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EFFECT OF THE DOMESTIC SEWAGE DISCHARGE ON THE HYDROGRAPHIC REGIME OF THE EASTERN HARBOUR OF ALEXANDRIA.

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ABSTRACT

The eastern harbour is a shallow, protected, semi-enclosed and circular basin. It receives an amount of about 63,000 m^3/day of unprocessed sewage which affects the physical, chemical and biological characteristics of the harbour waters. The hydrographic parameters namely; water temperature, salinity and dissolved oxygen were studied in the harbour during the period from October 1985 to September 1986.

During autumn season, the water temperature increases seaward. It varies from 18.8 to 23.5°C at the surface and from 18.75 to 23.17°C near bottom. Lowest values of water temperature were observed during the winter months. It ranges between 17.2 and 18.9°C at the surface and between 16.98 and 18.40°C near bottom. The highest values of water temperature at both surface (30.30°C) and bottom (28.50°C) were observed during the summer months.

Salinity of the eastern harbour water increases seaward in October and December, where the maximum values of salinity were observed near El-Boughaz (> 39.00 ‰). The effect of the polluted domestic sewage was clear on the surface salinity during spring and summer months.

During autumn, the dissolved oxygen content in the harbour water varies between 3 and 5 ml/l. While in November, the maximum values 9.43 - 9.65 ml/l were observed at the surface. The decrease in the oxygen content was observed in May, June and July in both surface and bottom waters, while in August, it was observed at bottom water only and during September in both surface and bottom.

INTRODUCTION

The eastern harbour is artificially obstructed from the open sea. It receives an immense anthropogenic input, and the domestic sewage is by far the major source of organic depositions. The daily discharge of unprocessed sewage into the harbour is estimated to be 63,000 m^3, through eleven outfalls of domestic sewage. Large quantities of metals and paint are also dumped into the harbour by the local boatyard.

El-Maghraby and Halim (1959) and Dowidar (1965) studied the plankton, temperature, salinity and nutrients in the eastern harbour of Alexandria. The biology, ecology and hydrography of the harbour has been reviewed by Halim (1973) and Al-Handahl (1979). The levels of heavy metals in surface water of the harbour were studied by El-Sayed et al., (1980). Temperature, salinity and the other chemical composition of the eastern harbour water were studied by Shriadach (1982).

The aim of the present work is to study the hydrographic regime of the eastern harbour and the effect of the domestic sewage discharge on the physical characteristics of the harbour water.

AREA OF INVESTIGATION

The eastern harbour is a semi-enclosed protected embayment covering an area of about 2.8 Km^2 and occupying the central part of the coast of Alexandria. The southern border of the harbour has been reinforced by concrete blocks, the northern one is protected by an artificial break-water. It is bordered to the east by a land projection, El-Silsila, and to the northwest by a long causeway. The harbour is connected with the Mediterranean Sea through El-Boughaz and El-Silsila openings. In most places the harbour is shallow, with an average depth of about 5.0 m. The deepest part of the area (12.0 m) is found near El-Boughaz inlet. The bottom slopes down gradually towards El-Boughaz opening (fig. 1-a).

MATERIAL AND METHODS OF ANALYSIS

During the period from October 1985 to September 1986, a monthly survey of the main hydrographic parameters was carried out in the eastern harbour area. Temperature, salinity and dissolved oxygen were measured at the surface and near the bottom from 10 hydrographic stations (fig. 1-b).

