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PHYTOPLANKTON POPULATION IN RELATION TO HYDROGRAPHIC CONDITIONS ALONG THE WEST-COAST OF ALEXANDRIA (EGYPT) TILL EL-HAMMAM

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ABSTRACT

Quantitative estimation of phytoplankton was carried out seasonaly along the Mediterranean continental area, extending western of Alexandria (Egypt), for about 55 km. Two sectors were selected perpendicular to the shore line at El-Mex and El-Hammam. The area is subjected to a constant discharge of Umum drain water contaminated with sewage and industrial wastes flowing into El-Mex Bay. Such water produced a pronounced eutrophication of sea water, particularly at the inshore of El-Mex and its effect extended westwards till El-Hammam.

The distribution of phytoplankton in the investigated area is mainly controlled by the prevailing hydrographic conditions, including water temperature, salinity and currents. The phytoplankton peaks were recorded at El-Mex in February (133,940 Cells /l) and at El-Hammam on October (670,620 Cells /l). The lowest counts appeared in July and August at the two sectors respectively, with average of 8310 and 550 Cells /l.

The phytoplankton community included a large number of species, although few of them (mostly diatoms) formed the main bulk. Most of the dominant species are temperate, neritic, marine forms of wide distribution in the Mediterranean waters. The average annual values of the standing crop at El-Mex and El-Hammam sectors amounted respectively 34,240 and 19,190 Cells /l.

INTRODUCTION

The investigated area extends for about 55 km, west of Alexandria (Egypt), between Latitudes 29° 50′ and 29° 20′ E. The shore line takes a south west direction and it is generally smooth, showing no irregularities except at El-Mex, where it forms a shallow sheltered bay (Fig. 1). The continental shelf slopes steadily towards the open sea, reaching a depth of 100 m at a distance of about 20-22 km away from the shore. The area receives a constant supply of drainage water collected from the cultivated land of Behiera province and is finally discharged into El-Mex Bay through

MATERIAL AND METHODS

Two sections perpendicular to the shore line were selected, as representing the investigated area, namely; El-Mex sector, which is situated on the western side of Alexandria and El-Hammam sector which lies infront of El-Hammam village, about 55 km apart of Alexandria (Fig. 1). Each section includes four sampling stations. The inshore stations I and II rpresent the shallow coastal area with depth less than 50 m, the offshore stations III and IV have depth, exceeding 50 m. The position and depths of the selected stations are summerized as follows:

	St. No.	Distance from shore (km)	Average depth (m)
Sector	I	3	5
El-Mex	II	6	25
	III	10	55
	IV	23	105
El-Hammam	I	9	15
	II	12	27
	III	17	65
	IV	25	105

Quantitative estimation of phytoplankton was carried out by collecting one litre of sea water from the standard available depth at each station (Surface, 10, 20, 30, 50, 75 and 100 m). Samples were preserved in 4 %, neutral formaline solution. Sedimentation was performed in volumetric cylinders and the samples were reduced to 25 ml by slow siphonation. Triplicate subsamples of 2 ml were examined microscopically and the different plankters were identified and counted. The phytoplankton standing crop was calculated as their total numbers per litre.

Some physical parameters were also estimated by Gergis (1979 during the same period of investigation. These included measurements of water temperature, salinity and surface water currents.

The period of sampling extended between January and October, 1977, covering the four seasons, namely; Winter (January and February), Spring (April and May), Summer (July and August) and Autumn (October).

RESULTS

1- Distribution of phytoplankton during Winter (January-February)

In winter, the surface water temperature averaged 16°C near to the coast, increasing to reach about 18°C at the offshores. The water appeared vertically homothermal due to winter convection, except at the inshore stations of El-Mex which showed both thermal and haline stratification as produced by Land discharge.

