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SOME WATER QUALITY CHARACTERISTICS OF EL-DEKHAILA HARBOUR, ALEXANDRIA, EGYPT.

BY

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Key words: Eutrophication, Nutrients.

ABSTRACT

Bimonthly collections of water samples were carried out in El-Dekhaila Harbour at nine selected hydrographic stations during the period from October 1990 to October 1991.

The study area is clearly affected by brackish polluted water discharged from El-Umoum drain through El-Mex pumping station. This can be indicated by high water column stability which enhanced phytoplankton growth specially at surface water during October 1991 (20.4 x 10^6 Units.l^{-1}). Surface water was characterized by high nutrient load particularly PO_4, NO_3, total and specific alkalinity and oxidizable organic matter. The water salinity had low values as well as transparency due to the heavy growth of phytoplankton. The harbour may be considered as eutrophic region.

INTRODUCTION

El-Dekhaila Harbour was recently constructed to serve Alexandria Iron and Steel Factory. The harbour is located at the western part of El-Mex Bay at latitude 29° 47' and longitude 31° 10' (Fig. 1) with a surface area of about 12.5 Km^2. Its water depth ranges between 6 and 19 m with an average of 12.4 m.

The harbour water is subjected to several sources of wastewater. A huge volume of brackish water (7.7 x 10^6 m^3 day^{-1}) loaded with domestic, agricultural and industrial wasts is discharged into El-Mex Bay through El-Umoum Drain. Also, El-Mex Bay receives at its western side near the harbour industrial wastes from a chloro-alkali plant and a less amount from several tanneries. The degree of water contamination of the harbour water from the above mentioned sources depends on the water circulation in the Bay. El-Dekhaila Harbour, like other harbours, also is affected by shipping activities including the possibility of water pollution with iron ore. The harbour has never been investigated before for its water quality or phytoplankton community. The main aim of this work is to study the most physico-chemical parameters helping to define the harbour water quality as a nutritive medium for phyroplankton standing crop.

MATERIAL AND METHODS

Water sampling was carried out bimonthly throughout the period from October 1990 to October 1991 at nine stations, seven of them covered the different ecological areas of the harbour, while the other two stations were taken from different habitats, one near the open sea (St. IX) while the other near the source of fresh-water discharged from El-Mex area (St. I), (Fig. 1). Sampling was made at three depths, surface (50 cm below water surface), middle (5 m depth) and near bottom water layer, using Ruttener sampler with a capacity of three litres. The depth of the selected stations was 14.5, 12.5, 12.9, 13.5, 11.8, 9.9, 6.6, 10.9 and 18.7 meters for the stations I to IX respectivily.

Water temperature was measured with an ordinary thermometer accurrate to 0.1°C. The pH value was measured on board of a boat using a portable pH-Meter. Water transparency was measured using a white enamelled Secchi disc 25 cm in diameter. Salinity was measured using "Beckman Salinometer Model No. R.S.-7c". Total alkalinity was measured by titration against standard HCl. Dissolved oxygen (DO) was estimated according to the winkler method (Strickland and Parsons, 1968). Oxidizable organic matter was determined by the method of Carlberg, (1972). Nutrient salts (NO_3, NO_2, NH_3, PO_4 and SiO_4) were determined colourimetrically according to the methods described by Strickland and Parsons (1968) and the results are expressed in µg at l^{-1}. Water column stability was calculated according to UNESCO tables (1987). Specific alkalinity was estimated as a ratio of total alkalinity to chlorosity. oxygen percentage stauration was computed using UNESCO tables (1973).