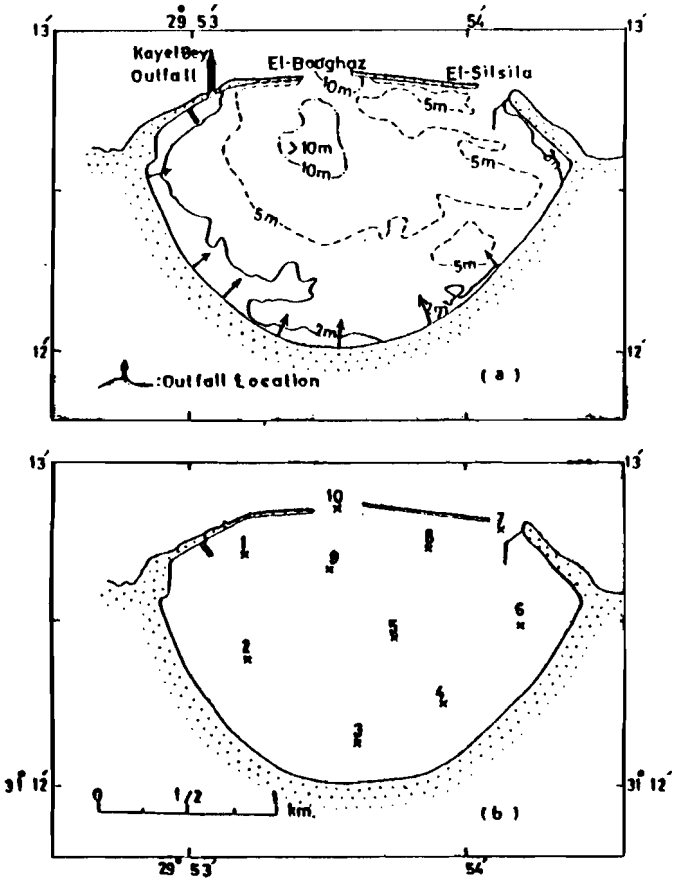

Fig. (1)
a- Area of investigation.
b- Location of the sampling stations.

Water temperature was measured using protected reversing thermomters. Temperature corrections were made using the calibration curves. Salinity determinations were carried out using the Beckman induction salinometer (Model RS - 7C). Dissolved oxygen was determined using Winkler's method (Strickland and Parsons, 1968).

RESULTS AND DISCUSSION

The available statistical information indicates that the total resident population in Alexandria is of about 3 million inhabitants, in addition to the visitors in summer. This makes Alexandria coast one of the relatively dense populated regions of the Eastern Mediterranean. Consequently, a considerable amount of domestic wastes are discharged to the coastal waters in the region off Alexandria. These wastes are directly disposed to the sea by pipelines reaching a distance of 735 m and at a depth of 16 m (Sharaf El-Din, 1976). Inside the eastern harbour there are eleven outfalls which discharge untreated sewage into the embayment (fig. 2).

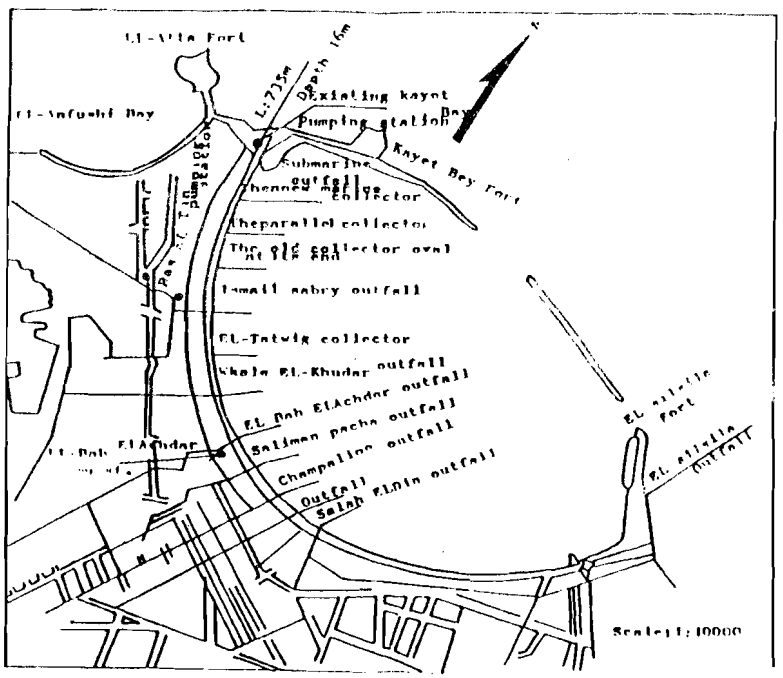

Fig. (2)
The Eastern Harbour area showing the main pumping station at Kayet Bey subsidiary opening.

It was estimated that the Alexandria system of domestic sewage pipelines disposes about 239,000 m^3 of wastes daily (Tech. Rep., 1978), 400,000 m^3/day (Eud, 1979) and is expected to reach 500,000 m^3 of wastes daily in 1986. This domestic sewage is disposed to the sea without any treatment, and thus presents a serious source of pollution particularly for Alexandria beaches which are considered to be the first summer resort in the region. The main sewage tube begins at Kayet Bey Pumping Station laying 350-400 m west of Kayet Bey Fort. It is about 750 m long and 1.25 m in diameter and discharges about 200,000 m^3 of wastes daily (Shridach, 1982).

