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DISTRIBUTION AND ECOLOGY OF PHYTOPLANKTON IN EL-MEX BAY, EGYPT

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ABSTRACT

El-Mex Bay is a semisheltered shallow estuary which receives large amounts of drainage water contaminated with sewage and industrial wastes from the Umum Drain. Quantitative and qualitative estimations of phytoplankton at both the surface and near botom layers have been carried out in the Bay for four seasons. According to the high load of nutrients discharged with the drain water, the Bay is highly eutrophic. The highest density of phytoplankton was recorded at the surface around the opening of the Umum Drain, while it decreased gradually towards the offshores. The near bottom layer was less productive throughout most of the year except in winter. The average annual standing crop for the whole Bay amounted respectively 96,560 and 26,980 u/l in the surface water and near bottom layer. The phytoplankton community included both allogenetic fresh and brackish water species introduced with the Umum Drain water and autogentic forms of marine origin. The former comprised green algae, euglenophytes, cyanophytes as well as many diatom species, while the latter included marine diatoms and dinoflagellates.

Chlorophytes constituted about 54.7% of the total phytoplankton in the Bay (average 33,805 cells/l). Diatoms ranked as the second important class with about 24.3% of the total phytoplankton counts (average 15,015 cells/l). Euglenophytes (Euglena spp.) appeared less frequent and they averaged 7,520 cells/l, forming about 12.2% of the total phytoplankton counts. They are indicators of water pollution. Dinoflagellates and cyanophytes were infrequently recorded.

The phytoplankton community showed an outstanding peak of 257,630 u/l during the spring, mainly due to green algae, while it ramained at more or less comparable lower values in the other seasons.

The Bay is considered among the eutrophic marine habitats. Nevertheless, the polluted water of the Umum Drain should be treated to improve its quality before being discarded into the Bay.

INTRODUCTION

El-Mex Bay represents a shallow sheltered estuary, lying west of Alexandria at longitude 29°50'E and latitude 31° 10 N. It extends parallel to the coast line for about 7 Km between El-Agamy headland and the Western Harbour and has an average width of 3 Km (Fig. 1). Its total area amounts to about 20 Km^2. The depth of water in the Bay fluctuates between 1.5 and 15 meters, being more shallow near to the shore and the depth increases gradually seawards.

The Bay receives a constant supply of drainage water discharged from the Umum Drain through El-Mex Pumping Station. Such water is heavily contaminated with sewage and industrial wastes discarded from Alexandria City. The amount of the drainage water discharged into the sea fluctuates between 4.8 and 7.1 million cubic meters per day with an annual average of about 2,420 million cubic meters. Other minor source of inland discharge is represented by the effluents discarded from the factory of Misr Chemical Industries and this is usually contaminated with traces of chlorine water.

The Bay lies in a temperate warm zone. The average monthly surface water temperature fluctuates between 15.0°C in winter and 28.4°C during the summer. The inland water discharged into the Bay has in general lower temperature than that of the Bay water during autumn and winter, while the reverse occurs in the summer. Thus, the water temperature infront of the outlet of the Umum Drain is usually lower by 1.5 and 0.5°C than the rest of the Bay during autumn and winter respecyivelly, while it increases by about 1.0°C in summer. No significant thermal stratification could be observed in the Bay except in spring when the rapid increace of air temperature causes a pronounced increase of the surface water temperature by about 1.5°C than the near bottom water.

As a result of the constant discharge of the slightly brackish water from the Umum Drain, the salinity in the surface water of El-Mex Bay is highly reduced throughout most of the year. This is more obvious in areas surrounding the outlet of the Umum Drain where the salinity fluctuates between 5.0 and 6.7%.. In ths rest of the Bay the surface water salinity fluctuates between 32.7 and 38.9%.. With the exception of the area surrounding the Umum Drain, the water salinity at the bottom layer of most stations appears more or less homogenous, with higher values fluctuating between 37.6 and 40.5 %. (Said, Personal communication).

The present investigation deals with the distribution and seasonal variations of phytoplankton at El-Mex Bay as affected by the prevailing ecological conditions.