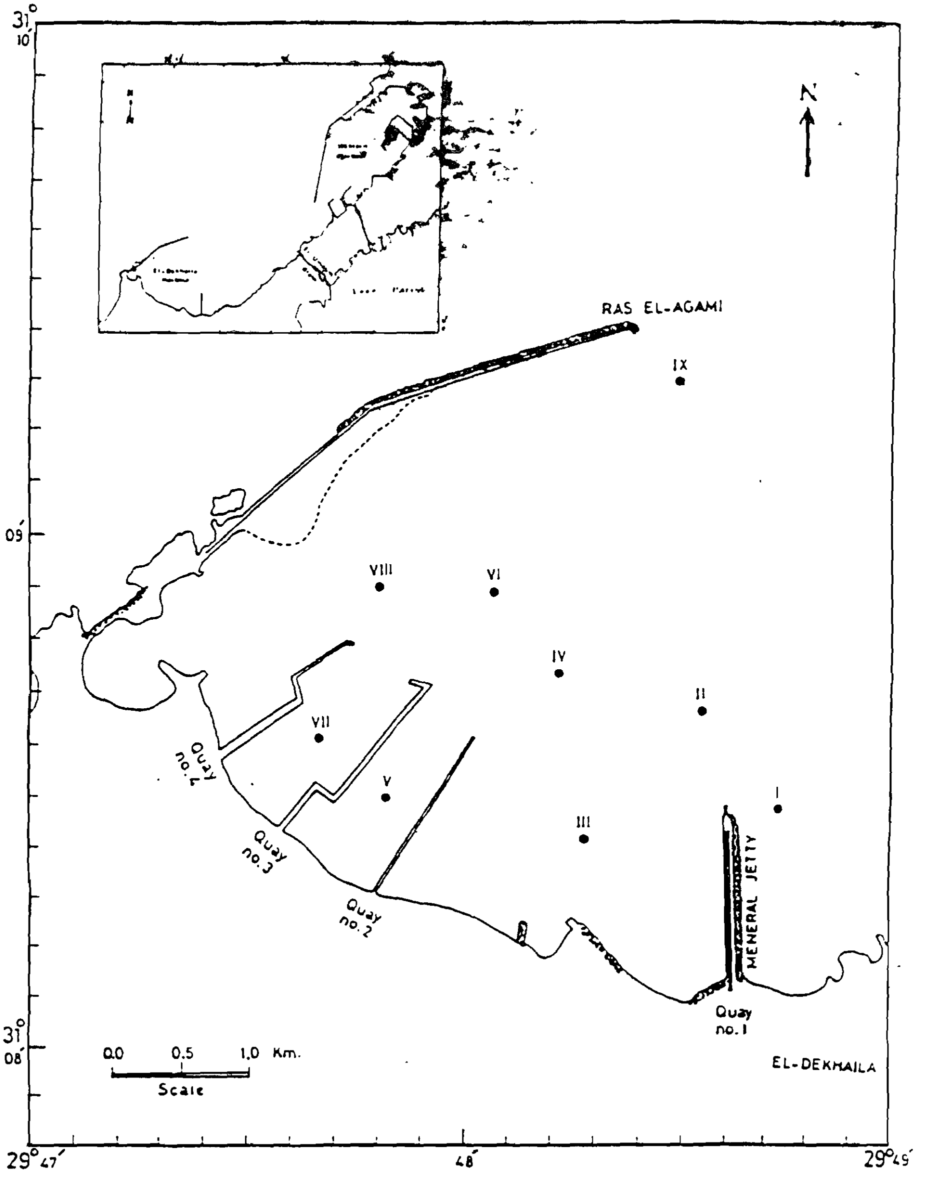

Fig. (1) : Investigated area (EL-Dekhaila Harbour) and position of stations.

Estimation of the phytoplankton standing crop was carried out by sedimentation method and the results expressed as units per liter.

RESULTS AND DISCUSSION

1- Temperature and Salinity :-

El-Dekhaila Harbour waters are stratified most of the time (Fig. 2), consisting of a dilute surface layer of mixed runoff from El-Mex pumping station and a more saline bottom layer. The highest average surface water temperature (29.3°C and 29.9°C) occurred during August and October 1991 respectively (Fig. 3) and the lowest in December 1990 and February 1991 (18.5°C and 18.3°C respectively).

Two thermal regimes can be observed during the time of investigation, the first lasted from April to October 1991, when surface temperature was normally higher than bottom temperature with a range of 1.0-3.2°C, the second extended from December 1990 to February 1991, when thermal stratification was inverse. During the transition period in October 1990, water was normally fully mixed (Fig. 3).

Surface salinity was always less than that of middle and near bottom layers attaining an average of 29.1, 38.0 and 39.2‰ at the three depths respectively. The average surface salinity fluctuated whithin a wide range from 19.50‰ (October, 1991) to 36.50‰ (June, 1991). Middle layer water salinity showed a narrow range of fluctuation from 35.10‰ (October, 1991), and 40.03‰ in February 1991 (Fig. 2). Similarly, near bottom layer salinity showed a narrower range (37.10‰ to 41.40‰). Salinity showed a strong vertical gradient which persisted most of the year round (Fig. 2).

Water columm stability tended to increase in December 1990 and October 1991 as a result of rising temperature and decreasing surface water salinity showing a clearly stratified water column particularly during October 1991. This water stabilization can act as important factor for phytoplankton active growth specially when incident light is sufficient for algal growth (Raymont, 1980). In our case the higher water column stability during October 1991 was met with higher phytoplankton standing crop attaining an average of 20.4×10^6 units.l^{-1} at surface water. This agrees with the results of Zaghloul (1995) in the Eastern Harbour.

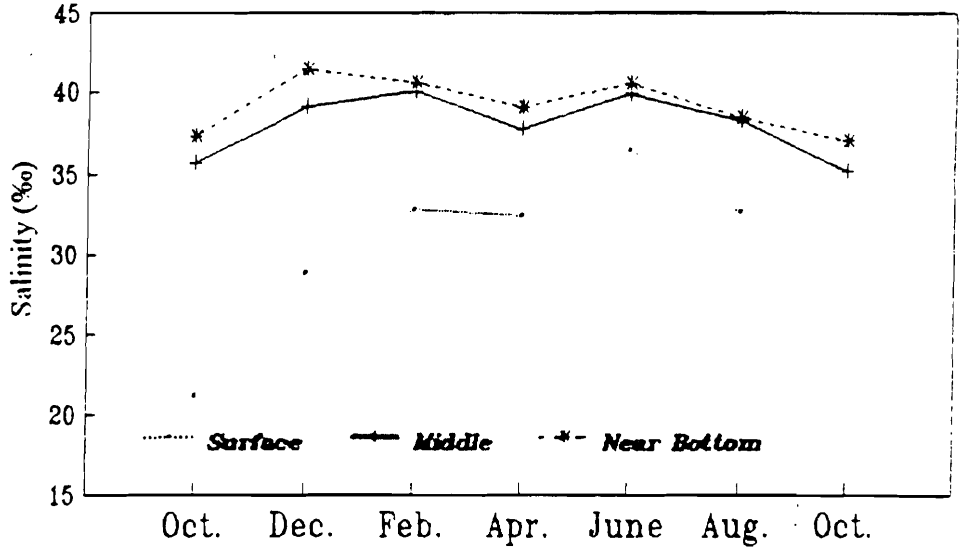

Fig. (2): Average bimonthly variations of water **salinity** (‰) in El-Dekhaila Harbour of the different depths during October 1990-October 1991.