The distribution of salinity and temperature in the two sectors indicate the existance of continental flow with relatively cold temperature and low salinity moving down the slope and a more saline water approaching the coast as a subsurface layer at 50 m depth (Gergis, 1979). The estimated surface currents revealed an eastward offshore current with an average velocity of 13-16 cm /sec. coinciding with reversal weak westward coastal current with an average velocity of 4-5 cm /sec.

a- At El-Mex sector (Table 1 and Fig. 2)

The total phytoplankton recorded at El-Mex sector during January remained at a moderate density with an average of 6340 cells /l. The inshore stations harboured higher values than offshores. The more rich continental flow extended seaward as a surface layer till St. IV, while the open sea flow with lower phytoplankton counts appeared over the continental slope below 50 m depth. Cyclotella kutzingiana was the leading diatom at all stations.

An outstanding peak of phytoplankton was recorded at all stations in February, showing more or less homogeneous vertical distribution. The highest density occurred at St. I and decreasing gradually towards the open sea. Skeletonema costatum was the dominant plankter at the inshore stations while Cyclotella kutzingiana and Chaetoceros affinis prevailed at the offshores.

b- At El-Hammam sector (Table 1 & Fig. 3).

The standing crop of phytoplankton at El-Hammam sector remained moderate in February at most stations, showing highest values (15,400 cells /l), at 20 m depth of St. III, and this was attributed to the increased numbers of Chaetoceros affinis. Otherwise, Cyclotella kutzingiana and to a much less extent C. meneghiniana, and Thalassiothrex frauenfeldii formed the major fraction of the community in the other stations. The open sea flow, poor in phytoplankton, extends over the continental slop as a subsurface layer at 40 m depth.

Table 1.

Distribution of total phytoplankton standing crop (Cell /l) along El-Mex and El-Hammam during the four seasons of 1977

Section	Season	Month	Inshore stations		Offshore stations		Average
			St. I.	St. II.	St. III.	St. IV.	
El-MEX	Winter	Jan., 77	7,410	8,300	5,120	4,520	6,340
		Feb.	322,520	165,610	35,640	71,970	133,940
	Spring	April	257,530	1,770	1,820	1,280	65,600
		May	101,700	1,020	880	1,460	26,260
	Summer	July	31,760	1,010	330	130	8,307
	Autumn	Oct.	23,570	6,440	14,310	6,040	12,565
	Average of Seasons		99,950	23,950	9,092.3	3,946	34.242
El-HAMMAM	Winter	Feb.	2,840	1,480	5,500	1,720	2,885
	Spring	April	780	1,440	1,350	1,230	1,200
		May	7,300	4,600	2,180	1,020	3,775
	Summer	July	440	2,750	340	220	937
		Aug.	870	860	280	290	575
	Autumn	Oct.	121,950	120,160	6,470	33,900	70,620
	Average of Seasons		32,370	31,620	3,511	9,250	19187

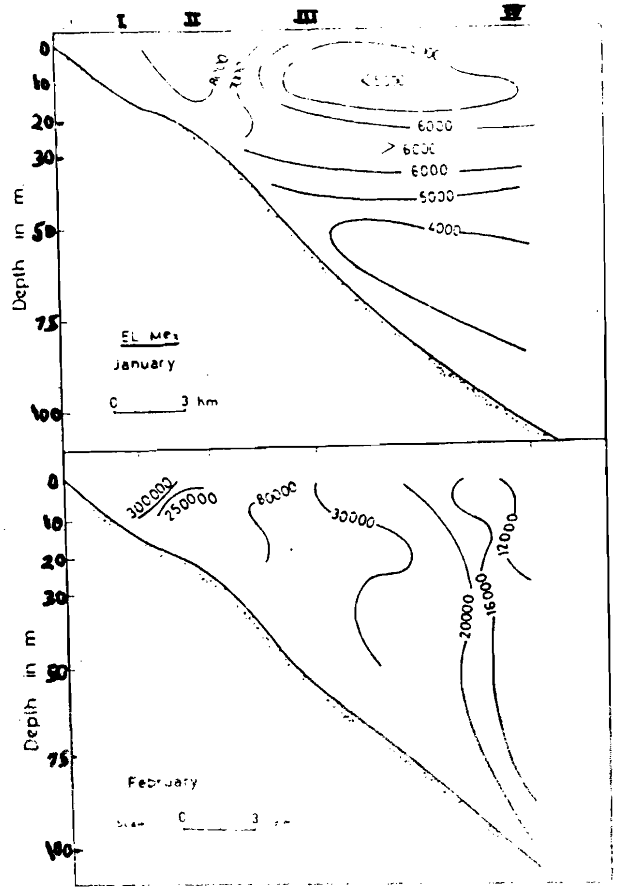


Fig. 2

Vertical distribution of phytoplankton standing crop (cell /l) for El-Mex section during winter.

