± 1018	2331 ± 1844	2012 ± 1335	1737 ± 1190

The flourishing of both phytoplankton species and counts were observed during June (Table 1, 2). It fluctuated between 3105 x 10^3 unit.L^{-1} (St. 14) and 9004 x 10^3 unit.L^{-1} (St. 3) as shown in Figure (6) with an average of 5535 x 10^3 unit.L^{-1} (Table 2). The community included 104 species (Table 1) where diatoms constituted the main bulk (64 species) and dominated by *Skeletonema costatum* (60.4 % of the total phytoplankton count). *Nitzchia serriata; Rhizosolenia delicatula* and *Leptocylindrus danicus* (10.6; 9.8 and 8.6 %, respectively) was frequently recorded (Figure 6). On the other hand *Thalassiosera rotulla* and *Prorocentrum spp.* (1.7 and 1.6 %) was rarely recorded (Figure 6).

The absolute values of species diversity index (Figure 7) displayed narrow temporal and spatial variations from 1.02 to 2.85 nats. Its average along the study period reported the lowest value (1.4 nats) in April and June and the highest (2.17 nats) in February. Throughout the bay, St. 3 sustained the lowest diversity index (1.38 nats), while St. 14 recorded the highest value (1.95 nats). The diversity index was negatively correlated with total phytoplankton and total Bacillariophyceae (r= -0.45 and -0.49, respectively ≥ 0.05).

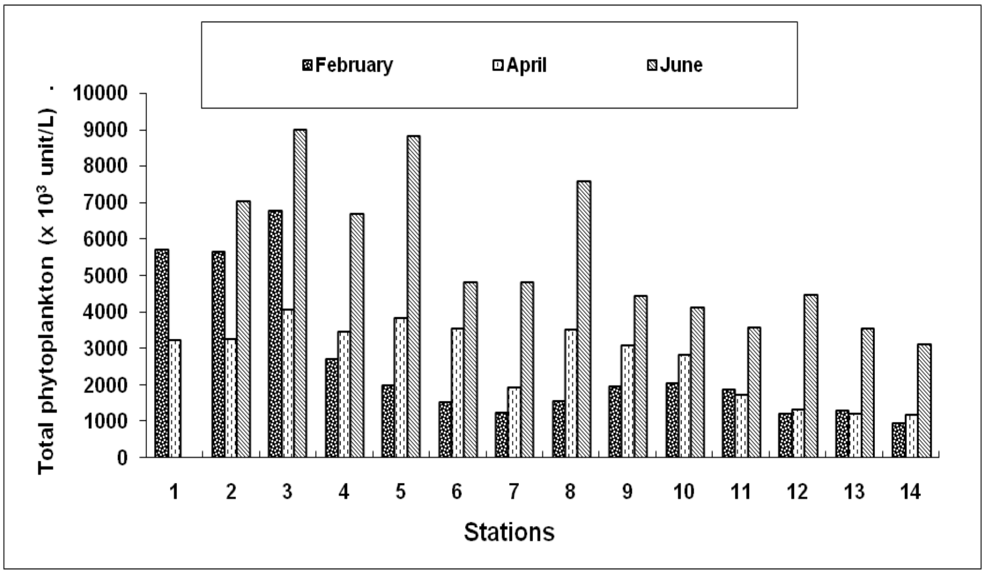

Figure (3): Variations of the total phytoplankton in Abu-Qir Bay at different stations during February during February, April and June 2004