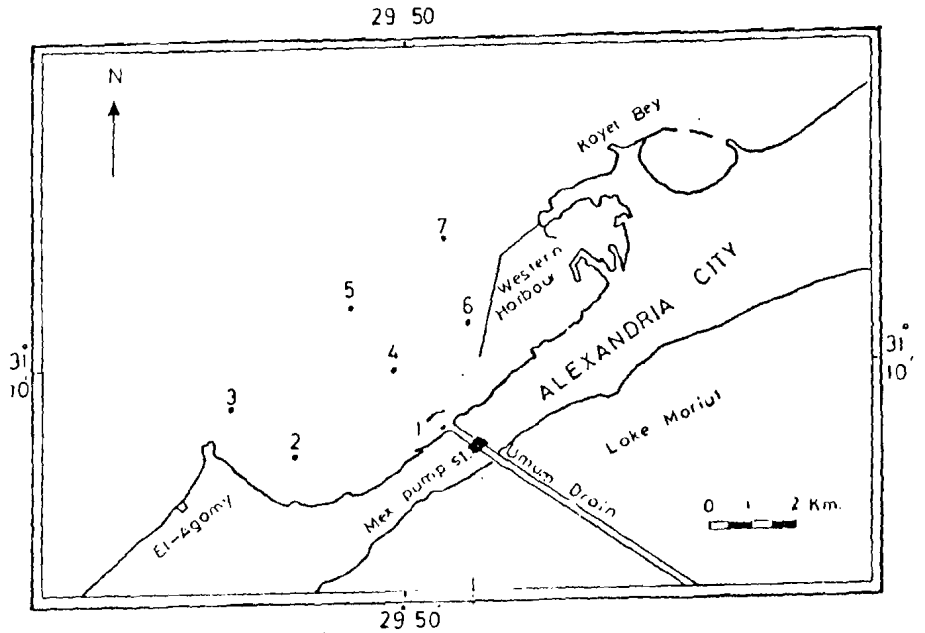

FIG. 1
Morphometry of El-Mex Bay and location of stations.

MATERIAL AND METHODS

Quantitative sampling of phytoplankton was performed at the selected stations from both the surface water and near bottom layers, using Niskin's water sampler. One liter from each water sample was transferred to a measuring cylinder, fixed with 4 % formalin solution and few drops of ligol's solution. The samples were left to sediment for 48 hours then concentrated to 100 cc, using the sedimentation technique. Subsamples of 1cc were transferred into a counting cell and each plankter was counted separately. The phytoplankton community was then calculated as their total numbers in units per liter (u/l). These include the cellular forms of Chlorophyceae, Bacillariophyceae, Euglenophyceae and Dinophyceae which are estimated in cells/l as well as the trichomes or coenobia of Cyanophyceae recorded per liter.

Seven stations were chosen to represent the different habitats in the Bay as shown in Fig. 1. Station 1 lies nearby to outlet of the Umum Drain, stations 2 and 3 represent the western coastal line, stations 4 and 6 are located about the middle of the Bay, while stations 5 and 7 are situated at the offshores.

Four trips were carried out during 1988 representing the four seasons, namely; winter (February), Spring (April), summer (August) and autumn (November).

RESULTS

Composition and distributiion of the total phytoplankton:

El-Mex Bay harboured a diversified flora of phytoplankton which included both fresh and brackish water species as well as marine forms. However, few of them formed the main bulk of the community. Altogether, about 159 species belonging to the classes Chlorophyceae (41 spp.), Bacillariophyceae (83 spp.), Euglenophyceae (4 spp.), Cyanophyceae (26 spp.) and Dinophyceae (5 spp.) were recorded.

Green algae formed numerically about 54.7 % of the total phytoplankton (average 33,805 cells/l). About 94 % of the chlorophytes were represented by the genera, Scenedesmus, Closterium, Chlorella, Micractinium, Sphaerocystis, Crucigenia, Palmellococcus and Pediastrum. They dominated the phytoplankton community infront of the outlet of the Umum Drain and the surrounding stations (stations 1-4) as shown in Fig. 2.

Diatoms ranked as the second major constituents and they comprised about 24.3 % of the total phytoplankton counts (average 15,015 cells/l). They were dominated by the genera, Cyclotella, Nitzschia, Melosira and Chaetocerous. Euglenophytes appeared less frequent and constituted about 12.2 % of the total phytoplankton (7,520 cells/l), being mostly confined to the winter and spring. The other two classes, namely; cyanophytes and dinoflagellates contributed collectively about 8.8 % of the total phytoplankton (averages 2,735 u/l and 2,695 cells/l respectively). They appeared more frequent in the spring and summer. The former class was represented mainly by Spirulina, Chroococcus and Oscillatoria, while the latter comprised Prorocentrum, Gymnodinium, Peridinium and Oxytoxum.

The surface water was in most cases more productive than the near bottom layer. This is reflected on the annual standing crops which averaged 96,560 u/l for the surface water and 26,980 u/l for the near bottom layer.

The following is a summary on the results obtained during the four seasons.

Distribution of phytoplankton during winter:
(Table 1 and Figs. 3 & 4)

The winter was characterized by low counts of phytoplankton at both the surface and near bottom layers in most stations except station 3 which harboured a bloom of 53,900 cells/l of Euglenacus in the surface water. The horizontal distribution of phytoplankton at the surface showed a general gradual decrease away from the outlet of the Umum Drain to reach lowest density about the middle of the Bay, while it increased again slightly at stations 5 and 7. The community was dominated at most stations by Cyclotella meneghiniana, Nitzschia microcephala, N. frustulum, Scenedesmus quadricauda, Sc. acuminatus, Sc. bijugatus, Crucigenia quadrata, C. tetrapedia and Euglena acus. Prorocentrum micans and Gymnodinium hiemale appeared also as frequent plankters at station 3.