2- Distribution of phytoplankton during spring (April-May)

The spring represents the beginning of warming up of air and consequently the surface water temperature increased to values fluctuating between 21.2 and 22.0 °C. The thermocline started to develop within the upper 30 m. Below the thermocline the water temperature was nearly homogeneous with values around 17.0 °C.

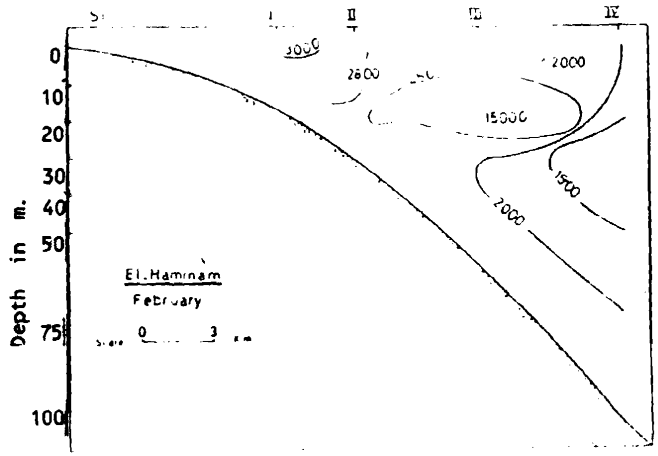


Fig. 3

Vertical distribution of phytoplankton standing crop (cell /l) for El-Hammam section during winter.

The variations of salinity with depth was still insignificant (average 38.8 ‰) except at the coastal station I of El-Mex, which was charaterized by salinity stratification as a result of inland influx which reduced the surface salinity to 35.3 ‰. The surface currents in April took an eastward direction with an average speed of 13 cm /sec. In May it was reversed to the west or south west directions as affected by the prevailing NE wind.

a- **At El-Mex sector** (Table 1 & Fig. 4)

The previous winter peak was succeeded by a sharp drop in the total phytoplankton during April, except at the coastal station I which still harboured a high density of 257,530 cells /l. This was mainly produced by **Lauderia boriales** which constituted about 51.7 % of the total phytoplankton counts, while **Chaetoceros affinis, Skeletonema costatum** and **Cyclotella kutzingiana** formed collectively about 38 % of the community. On the other hand, the community at offshores was dominated by **Cyclotella kutzingiana,** similar to the winter period. The fertile coastal water occupied the upper 10 m layer and extending seawards for about 4 km. An open sea flow poor in phytoplankton appeared at 20 m depth at the offshore stations and extending over the continental slop.

In May, the standing crop remained high at station I (average 101,700 cells /l). while it decreased sharply at the surface water of station IV (6340 cells /l), and this was attributed to **Chaetoceros** spp. The offshore stations were characterized by the presence of different water masses with variable densities of phytoplankton. Few species

