

## **WATER QUALITY IN THE COASTAL AREA OF ALEXANDRIA**

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### **ABSTRACT**

*Surface water samples were collected seasonally, during 1998 from fourteen stations covering four locations; Abu Qir Bay, Eastern Harbour, Kayet Bey outfall and El-Max Bay representing the more polluted coastal area of Alexandria. pH, salinity, dissolved oxygen dissolved inorganic nitrogen ( $NO_2$ ,  $NO_3$ ,  $NH_3$ ), total nitrogen, total phosphorus, reactive phosphate and Chlorophyll-a were determined in the samples. The annual range of the surface water pH-value and salinity in the studied four coastal areas were (7.55-8.22) and (33.96-37.87‰), respectively. The surface DO values fluctuated between 5.8 ml/l at El-Max Bay and 8.23 ml/l at Abu Qir Bay. High annual value of TN (84.59  $\mu M$ ) was recorded at Kayet Bey and the maximum annual content of total phosphorus (2.57  $\mu M$ ) recorded at Eastern Harbour: Large annual content of DIN (25.97  $\mu M$ ) was observed at Abu Qir region. DIN represent one-third of total Nitrogen (TN) in Abu-Qir water while exhibits only 1.6 at Kayet Bey region. The annual average concentrations of TP and chlorophyll-a can be arranged at the four regions as the following Eastern Harbour > Kayet Bey outfall > Abu Qir Bay > El-Max Bay.*

### **INTRODUCTION**

Considerable amount of wastewater is discharged into the coastal zone of Alexandria from the surrounding area. This occurs extensively at four regions, Abu Qir Bay, Eastern Harbour, Kayet Bey, and El-Max Bay. El-Max Bay is

affected by the discharged wastewater from El-Max pumping station through El-Umum Drain which amounted to  $6 - 11.8 \times 10^9 \text{ m}^3 \text{ d}^{-1}$  (Said et al., 1991) as well as the western Harbour which receives domestic, industrial and drainage waters through El-Noubaria channel (Nessim and Tadros, 1986). In addition, the area receives industrial waste from several plants. Abu Qir Bay, receives different types of wastewater from Tabia pumping station and industrial effluents (fertilizers factory), as well as an amount of 3.3 million  $\text{m}^3$ /day of brackish water introduced into the bay through Lake Edku (Nessim and El-Deek, 1995). These sources contain high concentrations of nutrient salts, which affect greatly the environment.

The objectives of this work are to evaluate the levels of nitrogen and phosphorus compounds and the level of chlorophyll-a biomass, in addition to the effect of wastewater discharged on the water quality of Alexandria seawater.

## *MATERIAL AND METHODS*

Surface water samples were collected representing four different locations of Alexandria coast; Abu Qir Bay, Eastern Harbour, Kayet Bey and El-Max Bay. These locations receive different wastewater; sewage, industrial water and agricultural run off Fig. (1).

Sampling was performed seasonally during January, April, August and October 1998. The samples were kept in clean polyethylene bottles. The dissolved nutrient salts were analyzed immediately in the water samples. pH of the water samples were determined using portable pH meter. Dissolved oxygen was carried out according to Winkler method. Reactive phosphate, nitrite, nitrate and ammonium were measured colorimetrically following the method described in Grasshoff, 1976 by using a UV-visible Shimadzu double beam spectrophotometer (model 150-02). The determination of total nitrogen and total phosphorus was carried out according to the method mentioned by Valderrama (1981). Salinity was determined using Beckman induction salinometer (Model RS-7C). Concentration of chlorophyll-a was determined according to Standard Methods (1985).