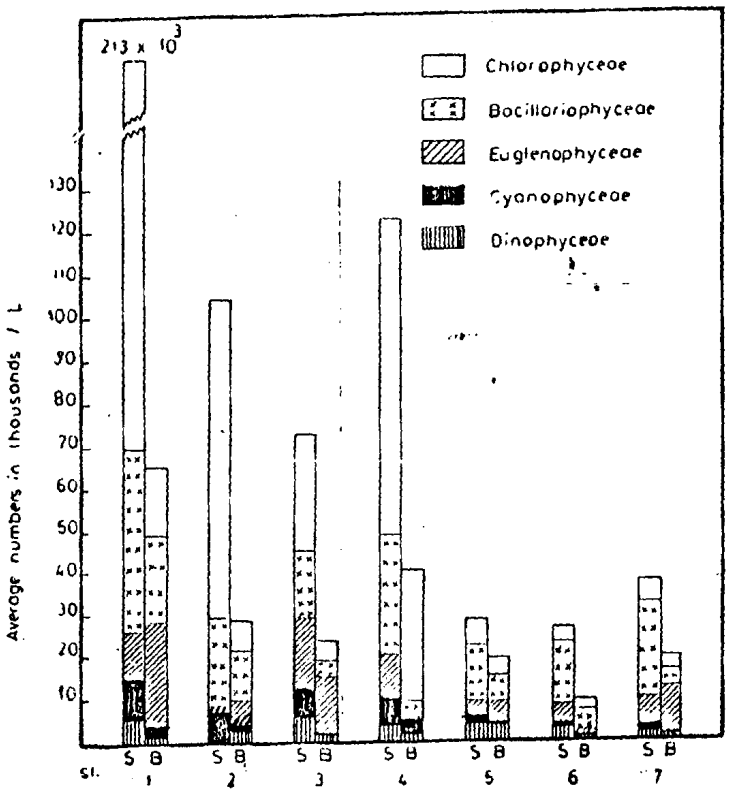

FIG. 2
Average numbers in thousands per liter of the different classes of phytoplankton in the surface water and at near bottom layer at the different stations.

Table 1

Average annual values of the standing crop of phytoplankton in units per liter recorded at El-Mex Bay during winter.

Phytoplankton Station No.	Chlorophyceae	Bacillariophyceae	Euglenophyceae	Cyanophyceae	Dinophyceae	Total
1	8,400	20,900	1,600	1,200	---	32,100
2	3,900	8,700	100	800	900	14,400
3	2,000	4,700	53,900	600	6,000	67,200
4	8,200	2,000	1,000	800	1,700	13,700
5	500	2,900	10,600	1,300	2,600	17,900
6	8,500	3,500	2,500	200	1,100	15,800
7	15,300	5,400	200	200	100	21,200
1	38,800	29,900	3,900	6,150	---	78,750
2	17,000	3,300	2,100	1,300	100	23,800
3	3,600	3,000	3,800	---	1,400	11,800
4	4,500	4,600	400	1,600	2,900	14,000
5	7,000	5,700	9,000	---	13,800	35,500
6	11,000	7,300	---	900	2,900	22,800
7	1,000	2,200	---	200	500	3,900

The near bottom layer sustained highest density of phytoplankton at station 1 which tended to decrease gradually along the western coastal stations and towards the middle of the Bay but increasing again at station 5. It harboured nearly the same community recorded at the surface water, in addition to considerable numbers of Prorocentrum micans at station 5. Unlike the other seasons, higher counts of phytoplankton appeared in the bottom layer of most stations when compared with the surface values except at stations 3 and 7. However, the average standing crops for the two layers were comparable and amounted to 26,050 u/l for the surface water and 27,220 u/l for the near bottom layer.