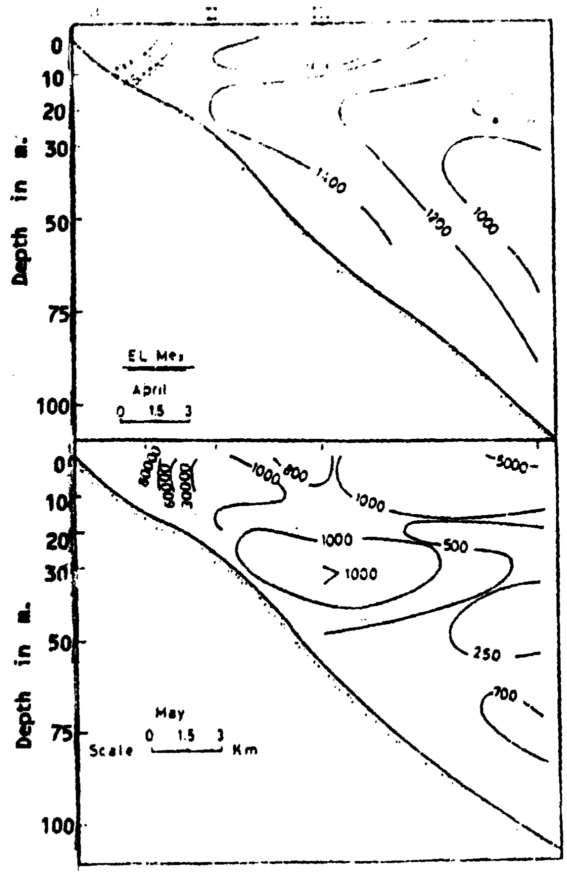


Fig. 4

Vertical distribution of phytoplankton standing crop (cell /l) for El-Mex section during spring.

appeared to contribute the main bulk of the community. The more dominant ones recorded at station I comprised **Skeletonema costatum** and **Cyclotella kutzingiana**. In the other stations, **Cyclotella kutzingiana**, **C. meneghiniana**, **Chaetoceros affinis**, **Ch. didymus**, **Leptocylindrus danicus** and **Melosira crucipunctata** were more frequent.

b- At El-Hammam sector: (Table 1 & Fig. 5).

The month of April sustained low standing crop of phytoplankton, particularly at the coastal stations. Cyclotella kutzingiana appeared as the leading plankter in the community. The vertical profile illustrates a surface layer poor in phytoplankton, extending for about 20 km, away from the shore. A more rich open sea flow approaches the continental slope at 40 m depth.

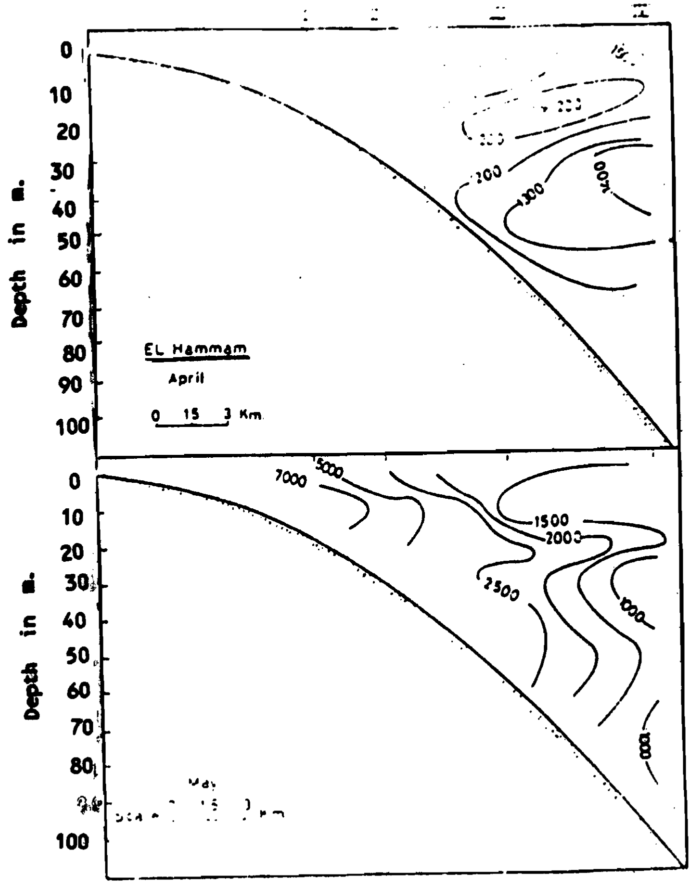


Fig. 5

Vertical distribution of phytoplankton standing crop (cell /l) for El-Hammam section during spring.