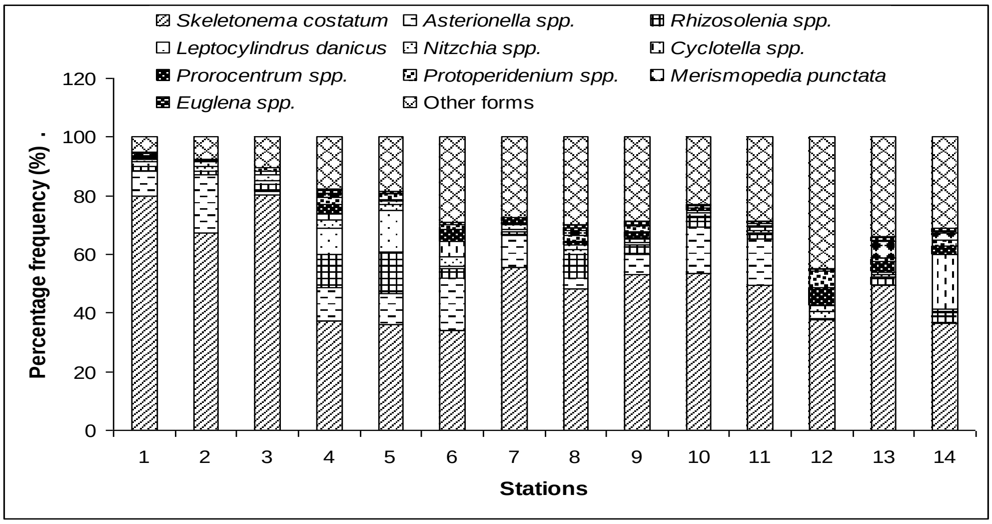

Figure (4): Percentage frequency of the main phytoplankton species at different stations in Abu-Qir Bay during February 2004

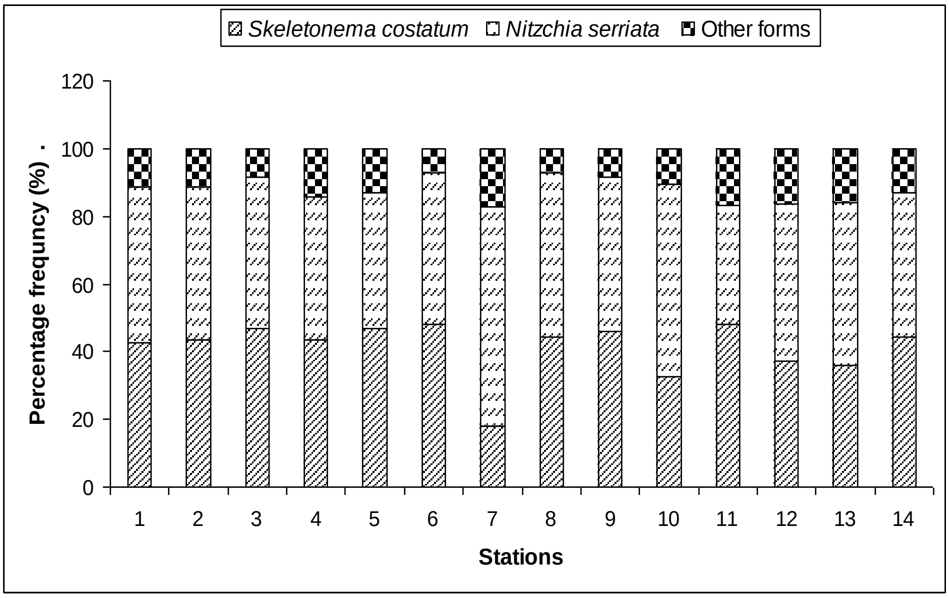

Figure (5): Percentage frequency of the main phytoplankton species at different stations in Abu-Qir Bay during April 2004