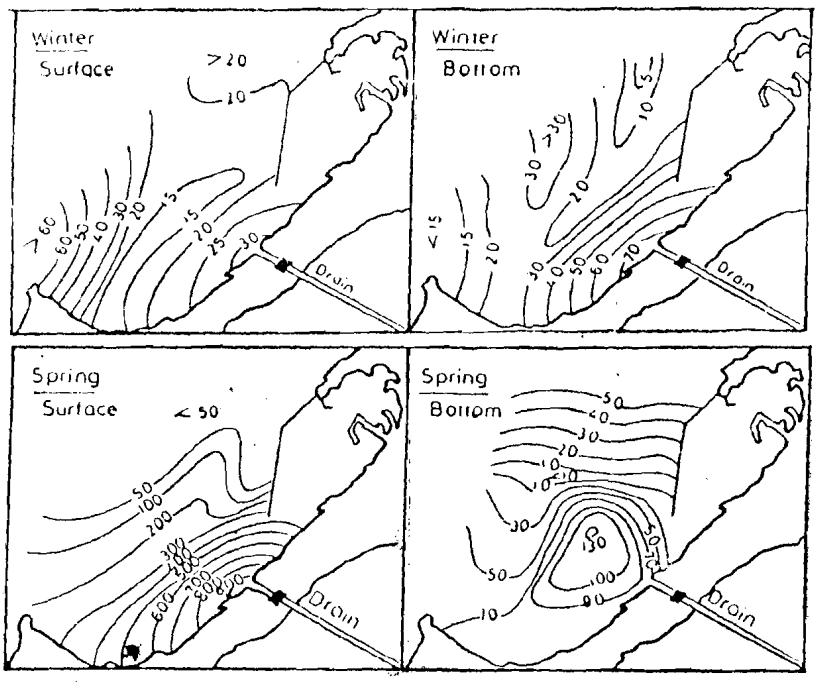

FIG. 3
Horizontal distribution of phytoplankton (thousand u/l) in the surface water and near bottom layer at El-Mex Bay during winter and spring.

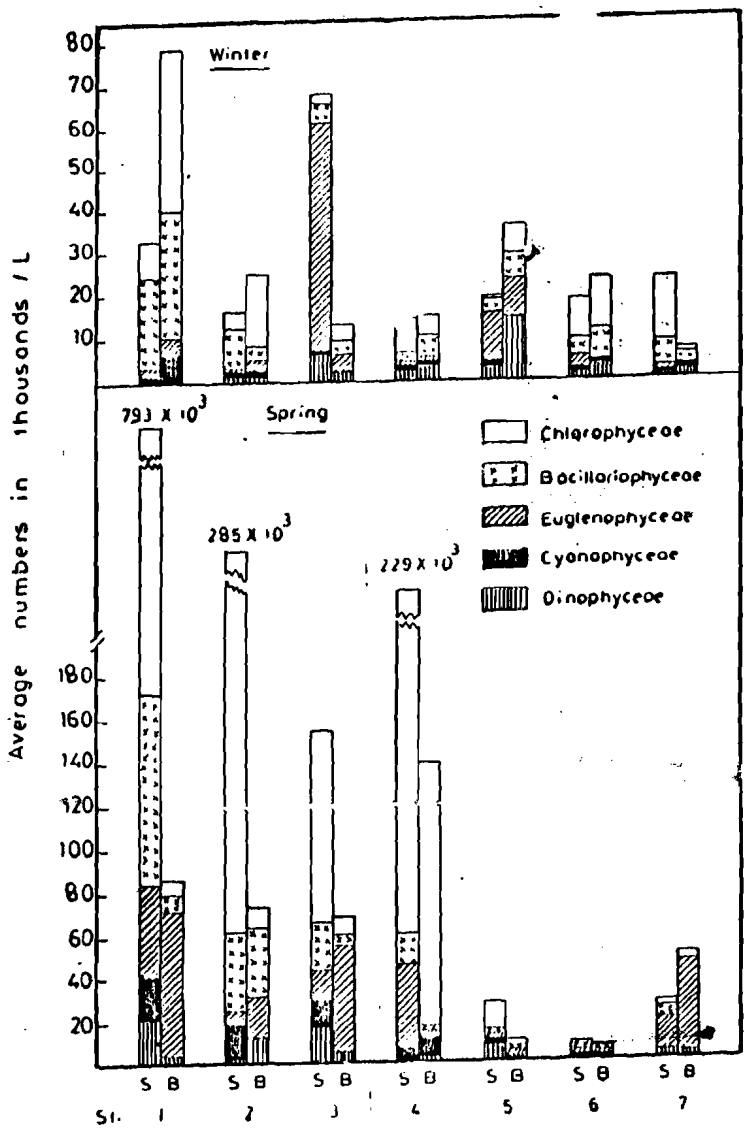

FIG. 4
Average numbers in thousands per liter of the different classes of phytoplankton in the surface water and near bottom at the differents stations during winter and spring.

Distribution of phytoplankton during spring:
(Table 2 and Figs. 3 & 4)

An outstanding peak of phytoplankton was recorded at the surface during spring, which reached an average of 257,630 u/l. This was attributed to the flourishing of the green algae particularly at stations 1-4 and less so to diatoms and euglenophytes. The highest density in the surface water was recorded at station 1 and it decreased gradually northwards. The community there was dominated by Scenedesmus acuminatus, Sc. quadricauda, Sc. bijugatus, Closterium moniliferum, Chlorella sp., Sphaerocystis schroeteri, Micractinium pusillum, Cyclotella meneghiniana, Nitzschia palea, N. closterium, N. longissima, N. microcephala, Euglena acus, E. granulata, E. ehrenbergii, Gymnodinium hiemale and Oscillatoria formosa. The diatoms Hemiaulus hauckii and Chaetocerous decipiens were also frequently recorded at the offshore stations.