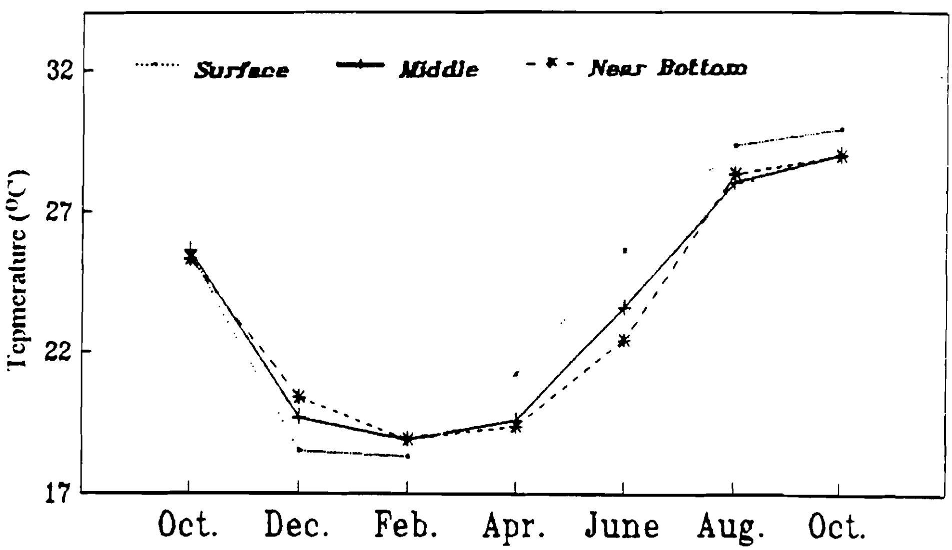

Fig. (3): Average bimonthly variations of water **temperature** (°C) in El-Dekhaila Harbour of the different depths during October 1990-October 1991.

2- Water Transparency :-

Secchi disc depth in El-Dekhaila Harbour showed a wide range of variation. The average depth varied from a minimum of 0.42 m in April 1991 to a maximum of 3.00 m in February 1991 (Fig. 4). The colour of the harbour water during the period of study appeared yellowish blue particularly during April 1991 when outstanding phytoplankton peak dominated by ***Skeletonema costatum***.

The transparency of El-Dekhaila Harbour was mostly affected by the amount of particulate matter suspended in water. During the study period, a negative correlation was found between transparency and phytoplankton standing crop as shown in figuer 4 ($r = -0.56$, $P = 0.05$) and oxidizable organic matter ($r = -0.42$, $P = 0.05$). The higher transparency during winter specially in February 1991 was mostly due to lower phytoplankton standing crop (2.0×10^6 units.l^{-1}) and lower oxidizable organic matter (6.7 mg. $O_2.l^{-1}$), while the lower reading during April 1991 is mainly due to the outstanding phytoplankton bloom (13.2×10^6 units.l^{-1}) as well as concentration of higher oxidizable organic matter (10.3 mg $O_2.l^{-1}$).

3- Hydrogen Ion Concentration (pH) :-

The pH value in El-Dekhaila Harbour lies on the alkaline side. It varied between a minimum value of 8.03 near the bottom water layer in April 1991 and a maximum of 8.84 at the surface water in October 1990. The pH values of the surface water was often slightly higher than those of the middle and near the bottom water layers (Fig. 5). This may be explained by the photosynthetic activity at surface water which consumes carbon dioxide, increasing pH, favoring the formation of carbonate ions (Raymont, 1980). The lower values near the bottom water may be due to the decomposition processes of descending planktonic remains and relatively high organic load of bottom water and surface sediments.

4- Total and Specific Alkalinity :-

The mean average value of total alkalinity in the surface water of El-Dekhaila Harbour was 3.6 milli- eq.l^{-1}. This value decreased with depth to 3.0 & 2.8 at middle and near the bottom water layers (Fig.6). The difference between surface

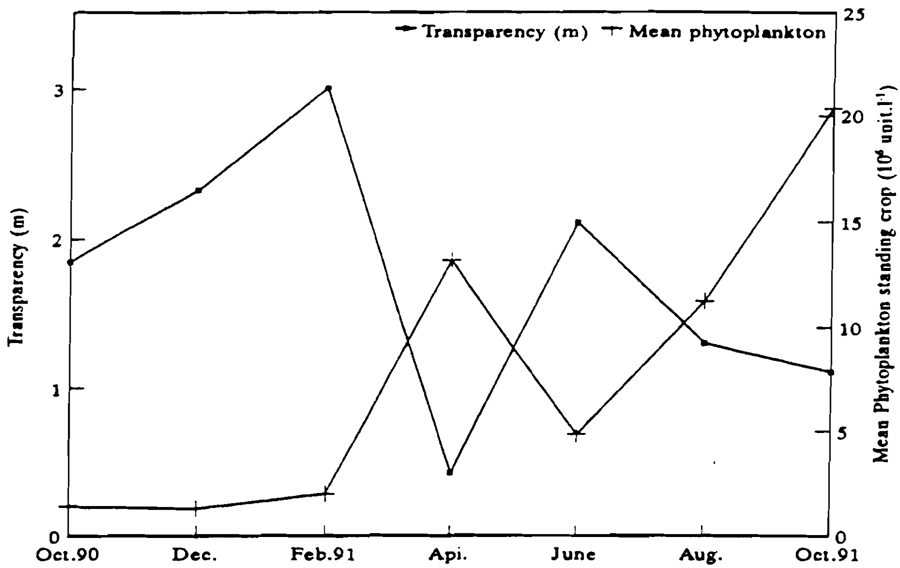

Fig. (4): Average bimonthly variations of water **transparency** (m) in El-Dekhaila Harbour of the different depths during October 1990-October 1991.