In May, relatively high density of phytoplankton appeared at station I (average 7800 cells /I), and the standing crop decreased gradually away from the shore. This is attributed to the effect of the south west surface current which convayed a portion of the more fertile water mass from El-Mex to the inshore stations of El-Hammam. Consequently, most of the dominant species were similar to that recorded at El-Mex sector during the same month, namely; **Chaetoceros affinis. Ch. decipiens, Ch. didymus, Leptocylindrus danicus, Cyclotella kutzingiana, C. meneghiniana** and **Melosira crucipunctata.**

The sub-surface open sea flow still existed in May and it extended over the continental slope at 30 m depth and was dominated by **Leptocylindrus danicus**.

3- Distribution of phytoplankton during summer (July-August)

A well defined thermocline appeared during summer and it occupied a subsurface layer between 50 and 100 m depth. In this layer the water temperature decreased by about 7.0°C (from 25°C to 18°C). The surface water temperature reached its highest value of 28°C at the coastal stations and decreasing gradually towards the offshores to about 25°C.

A weak halocline was also recorded in the two sectors as a subsurface layer between 50 and 75 m depth. The prevailing surface current took the westward direction similar to the month of May.

a. At El-Mex sector: (Table 1 & Fig. 6)

As a result of thermal stratification and expected nutrient depletion from the photic zone, the summer (July) sustained the lowest standing crop except at the coastal station I, which is still affected by the continental influx rich in nutrients. The latter station harboured relatively high density which averaged 31,775 cells /l and was dominated by **Skeletonema costatum**. The rich coastal flow extended for about 5 km away from the shore followed by a sharp drop of phytoplankton counts in the other 3 stations. The frequent plankters recorded at these stations included **Melosira crucipunctata, M. granulata, Cyclotella kutzingiana, C. meneghiniana** and **Skeletonema costatum**.

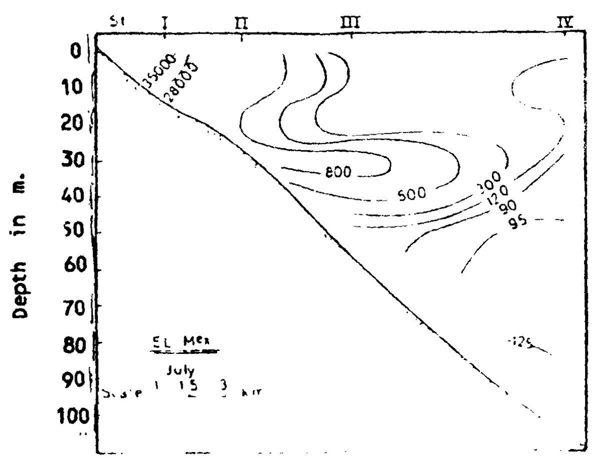


Fig. 6

Vertical distribution of phytoplankton standing crop (cell /l) for El-Mex section during summer.

b. At El-Hammam sector: (Table 1 & Fig. 7)

The phytoplankton counts were also low at El-Hammam during July except a relatively high value of 7190 cells /l recorded in the surface water of station II and was accompanied by a pronounced increase in the number of *Ceratium* spp. The subsurface layer below 30 m depth sustained the lowest density. The more frequent species other than *Ceratium* spp. included *Melosira crucipunctata*, *Leptocylindrus danicus*, *Cyclotella kutzingiana* and *C. meneghiniana*.

Further decrease in phytoplankton appeared in August particularly at the offshores and also with increasing depth. The more frequent plankters comprised, *Melosira crucipunctata*, *Leptocylindrus danicus* and *Nitzschia* spp.