The actual total yearly discharge through the Kayet Bey outfall and the eleven outfalls inside the harbour during the period (1983-1986) is observed in table (1).

Table (1)

The total daily and yearly discharge throughout Kayet Bey outfall and the eleven outfalls inside the harbour during the period 1983 - 1986.

Year	Amount of discharge million m^3/year	Average amount of discharge m^3 / day
1983	84	230,137
1984	88	241,096
1985	93	254,795
1986	96	263,014

At Kayet Bey Pumping Station, three pumps are at work discharging 200,000 m^3 of wastes daily to the open sea and the differences are discharged into the eastern harbour. This means that, the daily amount of the discharge of domestic sewage inside the harbour increased from 15,000 m^3 (Tech. Rep., 1978) to 30,137 m^3 in 1983 and reached 63,014 m^3 in 1986. This increase in the amount of the discharge affectes the chemical and physical characteristics of the harbour waters and consequently the marine life inside the harbour.

Horizontal Distribution of the Hydrographic Parameters :

The hydrographic data collected from the eastern harbour were divided into four groups to represent the four seasons. Autumn was represented by the data collected from October to December 1985. Winter was represented by the period from January to March 1986, spring was represented by the period of April to June 1986, and the summer was represented by the period July-September of 1986.

(I) Horizontal distribution of water temperature

(i) Autumn season:

During October, the water temperature varies between 21.80 and 23.50°C at the surface and between 21.81 and 23.17°C at the bottom (fig. 3-a,b).

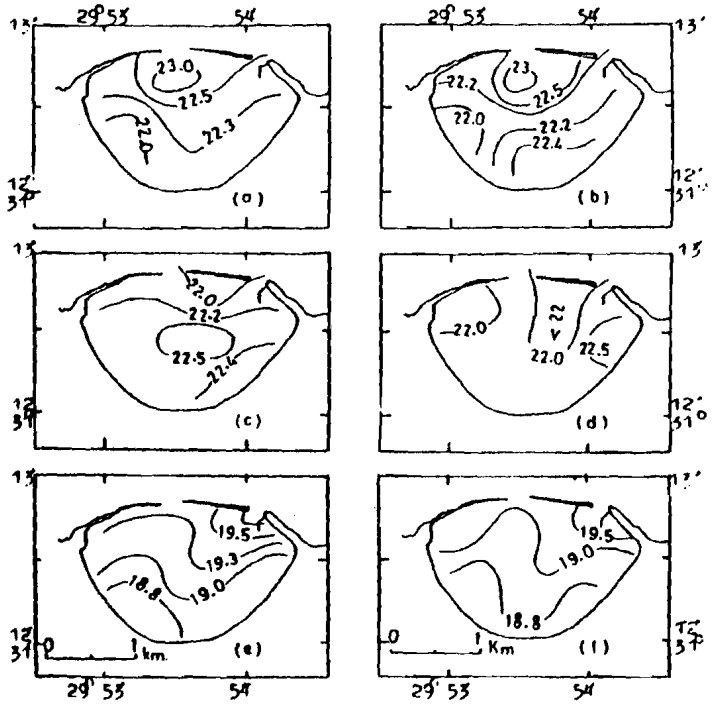

Fig. (3)
Horizontal distribution of water temperature during the autumn months (October, November and December) of 1985.
Left : surface, right : bottom.

The minimum value of temperature was observed near the shore, while the maximum value was observed in the central part of the harbour. Fig. (3-a,b) illustrates the increase in water temperature toward the north far from the shore-line. There is an indication that the water of temperature about 22.50°C enters the harbour from the open sea at both surface and bottom.

During November, the water temperature decreases from 22.60 to 21.80°C at the surface and from 22.80 to 21.52°C at the bottom (fig. 3-c,d). During that month the minimum values were observed in the central part of the harbour. In December, the temperature increases seaward from 18.80 to 20.05°C at the surface and from 18.75 to 20.05°C at the bottom (fig. 3-e,f).

(ii) Winter season :

Lowest values of water temperature were observed during the winter months. During January 1986, the water temperature increases seaward (fig. 4-a,b). At the surface it varies from 17.20 near the shore to 18.40°C at El-Boughaz (fig. 4-a). While at the bottom it varies between 17.10 and 18.40°C (fig. 4-b). During February, the water temperature varies between 17.50 and 18.50°C at the surface and between 16.98 and 17.90°C at the bottom (fig. 4-c,d). In March, it ranges between 17.90 and 18.90°C at the surface and between 17.61 and 18.29°C at the bottom (fig. 4-e,f).