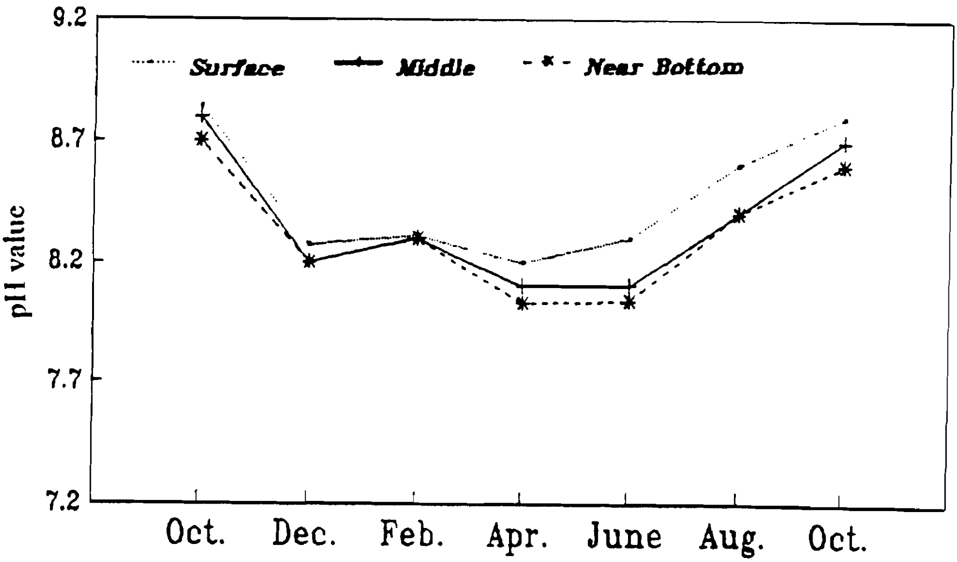

Fig. (5): Average bimonthly variations of Hydrogen ion concentration (pH) in El-Dekhaila Harbour of the different depths during October 1990-October 1991.

and near the bottom water layer is due to the less pH value at near bottom layer and subsequent increase of CO_2 leading to dissolving of more carbonate from the sediment (Aleem & Samaan, 1969). Total alkalinity values are comparable with those of polluted areas such as Western Harbour (Nessim & Tadros, 1988) and El-Mex Bay (Nessim, 1994).

Surface specific alkalinity in El-Dekhaila Harbour (an average of 0.220) was always higher than the normal open sea (0.126) Morcos 1970. However, during the period from February to June 1991 when the salinity was high due to the active mixing of harbour water with open sea water, the difference in total alkalinity between surface and near the bottom was minimum (0.06 milli- eq.l^{-1}) and the specific alkalinity was near to that of open sea. Before and after this period a general rise in specific alkalinity was observed attaining a value of 0.17 at surface water, this was accompanied with water stratification and high water column stability and higher phytoplankton activity due to mixing with land drainage, showing a high vertical gradient of specific alkalinity towards the near bottom water layer. This is also confirmed by the positive correlation between specific alkalinity and water stability (r = 0.68, P = 0.05), phytoplankton standing crop (r = 0.21, P = 0.05) and pH value (r = 0.41, P = 0.05) and also with a negative correlation with water salinity (r = - 0.80, P = 0.05).

5- Oxidizable Organic Matter (OOM):-

The source of OOM in the harbour water is from biological activities of living organisms, the decomposition products of died organisms and from the water discharged from El-Umoum Drain into El-Mex Bay. The average OOM ranged between a minimum of 3.1 mg $O_2.l^{-1}$ at near the bottom water layer in April 1991 and a maximum of 18.80 mg $O_2.l^{-1}$ in surface water in October 1991 (Fig. 7). The mean value of OOM in El-Dekhaila Harbour are more than that recorded by Aboul Kassim (1987) & Hussein (1994) in the Eastern Harbour and relatively less than that recoded in El-Mex region (Nessim, 1994). The OOM in the harbour water is mainly due to biological activities, this is indicated by its highly positive significant correlation with phytoplankton standing crop (r = 0.45, P = 0.05) and water temperature (r = 0.74, P = 0.05), particularly in the surface water. On the other hand, the negative significant correlation between OOM and salinity (r = - 0.35, P = 0.05) reflects the role of El-Umoum Drain in the increase of organic matter in the harbour water and this is also confirmed by inverse correlation of OOM with water transparency (r = - 0.43, P = 0.05).

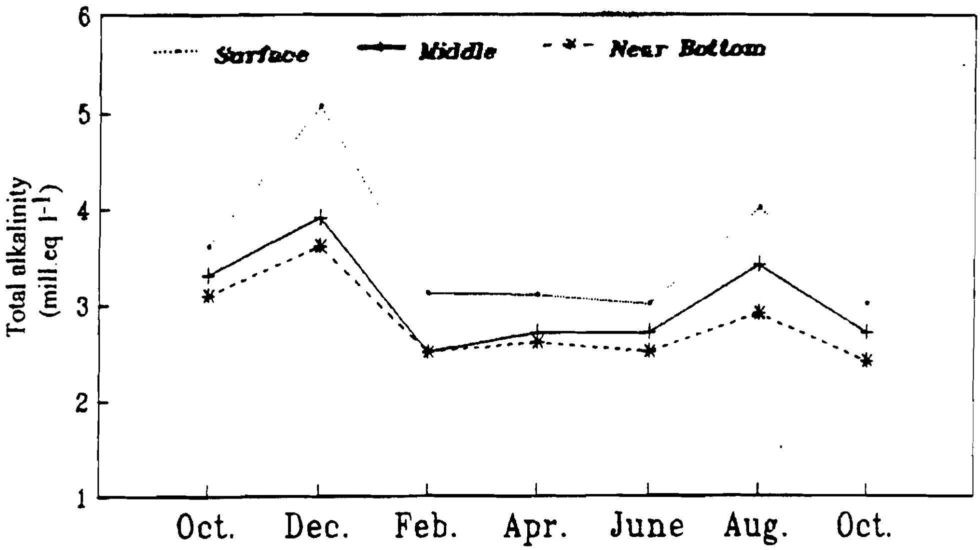

Fig. (6): Average bimonthly variations of **total alkalinity** (milli-eq.l^{-1}) in El-Dekhaila Harbour of the different depths during October 1990-October 1991.