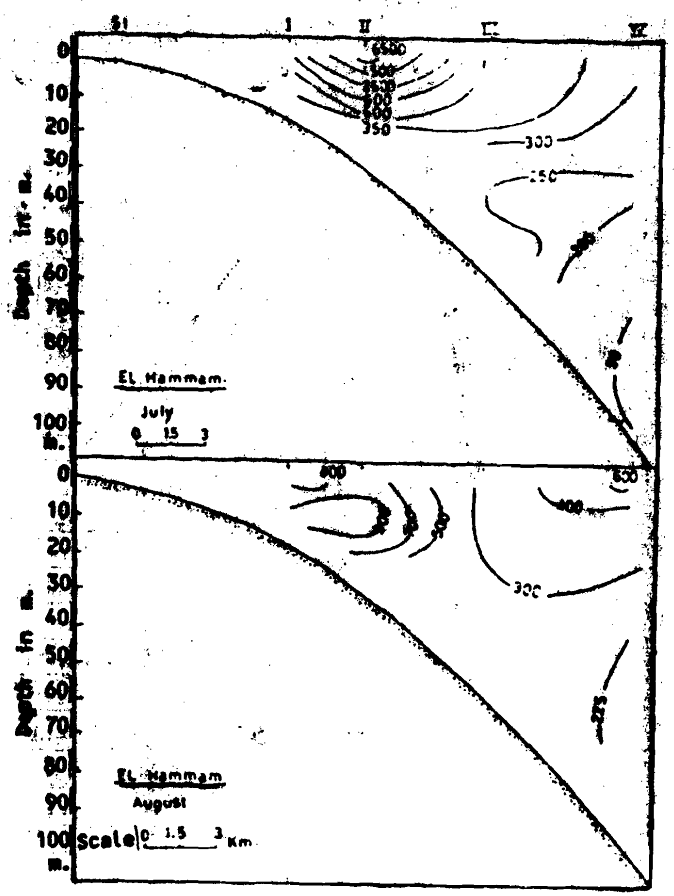
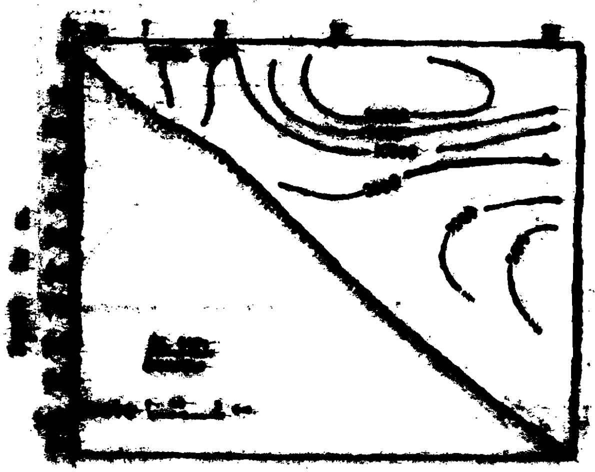


Fig. 7

Vertical distribution of phytoplankton standing crop (cell /l) for El-Hammam section during summer.



DISCUSSION

The investigated area extends for about 55 km western of Alexandria between El-Mex and El-Hammam and it represents a boundary between the eastern and western regions of the Egyptian Mediterranean coast. The former one receives a constant supply of fresh or slightly brackish water discharged from Rosetta Nile Branch and the Northern Delta lakes and it is usually rich in phytoplankton. On the other hand the water mass extending along the western coasts from El-Hammam to El-Sallum appears more or less homogeneous with no continental discharge and it harbours low standing crop of phytoplankton like most eastern Mediterranean regions.

El-Mex Bay receives drainage water contaminated with sewage and industrial wastes at a daily rate of about 6.5 million cubic meter. According to the high load of nutrients discharged with the drain water, the Bay is considered as highly eutrophic (El-Sherif, 1989 and Dorgham et al., 1987). The eutrophication effect of such water usually extends for several kilometers northwards towards the open sea as well as along the western coasts and may on ceratin occasions reach El-Hammam area.

The hydrographic conditions prevailing during the different seasons appear to have a controlling effect on the distribution of phytoplankton. The surface water currents at the offshores show a permanent eastward direction which is greatly affected by the general circulation of the east Mediterranean (Gergis, 1979). In the same time, a weak westward countercurrent extends along the coast line and is mainly produced by the combined effect of both the prevailing N-NE wind and the configuration of shore line which extends to the southwest. This coastal current is responsible for transportation of the more fertile water of El-Mex Bey to the west. Thus, the peaks of phytoplankton recorded at the inshore stations of El-Hammam during May and October is related to the eutrophication effect of El-Mex water.