From fig. (4), one can notice that, the water enters the harbour from the open sea during January and March at the both surface and bottom.

(iii) Spring season :

In that season, the air temperature starts to rise and consequently the surface water temperature increases. The water temperature has a general trend of decrease seaward (fig. 5), except in April the surface temperature increases seaward (fig. 5-a).

During spring season (April-June) of 1986, the surface water temperature varies between 19.40 and 28.40°C, and between 18.88 and 26.94°C at the bottom. The minimum values were observed in April and the maximum ones were observed in June.

(iv) Summer season :

In that season, the air temperature reaches its maximum value throughout the year.

The surface water temperature varies between 27.80 and 28.60°C in July (fig. 6-a) and between 29.20 and 30.30°C in August (fig. 6-c). At the bottom, it ranges between 27.42 and 28.45°C and between 27.45 and

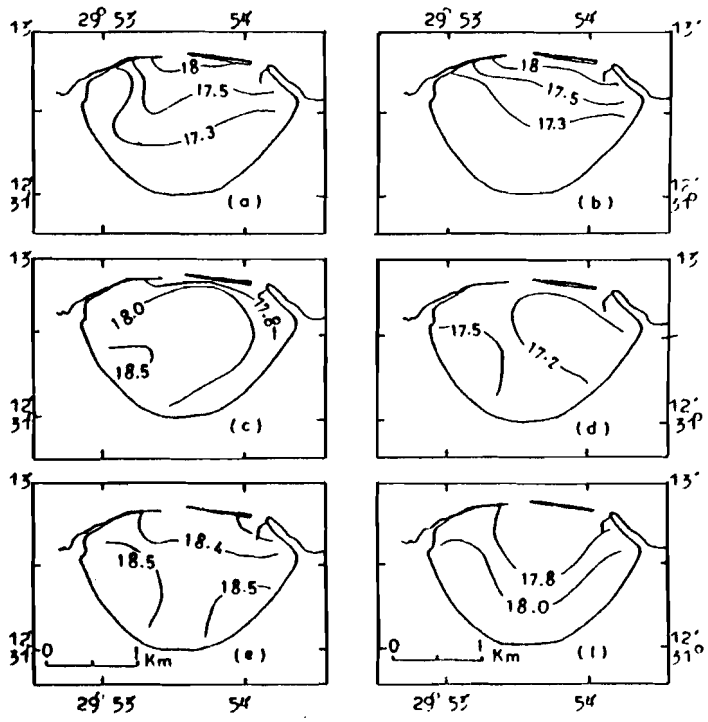

Fig. (4)
Horizontal distribution of water temperature during the winter months (January, February and March) of 1986.
Left : surface, right : bottom.

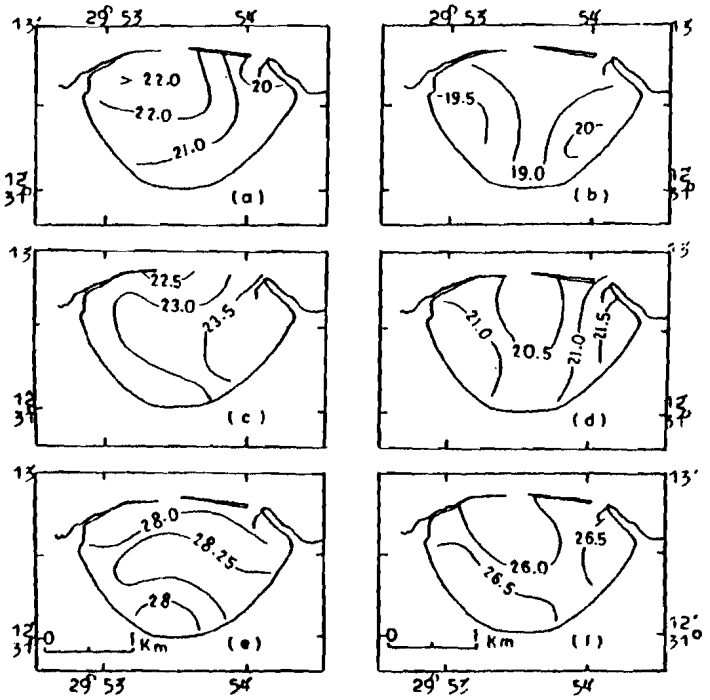

Fig. (5)
Horizontal distribution of water temperature during the spring months (April, May and June) of 1986.
Left : surface, right : bottom.

