Proc. Symp. Mar. Chem. in the Arab Region, Suez., April, 1991 : 71 - 80

Nutrient and Chlorophyll at Kait Bey Region (Alexandria)

By

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Abstract

A monthly collection of surface and bottom water samples at selected nine stations representing the polluted Kait Bey area and surrounding the main sewage pipelines, was carried out during August 1987 - August, 1988. Determination of nutrient content; nitrate, nitrite, ammonia, dissolved inorganic phosphate and sillicate as well as chlorophyll estimation were done. The spatial and temporal variations, nutrient ratios and its correlation with chlorophyll-a were described.

The surface water near the sewer openings is generally enriched with nutrient from allochthonous origin, the values tend to decrease seawards or downwards.

The calculated P : N : Si average ratio of 1:9:6 deviates markedly below the normal oceanic ratio. Near the outfall openings the N : P ratio tends to increase (17-27), indicating that phosphorus could be critical than nitrogen for phytoplankton growth. Away from the outfall the relation is reversed.

Chlorophyll-a, -b and -c showed ratios of 1:1.4:2.3. Their peaks were detected during warm September being 15.15, 19.28, 48.46 mg/m^3, respectively.

Positive correlations were calculated between chlorophyll-a and each of temperature, pH-value, phosphorus and sillicate while salinity and water transparency showed negative correlation coefficients.

Introduction

There is evidence that in some coastal areas of the Mediterranean sea the input of eutrophying substances; particularly phosphorus, nitrogen and organic matter, leads to significant alterations in the natural ecosystem. Alexandria coastal water is subjected recently to a certain degree of eutrophication caused by the wastewater discharged from several outlets distributed along the shore. The area of study (4 Km^2) located at Kait Bey region and surrounding the main sewage pipelines is considered as a polluted point where a huge amount of domestic water (> 0.5 million m^3) is disposed daily. The present work is an attempt to study the monthly and seasonal variations of the nutrient levels and its effect on chlorophyll-a content; i. e, the phytoplankton biomass. The infleunce of pollution on the zooplankton population is previously discussed (Zaghloul & Nessim, 1990). A detailed study showing the effect of the environmental condition changes on the phytoplankton distribution will appear later.

Materials and Methods

Nine stations were selected in an area about 4 Km^2 surrounding the main pipelines at Kait Bey in front of Alexandria (Fig. 1). Surface and bottom water samples were collected monthly at these locations during the period (August 1987 - August 1988), using a flat type Ruttner plastic sampler of 2 L capacity.

Water samples were analyzed to determine nutrient; nitrate, nitrite, ammonia, dissolved inorganic phosphate and silicate spectrophotometrically according to the methods described by Grasshoff (1976). A Shimadzu double - beem spectrophotometer UV-150-02 was used for the different measurements.

Chlorophyll concentration was determined spectrophotometrically as a pigment extract according to Strickland & Parsons (1968). The following equations are used to calculate the concentrations of chlorophyll forms, a, b and c expressed as mg/m^3 after substracting the readings taken at 750 mu from the other readings for the turbidity correction.

Chl. -a (mg/m^3) $= (11.6\ D_{665} - 1.31\ D_{645} - 0.14\ D_{630})\ v. /VL$

Chl. -b (mg/m^3) $= (20.7\ D_{645} - 4.34\ D_{665} - 4.42\ D_{630})\ v. /VL$

Chl. -c (mg/m^3) $= (55\ D_{630} - 4.64\ D_{665} - 16.3\ D_{645})\ v. /VL$

Where D = absorbance at wave length indicated by subscript.

v = volume of acetone (cm).

V = volume of filtered water (liter).

L = cell (cuvette) length (cm).

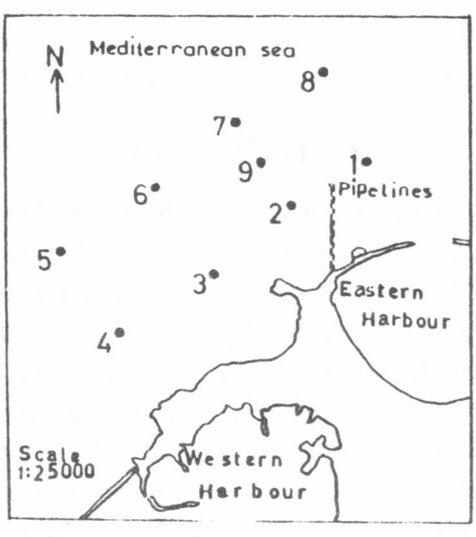

Fig. (1)

Kait Bey area, Alexandria, Sampling stations

Results and Discussion

a) Nitrate - Nitrogen

The annual average of NO_3 -N / dissolved inorganic nitrogen, (DIN) - ratio is about 32% varying between 3.8% (June) and 92% (December). The NO_3-N values, varied from complete depletion in several summer samples to 9.33 ug at/1 during December with an annual average of 1.32 ug at/1.

