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DISTRIBUTION OF NUTRIENT SALTS IN THE WATER AND POREWATER OF THE WESTERN HARBOUR OF ALEXANDRIA, EGYPT.

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ABSTRACT

Water and surface sediment samples were collected seasonally during the year 1985 from nine stations in Alexandria western harbour. The nutrient salts; Phosphate, Nitrate, Nitrite and Silicate as well as Ammonia concentrations were studied in water column and porewater of sediment. Seasonal distribution paterns of the nutrient contents were detected at different parts of the harbour. The P : N : Si average ratio, which is 1 : 23 : 27 in the water and 1 : 129 : 49 in the porewater of the harbour, deviate strongly from the normal oceanic ratio. The sediment interstitial water contains much nutrient concentrations than the overlying water column, particularly ammonia, silicate and phosphate.

The concentration ratios of (porewater: water) for different nutrient salts are calculated. The harbour receives Pollutants; drainage and industrial waters from El-Noubaria canal and domestic wastes at El-Mahmoudia area, the pollutants disposed into the harbour may creat an eutrophication condition not greatly different from that in brackish Egyptian delta lakes.

INTRODUCTION

The western harbour of Alexandria is considered one of the most important trade harbours in Egypt. It lies to the west of Alexandria city along the Mediterranean coast and almost completly surrounded by land and artificial break waters. The harbour is elliptical in shape with a length of 4.8 km and a maximum breadth of 2 km. It occupies an area of 1,862 acres with a maximum depth of 16 m. The harbour could be divided into two parts separated by the line running across the coal quays and the inner break water. The eastern part is known as the inner harbour while the western part is known as the outer harbour (Fig. I). The sediments on the bottom of the western harbour is mainly muddy to sandy mud , mostly covered with sludge which include high content of organic constituents and heavy metals (Rifaat, 1982). The harbour handels most of the Egyptian external trade such as industrial products, agricultural crops as well as considerable

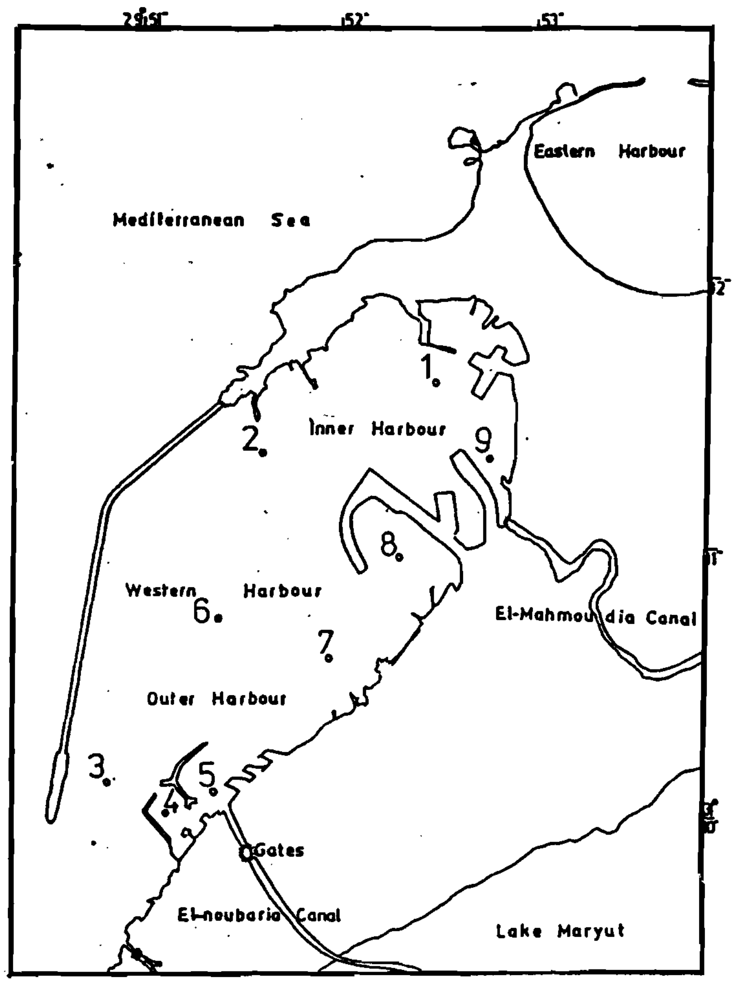

Fig. (1)
Alexandria western Harbour, location
of sampling stations.

amounts of Oil. In addition to hunderdes of passenger ships, mainly tourist, are received annually by the harbour.