The bottom layer sustained lower counts than the surface water which averaged 58,940 u/l. The maximum persistence of phytoplankton appeared about the middle of the Bay (st. 4) and it decreased gradually towards the line and at the offshore except at station 7 which sustained a relatively high value of 47,900 u/l. Green algae, diatoms and euglenophytes were dominant at most stations. The other two classes remained infrequent except at station 2 which harboured considerable numbers of Prorocentrum micans and Peridinium spp., while station 4 sustained high counts of Spirulina platensis. The dominant phytoplankton recorded at bottom layer during that season comprised, Cyclotella meneghiniana, Melosira granulata, M. crucipunctata, Chaetocerous crinitus, Palmellococcus miniatus, Closterium moniliferum, Sphaerocystis schroeteri, Scenedesmus quadricauda, Pediastrum simplex, Euglena acus, E. ehrenbergii and Prorocentrum micans.

Distribution of phytoplankton during summer:
(Table 3 and Fig. 5 & 6)

The average counts of phytoplankton for the whole Bay dropped again during the summer to 44,330 and 10,420 u/l at surface and near bottom water respectively.

The horizontal distribution of the community illustrates nearly the same pattern at the surface and bottom, but showing lower values in the latter one. Thus, the highest counts of phytoplankton appeared at station 1 and it decreased gradually towards both the north and west. A remarkable increase was also noticed at station 7. Diatoms were more dominant than chlorophytes during that season. Members of cyanophytes appeared frequently in the surface water. Dinoflagellates were also abundant at the surface of the offshore stations, otherwise the community compostion was more or less similar at both the surface and bottom. The dominant diatoms comprised Cyclotella meneghiniana, Nitzschia microcephala, Melosira varians, M. granulata,

Table 2

Average annual values of the standing crop of phytoplankton in units per liter recorded at El-Mex Bay during spring.

Phytoplankton Station No.	Chlorophyceae	Bacillariophyceae	Euglenophyceae	Cyanophyceae	Dinophyceae	Total
1	792,800	87,300	41,600	18,900	22,400	963,000
2	285,000	35,400	4,800	17,200	1,800	344,200
3	87,500	21,300	14,400	11,700	17,200	152,100
4	227,400	14,100	38,400	5,400	1,200	286,500
5	13,700	2,200	1,400	1,900	8,100	27,300
6	---	2,700	700	400	1,800	5,600
7	2,000	4,300	14,500	---	3,900	24,700
1	5,600	7,200	68,400	---	4,400	85,600
2	8,400	30,800	19,700	300	12,000	71,200
3	7,100	3,800	48,700	---	5,400	65,000
4	118,800	600	3,300	7,800	3,000	133,500
5	1,200	200	3,100	---	1,500	6,000
6	600	200	1,300	300	1,000	3,400
7	2,500	---	42,500	---	2,900	47,900

Synedra longissima, S. tabulata. The other groups were mostly represented by Scenedesmus acuminatus, Pediastrum simplex, Crucigenia quadrata, Spirulina platensis, Euglena acus, Gymnodinium hiemale, Peridinium cerasus and P. bipes.

Distribution of phytoplankton during autumn:
(Table 4 and Fig. 5 & 6)

The magnitude of the standing crop during autumn was slightly higher than the summer records and it amounted to 58,220 and 11,280 u/l at surface and near bottom respectively. The horizontal distribution of phytoplankton at the surface illustrates maximum frequency about the middle of the Bay, at station 4 (141,400 u/l), which decreases gradually towards both the coastline and offshores. The community was dominated by chlorophytes and diatoms. Cyanophytes were inferquantly recorded at stations 1 and 4, while the other two classes were poorly represented. The dominant species comprised Cyclotella meneghiniana, Melosira crucipunctata, M. granulata, Nitzschia closterium, N. sigma, Chaetocerous affinis, Lithodesmium undulatum, Scenedesmus bijugatus, Sc. accuminatus, Crucigenia tetrapedia, Pediastrum simplex and Selenastrum gracile.

Table 3
Average annual values of the standing crop of phytoplankton in units per liter recorded at El-Mex Bay during summer.