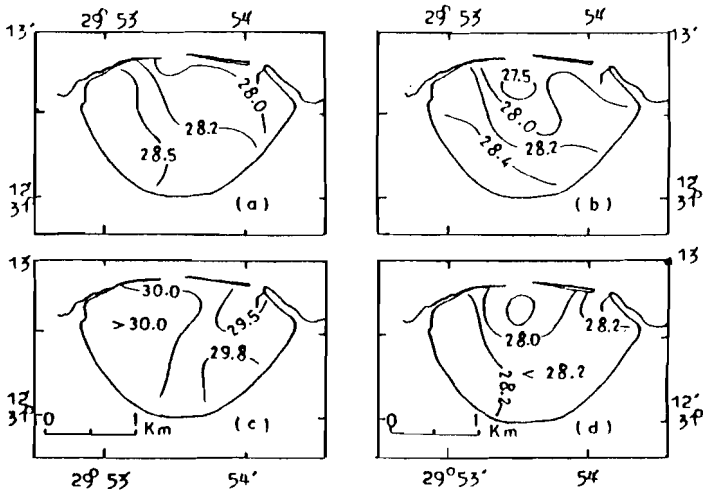

Fig. (6)
Horizontal distribution of water temperature during the summer months (July and August) of 1986. Left : surface, right : bottom.

28.50°C during JUly and August respectively (fig. 6-b,d). During the summer months (July and August) the highest values of water temperature at both surface and bottom were observed near the coast and the lowest ones were observed at the harbour's openings. This is may be due to the bottom effect.

(II) Horizontal distribution of salinity

(i) Autumn season :

Fig. (7-a,b) indicates the horizontal distribution of salinity at the surface and the bottom during October 1985. The surface water salinity varies between 37.29 and 38.80 %., while at the bottom the salinity increases seaward from 37.69 to 39.15 %.. From the figure, it is clear that, a water of salinity > 38.50 %. enters the harbour from the open sea. Meantime, the water of salinity < 38.00 %. is observed near the shore-line especially in the southwestern part of the harbour.

The lowest values of salinity were observed in November. Salinity of the surface water varies from 37.20 at the entrance of the harbour to 37.81 %. near the shore-line (fig. 7-c). In November, due to the northwesterly winds, the less saline water found near the main outfall

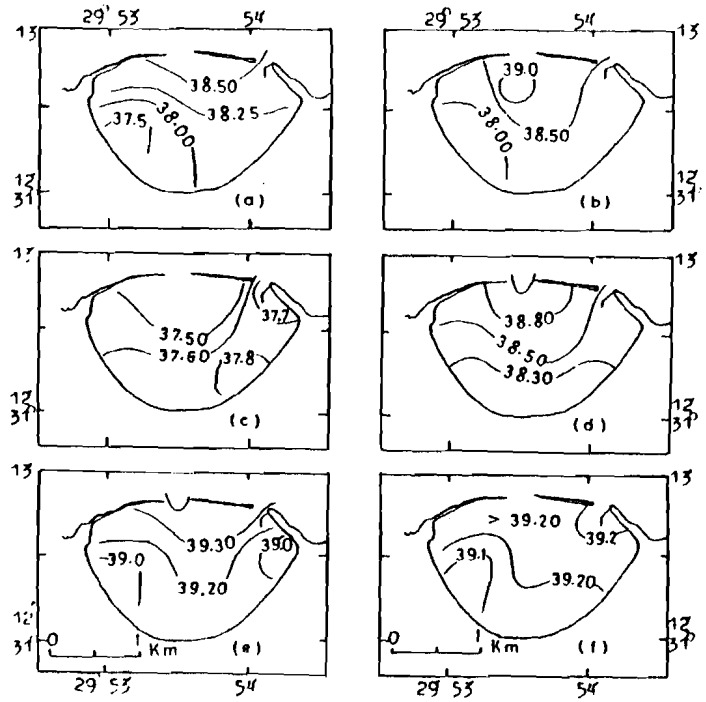

Fig. (7)
Horizontal distribution of salinity during the autumn months (October, November and December) of 1985.
Left : surface, right : bottom.

at Kayet Bey enters the harbour, through the two openings, pushing the more saline water toward the southern border of the harbour. This phenomenon was also observed in November 1980 (Shriadach, 1982). In the meantime, salinity of the bottom water varies between 39.04 %. at El-Boughaz and 38.04 %. near the shore (fig. 7-d). During December, the maximum values of salinity throughout the year were observed (fig. 7-e,f). Salinity varies between 38.995 and 39.30 %. at the surface and between 39.04 and 39.27 %. near the bottom.

