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EFFECT OF POLLUTION ON THE CHEMICAL COMPOSITION OF THE WESTERN HARBOUR WATERS (ALEXANDRIA).

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ABSTRACT

Western Harbour water was analysed for salinity, pH, dissolved oxygen, ammonia, organic matter and H_2S in addition to temperature and transparency measurements. The pollutants dissposed into the harbour changed its water composition, as mainfested by low values of oxygen and salinity, high values of ammonia and organic matter and appearing of H_2S.

INTRODUCTION

The most important harbours in Egypt is the Alexandria Western Harbour. It lies along the Mediterranean coast in front of the western side of Alexandria city. The Harbour has an area of 7.54 Km^2 with a maximum depth of 16 m and connected to the sea by a narrow mouth "El-Boughaz". It is divides to two parts; inner and outer Harbours (Fig. 1). The Harbour receives more than 90,000 m^3/day of domestic, industrial and drainage waters through El-Noubaria canal in addition to a certain amount of untreated domestic water inflowing into the Harbour from several outlets as well as changeable amounts of oil and chlorinated hydrocarbons. Outside the harbour a quantity of polluted brackish water, 6 million m^3/day is discharged from El-Mex Pumping Station and could partially be introduced into the Harbour under the effect of westerly wind.

As a result of uncontrolled discharge of unprocessed pollutants, the water composition tends to deviate from normal. The chlorinity ratios of the major constituents; Ca^{++}, Mg^{++}, SO_4^{--}, Br^- and specific alkalinity declined significantly from the oceanic ratios (Nessim, 1988). The Harbour water and sediment tend to be enriched with nutrient salts (Nessim and Tadros, 1986). The concentration of heavy metals such as Fe, Cu and Mn was also higher than that in the open water (Tadros and Nessim, 1988).

The present work aims to investigate the effect of sewage, drainage and industrial waters on the constitution of the Harbour water.

MATERIALS AND METHODS

Water samples were collected seasonally during 1985 at selected nine stations (Fig. 1) at different depths. Interstitial water samples were also obtained by centrifugation of sediments collected at the same stations. Water temperature was determined using an protected thermometer fixed

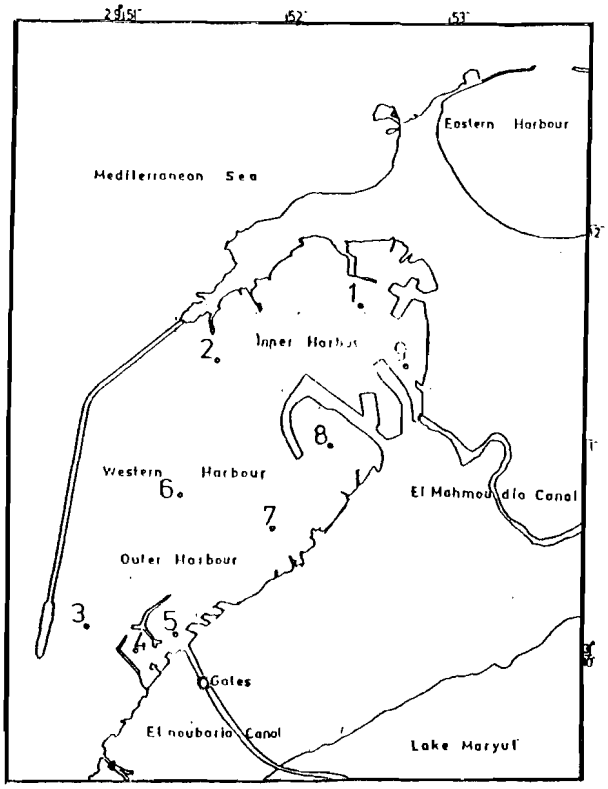

FIG. 1
Alexandria western harbour, location of sampling stations.

in the reversing bottle. Transparency was measured by means of enamled white secchi disc, 25 cm in diameter. the pH-values were determined on board using a portable pH-meter. Salinity was calculated from the electrical conductivity measured by induction salinometer, Beckman, Model R.S. 7B. The determination of oxidizable organic matter was done according to Carlberg (1972). Dissolved oxygen as well as ammonia determinations were carried out according to methods described by Grasshoff (1976). H_2S was analysed titrimetrically in anoxic water samples according to the method mentioned in Standard Methods of Water and Waste Water Analysis, publiched by American Public Health Association APHA (Anon., 1965).