The distribution of nitrate displays more or less similar pattern for most stations with slight seasonal variations and a peak during December (Fig. 2a). Most of surface samples collected during autumn were relatively higher in nitrate content than the bottom ones. This relation is reversed during summer. The NO_3 - N peak detected during December coincided with the lowest salinity of 35.877‰ in the water column suggesting its allochthonous origin (sewage). The uptake of nitrate by phytoplankton was also not great during this cold month (15.1 - 15.9°C), demonstrated from the Chl.- a content (< 1 mg/m^3). During September the drop in salinity (33.883‰, on average) was accompained by high exhaustion of nitrate from the water column due to phytoplankton bloom developed under warm condition, demonstrated by maximum values of Chlorophylls a, b and c.

At the nearshore stations (1 - 4) the nitrate content is relatively higher than that at the offshore stations located away from the outfall openings. The minimum average of 0.84 ug at/1 was detected at St. 5 while the maximum of 2.15 ug at/1 was recorded at St. 1.

b) Nitrite - Nitrogen

Nitrite is a minor component of DIN (<10%). Its amount in the Kait Bey area varied between zero and 1.56 ug at/1 and shows slight seasonal and spatial fluctuations. During spring (April & May), the water column tends to be depleted from nitrites (Fig. 2 b). The exhaustion of ions from the area was observed after the nitrite-peaks detected during February and March and accompanied the phytoplankton bloom. The well oxygenated or supersaturated water (50.3 - 123.6% O_2Sat.) may accelerate the oxidation of these unstable ions similar to the noticable condition in Alexandria western harbour (Nessim & Tadros, 1986). The increase in nitrite content in the surface water during September may be attributed to the nitrate reduction in the relatively oxygen poor water with low salinity (Calvert & Price, 1971; Broandhors, 1959) and the extracellular release of nitrite accompaning the assimilation of nitrate by marine phytoplankton (Vaccaro & Ryther, 1960) and (Ward et al., 1984).

Refering to the spatial variation, the annual average of ions content at the nearshore localities is nearly two times greater than that of the far stations. The nitrite - peak observed in the nearshore area coincided with the ammonia - peak, and suggestied the input of nitrite in sewage. It was also noticed that the highest values of nitrite ions were accompanied by high turbidity, low salinity and Chl. maximum.