Phytoplankton Station No.	Chlorophyceae	Bacillariophyceae	Euglenophyceae	Cyanophyceae	Dinophyceae	Total
1	18,800	41,800	300	12,700	---	73,600
2	1,600	12,600	---	3,800	---	18,000
3	2,800	6,800	100	9,600	400	19,700
4	4,000	20,700	1,000	9,400	11,000	46,100
5	6,900	23,700	900	3,900	3,800	39,200
6	---	25,900	11,500	1,500	9,100	48,000
7	300	56,100	4,300	3,600	1,400	65,700
1	7,400	22,400	500	500	---	30,800
2	100	2,000	---	200	100	2,400
3	---	4,600	300	700	1,100	6,700
4	---	4,700	100	4,300	---	9,100
5	1,500	900	100	---	100	2,600
6	1,600	2,600	---	500	300	5,000
7	8,200	8,000	---	100	---	16,300

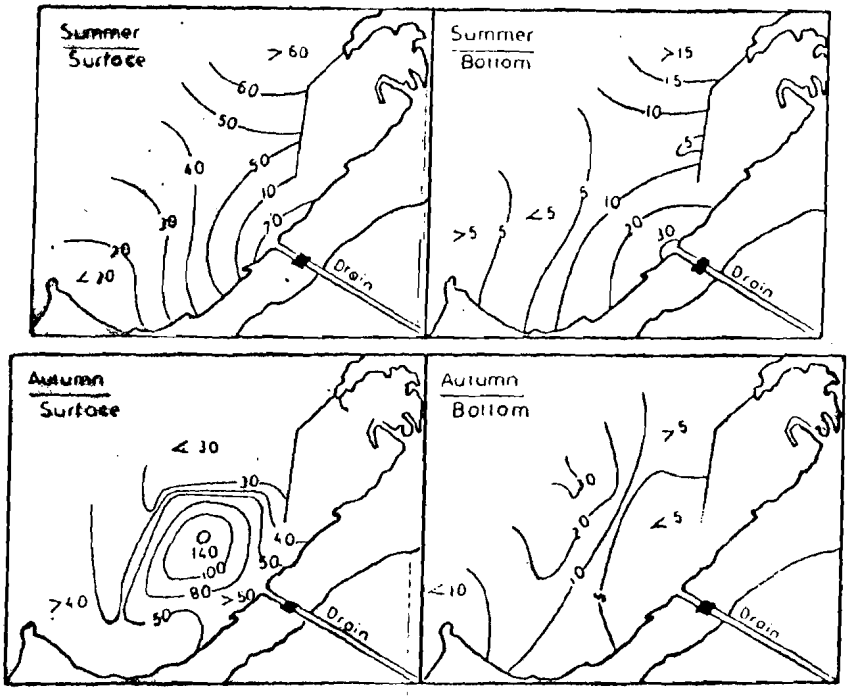

FIG. 5
Horizontal distribution of phytoplankton (thousand u/l) in the surface water and near bottom layer at El-Mex Bay during summer and autumn.

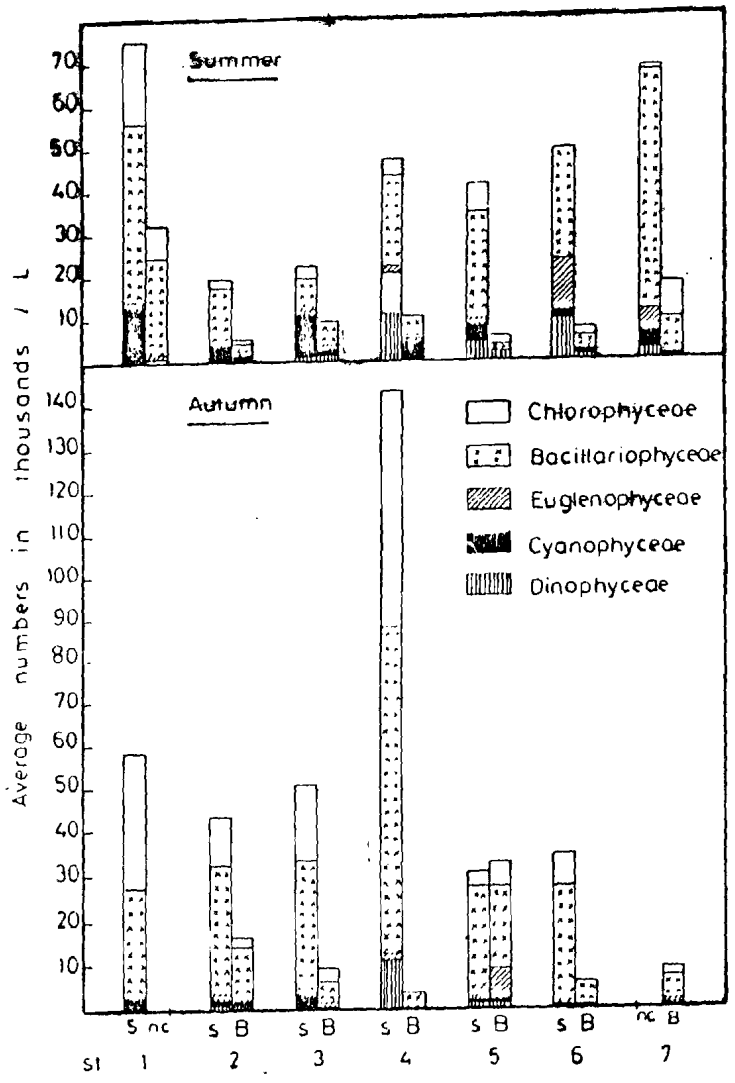

FIG. 6
Average numbers in thousands per liter of the different classes of phytoplankton in the surface water and near bottom at the different stations during summer and autumn.