A few studies, mainly geochemical and hydrographical, had been done on the harbour starting from Steuer (1939) to El-Awady (1972), El-Wakeel (1964), ElWakeel and El-Sayed (1978) and Rifaat (1982).

The harbour receives huge amounts of polluted water exceeding 13 million cubic meters daily, includes industrial, agricultural and domestic wastes. A small canal, El-Noubaria, passes across lake Maryut inflow into the outer harbour and discharges daily about 90,000 m^3 of fresh water loaded with suspended material. Another canal, El-Mahmoudia, used to open into the inner harbour through water- gate but recently it seized to flow in.

The present work deals with the distribution patterns of the nutrient salts in the harbour to asses the degree of its eutrophication results from the pollutants disposed into it. The adsorption or release of ions from the sediments and the ratio of P : N : Si were also discussed.

MATERIALS AND METHODS

Water sampling was carried out using a flat type Ruttner plastic sampler of 21 capacity. Nine stations were selected to represent the different regions of the harbour (Fig. 1). All stations were sampled once every season during the year 1985. Water samples were collected at the depths 0, 5, 10 and 15 m. At each station, a surface sediment sample was taken using a grab sampler. Pore water was obtained from the sediment through its centrifugation immediately after collection.

Ammonia as well as Phosphate, Nitrite, Nitrate and Silicate were analyzed in water and pore water samples according to the methods described by Grasshoff (1976). A Shimaduze double - beam Spectrophotometer UV-150-02 was used for the colorimetrically measurments.

RESULTS

The Effect of Pollutants on the Nutrient Chemistry

Owing to the relative shallowness of the harbour and its semienclosed shape the temperature of its water was slightly higher than that of the open water and varied from 15 to 27 °C. The salinity average of the harbour water of 37‰ was significantly lower than that recorded in the Mediterranean water, El-Rayis (1973). Morcos and Hassan (1973) found a range of (39–39.4‰) in front of the harbour. El-Awadi (1972), on the other hand, recorded a minimum salinity of 4.46‰ at El-Mahmoudia area (St. 9).

The investigated area was well oxygenated during most of the year. Dissolved oxygen was occasionally reduced or completly depleted in the inner harbour during summer and autumn seasons. The domestic, drainage and industrial waters loaded with suspended material and discharged into the harbour may be responsible for the decrease of dissolved oxygen content and salinity.

Phosphate - P:

Seasonal variation of Phospate-P in the harbour water was found in between 0.0 and 11.9 ug-at/l. The concentration of phoshate-P showed nearly complete depletion in the harbour water during autumn, the highest concentration was recorded during winter. On average, the winter value of 1.88 ug-at/l is nearly two times greater than that of spring, three times of summer and exceeds 25 times that of autumn value.

The drainage water inflowing through El-Noubaria gates, loaded with considerable amounts of phosphate resulting from the washing of phosphorus fertilizers used for winter crops (Shaheen and Yosef, 1978), is responsible for the enrichment of the harbour water with these ions during winter. This was clear at El-Noubaria area during winter where the bottom water showed maximum phosphate-P content. Through the adition of sewage, some industrial products and detergents, the phosphorus concentration in the harbour water tends to increase markedly. The accumulation of phosphate recorded during winter in the surfcae water at most stations (Fig. 2) was realized in saline and brackish waters by many authors; Harvey (1955) in sea water, Aleem and Samaan (1969) in lake Maryut and El-Wakeel and Wahby (1970) in lake Manzalah. In general, the total average of phosphate-P content of 0.84 ug-at/l in the harbour water was greatly higher than the values given for the Mediterranean water in front of the harbour, where the average concentration did not exceed 0.18 ug-at/l (Asaad, 1981).

Ammonia - N:

Ammonia concentration in the harbour water was high (0.05 - 115.8 ug-at/l) with an average of 15 ug-at/l. High averages were found during autumn (31.7 ug-at/l) and summer (25.7 ug-at/l) while the averages recorded during winter and spring did not exceed 2.6 ug-at/l. The high values (>100 ug-at/l) recorded near stations 8 & 9 during autumn were mainly attributed to the decaying processes of extra organic substances accumulated during summer stagnation. The ammonia produced at these two areas is 2 - 5 times greater than that for any studied station.