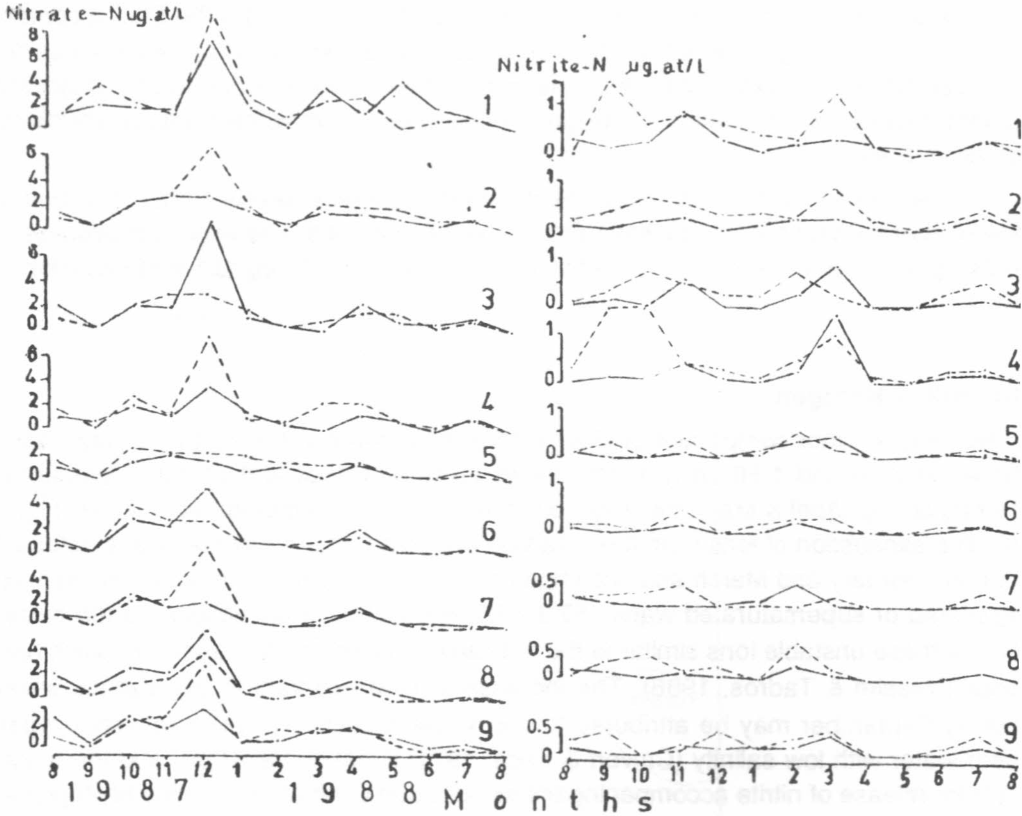

Fig.(2)

Monthly variations of NO_3N (a) and NO_2N (b) in the surface .... and bottom waters .—— at different stations during the period 1987-1988.

c) Ammonia - Nitrogen

The most abundant form of DIN in the Kait Bey water is ammonia comprising 60.3% which is introduced into the ecosystem through the direct inputs of sewage. Ammonia showed considerable seasonal variations with nearly identical pattern for most localities (Fig. 3a). High averages were detected during March (6.09 ug at/1) and June - July period (5.3 - 4.3 ug at/1), while the rest of the year gave relatively low averages (<3.0 ug at/1).

Away from the pipeline openings, stations (5-8) being less affected with sewage discharge showed low ammonia averages. The nearby stations (1-4), on the other hand, are enriched with ammonia (4 folds). In the open water in front of Alexandria, El-Rayis (1973) found ammonia contents between 0.21 and 2.4 ug at/1 which is too low when compared with our findings (0.00 - 38.68 ug at/1).

The enrichment of surface water with ammonia characterized the area near the sewer openings when compared with the bottom water comprising 34 folds at St. 2. This indicates the allochthonous origin of ammonia; i.e., derived from sewage.

Ammonia has been recognized as important alternative nitrogen source for various aquatic plants and in most environments may even be assimilated in preference to nitrates (Wafer et al, 1986). In principale, ammonium salts are the form of nitrogen preferred by algae and only when ammonium contents are depleted to <0.15 ug mol/dm^3 will nitrate and nitrite be utillized. Ammonia may be used, on the other hand, as a good indicator for the degree of pollution (Thomas, 1948).

According to the annual average, Kait Bey water is less polluted with ammonia when compared with the western harbour (Nessim & Tadros, 1986) or the eastern harbour waters (Nessim, 1989). Owing to the semienclosed configuration of these two harbours, their water contain ammonia nearly 7 times greater than that at Kait Bey open waters.

d) Phosphate - P

Phosphorus is one of the most important nutrient elements in the marine environment and when present in high concentrations it causes eutrophication and it may be considered as a potential pollutant. It is mainly brought into the sea by rivers and from municipal and industrial sources, while agricultral and atmospheric contributions are minor. P - compounds may be present in significant amounts as they are found in detergents and may also be formed by marine phytoplankton (Solórzans & Strickland, 1968).

It is evident from the data that the P- content was slightly higher at the surface than at the bottom and in the nearshore stations than in the offshore lones which indicate its allochthonous source (sewage). This is proved by the inverse correlation coefficient between P and salinity (r = 0.31) which resembles the finding of Abul-kassim (1987) in the eastern harbour water.