(ii) Winter Season :

The horizontal distribution of salinity during the winter season (January, February and March) of 1986 at both surface and bottom are shown in fig. (8).

(iii) Spring Season :

In that season, the trend of change in salinity was increasing in the seaward direction at both surface and bottom (fig. 9). Salinity values in the harbour were generally in spring lower than that were observed in winter.

During the spring months (April, May and June), the surface salinity varies between 36.14 and 37.97 %. in April, between 34.36 and 37.54 %. in May and between 30.64 and 36.60 %. in June (fig. 9-a,c,e). The effect of the polluted water from the pipelines of domestic sewage was considerable on the surface salinity during the spring months especially in May and June. At the bottom, salinity changes from 37.80 to 38.55 %. during April (fig. 9-b). It varies between 37.00 and 38.66 %. during the other two months.

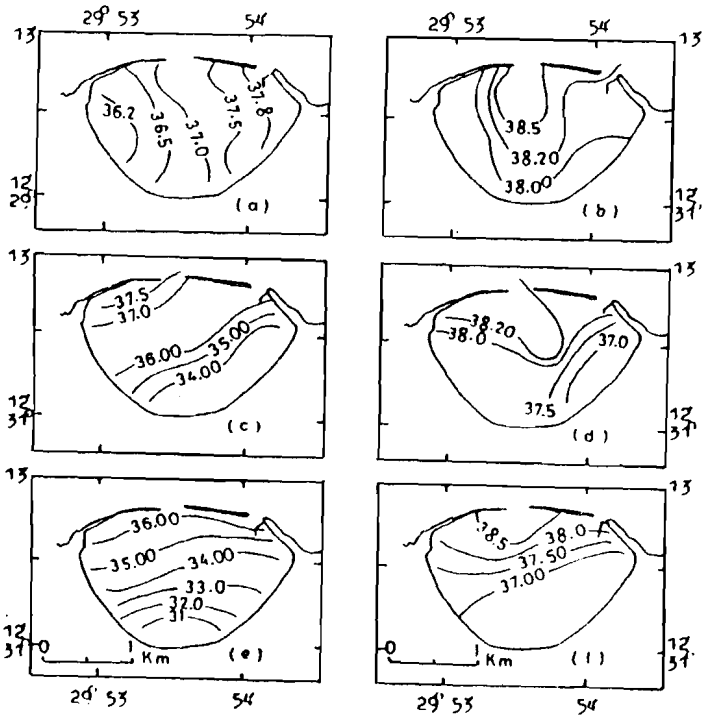

Fig. (9)
Horizontal distribution of salinity during the spring months (April, May and June) of 1986.
Left : surface, right : bottom.

(iv) Summer Season :

During the summer season, the polluted water from the pipelines of the domestic sewage was large compared with the other seasons and affects the structure of the salinity of the harbour (fig. 10-a,c,e). The surface salinity increases from 33.30 near the shore to 36.20 %. at El-Boughaz during July (fig. 10-a), from 31.60 to 36.94 %. during August (fig. 10-c) and from 34.90 to 38.44 %. during September (fig. 10-e). Low values