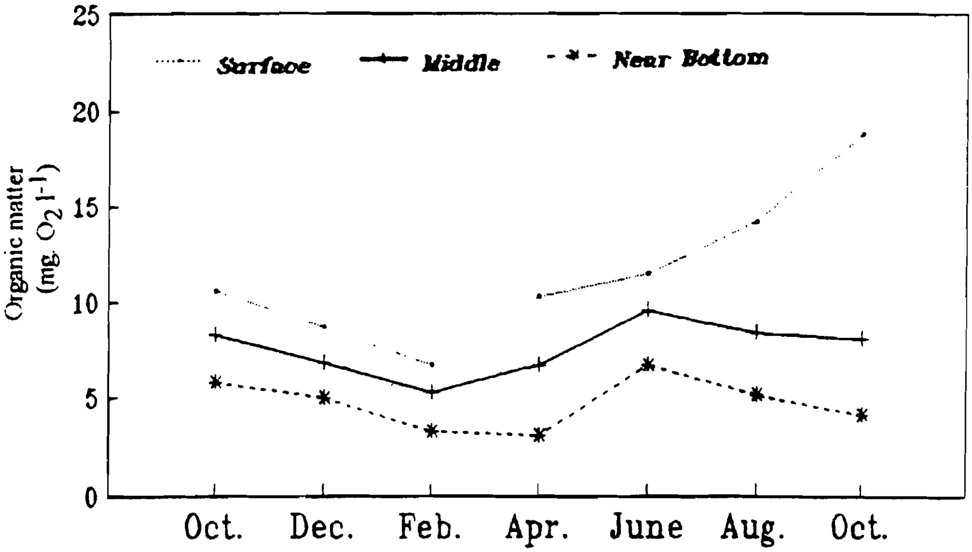

Fig. (7): Average bimonthly variations of **oxidizable organic matter** (mg. O_2.l^{-1}) in El-Dekhaila Harbour of the different depths during October 1990-October 1991.

6- Dissolved Oxygen (DO) :-

El-Dekhaila Harbour is moderately oxigenated, with an average of 2.91 ml $O_2.l^{-1}$ at the surface water, decreased with depth to 2.39 and 2.0 ml $O_2.l^{-1}$ at middle layer and near the bottom respectively. During the period of investigation, dissolved oxygen varried between a minimum value of 1.01 ml $O_2.l^{-1}$ during both October 1990 (22.5% saturation) and December 1990 (20.2% saturation) at near the bottom water layer and a maximum value of 3.74 ml $O_2.l^{-1}$ (82.1% saturation) in August 1991 in the surface water (Fig. 8). Dissolved oxygen in the present study was positively correlated with phytoplankton standing crop (r = 0.47, P = 0.05) at surface layer, consequently it is also correlated with most physico-chemical parameters, which affect photosynthetic activity, such as temperature (r = 0.34, P = 0.05). Moreover, the concentration of most important nutrient salts was negatively correlated with dissolved oxygen, PO_4 (r = - 0.34, P = 0.05), NO_3 (r = - 0.30, P = 0.05), NO_2 (r = - 0.60, P = 0.05) and NH4 (r = - 0.54, P = 0.05). The negative correlations with NO_2 and NH_4 indicat not only their active uptake during photosynthetic activity, but also importance of the dissolved oxygen in their transformation to nitrate. Dissolved oxygen is also consumed in the biological and nonbiological oxidation of organic matter, so a logic negative correlation with oxidizable organic matter was detected in harbour water specially near the bottom water layer (r = - 0.23, P = 0.05). It is to be noted that, the average DO in El-Dekhaila Harbour was lower than that recorded in the Western Harbour (Nessim & Tadros, 1992 and Zaghloul & Nessim, 1991) and the Eastern Harbour (Zaghloul, 1988 and Hussein, 1994). This may be due to the disturbance of water column during the construction of quays during the study period.

7- Nutrient salts :-

I- Dissolved Inorganic Nitrogen

i) Nitrate :-

Surface nitrate concentration constituted nearly 20.3% of the total inorganic nitrogen, ranging in average from 0.52 μg $at.l^{-1}$ (April, 1991) and 8.28 μg $at.l^{-1}$ (December, 1990), with a mean of 2.46 μg $at.l^{-1}$. It decreased with depth to 1.71 μg $at.l^{-1}$ in middle layer and 1.18 μg $at.l^{-1}$ near the bottom water layer. The variation of nitrate concentration in El-Dekhaila Harbour water reflects an equilibrium between outside inputs of nitrogen salts through water discharge from El-Mex pumping station, nitrogen fixation , nitrogen salts regeneration from the bottom and the loss of nitrogen salts by phytoplankton uptake besides bacterial denitrification (Clavert and Price, 1971).