The pore water was highly enriched with ammonia at any point of the harbour allover the year, being on average, greater by 180 times than the water above. The sediment at El-Mahmoudia area exhibited in its pore water a maximum concentration of ammonia during autumn, up to 12 mg. at/l. This is mainly attributed to the domestic wastes inflowing into the inner harbour.

Nitrite - N:

The harbour water showed a wide range of nitrite content than that recorded by Asaad (1981) in front of the harbour. The seasonal variation of nitrite was similar to that of phosphate; a peak in winter, was followed by a gradual decrease till autumn. The winter average of 0.433 ug-at/l was 1.5 times greater than spring, 2.3 times of summer and exceeded 11 times the autumn value. The well oxygenated sea water flow into the harbour under the northerly or northwesterly winds may accelerate the oxidation of these unstable ions, dilute or deplete it from the water column during autumn.

Similar to ammonia pattern, the annual average of nitrite concentration at most stations was more or less identical, around 0.2 ug-at/l, the averages at stations 8 & 9 were nearly douppled.

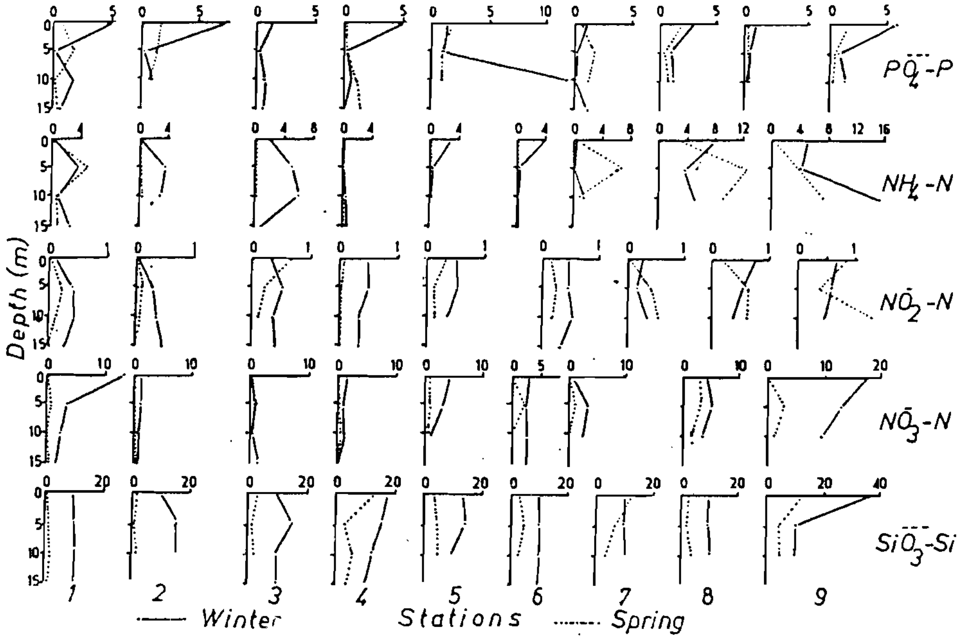

Fig. (2)
Vertical variations of nutrient salts (μg. at / l) in the western Harbour water during winter-spring, 1985.

The disappearance of nitrites from pore water takes place faster than in water column. Summer and autumn pore water samples were completly free from nitrite. The sediment fluid at St. 6 had a maximum concentration of 10.9 ug-at/l during winter which is 18 times greater than the average concentration of nitrite ions in the water column. According to the total average of nitrite, the pore water value is aboutly 2.5 times greater than the water one.