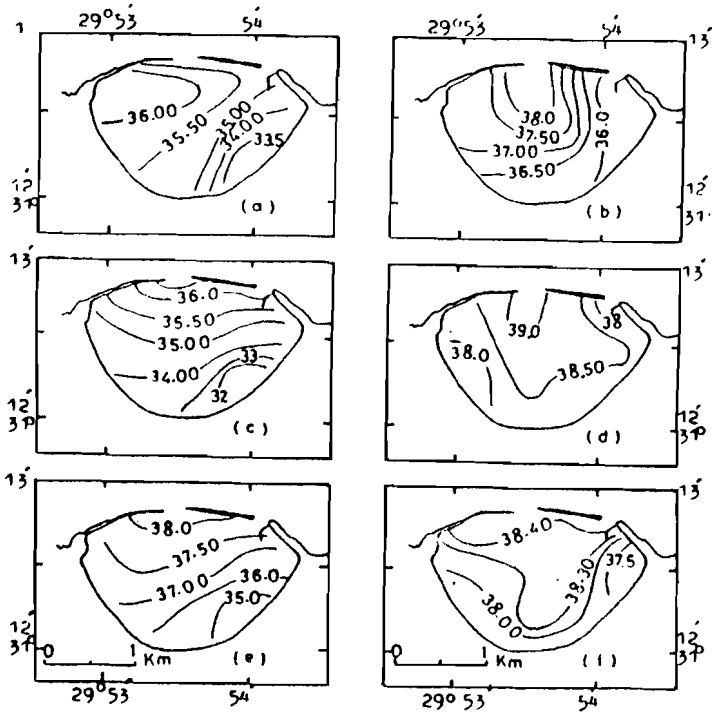

Fig. (10)
Horizontal distribution of salinity during the summer months (July, August and September) of 1986.
Left : surface, right : bottom.

of surface salinity were observed near the shore-line of the harbour as a result of the effect of the polluted water from the pipelines of the domestic sewage.

At the bottom, salinity increases seaward from 35.90 to 38.40 %. during July (fig. 10-b), from 37.90 to 39.06 %. during August (fig. 10-d) and from 37.30 to 38.44 %. during September (fig. 10-f).

(III) Horizontal Distribution of the Dissolved Oxygen

Dissolved oxygen is considered as one of the most important parameter in assessing the degree of pollution. Sewage pollution has been generally regarded as an organic pollution, adversely affecting aquatic life, through oxygen depletion.

(i) Autumn Season :

In October, the dissolved oxygen content in the harbour water varies from 3.43 ml/l to 5.15 ml/l at the surface and from 2.68 to 4.51 ml/l at the bottom (fig. 11-a,b). The maximum values of the dissolved oxygen were observed at the surface is in the central part of the harbour, while the minimum were observed at the both sides of the harbour. At the bottom, the lowest values values were observed in the northern part of the harbour.

In November, the intrusion of water of low salinity (37.20‰) rich in organic matter into the Eastern Harbour, caused a sort of eutrophication in the area, this resulted in an increase of diatom populations. The maximum values of the dissolved oxygen content were observed at the surface and range between 9.43 and 9.65 ml/l. At the bottom, the dissolved oxygen varies between 3.77 and 7.60 ml/l (fig.11-c,d).

In December, fig. (11-e,f), illustrates the horizontal distribution of the dissolved oxygen at the surface and the bottom. From this figure the maximum values of dissolved oxygen were observed in the northern and central parts of the area and the minimum values were observed at the both sides of the harbour. The values vary from 3.47 to ml/l at the surface and from 3.62 to 4.49 ml/l at the bottom (fig. 11-e,f).

(ii) Winter Season :

In the winter season (fig. 12), the maximum oxygen content was observed at the surface. This high oxygen content is explained as a result of strong winds during the winter months.

In January, the dissolved oxygen content in the harbour water varies from 3.79 to 4.76 ml/l at the surface and from 3.72 to 4.74 ml/l at the bottom (fig. 12-a,b). In February, it ranges between 3.50 and 7.74 ml/l

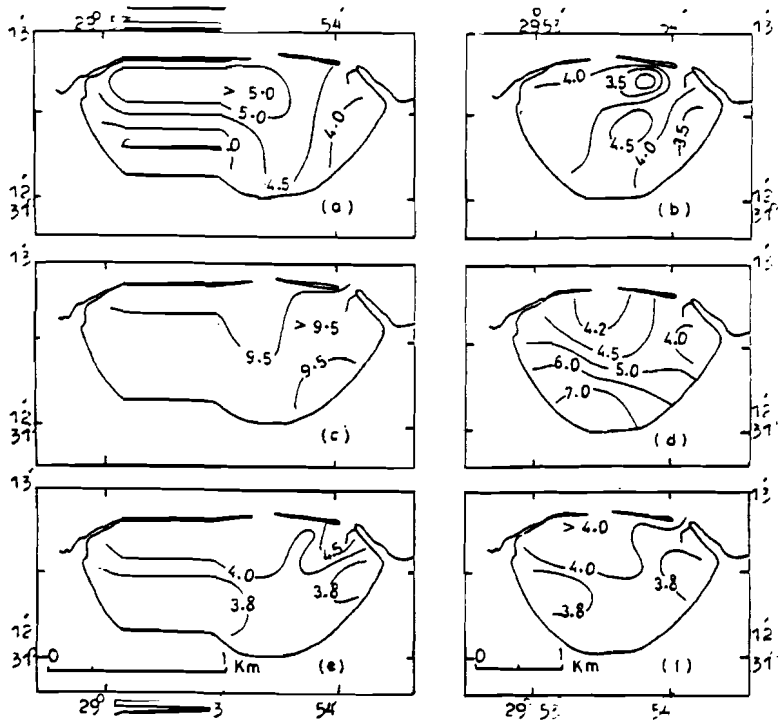

Fig. (11)
Horizontal distribution of dissolved oxygen (ml /L) during the autumn months (October, November and December) of 1985. Left : surface, right : bottom.