The bimonthly variation of nitrate concentrations in El-Dekhaila Harbour showed two successive maxima in October and December 1990 due to the increase of discharged water from El-Mex pumping station. This reflects higher values of total alkalinity (average 5.05 milli- eq.l^{-1}) during December 1990 The relatively low nitrate concentration observed during April and August 1991 at the three depths (Fig. 9) may be attributed to consumption by phytoplankton A significant negative correlation between nitrate and total phytoplankton standing crop (r = - 0.28 and r = - 0.35, P = 0.05). Strickland ***et al.*** (1970) attributed the increase in plant nutrient utilization to heat of the water column. which stimulates phytoplankton growth. An inverse relationship between water temperature and nitrate concentration existed during the investigation period (r = - 0.35, P = 0.05) which is also in agreement with the results of Aboul-Kassim (1987) in the Eastern Harbour and Friligos (1977) in Tharonaikos Gulf.

ii) Nitrite :-

Nitrite content was usually low, forming a minor part of total nitrogen (12.6%). Surface water concentration usually ranged between an average of 1.23 μg at.l^{-1} (August, 1991) and 2.1 μg at.l^{-1} (October, 1990) and decreased with depth to 1.52, 1.17 and 0.79 μg at.l^{-1} at the surface, middle and near the bottom water layers repectively (Fig. 10). The highest content recorded during October 1990 (2.16 μg at.l^{-1}) was accompanied by a lower value of dissolved oxygen (1.77 ml O_2.l^{-1}), indicating the allochthonous input of nitrite brought by the water from El-Mex Bay (average water salinity 21.2‰ for surface water) and the excretion of nitrite by phytoplankton during assimilation (Ward ***et al.*** 1984 and Wafar ***et al.***, 1986).

Nitrite could hardly be a nitrogen source for phyroplankton since it is rarely present in measurable quantities (Wafar ***et al.***, 1986). In the surface water. a significant negative correlation between nitrite concentration and phytoplankton standing crop was recorded (r = - 0.31, P = 0.05). This may be due to the excess of oxygen liberated during photosynthesis which help in oxidation of nitrite to nitrate.

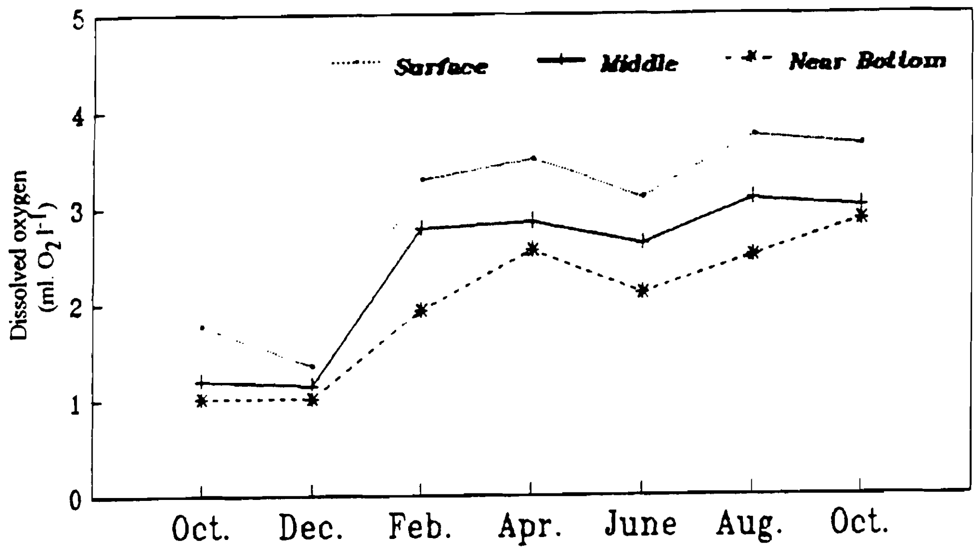

Fig. (8): Average bimonthly variations of **dissolved oxygen** (ml. $O_2.l^{-1}$) in El-Dekhaila Harbour of the different depths during October 1990-October 1991.

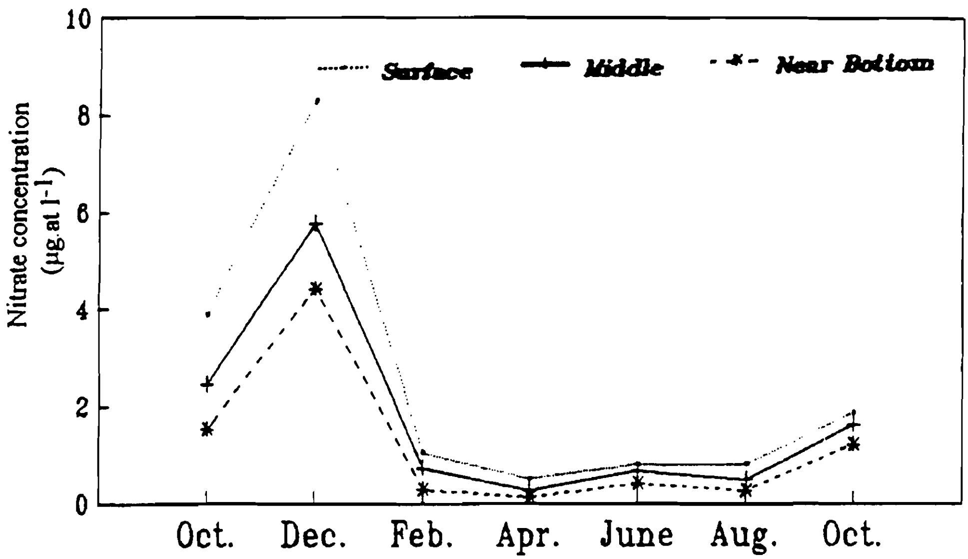

Fig. (9): Average bimonthly variations of **nitrate** (μg-at.l^{-1}) in El-Dekhaila Harbour of the different depths during October 1990-October 1991.

iii) **Ammonia :-**

Ammonia comprised nearly 67.1% of the total nitrogen in the harbour. Its concentration in sea water is considered as a good indicator for the degree of pollution. At the same time, ammonia is an important nitrogen source for aquatic palnts in most environments in preference to nitrate (Wafar, *et al.*, 1986).