RESULTS AND DISCUSSION

Temperature

Natural water temperature, which follows more or less air temperature, is greatly influenced by several factors such as location, season, wind, depth and turbidity. Winter data, as expected, represent the lowest values (16.9-18.4°C) and the summer the highest (26.2-28.8°C) with an annual amplitude of about 12°C which is identical to the finding of Shriadah (1982) for the Eastern Harbour water. According to seasonal average, a gradual increase in water temperature (Fig. 2) was measured in winter (17.5°C) through spring (21.1°C) to summer (27.1°C) followed by a sharp decrease during autumn (22.0°C) which is found in a good agreement with the average taken by El-Awady (1972). Almost 80% of his results indicate slight higher temperatures in the inner harbour than those in the outer harbour waters. In general, the water temperature tends to decrease seawards. El-Boughaz area showed lowest annual average of 21.4°C while El-Mahmoudia water gave highest one being 22.2°C.

Although the Western Harbour lies in a semi-enclosed area and its water mass is separated by several quays, a complete water stratification could not be detected. The relative shallowness of the Harbour water and the turbulence caused by ships in addition to the currents caused by water inflow are responsible for the nearly homothermal condition in the water column. Slight vertical gradient was detected as shown in the following table:

Seasons	STATIONS								
	1	2	3	4	5	6	7	8	9
Winter	0.5	0.4	0.5	0.3	0.4	0.5	0.4	0.3	0.4
Spring	1.1	1.1	1.4	2.2	0.7	1.4	2.7	1.4	2.2
Summer	1.1	0.5	0.9	2.0	0.8	1.6	2.4	0.9	0.8
Autumn	0.3	0.1	0.2	0.1	0.7	0.1	0.1	0.2	1.0

70% of data showed gradient below 1°C, maximum gradients were noticed at station 7 during spring and summer, being 2.7 and 2.4°C, respectively. In front of El-Noubaria gage the water coulmn was neraly mixed allover the year (gradient, 0.8°C).

Transparency:

Light penetration measurements in the Harbour water showed low values during spring and summer (100-135 cm, on average), the water was much transparent (215-250 cm) during winter and autumn seasons. The more polluted areas near the outlets at El-Mahmoudia area as well as in front of El-Noubaria Canal showed turbid water particularly during summer where secchi disc readings did not exceed 50 cm.

The exhaustion of floating, suspended or dissolved materials from great numbers of vessels entered the Harbour, domestic, silty or dusty wastes

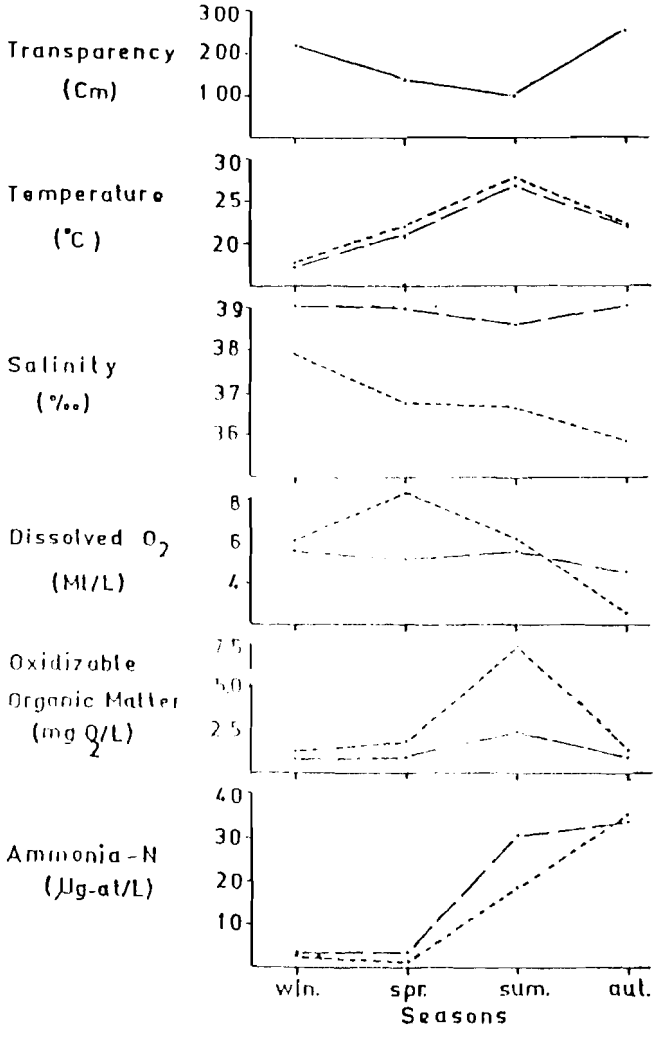

FIG. 2
Average of seasonal variation of different studied parameters in surface (..-..) and bottom (.-.-) waters in the western harbour of Alexandria during (1985).

discharged from several outlets and from El-Noubaria Canal, considerable amounts of oil and coal dust as well as sinking materials in addition to the plankton bloom during spring and summer contribute the relative low transparency of the Harbour water. The relative shallowness of the Harbour water as well as its semi-enclosed configuration may act as additional factors for its low transparency. The northerly and westerly winds blowing on the Mediterranean coast show a considerable effect on the Harbour water transparency (El-Awady, 1972). The inflowing of great amounts of clear sea water into the Harbour under the effcet of wind dilute its water turbidity and increases its water transparency as recorded at St. 2 during autumn (400 cm).