Table 4

Average annual values of the standing crop of phytoplankton in units per liter recorded at El-Mex Bay during autumn.

Phytoplankton Station No.	Chlorophyceae	Bacillariophyceae	Euglenophyceae	Cyanophyceae	Dinophyceae	Total
1	30,900	24,300	---	3,100	---	58,300
2	10,700	27,800	100	1,200	500	40,300
3	17,400	29,000	200	2,500	---	49,100
4	55,100	75,100	500	10,700	---	141,400
5	2,500	23,600	400	400	600	27,500
6	6,800	25,700	200	---	---	32,700
7	n.c	n.c	n.c	n.c	n.c	n.c
1	n.c	n.c	n.c	n.c	n.c	n.c
2	1,400	11,300	100	1,200	100	14,100
3	3,200	4,300	100	---	100	7,700
4	---	3,400	---	---	---	3,400
5	5,200	17,900	6,600	600	800	13,100
6	---	4,700	---	100	---	4,800
7	1,200	4,600	400	---	400	6,600

n. c = sample was not collected.

The phytoplankton at the bottom layer showed highest frequency at station 5 (31,100 u/l), while it remained low along the coastal area till the middle of the Bay. The community there was nearly similar to that of the surface water. Euglena was also frequently recorded at bottom of station 5.

DISCUSSION

El-Mex Bay is a semi sheltered shallow estuary which receives constantly large amounts of drainage water contaminated with sewage and industrial wastes from the Umum Drain. Subsequently, the Bay is characterized by certain chemical features indicating water pollution such as high concentration of nutrient salts and high values of both dissolved organic matter and biological oxygen demand (Mahmoud, 1985).

The salinity in the surface water of the Bay is highly reduced particularly infront of the outlet of the Umum Drain (st. 1) where it sustained low values, not exceeding 6.7%. from surface to bottom. In the other stations the surface salinity fluctuated between 32.7%. and 38.9%..

The salinity of the near bottom layer was less affected by the drain water and it remained more or less homogeneous with higher values fluctuating between 37.6%. and 40%..

From the records of the salinity data, it appears that the drain water flows into the Bay as a surface current along the western coast as well as towards the northwest. Such current would be expected to take a clock wise circulation at the offshores when it meets the dominant eastward current prevailing the Egyptian Mediterranean Coast. This is well established during the autumn where a lense of water mass with high phytoplankton counts occupies the center of the estuary (st. 4).

According to the high load of nutrients discharged with the drain water, the Bay becomes highly eutrophic particularly around the outlet of the Umum Drain (st. 1). Thus, the average annual standing crop of phytoplankton at the surface water of station 1 reached 281,750 u/l. This value decreased gradually along the western coast to 104,225 and 72,625 u/l at stations 2 and 3 respectively. Station 4 which lies about the middle of the Bay harboured relatively high counts of 121,925 u/l. The offshore stations 5 and 7 as well as station 6 contained the lowest values which averaged respectively 27,975 , 37,200 and 25,525 u/l..

The near bottom layer was less productive throughout the four seasons, except at stations 1, 2 and 5 in winter. Thus, the average annual standing crop at the bottom layer at station 1 decreased to 54,050 u/l and it fluctuated between 5,000 and 10,000 u/l in the other stations.

The phytoplankton community of El-Mex Bay included, both allogenetic fresh and brackish water species introduced with the Umum Drain water and autogentic forms of marine origin. The allogenetic phytoplankton comprises those species which can withstand the highly brackish conditions prevailing in the Bay and they include the green algae, euglenophytes, cyanophytes as well as many diatom species. They dominated the community particularly infront of the outlet of the Umum Drain and the surrounding stations (stations 1-4). On the other hand, the autogenetic plankton was confined to diatoms and dinoflagellates, and they appeared more frequent at the offshore stations.

Chlorophytes comprised about 60.4 % of the total phytoplankton counts in the surface water (average 58,340 cells/l) and 34.4 % at bottom layer (average 9,270 cells/l). They appeared all the year round, showing a peak of 201,200 cells/l at surface water during the spring. They were dominated by Scenedesmus acuminatus, Sc. bijugatus, Sc. quadricauda, Closterium moniliforms, Crucigenia quadrata, C.

tetrapedia, Micractinium pusillum, Sphaerocystis schroeteri, **Pediastrum simplex, Selenastrum gracile, Palmellococcus miniatus** and Chlorella sp.. These species are considered as oligohalobous-halophilous forms (Salah, 1960), widely speared in the Egyptian Delta lakes (Samaan et al., 1989 and Ghobrial, 1987), drains (Soliman, 1983) as well as in the Nile water (Zaghloul, 1976 and Abbas, 1980).