The area belongs to the warm temperate zones. The water temperature fluctuated from a minimum of 16°C in late winter (February) and a maximum of 28°C in summer (July & August). The thermocline begins to develop gradually to occupy a subsurface layer between 50-100 m. at the offshores in summer and autumn. The effect of thermal stratification is manifested in the exhaustion of nutrients in the photic zone. Thus, the lowest phytoplankton counts appeared during summer with average of 8310 and 670 cells /l at El-Mex and El-Hammam respectively.

The water salinity showed pronounced variations particularly at the coastal station I of El-Mex as a result of inland discharge. The salinity values fluctuated between 35.27 ‰ at the surface water of station I of El-Mex during April and 39.31 ‰ at 50 m depth of station III of El-Hammam in October. The water was generally vertically homohaline during winter and spring, followed by development of a weak halocline in summer.

The dominant plankters are mostly euryhaline estuarine forms which can tolerate wide variations of salinity. The drainage water discharged into El-Mex Bay produces a coastal flow rich in phytoplankton and extending towards both the open sea and westwards as mentioned previously. In the same time, the open sea flow usually approaches the coast as a surface or subsurface layer, depending on water density. Water instability and turbulance may occur due to variations in density giving rise to different water masses with different phytoplankton counts as shown at the offshores of the two sectors during spring (Figs. 4 & 5). Upwelling occurred also at station II of El-Mex and station III of El-Hammam in October where the subsurface layer of the open sea flow was brought up, producing a patch of less productive layer.

The standing crop of phytoplankton in the investigated area is characterized by the presence of a large number of species, although few of them formed the main bulk of the population. Diatoms contributed numerically over 94 % of the total phytoplankton, the rest was mostly represented by dinoflagellates, while silicoflagellates remained scarce. Most of the dominant species are warm temperate, neritic, showing wide distribution in the Mediterranean waters.

Skeletonema costatum (Grev) Cleve, represented the most dominant diatom at the inshore station of El-Mex, contributing about 43.5 % of the total population (average 29,130 cells /l). It appeared also frequently at the inshore stations of El-Hammam with an average annual of 4810 cells /l.

Its maximum persistance was in winter and autumn in the two sectors respectively. The species is regarded as a cosmopolitan, neritic meroplanktonic diatom (Cupp 1943), widely distributed in the Mediterranean all the year round (Pavillard, 1925, Wawrik, 1961), and in the Egyptian Mediterranean waters (Dowidar, 1974).

Asterionella japonica Cleve, was the most important diatom at El-Hammam sector in October (average 41.080 cells /l), and it was responsible for the autumn peak, It appeared also in abundance at the 4 stations of El-Mex during the same month with an average of 5080 cells /l. Other wise, it was missed in the other seasons. The species is a cosompolitan, neritic diatom, being more abundant in temperate waters. It is widespread in the Mediterranean (Tregouboff & Rose, 1957), previously reported in the Egyptian waters contributing to both winter and autumn blooms (El-Maghraby & Halim 1965).

The genus **Cyclotella** was represented by **C. kutzingiana** Thwait and **C. meneghiniana**, Kutz. It appeared more common at El-Mex sector than El-Hammam (averages 3220 and 650 cells /l respectively). Its maximum frequency was in winter. **C. kutzingiana** is regarded as a littoral diatom, tolerant to different habitats (Round, 1961).

The genus **Chaetoceros** was represented by 10 species, among which **Ch. affinis** Lauder, **Ch. didymus** Ehr. and **Ch. decipiens** cleve were more dominant, The average annual genus counts amounted respectively, 8,860 and 2,530 cells /l at inshore stations at El-Mex and El-Hammam decreased to 1040 and 1000 cells /l at the offshores. **Ch. affinis** was the leading species of the genus. It appeared more frequent in winter and spring at El-Mex sector and in autumn at El-Hammam. The species is a cosmopolitan, neritic, temperate diatom (Cupp 1943), widespread in the Mediterranean (Pavillard, 1925), Previously recorded inthe Egyptian waters (Dowidar 1974).

Ch. didymus appeared more frequent in spring. It is a neritic temperate species, typical Mediterranean form (Tregouboff & Rose, 1957). **Ch. decipiene** appeared frequently during spring while it was missed in summer. The species is regarded as arctic and boreal form, widespread in the Mediterranean.