Salinity:

Salinity of the Harbour water is affected by several factors such as; the water exchange between open sea and the Harbour, the disposed sewage, domestic, industrial and fresh waters in addition to evaporation, raifall and other physical and climatic conditions. On the surface, water salinity averages 33.464‰, while on the bottom water is relatively higher (37.795‰-39.935‰). All these extremities were recorded during spring. Salinity of the Harbour water, on average, (38.030‰) is relatively lower than that recorded in the open water (39.0‰) by Morcos and El-Rayis (1973).

The seasonal changes in salinity of surface water were high and reached 4.213‰ which is 12 times greater than that for the water at El-Mex area (Asaad, 1981). According to the seasonal average salinity of the surface water tends to decrease starting from winter till autumn (Fig. 2) while in the bottom water the variation is low. The bottom water is less affected by the pollutants and fresh water and its salinity shows slight seasonal variation (< 1.5 ‰).

In the Harbour water, salinity gave irregular vertical variation, the highest gradients were recorded at the Harbour-Sea opening area, being 5.585‰ during spring and 4.273‰ during summer, reflecting the inflow of El-Mex brackish water into the Harbour.

At El-Mahmoudia outlet area, where the most polluted water in the Harbour, salinity gave the lowest value of 20.111‰. El-Awady (1972) found salinity below 5‰ in the surface water of the same area. However, the annual average of salinity at this station was below 37‰. El-Noubaria and El-Boughaz regions, receiving brackish water, showed averages below 38‰. The other stations are less affected with dilution and showed averages around 38.250‰.

Interstitial water showed wide variations in salinity (22.140-48.160‰) with an annual average of 38.130‰ which is closely similar to that of the water column. The proportion of salinity ratio (interstitial water/water column) varied from 0.86 to 1.11.

Hydrogen Ion Concentration:

The pH of the Harbour water was slightly low relative to the open water off Alexandria (Emara, 1969). It depends on a compination of factors; algal photosynthetic activity, water temperature, dissolved oxygen content and sewage discharge. Hence it contains weakly dissociated acids and basis as well as organic matter.

The pH value in the surface water of the inner Harbour, particularly close to the outlets of El-Mahmoudia district, was low (8.0) relative to that of outer Harbour. The surface water, in general, is slightly higher in its pH value (7.05-8.35) than the bottom one (7.00-8.10). This is due to the increase of photosynthetic activity near the surface which reduces the amount of CO_2 in water. The low pH value of bottom water is mostly due to the decomposition of organic matter, plants and organic remains near the bottom and sulphide accumulation (Strom, 1936). The pH-gradient downwards the water column varied from (0.00-0.20) during winter turbulence to (0.00-1.15) in summer.

The pH of the interstitial water (5.55-7.75) was lower than that of water column, while most of spring and summer samples were neutral or slightly alkaline. The partial and temporary stagnation occurred at certain areas during spring and summer, associated relative high temperature and allowed much precipitation and decomposition of organic matter in the sediment, contrary to the complete mixing condition during winter and autumn and renewing the water column. The interstitial water at the central part of the Harbour as well as at El-Boughaz region showed lowest pH values during summer.

Dissolved Oxygen:

The oxygen condition in the Harbour water is changeable depending on several autochthonous and allochthonous sources. During spring algal bloom, an oxygen peak was noticeable after which a gradual decrease in summer and autumn values was detected (Fig. 2). 77% of winter samples were found in supersaturated condition (> 100% O_2 sat.), decreased to 70% in spring, 61% in summer and only 15% in autumn. A great gradient in oxygen content was detected downwards during spring (8.75 ml/l at St. 7), reduced in winter and summer or reversed in most of autumn samples. The surface water at the latter station was supersaturated with oxygen (> 100% O_2 sat.) along the year with a maximum of 265.6% during spring. Most of the outer Harbour waters (Fig. 1) were well oxygenated (5-6 ml O_2/l). El-Noubaria area was considerably affected with drainage and industrial waters with poor oxygen. The anoxic or poor oxygenated water noticed at El-Mahmoudia area during summer and autumn, influnced by sewage, was accompanied by a high ammonia content (Nessim and Tadros, 1986). Nitrogen, present in a reduced organic nitrogen form, may be responsible for this anoxic condition (Wahby et al, 1976). Hydrogen sulphide of apparent smell at ElMahmoudia area (6.0 mg/l, on average) was mainly produced through the decomposition of organic effluents from discharghed sewage and other wastes.