The average concentration of ammonia showed wide fluctuations, particularty in the surface water (Fig. 11), it ranged between 4.38 μg at.l^{-1} (October, 1991) and 14.2 μg at.l^{-1} (December, 1990). Vertically, ammonia concentration decreased from a mean of 8.12 at the surface to 4.50 μg at.l^{-1} at middle to 3.50 μg at.l^{-1} near the bottom water layer. The high ammonia concentration in the surface water reflects the effect of discharged water on the area. This is also indicated by the significant positive correlation between surface ammonia content and total alkalinity ($r = 0.64$, $P = 0.05$). Compared with the other harbours of Alexandria, El-Dekhaila Harbour had an average ammonia concentration less than the Western Harbour (Zaghloul & Nessim, 1991) and more than Eastern Harbour (Hussein, 1994). Surface ammonia concentration was negatively correlated with phytoplankton standing crop ($r = -0.50$, $P = 0.05$) indicating a high rate of ammonia utilization during the active time of phytoplankton growth.

II- Reactive Phosphate :-

The phosphate concentration in El-Dekhaila Harbour showed a narrow range of variation at the three depths (Fig. 12). In the surface water the average concentration fluctuated between 0.3 μg at.l^{-1} (August, 1991) and 0.60 μg at.l^{-1} (December, 1990) with a mean of 0.40 μg at.l^{-1} (Fig. 12). Gradual decrease was observed with depth indicating, phosphate input through El-Mex pumping station. This is confirmed with positive correlation between phosphate and total alkalinity in the surface layer ($r = 0.30$, $P = 0.05$).

High concentration of phosphate were detected during the period from October to February 1991, this is mainly related to less phytoplankton standing crop. During the period of heavy phytoplankton bloom (April-August, 1991) phosphate content was reduced. This may explain the inverse significant correlation between phosphate content and phytoplankton standing crop at the surface and near bottom water layer ($r = - 0.41$ & $r = - 0.60$, $P = 0.05$ respectively). Stirn (1972) stated that, the average phosphate in the euphotic

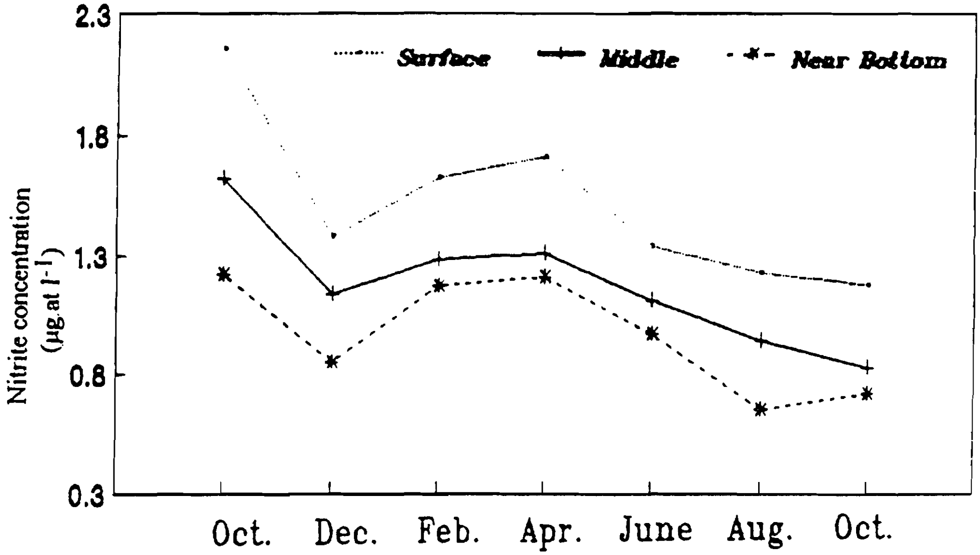

Fig. (10): Average bimonthly variations of **nitrite** (µg-at.l^{-1}) in El-Dekhaila Harbour of the different depths during October 1990-October 1991.

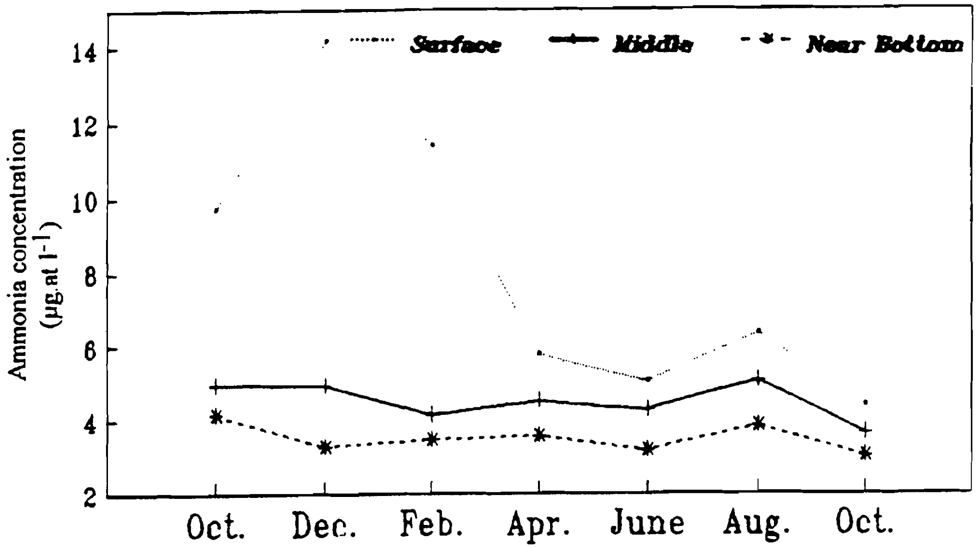

Fig. (11): Average bimonthly variations of **ammonia** (µg-at.l^{-1}) in El-Dekhaila Harbour of the different depths during October 1990-October 1991.

layer in the productive temperate coastal water are around 0.3 μg at.l^{-1}.. According to these findings, it seems that, El-Dekhaila Harbour can be classified as one of the eutrophic water masses in the Mediterranean Sea. The phosphate concentration in the investigated area was less than that recorded in the Eastern Harbour (Zaghloul, 1988) and Western Harbour (Zaghloul and Nessim, 1991).