Nitrate - N:

The distribution pattern shows nitrate - poor seasons; spring and summer followed by nitrate-rich seasons; autumn and winter, which in a good agreement with the founding of Morcos and El-Rayis (1973) off Alexandria. The autumn average of 7.38 ug-at/l is nearly two times greater than winter, four times than summer and exceeds eight times than spring value. Complete depletion of nitrate from the water column rarely happened and the uptake of phytoplankton and algae during spring did not exhaust all of nitrate. The surface water was mostly richer in nitrate than the bottom water, the ion content reached 17.9 and 22.6 ug-at/l in the surface water at El-Mohmoudia area during winter and autumn, respectively (Fig. 2 & 3). The

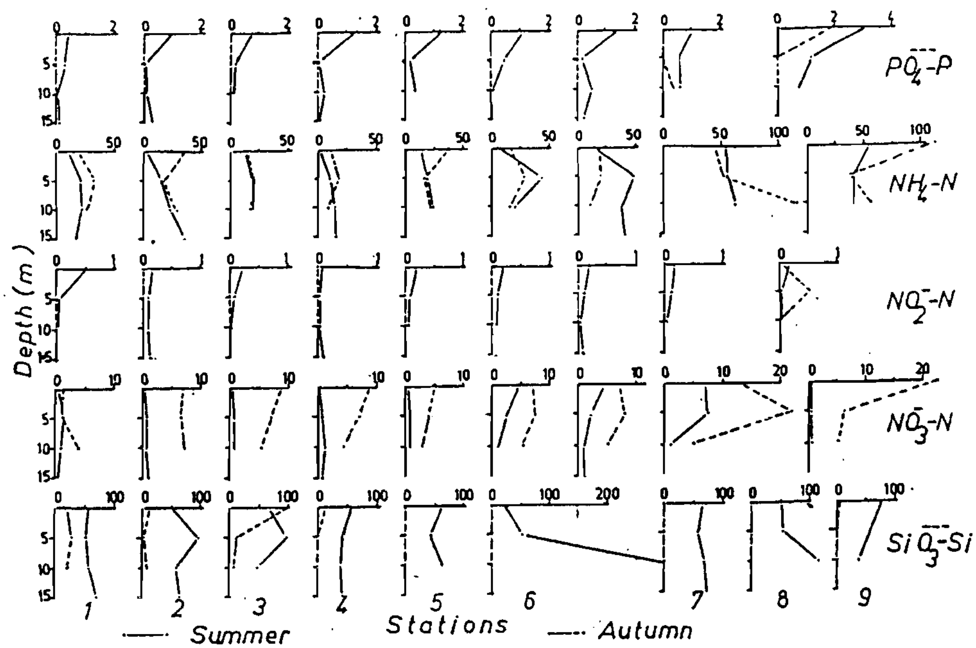

Fig. (3)
Vertical variations of nutrient salts (μg. at. / l) in the western Harbour water during summer-autumn, 1985.

nitrate concentration in the bottom water, on the other hand, at this area did not exceed 10 ug-at/l. Similar to nitrite condition, the annual average of nitrate at each of stations 8 & 9 (round 6.6 ug-at/l), was more or less twice the average of the other stations.

The pore water at stations 4 & 5 was relatively high enriched with nitrate during winter (25 ug-at/l), this may be correlated with the phosphate pattern, and this was mainly due to the arrival of drainage water loaded with nitrogenous and phosphorus fertilizers, which washed from agricultural land during winter crops. The drastic depletion of nitrite and nitrate from the pore water during autumn was met with a drastic apperance of ammonia. The seasonal average of nitrate in pore water was not so differ from that of water column during spring or summer, while was 3 times greater for winter samples.

Silicate - Si:

The seasonal variations of silicate in the harbour water showed wide range of concentrations (0.0 - 300 ug-at/l) with an average of 23.6 ug-at/l. The summer average, the highest, was nearly 6 times greater than winter, 8 times than autumn and exceeded 16 times than spring ones. On average, the adjacent water to the west of Alexandria analyzed by Asaad (1981) was relatively very low in its silicate cotent and exhibit only 1/5 the concentration in the harbour water. The increase in the silicate content in the harbour water can be attributed to the influx of drainage water rich in silicate into it.

The silicate concentration in the pore water was greatly fluctuated (4 - 3125 ug-at/l) with an average of 1981 ug-at/l which exceeds 40 times the silicate average in the water above. Seasonal variations of silicate in the sediment fluid follow that in the water; the high summer average is more than two folds of winter, four folds of autumn and exceeds than 28 folds of spring ones. The spring decline shows the exhaustion of silicate due to diatom bloom.