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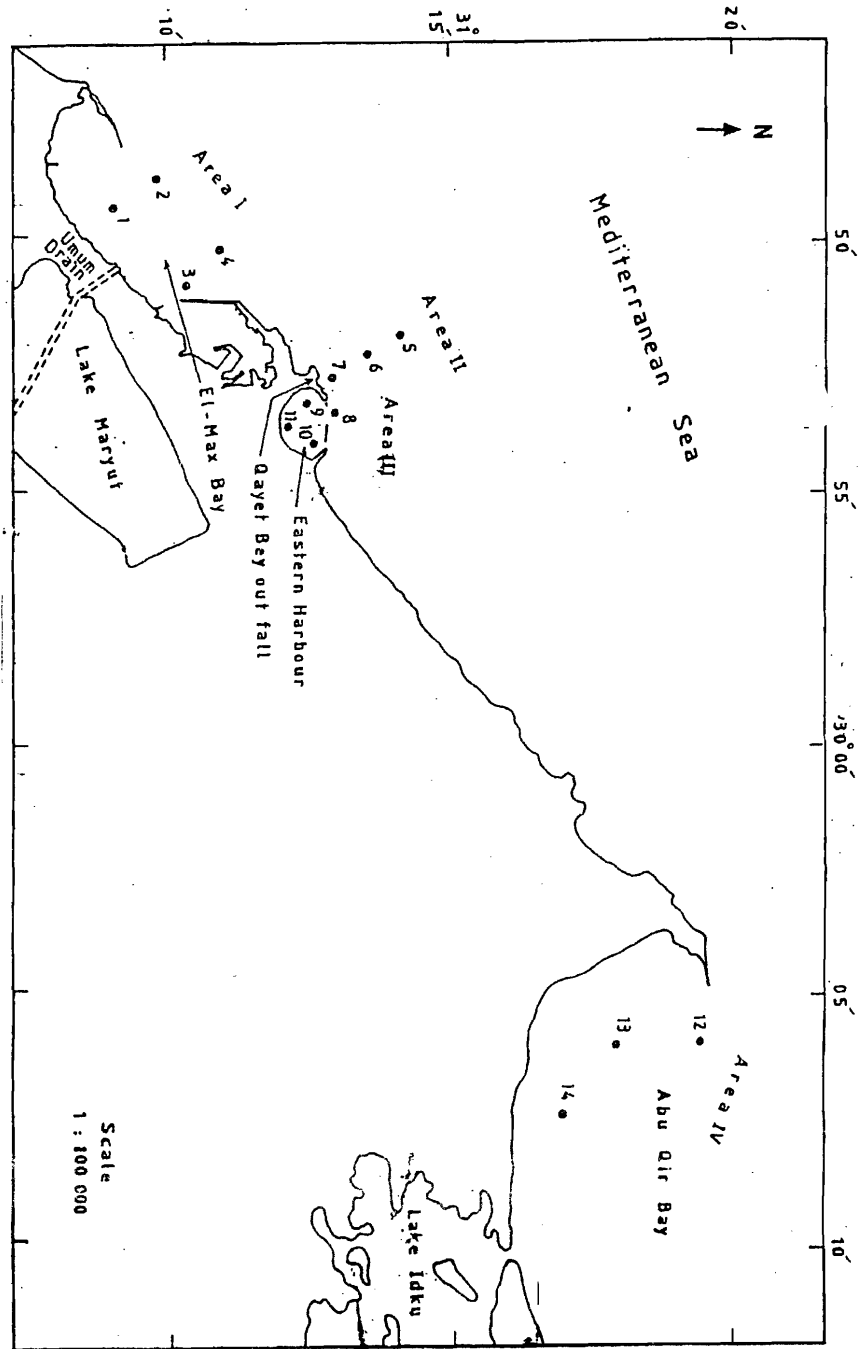


Fig. (1): Areas studied and sampling stations.

## **RESULTS AND DISCUSSION**

### **PH-value:**

The pH plays an important role in many of life processes. It is affected greatly by the photosynthetic activity of aquatic organisms. The pH values in the present study were found to lie on the alkaline side. The data (Table 1) showed regional variation in the pH values. The annual range of the surface water pH values in the studied four regions were (7.90-8.20) for Abu Qir area, (7.76-8.22) for Eastern Harbour, (7.55-8.21) for Kayet Bey area and (7.76-8.10) for El-Max Bay. The pH values in the surface water of Abu Qir region showed relatively high levels comparing with those recorded in the other regions. The high surface pH-values are mainly related to the increase in photosynthetic activity in the surface euphotic zone. The decrease in pH- values coincided with the decrease in oxygen content due to the effect of accumulating organic pollutants (Saad, 1976) as well as the discharge of brackish water.