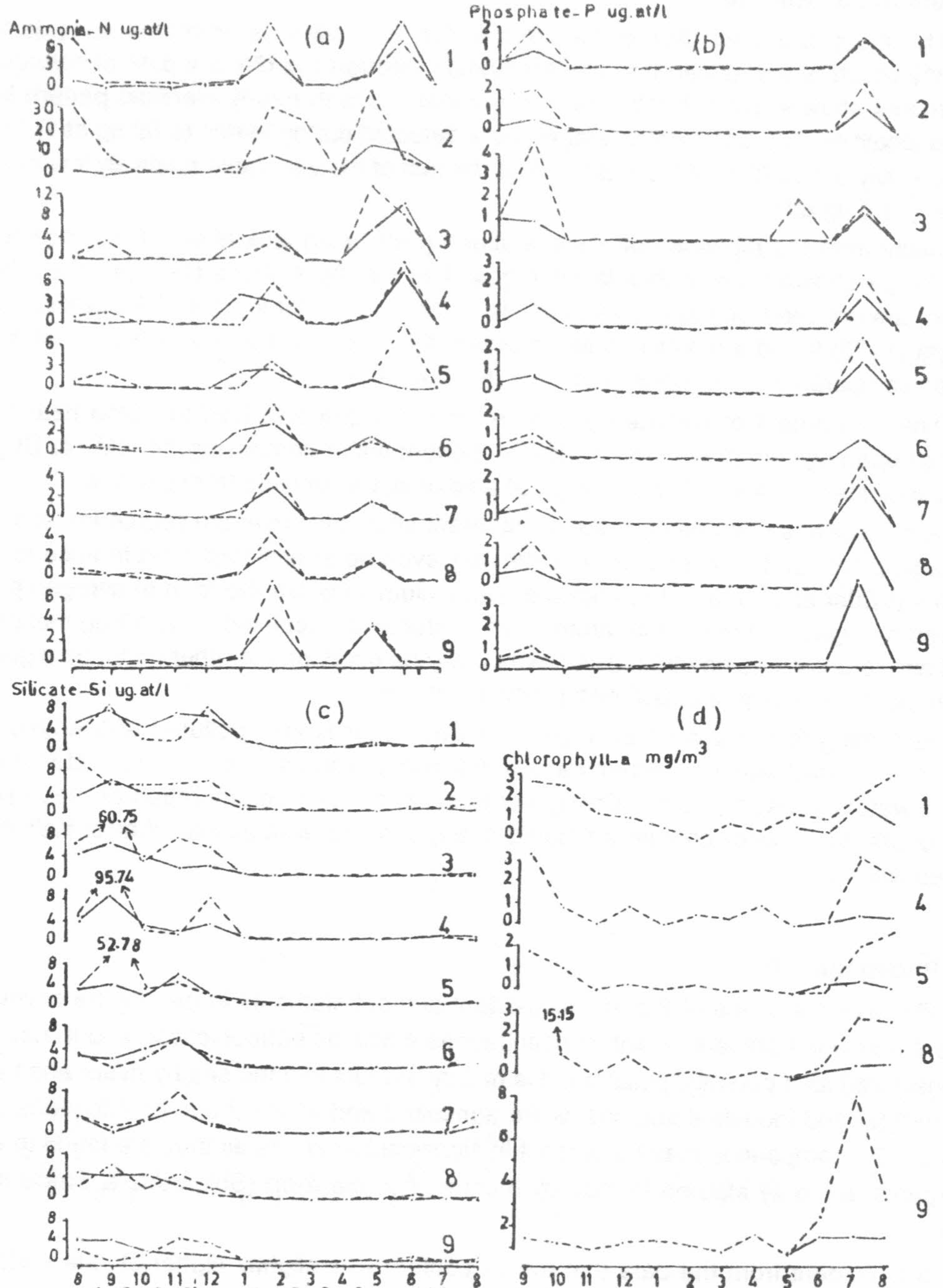

Fig.(3)

Monthly variations of ammonia (a), phosphate (b) and chlorophylla (d) in surface ______ and bottom waters --------- at stations during 1987-1988.

At St. 4, P - concentration in the surface water showed its maximum value which exceeds 7 times the bottom content. A gradual increase of the average phosphorus content in the surface water westwards starting from 0.29 ug at/1 at St. 1 to 0.86 ug at/1 at St. 4 was observed. No trend could be detected among the offhore localities.

Phosphorus showed slight monthly fluctuations (0.02 - 1.85 ug at/L). Two summer peaks were recorded during July and September (5.51 and 7.73 ug at/1 respectively), Fig. (3 b). The maximale values in surface water were exactly coincident with the chlorophyll maximum and salinity minimum. As expected, the spring phytoplankton bloom causes a drastic decrease in the P - content or a complete depletion which extends till winter months.

The water current produced by the prevailing wind affects markedly the nutrient distribution in this open area making the P - content around 0.53 ug at/1 in the surface water and 0.28 ug at/1 in the bottom ones. The overall average of P is higher than that recorded by Asaad (1981) in the open Mediterranean sea in front of Alexandria (2.2 folds).

e) Silicate - Si

Sillicate is brought into the seas by fresh water discharge from the rivers or from sewage outfalls. Its seasonal and temporal variations are also infleunced by uptake, sedimentation and remineralization of silicate by diatoms.