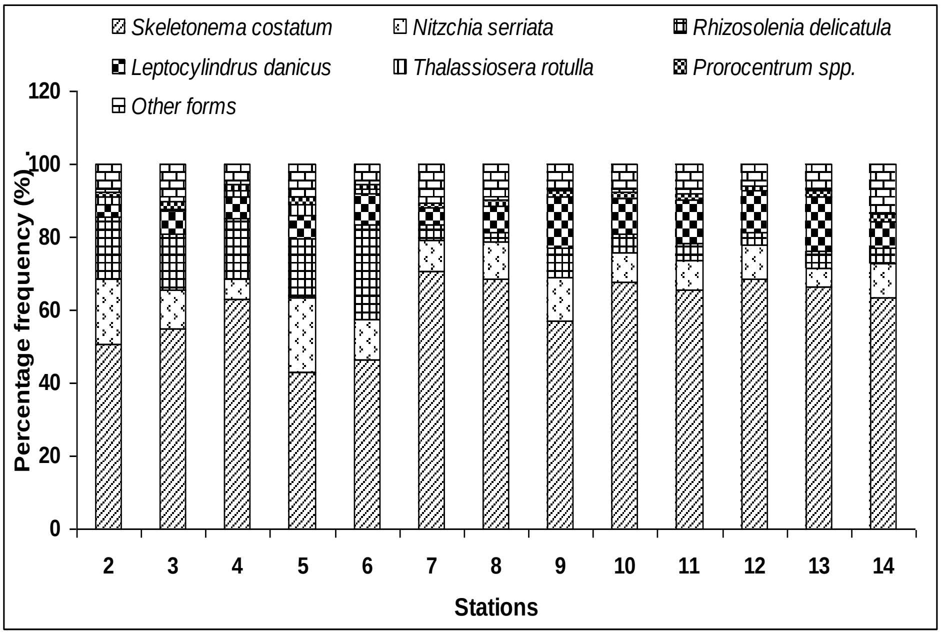

Figure (6): Percentage frequency of the main phytoplankton species at different stations in Abu-Qir Bay during June 2004

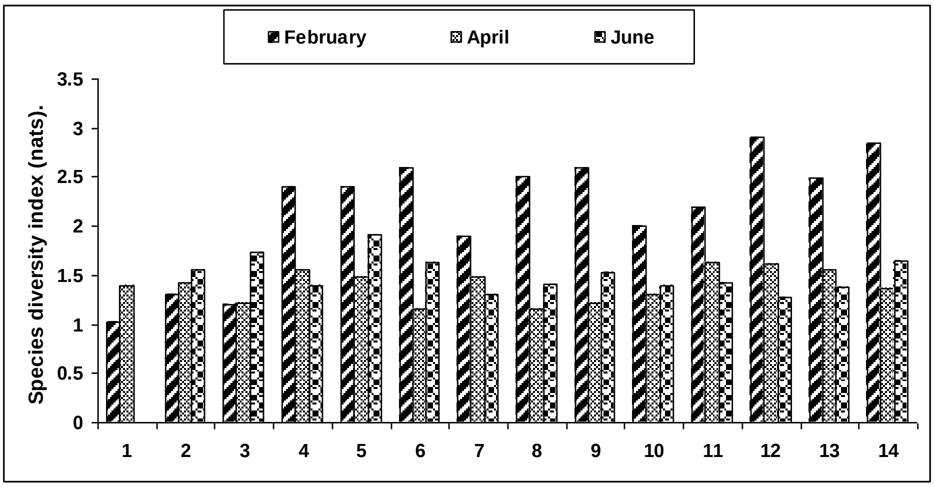

Figure (7): Species diversity index at different stations in Abu-Qir Bay during February, April and June 2004

Discussion

Semi-enclosed coastal systems, such as estuaries and bays have generally been regarded as one of the most productive aquatic systems in which nutrient supply is an important factor in sustaining the higher phytoplankton abundance and biomass (Bizsel *et al.,* 2001). Abu-Qir Bay is considered one of the heavy polluted areas because it lies in the vicinity of discharged wastes and referred as a hot spot. In the present study, the high levels of nutrient salts (discussed and published by Aly-Eldeen, 2006) and high density of phytoplankton in addition to low dissolved oxygen concentrations (<1.0 mg O_2L^{-1}), indicate an acute eutrophication in the bay. Water salinity values could be used as indicator of the flow of discharged wastes rich in nutrient salts which in turn reflect on the density and structure of the phytoplankton community throughout the bay. Stations 3-6 which are mainly subjected to the discharged water from Lake Edku and TPS usually showed high phytoplankton density, this mean that the discharge water promotes algal growth.