### **Salinity (S‰):**

Salinity, which reflects changes, caused by mixing of both fresh and seawater showed a wide range of variations. Table 1 shows the annual range and mean values of salinity in the four studied areas of Alexandria. The annual mean of salinity values ranged between 35.7‰ and 36.60‰, the relative highest annual mean content were recorded at Eastern harbour which is semiclosed system. On the other hand, the annual range concentration of salinity showed that the lowest value (around 34‰) was presented at Kay Bey and El-Max Bay. Surface salinity values recorded at these two areas are mostly controlled by the amount of wastewater discharged and water exchange with seawater as well as the rate of mixing.

### **Dissolved oxygen (DO):**

Dissolved oxygen is very important to the aquatic organisms, because it affects their biological processes, the parameter respiration of animal and oxidation of the organic matter in water and sediments. In this latter process, complex organic substances are converted to simple dissolved inorganic salts which could be utilized by the micro and macrophyta. The absolute surface DO values fluctuated between a minimum content of 5.8 ml/l at El-Max Bay and a maximum value of 8.23 ml/l at Abu Qir region.

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Table (1): The annual ranges and means concentrations of the water quality parameters in the studied coastal areas of Alexandria.

Location	pH	S‰	DO <sub>2</sub>	NO <sub>2</sub> -N	NO <sub>3</sub> -N	NH <sub>3</sub> -N	DIN	TN	PO <sub>4</sub> -P	TP	DIN/DIP	Chl-a
			(ml/l)				(µM)					(mg/m <sup>3</sup> )
Abu Qir Bay	7.90-8.2	35.66-36.7	6.41-8.23	1.16-2.60	4.42-19.11	2.24-45.80	6.92-66.26	47.2-156.8	0.13-1.08	1.10-2.38	19-110	4.98-6.41
			7.47				25.97					81.15
Eastern Harbour	7.76-8.22	35.5-37.23	6.56-7.06	0.15-0.99	1.2-6.15	1.97-6.45	6.71-11.79	38.8-101.4	0.29-0.97	1.57-3.25	7-41	4.32-17.86
			6.86				0.40					3.80
Kayet Bey	7.55-8.21	33.96-37.3	6.25-7.60	0.21-1.63	5.01-8.85	4.24-9.57	9.5-18.98	54.5-150.1	0.29-1.73	1.31-2.81	9-65	1.73-32.36
			7.04				0.96					6.67
El-Mex Bay	7.76-8.10	34.2-37.87	5.80-7.62	0.34-1.01	4.3-10.38	4.57-12.74	9.23-23.34	50.1-75.54	0.49-1.45	1.19-2.43	14-36	1.32-1.84
			6.43				0.78					6.54

In general the annual mean concentrations of dissolved oxygen in the studied coastal areas were around 7 ml/l. The high value of DO may be due to the exchange of water with the adjoining open seawaters and the high rate of photosynthetic activity of phytoplankton production (Aboul-Kassim, 1987).

As shown in Table (1), the annual mean surface DO calculated at Abu Qir region (7.4 ml/l) was noticeably high compared with those recorded for the other three studied areas. These coincided mainly with the strong currents and water agitation in this open area.

#### **Nitrite (NO<sub>2</sub>-N):**

The regional average of nitrite (Fig. 2) shows considerable seasonal variations at the different locations, the highest average value of 2.6  $\mu\text{M}$  was found at Abu-Qir region during spring and the lowest values (0.15  $\mu\text{M}$ ) at Eastern Harbour in winter.