Leptocylindrius danicus Cleve. appeared frequenly in the two sectors, showing higher counts at the inshore ststions of El-Mex during autumn and spring as well as at El-Hammam in autumn. It is regarded as neritic tempearte species, of wide distribution in the Mediterranean but never found in abundance far from the coast (Pavillard, 1916).

The distribution of **Lauderia borealis** Gran. was restricted to the inshore stations of El-Mex during spring (average 25720 cells /l whereas much lower counts were noticed in autumn and winter. It is a neritic temperate species, widely distributed in the Mediterranean, perviously recorded by Dowidar (1974) in the Egyptian Mediterranean waters.

Melosira granulata Mull. and **M. crucipunctata** Bachm were frequently recorded during winter and spring showing highest counts at the inshore of El-Mex with 1850 and 2250 cells /l in the two seasons respectively. The 2 species are regarded as indifferent forms (Foged, 1948), previouslyrecorded along Alexandria coasts during the Nile flood (Dowidar, 1974).

The genus **Rhizosolinia** included 9 species and was dominated by **Rh. delicatula** Cleve. The species appeared all the year round, being more frequent in winter and autumn. It is a neritic temperate form (Cupp 1934), previously recorded in the Egyptian Mediterranean waters (Sultan 1975).

Thalossiothrix frauenfeldii Cleve & Grun appeared more frequent in autumn. It is a cosmopolitan species, widely distributed in the Mediterranean (Tregouboff & Rose, 1957).

Ceratium furca (Ehr) Clap & Lachm and **C. pulchellum** shorder were the main represntatives of dinoflagellates. They appeared mostly frequent in summer particularly at the inshore stations of El-Hammam with an average of 320 cells /l.

The average annual values of the total phytoplankton at the inshore stations of El-Mex and El-Hammam sectors amounted respectively 66,950 and 32,110 cells /l decreasing rapidly to 6520 and 6380 cells /l at the offshores. Such values rank the area among the most fertile Egyptian Mediterranean coasts as a result of inland discharge. It is also similar to the eastern Egyptian coasts which receives continental influx. Thus the values estimated infront of Rosetta Nile Branch during the same period of investigation averaged 50590 cells /l for the inshore stations and 350 cells /l at the offshores (Samaan et al, 1985). Also, the sector infront of Abu Qir Bay harboured average annual values of 18610 and 3310 cells /l at inshore and offshore stations respectively. (Samaan & Mikhail 1990). On the other hand, the Egyptian coast extending western of El-Hammam till Marsa Matrouh (185 km long) does not receive any continental influx and consequently appeared more or less homogeneous with low standing crop of phytoplankton all the year round. It also harbours comparable densities of phytoplankton at both the inshore and offshore areas (averages 1910 and 2120 cells /l respectively).

The general trend of the seasonal variation of the total phytoplankton along the Egyptian coasts illustrates a winter peak, associated with the winter convection. The magnitude of the standing crop decreases gradually during spring to reach minimum values in summer and autumn due to the development of thermocline and nutrient depletion from the photic zone. Expentional cases were met with in areas subjected to continental discharges. Thus, El-Mex sector sustained a peak of phytoplankton during winter (February), while the summer still harboured the lowest density with the exception of station I. At El-Hammam sector there was also a similar increase in Febuary and a sharp drop during July and August. Besides, an autumn bloom (October) appeared at most stations, which is attributed to the effect of water flowing from El-Mex area.

In conclusion, the investigated area, particularly the inshores of El-Mex, is considered among the eutrophic regions due to the high load of sewage and industrial wastes discharged with the Umum drain water. The assessment of the general coastal currents in the area allows such eutrophication to extend westward along the shore line till El-Hammam. This abviously leads to a gradual deterioration of water quality along these shores and consequently creates on the long run nuisance and aesthetic problems in the recreational beaches. Accordingly, it is recommended that the waste water discharged into El-Mex Bay should be treated according to sanitary regulations to improve its quality before being discarded into the Bay.

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