III- Reactive Silicate :-

Surface silicate concentrations showed a wider range of variations (2.40-9.50 μg at.l^{-1}) than both of middle (1.50-4.50 μg at.l^{-1}) and near the bottom water layers (1.40-3.20 μg at.l^{-1}). The variations of silicate concentrations were clearly related to the supply of silicate from El-Umoum Drain water on one hand, and consumption by diatoms on the other hand. Since the drop in salinity during October to December 1990 is accompanied by a high peak in surface silicate concentration, a strong positive correlation was found between silicate concentration and total alkalinity in the surface water ($r = 0.54$, $P = 0.05$). On the other hand, rapid uptake of silicate by phytoplankton bloom, lowered its concentration to a mean of 2.4 μg at.l^{-1} in April 1991 (Fig. 13).

The average surface silicate value (5.7 μg at.l^{-1}) in El-Dekhaila Harbour is too low as compared with that of the Western Harbour (23.6 μg at.l^{-1}) Nessim & Tadros, (1986) as well as in the Eastern Harbour (7.8 μg at.l^{-1}) by Hussein (1994).

CONCLUSION

Data show a difinite two layer system existed most of the year. There is a pronounced vertical gradient, i.e. decreasing of all values of parameters towards near the bottom layer except for salinity. As indicator of brackish water discharge, the specific alkalinity in surface water was higher in the area than in the open sea, this was also accompanied by higher oxidizable organic matter, high content of nutrient salts and low secchi disc transparency. The water of the harbour may be considered as eutrophic coastal marine area charactrized by high phytoplankton standing crop.

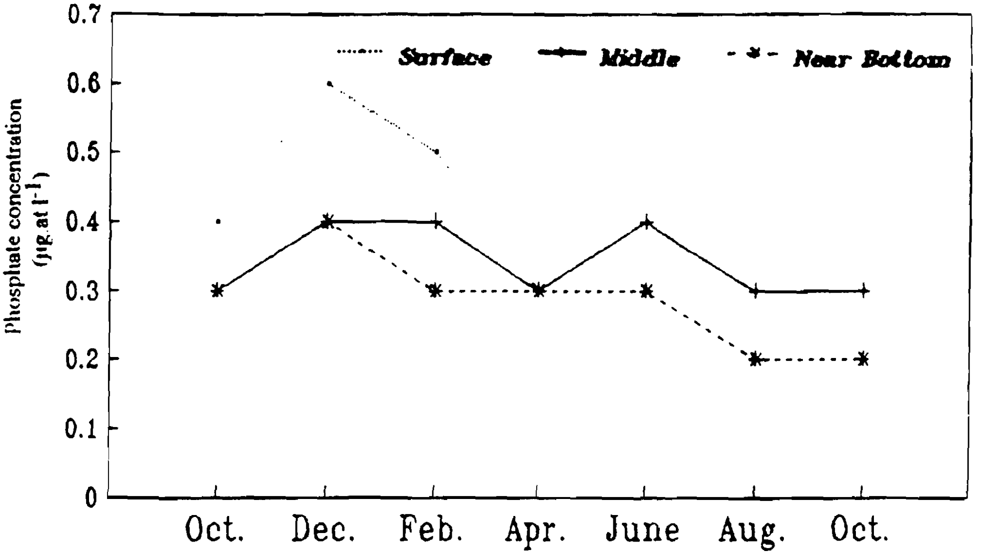

Fig. (12): Average bimonthly variations of **phosphate** (μg-at.l^{-1}) in El-Dekhaila Harbour of the different depths during October 1990-October 1991.

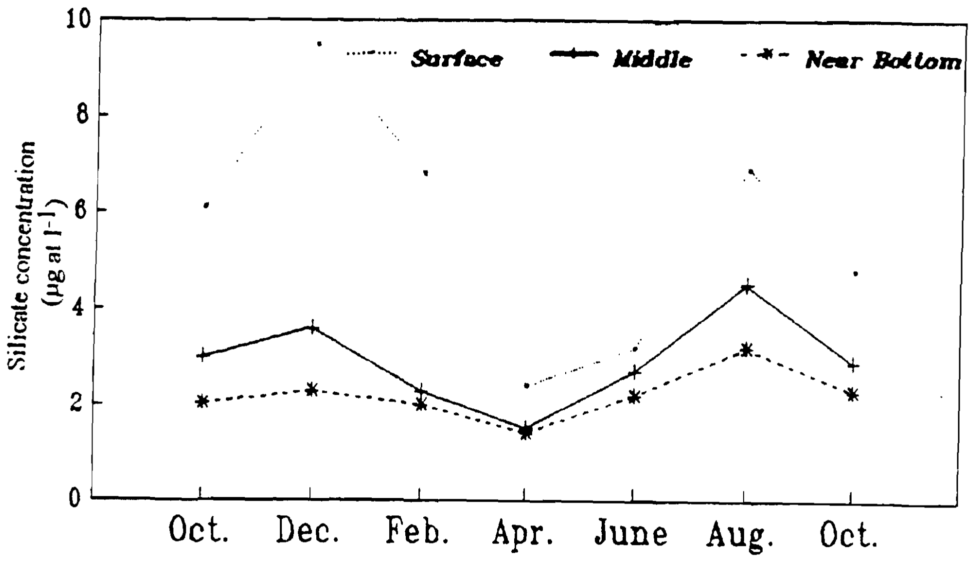

Fig. (13): Average bimonthly variations of **silicate** (μg-at.l^{-1}) in El-Dekhaila Harbour of the different depths during October 1990-October 1991.

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