Table (1) shows that, the annual average concentration of nitrite in Abu Qir Bay (1.34  $\mu\text{M}$ ) represents 2.4% of TN. Its annual average at El-Max Bay, Kayet Bey, and Eastern Harbour were 0.78, 0.96 and 0.40  $\mu\text{M}$ , respectively. The high value of nitrite at Abu Qir region due to wastewater discharged from El-Tabia Pumping Station and the effect of the discharge of fertilizers factories to the bay, which contain high nitrite content. The obtained results at Abu Qir noticed to be higher than those found by Tayel, 1992 (0.62  $\mu\text{M}$ ) and by Nessim and El-Deek, 1995 (1.68  $\mu\text{M}$ ) at the same area.

#### **Nitrate (NO<sub>3</sub>-N):**

The regional and seasonal distribution of the concentration of nitrate (Fig. 2) shows that nitrate average content ranged between 1.20  $\mu\text{M}$  at Eastern Harbour and 19.11  $\mu\text{M}$  at Abu Qir area in the summer period. The relative increase of nitrate at Abu Qir region reflects the influence of wastewater discharge from Abu-Qir Fertilizer Company and El-Tabia Pumping Station.

Table (1) illustrated that the annual average nitrate concentration at Abu Qir area exhibits maximum value (9.78  $\mu\text{M}$ , represent 17.4% of TN) and corresponding high values at both El-Max Bay and Kayet Bey (6.54 and 6.67  $\mu\text{M}$  respectively) and this can be attributed to the discharge of wastewater without any treatment at El-Max region. The high value recorded at Kayet Bey can be attributed to sewage discharged into the area via main sewage outfall

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plant located at this area. Nitrate constitute 14% of TN for El-Max Bay and 10% of TN for Kayet Bey outfall.

The average value for nitrate recorded at the Above mentioned areas found to be higher than recorded by Tayel (1992) amounting to 0.99  $\mu\text{M}$  for Abu Qir Bay. On the other hand, the results indicate that Eastern Harbour exhibits the lowest values about 3.80  $\mu\text{M}$ , (7.5% of TN).

### **Ammonium (NH<sub>3</sub>-N):**

Fig. (2) showed seasonal and regional distribution of ammonium in the investigated areas. The highest value was found in summer (45.80  $\mu\text{M}$ ) at Abu Qir region, this is coincided with low nitrate (20  $\mu\text{M}$ ). This may be due to the reduction process of nitrate into ammonium.

The annual mean content of NH<sub>3</sub>-N in the four studied areas ranged from 4.1  $\mu\text{M}$  (represent 8.1% of TN) at Eastern Harbour to 14.85 (represent 26.4% of TN) at Abu Qir area (Table 1). The highest annual value of NH<sub>3</sub>-N obtained at Abu Qir area can be explained by the influence of the allochthonous source of NH<sub>3</sub>-N and the increasing in the amounts of wastewater discharged into the area from the Fertilizer Factory as well as from El-Tabia Pumping Station.

The seasonal average value was relatively low in autumn and winter at Abu-Qir (round 2.00  $\mu\text{M}$ ) and in spring at Eastern Harbour (2.50  $\mu\text{M}$ ). This may be due to the increase consumption of ammonium by phytoplankton. At El-Max Bay, seasonal distribution of ammonium (Fig. 2) shows that the highest value was found in spring and summer (around 12  $\mu\text{M}$ ). The relatively high content due to sewage discharged from El-Max pumping station and Lake Maryut. Also, in the summer period, Alexandria population increases by about two million i.e. more sewage discharge. The lowest annual average value of ammonium (4.10  $\mu\text{M}$ ) at Eastern Harbour region (Table 1) due to its utilization by phytoplankton. This is evident by the pronounced minimum average values of nitrate and nitrite at the same area (3.8 and 0.4  $\mu\text{M}$ ) which reflects the increase in the rate of uptake of these inorganic nitrogenous forms by phytoplankton abundance in the area (the content of chlorophyll-a is round to 10  $\text{mg}/\text{m}^3$ ). Comparing the average concentrations of ammonium for the studied areas with those previously studied on the coastal Mediterranean areas, the present study showed markedly higher values of nitrite, nitrate