Oxidizable Organic Matter:

Organic substances in the Harbour water are mainly produced through the decomposition of domestic and industrial wastes discharged from several sewers into the Harbour as well as from El-Mex Pumping Station through El-Boughaz opening, also from the decaying of planktonic organisms, particulate organic detritus and vessel remains near the bottom.

The surface water was highly enriched with organic matter, particularly near the outlets and during summer, being equivalent to 6.0-8.7 mg O_2/l. The summer average of organic content in the water column was 3 times greater than that for the rest of the year (Fig. 2). In winter the Harbour water was completly mixed, considerable oxidation of organic matter through aeration was happened, and low values (0.72-1.71 mg O_2/l) were obtained. Bottom water was still nearly similar to normal open sea in its organic content and less affected by surface allochthonous organic supplies. Very low organic contents (0.04-0.07 mg O_2/l) were detected during spring in bottom waters at El-Boughaz and central parts of the Harbour,demonstrating by sea subsurface water layer with high salinity introduced into the Harbour.

Regionally, the two areas at El-Mahmoudia and St. 7, situated in front of several outlets showed a highest annual average, 2.3 mg O_2/l, decreased to 2.0 mg O_2/l at El-Noubaria area. The rest of the stations showed relative low averages (1.5-1.8 mg O_2/l).

Broad variation in organic content between interstitial water and water column above was noticed. Interstitial water exhibit, on average, 24 times as much as organic content in the water above. The lowest value of 2.6 mg O_2/l in the interstitial water was detected at El-Boughaz station (sandy sediment) during winter turbulence, while the highest values (>110 mg O_2/l) were recorded at St. 2 during summer and autumn.Interstitial organic content is controlled with several factors such as sediment grain size, water movement and sewage discharge.

Ammonia Nitrogen:

Ammonia is found in the Western Harbour water as a result of biological processes and decomposition of organic substances as well as allochthonous constituents in industrial and demostic wastes. Its amount is high ranging between 0.05 and 115.8 µg at/l with an average of 15.0 µg at/l. The high averages of 25 µg at/l were found in autumn and summer samples (Fig. 2). Winter and spring averages did not exceed one tenth this value (Nessim and Tadros, 1986).

El-Mahmoudia outlet area, and the area adjacent to St. 8 are directly subjected to sewage discharge. Their waters showed high ammonia averages, being two times greater than those for the other stations. Near Sea-Harbour connection ammonia content tends to decrease.

The amount of undissociated ammonia, which related to pH (Mckee and Wolf, 1963) and temperature (Ball, 1967), determine the lethal limit for

the marine organisms. Applying the calculation of Emerson et al.(1975), the maximum undissociated ammonia in the Harbour water amounted to 5 µg at/l. Edwards and Brown (1967) and Herbert (1963) recorded an undissociated ammonia concentration of 0.3-0.4 parts per million as a lethal limit, which is too high than our finding.

A tremendous amounts of ammonia-nitrogen was found in interstitial water, up to 12 mg at/l during autumn at El-Mahmoudia area. The concentration of ammonia-nitrogen in the interstitial water followed more or less that of the water column and exceed 180 times the average and could be harmful to the bottom fauna.

SUMMARY AND CONCLUSIONS

The Harbour receives different kinds of pollutants; drainage, domestic and industrial waters as well as considerable amounts of oil, chlorinated hydrocarbons, coal dust and vessel remains, from different sources such as El-Mex Pumping Station, El-Noubaria Canal, several sewers, vessels and quays. The organic matter and ammonia nitrogen concentrations are high; particularly in the surface water, and several times greater in the interstitial water than those in the open water. Organic matter derived from domestic sewage, ammonia and H_2S are considered as decomposition products of organic substances. The accumulation of these constituents in sediment is a sign of bottom pollution. These components could not completly diffuse into the water column during stirring, resulted in the acidic medium of most interstitial water as well as anoxic condition, particularly at El-Mahmoudia area in summer and autumn.

The continuous water mixing resulted by vessel movements and the currents of disposed water do not allow thermal stratification to persist and help in oxidation of organic matter and consequently self purification. The variations in water temperature, pH, transparency and salinity were found in a good agreement with the other studied constituents.

It is expected that water and bottom sediment pollution in the Harbour will increase unless alternative methods of wastes disposal are adopted.

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