Throughout the last decade, dissolved inorganic nitrogen fluctuated from year to year, but dissolved inorganic phosphate showed a steady decrease, they were 23.27 and 1.42 µM during 1998-1999 (Shams-El-Din and Dorgham, 2007) and during 2004 parallel to that studied was 19.64 and 0.68 µM (Aly-Eldeen, 2006) for dissolved inorganic nitrogen and dissolved inorganic phosphate, respectively.

A total of 117 species of 5 classes were distinguished, Bacillariophyceae (> 90 %) exhibited the widest range of maximum potential growth rates and occurred under a wide range of discharges. The freshwater groups Chlorophyceae, Cyanophyceae and Euglenophyceae appeared mainly at near shore stations, but usually with low percentage to the total phytoplankton count. Mohammed (1981) stated that, the current in Boughaz El-Maadiya is mostly directed seawards during spring and summer, but in winter it directed towards the Lake Edku. This observation is in agreement with the present results which showed that, the discharge waters covered most of the bay stations during June.

The phytoplankton count during the present study was markedly high (average 5535 x 10^3 unit.L^{-1}). When compared it with previous records, the phytoplankton counts were 36 x 10^3 unit.L^{-1} (Samaan and Mikhail, 1990); 33 x 10^3 unit.L^{-1} by El-Sherif and Gharib (1994); 5 x 10^3 unit.L^{-1} (Shams-El-Din and Dorgham, 2007) and 780 x 10^3 unit.l^{-1} (El-Sherif and Mikhail, 2003). Furthermore, the dominance of species was mostly different, Shams-El-Din and Dorgham (2007) reported species as *Nitzchia pungens*, *Nitzchia pacifica, Asterionella japonica, Thalassionema nitzchoides, Chaetoceros affinis, Chaetoceros didymus*, *Prorocentrum micans* and *Euglena acus* were the dominant species during 1998-1999. But during the next year 1999-2000 (El-Sherif and Mikhail, 2003) recorded other different species as, *Asterionella glaciales, Skeletonema costatum, Rhizosolenia fragilissima*, *Leptocylindrus minimus, Chaetoceros affinis, Nitzchia* longissima, *Nitzchia serriata, Cyclotella meneghiniana, Cyclotella nana, Prorocentrum triestinum, Scripsiella trochoidea* and *Carteria cordiformis.* During the present study, species as *Skeletonema costatum, Nitzchia serriata,* and *Asterionella glaciales* showed continuous dominancy. Furthermore, high counts of fresh and brackish water forms as *Cyclotella meneghiniana*, *Scenedesmus spp*., *Nitzchia palea* were recorded during 1997 in front of Boughaz El-Maadiya by Gharib and Dorgham (2000). 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.

The differences in the community composition between the present study and previous records may be attributed mainly to that the present study based on sampled collected in three months only, where the earlier study samples collected monthly all the year round. This was emphasized by the low number of species recorded in the present study (117 species) compared by 183 species (Shams-El-Din and Dorgham, 2007) and 241 species (El-Sherif and Mikhail, 2003). Such great increase in the phytoplankton density during the present study, the dominancy of few species and the decreased in dissolved oxygen reached <1.0 $mgO_2.l^{-1}$ in some stations may be a serious sign to the eutrophication in the bay.