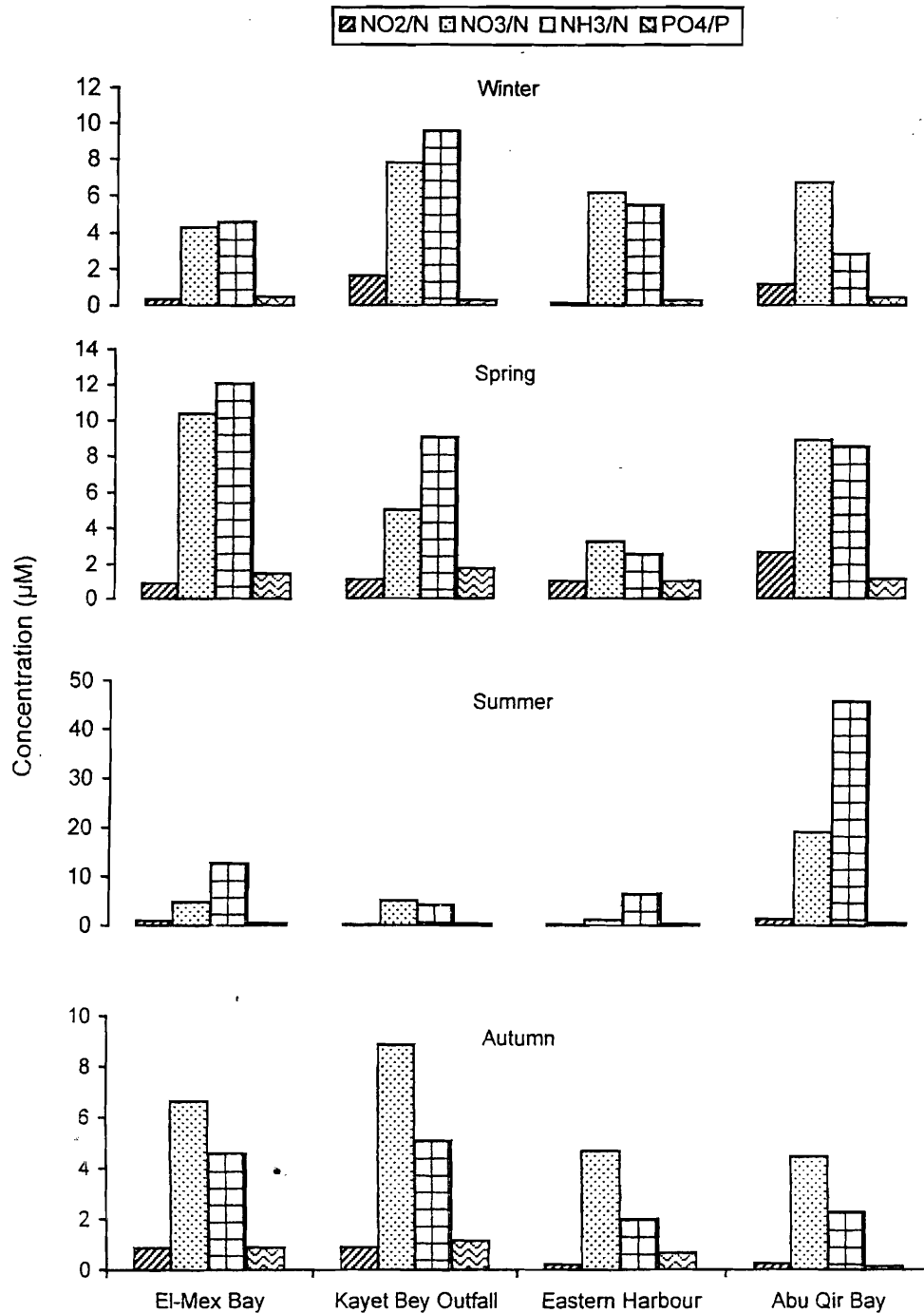


Figure (2). Regional and seasonal average concentrations of  $\text{NO}_2/\text{N}$ ,  $\text{NO}_3/\text{N}$ ,  $\text{NH}_3/\text{N}$  and  $\text{PO}_4/\text{P}$  ( $\mu\text{M}$ ) at the different coastal areas of Alexandria.