DISCUSSION AND CONCLUSIONS

Eutrophication along the Mediterranean coastal waters or lakes and semiclosed harbours is an important problem in the Mediterranean district. Among the nutritional elements essential for algal growth nitrogen and phosphorus and to a less extent silicon are generally considered as the perincipal factors responsible for eutrophication. Furthermore, nitrogen and phosphorus in the eutrophicated zone are mainly of antropic origin (Chiaudani, Gaggino and Vighi, 1980). It is always observed that phosphorus is generally associated with domestic sewage in Mediterranean coastal waters (Hardy and Jubayli, 1974). Therefore, the high phosphorus and organic matter levels in our harbour particularly at El-Mahmoudia area could be considered as indices of the sewage pollution. Phosphorus is easily adsorbed on fine sediments (Jitts, 1959) and this met the high concentration of it in most of pore water samples taken during spring - summer stagnation. On the contrary in autumn, when the sediment surface under stirring effect is aerated, phosphorus tends to decrease to a very low value (Mortimer, 1971).

The pore water was highly enriched with phosphate-P, reached to 65 ugat/l, which is precipitated, adsorbed and trapped on the bottom sediments. The phosphate concentration increased in the sediment fluids from winter (17.75 ug-at/l) through spring (25.56 ug-at/l) till summer stagnation (40.66 ug-at/l) after which it was depleted and washed out from the sediment under the effect of fall overturn and the renewal of the harbour water.

High concentrations of nitrate - N observed during winter were propably developed from the large input of nutrients in front of El-Mahmoudia and El-Noubaria gates in addition to the oxidation of most of stored ammonia. In anoxic condition occurred in most of the surface sediment during summer - autumn period, nitrite and nitrate tend to disappear while ammonia accumulates in the interstitial water. A high content of ammonia in the pore water is of particular importance for N- fixation (Olah, Abdel Moneim and Toth, 1983).

The ratio of N to P by atoms, presented in table 1, deviates much from the normal ratio found by Richards (1958) in north Atlantic (16:1). Chiaudani and Vighi (1978) demonstrated that marine algae, in general, are P-limited when N/P ratio is>6 and N-limited when this ratio is <4.5. In the range of 4.5-6 the two nutrient elements are near the optimal assimilative proportion. The mean annual ratio (Table 1) of 23 in the water and 129 in the pore water suggest that P is, in general, the most limiting factor for the growth of the algae in the harbour. However, the ratio tends to decrease below 4.5 in winter and spring and Nitrogen becomes the limiting factor which agree with the finding of McGill (1965). This indicates also that the assimilation of inorganic N is faster than P. In front of the harbour, El-Rayis (1973) and Asaad (1981) found similar low N/P ratio of (4:1). The drainage water loaded with P-fertilizers may be responsible for diminishing the ratio during winter and spring seasons. The high ratios calculated for summer and autumn are mainly due to the extra production of ammonia in the final step of degradation process of organic nitrogenous matter accumulated during summer and from allochthonous origin e.g. sewage input.

TABLE (1)

Seasonal average ratios (Phosphorous : Nitrogen : Silicon) in the water (W) and interstitial water (I W) in the western harbour of Alexandria during 1985.

Season		P	N	Si
Winter	W	1	3.6	6.2
	I W	1	60	1
Spring	W	1	4.2	5
	I W	1	163	3.3
Summer	W	1	45	111
	I W	1	50	67
Autumn	W	1	559	119
	I W	1		
Annual average	W	1	23	27
	I W	1	129	49

Si/P ratio in the harbour water showed more or less analogous seasonal trend; in winter and spring<10 and exceeds than 100 during summer and autumn. The mean ratio of 27 is in a good agreement with the finding of El-Rayis (1973) and Asaad (1981).

In the interstitial water N/P ratio was not below 50 and the annual mean ratio is exceeded 5 folds that of the water above. The Si / P ratio in the pore water is greatly fluctuated (1-57).

The average concentration proportion (pore water : water) are 23 for phosphate-P, 183 for ammonia-N, 2.4 for nitrite-N, 0.9 for nitrate-N and 42 for silicate-Si. These ratios revealed the great capacity of the bottom sediment of the harbour to trap and storage most of the nutrients. The adsorption processes and the ions exchange between sediment and water depend on different electrochemical properties of the interface (Serruya, Picard and Chilingar, 1967) and thus it would advisable to study carefully all factors affecting the interface; the deposition or the release of the fixed nutrients to diffuse again into the water.

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