The present study indicated that *Skeletonema costatum* as the dominant form, it is considered as indicator for pollution (Mihnea, 1985) and this species was euryhaline and eurythermal, it known as indicator of eutrophication everywhere (Huang *et al.,* 2004; Toming and Jaanus, 2007). *Skeletonema costatum* seem to respond quickly to new nutrients induced, known as fast-growing diatoms (Malej *et al.,* 2003) and previously recorded as dominant species in Abu-Qir Bay (Anonymous, 1981; Samaan and Mikhail, 1990; El-Sherif and Gharib, 1994). *Asterionella glaciales* and *Skeletonema costatum* are well known red tide species, with occurrence closely related to land drainage (Revelante and Gilmartin, 1985; Labib, 1997). *Asterionella glaciales* reached 20 x 10^6 cell.L^{-1} east of Boughaz El-Maadiya and 12 x 10^6 cell.L^{-1} in front of TPS (Anonymous, 1981). *Skeletonema costatum* is a neritic diatom species with optimum salinity of 19.5 ppt and declines as salinity deviates from this optimum (Cloern and Cheng, 1981). *Skeletonema costatum* is considered the most important species in Alexandria waters (Dowidar, 1965; El-Maghraby and Halim, 1965). *Nitzschia serriata* was recorded as dominant species beside *Skeletonema costatum* during summer. The members of the genus *Nitzschia* are highly eurythermic and flourished well at temperature ranging between 10^0C and 27^0C (Goldman, 1977). This explains the non-dependence of the genus growth on temperature variations. *Nitzschia serriata*, gives an indication for eutrophication (Rao and Mohanchand, 1988). The presence of *Nitzschia serriata* in the bay gives an indication for eutrophication (Revelante and Gilmartin, 1985).

A stepwise multiple regression equation applied to predicting the average levels of environmental parameters in water bodies which affects phytoplankton community, the regression equation showed that:

Total phytoplankton = 37325+ 363 Temperature – 1108 Salinity.

Skeletonema costatum = 29525 + 233 Temperature - 868 Salinity.

Asterionella glaciales = 3802 + 104 Salinity + 46 DO.

Nitzschia serriata = - 7445 + 232 Salinity – 145 DO.

This equation illustrate that the studied environmental factors which affect the magnitude of phytoplankton standing crop and the dominant species.

In conclusion, the ecological conditions of Abu-Qir Bay are of great variability due to interaction of several factors, including discharged wastewater from El-Tabia pumping station; out let of Lake Edku and Rosetta mouth of the River Nile. This variability caused high eutrophication, increase in species diversity index and the dominancy of some species which as indicator for eutrophication.

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توزيع الهائمات النباتيه فى منطقه الجنوب الغربى للأسكندريه (خليج أبى قير) مصر

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يقع خليج أبى قير على مسافه 35 كم شرق مدينه الأسكندريه و يواجه خليج أبى قير العديد من المشاكل البيئيه نتيجه لصرف كميات كبيره من مخلفات الصرف الصناعى والأسمده من خلال محطه طلمبات الطابيه بالاضافه الى كميات المياه العذبه التى تصب فى الخليج من بحيره ادكو عبر فتحه بوغاز المعديه وكذلك من فرع رشيد لنهر النيل والتى تؤثر على الصفات الطبيعيه والكيميائيه للمياه والتى تنعكس على الأحياء البحريه فى خليج أبى قير.

قد تم جمع عينات للهائمات النباتيه من 14 محطه تمثل البيئات المختلفه بخليج أبى قير خلال الفتره من فبرايرالى يونيه 2004 .

وقد سجلت الدراسه 117 نوع من الهائمات النباتيه ضمن 66 جنس ينتمو الى خمسه مجموعات هى الدياتومات وثنائيه الأسواط ومجموعه الطحالب الخضراء والخضراء المزرقه واليوجلينات وأظهرت النتائج سياده مجموعه الدياتومات حيث سجلت 2, 94 % من المجموع الكلى لمجتمع الهائمات النباتيه.

كما أظهرت النتائج ازدياد الكثافه العدديه للهائمات النباتيه خلال شهر يونيه (متوسط 5536 X 10^3 وحده لكل لتر) وكانت المحطات القريبه من محطه طلمبات الطابيه (محطه1 ،2 ،3، 4) هم الأكثر انتاجيه.