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and ammonium than those found in front of Rosetta (Abu El-Khair, 1993), Western harbour (Tayel, 1992) and Abu Qir Bay (Nessim and El-Deek, 1995).

### **Dissolved Inorganic nitrogen (DIN):**

The results (Table 1) revealed regional variations in the annual mean content of DIN. The data indicate that Abu Qir region, enriched with DIN ranged between 6.92 and 66.3  $\mu\text{M}$  with an annual mean value of 25.97  $\mu\text{M}$  (46% of TN, one-third of TN) for Abu Qir area and ranged between 9.23 and 23.34  $\mu\text{M}$  with an annual mean content of 15.81  $\mu\text{M}$  (34% of TN) for El-Max Bay. This coincide with the huge quantity of industrial waste water and sewage discharged into the two areas. On the other hand, the lowest annual content of DIN observed in the Eastern Harbour (8.3  $\mu\text{M}$ , 16% of TN), the annual mean value of DIN at Kayet Bey area has the same content of El-Max Bay.

Inorganic nitrogen in both El-Max and Kayet Bey seemed to be higher around 15  $\mu\text{M}$  than that of the Eastern Harbour (8  $\mu\text{M}$ ) and this coincide with the huge quantity of industrial wastewater and sewage discharged into the two areas.

### **Total nitrogen (TN):**

Total nitrogen means the summation of all forms of nitrogen including dissolved inorganic forms (nitrate, nitrite and ammonium) and the particulate nitrogen. The results (Table 1) indicate that the annual content of total nitrogen at Kayet Bey and Abu-Qir regions exhibit high values (47.15 - 157  $\mu\text{M}$ ) and this can be attributed to the effect of sewage disposed via Kayet Bey sewage plant which contain huge amounts of organic nitrogen. El-Max Bay and Eastern Harbour regions occupied the second order of magnitude in their annual concentrations of TN (around 60  $\mu\text{M}$ ). Their content ranged between 38.8 and 101.4  $\mu\text{M}$  for Eastern harbour and ranged from 50.14 to 75.54  $\mu\text{M}$  for El-Max Bay, this can attributed to their high concentration of organic nitrogen content. The lower annual value of TN (62.27  $\mu\text{M}$ ) coincided in El-Max Bay with dilution by freshwater via El-Ummum drain.

Fig. (3) shows that the maximum seasonal mean of total nitrogen was obtained in summer (156.84  $\mu\text{M}$ ) at Abu Qir region, the same region has the maximum content of dissolved inorganic nitrogen (66.3  $\mu\text{M}$ ). This reflects the direct effect of the discharge wastewater without treatment through Abu Qir Fertilizer Company. On the other hand, the relative high value of total nitrogen