The monthly distribution of ions showed a more or less identical pattern for the different localities (Fig. 3c); one or two peaks were detected clearly during September and November or December followed by a sudden drop in concentration as the water temperature tends to decrease. The water column was nearly depleted in silicate during winter and spring bloomings of diatoms after which the ions tend to increase again.

The high values of silicate (53-96 ug at/1) recorded during September in the surface water of stations 3, 4 & 5 are mainly due to the strong effect of sewage discharge which reduces the water salinity (22.5 - 30.0%).

Although a chlorophyll maximum was found in the surface water during September, the silicate content was still high because there are no diatom bloom during the warm season (Fredrik & Lars, 1988). The role of phytoplankton uptake in silicate removal from the water is clearly apparent during winter and spring seasons (January - March).

On average basis, the silicate content in the surface water at the nearshore stations is about two times higher than that of the bottom ones suggesting its origin (sewage). During September, the surface water value rose to 10-13 times that of the bottom. Away from the outfall, the ions content showed slight vertical gradient.

A strong negative correlation (r = - 0.85) was found between silicate and salinity, but this weakens downwards (r = - 0.15 for the bottom water) indicating the allochthonous origin of silicates.

Nutrient Ratio

Nitrogen, particularly ammonia, tends to increase markedly towards pipeline openings rather than phosphorus (raised N : P ratio, 17-27). Although the relative low P - content at most stations located away from sewer, the N : P ratio tends to decrease probably due to the comparable faster assimilation process of N. than P.

Si : P ratio showed a more or less similar trend as N : P ratio where the nearshore water gave higher ratios than that at the offshore samples (nearly double). The Si : P ratios, in general, are low being (2-10).

The P : N : Si average ratio of 1:9:6 for the studied area deviate markedly from the normal oceanic ratio as well as from the nearer polluted semienclosed area; ie., the eastern and western harbours.

f) Chlorophylls

Four Chlorophylls (Chl.) are found: Chl.-a, Chl.-b, Chl.-c and Chl.-d. Chl.-a is the primary photosynthetic pigment in marine plant algae and phytoplankton, but the other forms have a limited distribution and little significance. Determination of Chl.-a is considered as the most common method for measuring the phytoplankton biomass of aquatic environment (Carlson, 1971).

Chorophylls-a, -b and -c showed their peaks during warm September at St. 8 located in front of the pipeline openings, being 15.15, 19.28 and 48.46 mg/m^3 respectively, Fig. (3d).

In the Kait Bey water, the average Chl.-a, (1.40 mg/m^3) is close to the findings of Moustafa (1985) for the Egyptian coast surface inshore waters. His value for the offshore water is about 0.28 that of our overall average.

Chl.-a showed a wide variation. During September and July, maximal values of 15.15 and 8.32 mg/m^3 respectively were found in the surface water. These peaks coincided with lower salinity averages (33.833 & 36.729%), lower sechi disc readings (4.0 & 3.7 m), high values of oxidizable organic matter (2.0 & 1.0 mg/l), high phosphorus averages (1.85 & 2.42 ug at/l) and high silicate average (15.03 ug at/l). The low values of Chl.-a, on the other hand, was accompanied by more or less reversible conditions.

It is evident from the data that P, and not N, is good correlated with Chl. a ($r = 0.48$), while silicate showed a weak correlation coefficient ($r = 0.14$) with P. The water temperature activates the photosynthesis process and, consequently, raises the Chl.-a content ($r = 0.56$). A significant correlation was found between the pH-value and Chl.-a ($r = 0.33$). Water transparency, on the other hand, showed a negative correlation with Chl. a ($r = - 0.30$).

Conclusions

Eventhough the great huge amounts of untreated domestic water discharge at Kait Bey àrea, the change in nutrient level and chlorophylls content is still not great. This is probably due to the effect of surface currents which are mostly directed away from the coast under the prvailing wind. The relative enrichment of surface water in the vicinity of the outfall openings with nutrient and chlorophylls indicate their allochthonous origin (sewage). As a result of these significant nutrient inputs; particularly P, there is marked chlorophyll contents and consequently dense biomass. A positive correlation is found between Chl.-a and P (r = 0.48), and to a less extent with silicate (r = 0.14).

Near the outfall openings a more rapid increase of N than P was detected giving high N/P ratios, while away from the pipeline a reversiable condition was detected. The calculated low Si : N : P ratio, in general, is contributed to the silicate depletion by diatoms and the slower turnover rate than that of P.

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