Diatoms ranked as the second important plankters. They constituted about 24.0 % of the total phytoplankton counts in the surface water (average 22,960 cells/l) and 26.2 % at the bottom water (average 7,070 cells/l). They included both fresh and brackish water species as well as marine forms. **Cyclotella meneghiniana** was by for the most dominant diatom in the Bay all the year round. It is of wide distribution along the Egyptian Mediterranean Coast (Gergis, 1983) and in the Egyptian Delta lakes (Aleem and Samaan, 1969; Samaan, 1974 and El-Sherif et al., 1989). This agrees with the observations of Foged (1948), who states that the species occurs at both high and low salinities. Members of the genus **Nitzschia** were frequently recorded. They comprised both fresh water and marine forms. **Nitzschia closterium, N. longissima** and **N. sigma** are littoral marine species (Hendey, 1964). While, Nitzschia acuminata, **N. microcephala, N. frustulum, N. punctata, N. palea** and **N. circumsuta** are oligohalobous-halophilous (Salah, 1960). Also, the genus **Melosira** was represented in the Bay by **M. granulata, M. varians** and **M. crucipunctata.** They are considered oligohalobous species (Salah, 1960). **Chaetoceous** spp., **Bacillaria paradoxa** and **Synedra** spp. were less frequent in the Bay. They were previously recorded in both the Mediterranean Sea and brackish water Delta Lakes (Gergis, 1983 and El-Sherif et al., 1989).

Some other neretic marine diatoms were mainly confined to the offshore stations. These comprised; **Thalassiora rotula, Coscinodiscus nobilis, Cos. radiatus, Ceratulina bergonii, Hemiaulus hauckii,** Licomphora lyngbyei, **Rhizosolenia fragillima, R. styliforms, Achnanthes brevipes, Caloneis silicula, Bellerochea malleus, Skeletonema costatum, Guinardia flaccida, Actinoptychus valgaris, Ditylium intriactum** and **Asterionella japonica.** Besides, **Schroderella delicatula** and **Biddlulphia favus** are considered as littoral marine forms and they were only recorded at the near bottom layer.

Euglenophyceae formed about 7.6 % (average 7,340 cells/l) and 28.5 % (average 7,700 cells/l) of the total phytoplankton counts in the surface and bottom water respectively. They were represented by **Euglena acus, E. granulata** and **E. ehrenbergii.** Their maximum persistence was observed during the winter and spring particularly at the inshore stations. Euglena spp. are regarded as indicators of water pollution and they are usually abundant in water rich in organic matter (Palmer, 1969; Munawar, 1972 and Mihnea, 1985).

Dinoflagellates were inferquently recorded in the Bay forming about 3.5 % and 7.3 % of the total phytoplankton at the surface and bottom water respectively (average 3,420 and 1,970 cells/l). They are considered as marine forms, being more abundant in the spring. **Prorocentrum micans** and **Gymnodinium hiemale** were the main representatives of dinoflagellates.

Cyanophytes formed about 4.7 % and 3.6 % of the total phytoplankton at surface and bottom respectively (average 4,500 and 970 u/l). They were more frequent in the spring and the summer, particularly at the inshore stations and were dominated by Spirulina platensis, Chroococcus dispersus and Oscillatoria formosa.

The eutrophication effect of the Umum Drain water on El-Mex Bay appears clearly when comparing the present results with previous data concerning the annual distribution of phytoplankto along a vertical sector north to the Bay as given by Samaan and Gergis (1983). Thus the magnitude of the standing crop amounted to 29,290 cells/l at a distance of about 6 Km away from the coast. This value decreased gradually to 10,290 cells/l and 4,510 cells/l at distances of about 10 and 23 Km respectively. Such values are much lower than the present records for El-Mex Bay which averaged 61,770 u/l. However, estimations on the other Egyptian Mediterranean estuaries reveal that they are more productive. Thus, the average annual standing crop of phytoplankton reached 906 thousand cells/l in Abu Qir Bay (Samaan and Mikhail, 1989), 2,488 thousand cells/l in the Eastern Harbour (Sultan, 1975) and 1,259 thousand cells/l in Rashid Estuary (Zaghloul, 1976). This may be attributed to the fact that these estuaries are semi-closed and much more sheltered areas than El-Max Bay. They also receive constant supplies of inland discharges rich in nutrients. For protection of El-Mex Bay against hazardous pollution, it is recommended that the polluted water of the Umum Drain should be primarily treated to improve its quality before being discarded into the sea.

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