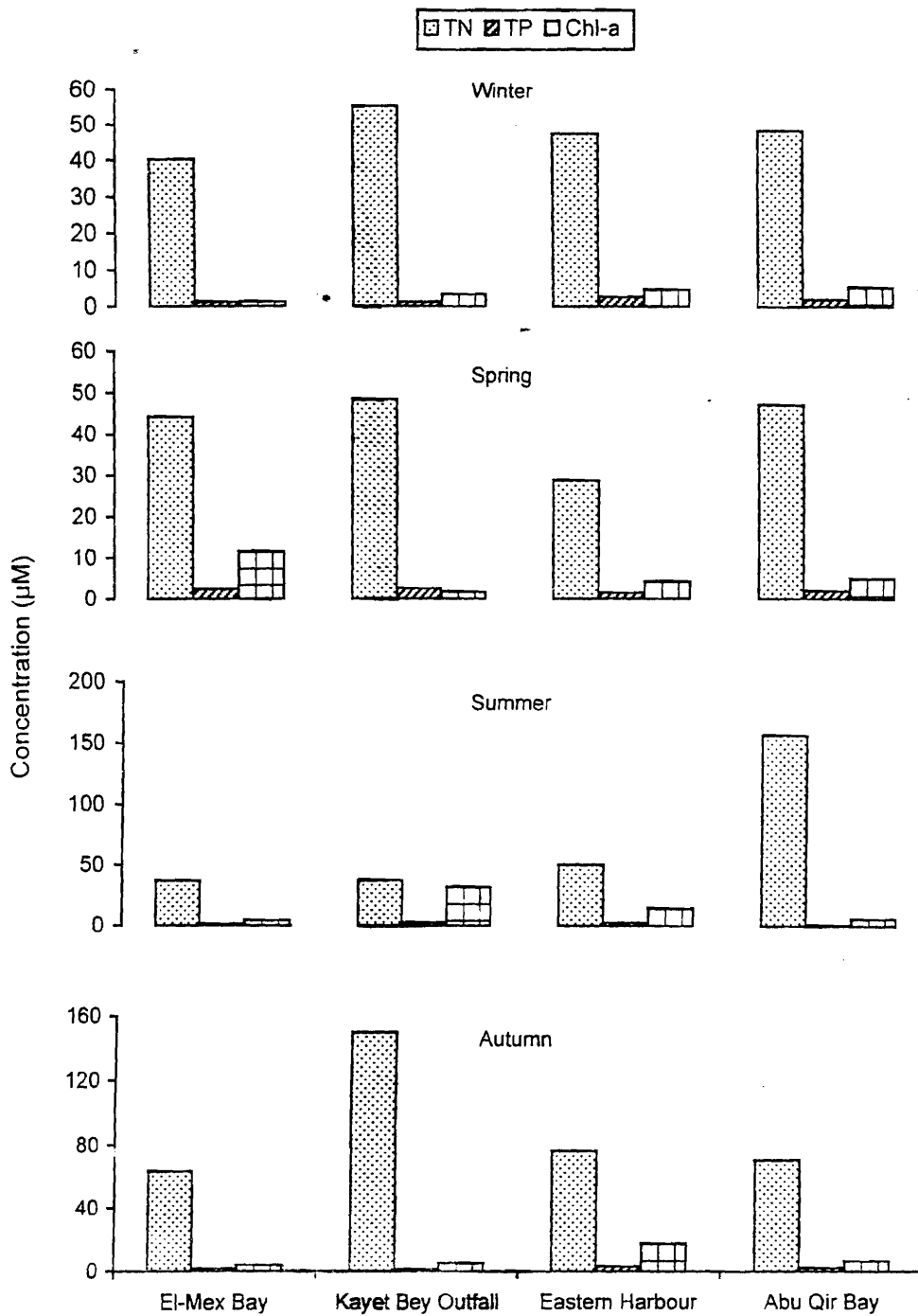


Figure (3). Regional and seasonal average concentrations of TN, TP (µM) and Chlorophyll-a (mg/m<sup>3</sup>) at the different coastal areas of Alexandria.

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(150.06  $\mu\text{M}$ ) at Kayet Bey region in Autumn is probably due to the large content of organic nitrogen discharged through Kayet Bey outfall. The values of TN in the four studied areas are comparable with the content of TN in the Western Harbour (Nessim, 1995).

### **Reactive phosphate ( $\text{PO}_4\text{-P}$ ):**

Phosphorus is an important element for primary production in aquatic system. It is important for growth and reproduction of phytoplankton (Riely & Chester, 1971). Large amount of phosphorus leads to eutrophication which it becomes a potential pollutant.

As shown in Fig. 2 the regional and seasonal distribution of reactive phosphate shows that the highest mean value (1.73  $\mu\text{M}$ ) at Kayet Bey region in winter and spring periods and the lowest value (0.13  $\mu\text{M}$ ) at Abu-Qir region in autumn.

The annual average content of reactive phosphate at Kayet Bey region is 0.88  $\mu\text{M}$  (Table 1) represent 41% of TP attributed to the highest discharge of municipal sewage via Kayet Bey outfall.

The annual mean content of reactive phosphate tends to decrease at the other areas, it was 0.57  $\mu\text{M}$  (31% of TP) for Abu Qir, 0.58  $\mu\text{M}$  (23% of TP) for Eastern Harbour and 0.84  $\mu\text{M}$  (48% of TP) for El-Max Bay. This results reflect that the source of reactive phosphate is mainly from allochthonous origin.

### **Total phosphorus (TP):**

Fig. (3) shows seasonal and regional distribution of total phosphorus. The higher values are given in autumn at Eastern Harbour (3.25  $\mu\text{M}$ ) and at Kayet Bey region (2.61 and 2.81  $\mu\text{M}$  in Spring and Summer, respectively). Such increase in TP concentration is mainly due to the increase in the organic form, which might be originated from disposable organic matter. The regional and seasonal variations in total phosphorus is probably due to the local waste discharge (Saad, 1973).

The annual mean values of TP varied from 1.76 to 2.57  $\mu\text{M}$  (Table 1). According to the regional average of TP, the studied areas could be arranged in the order: Eastern Harbour > Kayet Bey > Abu Qir > El-Max Bay. The annual mean of TP (Table 1) reaches maximum value at Eastern harbour and Kayet

Bey regions. This may be due to the huge amount of domestic water (>0.5 million m<sup>3</sup> is desposed daily from Kayet Bey outfall (Nessim and Zaghloul, 1991).

**Chlorophyll-a (Chl-a):**

Chl-a is the essential pigment involved in light absorption and photochemistry in high plants and algae. Chl-a was subjected to seasonal fluctuations. Fig. (3) shows the highest value in summer at Kayet Bey (32.36 mg/m<sup>3</sup>), which is probably due to the blooming of phytoplankton. The lowest concentrations (Fig. 3), on the other hand were observed at El-Max Bay region (1.32 mg/m<sup>3</sup>), during winter.

Comparison with the other previous work, the concentration of Chl-a reported in the present work was higher than the levels given by Shriadah *et al.*, 1990 for the Eastern Harbour (0.18 mg/m<sup>3</sup>) and by Said *et al.*, 1991 for El-Max Bay (0.32 mg/m<sup>3</sup>), and Shriadah and Tayel, 1992 for the Western Harbour (0.48 mg/m<sup>3</sup>) and by Tayel, 1992 for Abu Qir Bay (0.82 mg/m<sup>3</sup>) and by Zaghloul and Nessim, 1990 for Kayet Bey (ranged between 0.01 and 15 mg/m<sup>3</sup>).

**Nitrogen/phosphorus ratio:**

Dissolved inorganic nitrogen and dissolved inorganic phosphorus are very important compounds in the growth and reproduction of phytoplankton. When present in large content it causes eutrophication and may be considered as a potential pollutant.

Chiaudani and Vighi (1987) showed that marine algae are considered to be P-limited when N/P ratio > 6 and N-limited when the ratio is <4.5, in the range 4.5-6, the ratios of nutrient elements are near the optimal assimilative proportion.

The regional and seasonal variation of DIN/DIP ratio (Table 1) showed strong deviation in the studied areas, it ranged from 7:1 at Eastern Harbour in spring to 110:1 at Abu Qir area in summer.

The annual mean ratios of DIN/DIP (Table 1) were found to be (46) for Abu Qir; (14) for Eastern Harbour; (17) for Kayet Bey and (19) for El-Max Bay.

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The high ratio in Abu Qir region is due to the high drainage of wastewater, containing high content of nitrogen compounds. Its sources from sewage, agricultural waste (Lake Edku) and industrial waste (El-Tabia Pumping Station and Abu Qir Fertilizer Company).

In general, the N/P ratio for the different locations indicated that phosphorus was the limiting factor for the growth of algae in all studied sites.

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