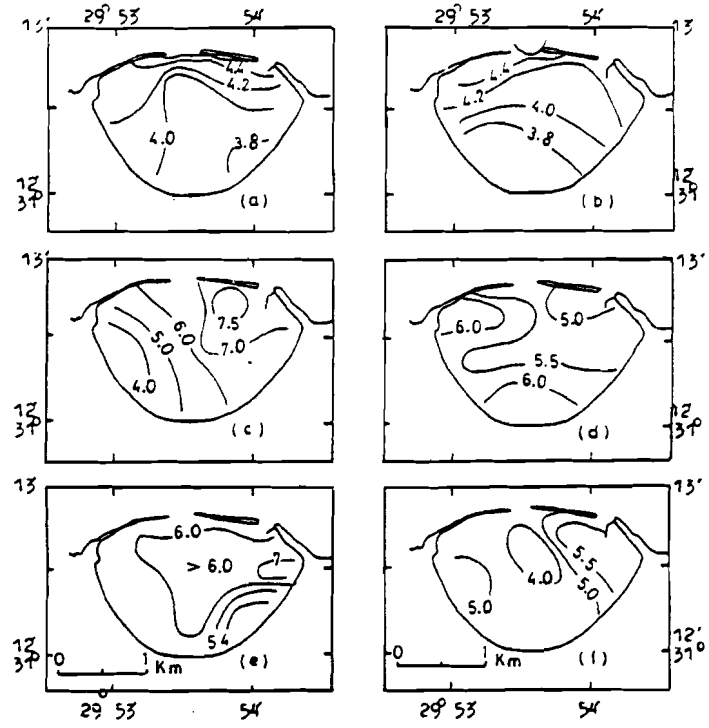

Fig. (12)
Horizontal distribution of dissolved oxygen (ml /L) during the winter months (January, February and March) of 1986. Left : surface, right : bottom.

at the surface and between 4.62 and 6.54 ml/l at the bottom (fig. 12-c,d). During March, the dissolved oxygen varies between 3.66 and 7.54 ml/l at the surface, while it varies from 3.24 to 6.00 ml/l at the bottom (fig. 12-e,f).

(iii) Spring Season :

Figure (13) illustrates the horizontal distribution of the dissolved oxygen content in the harbour water at both the surface and the bottom during the spring months.

In April, the dissolved oxygen ranges between 4.22 and 9.37 ml/l at the surface and between 3.62 and 8.53 ml/l at the bottom (Fig. 13a & b). The central part of the area is characterized by higher values from that of the eastern and western parts, and there is a tendency to increase in a seaward direction.

In May, the dissolved oxygen varies from 1.87 to 6.26 ml/l at the surface and from 2.00 to 4.67 ml/l at the bottom (Fig. 13-c & d). Low oxygen content was observed in June, where it varies between 0.29 and 7.64 ml/l at the surface and between 0.0 and 4.21 ml/l at the bottom (Fig. 13-e & f). The minimum values of oxygen content were observed near the harbour shoreline.

(iv) Summer Seasom :

Lowest values of oxygen content throughout the year were observed during the summer months.

In July, it varies from 0.41 to 5.23 ml/l at the surface and from 0.0 to 5.01 ml/l at the bottom (Fig. 14- a & b). In August, the dissolved oxygen content ranges between 3.69 and 7.58 ml/l at the surface and between 0.0 and 4.26 ml/l at the bottom (Fig. 14- c & d). In September, it varies between 0.05 and 4.73 ml/l at the surface and between 0.0 and 3.05 ml/l at the botom (Fig. 14- e & f).

The low oxygen content starting in May, June and July in both surface and bottom waters, in August, bottom water only and in September both surface and bottom water is evidently affected by two factors : 1- position of sewage outfalls situated at the southern and western borders of the harbour and 2- salinity distribution as in the bottom water in August. Water with high salinity at the bottom showed low oxygen content, probably due to consumption of bacteria organic matter.

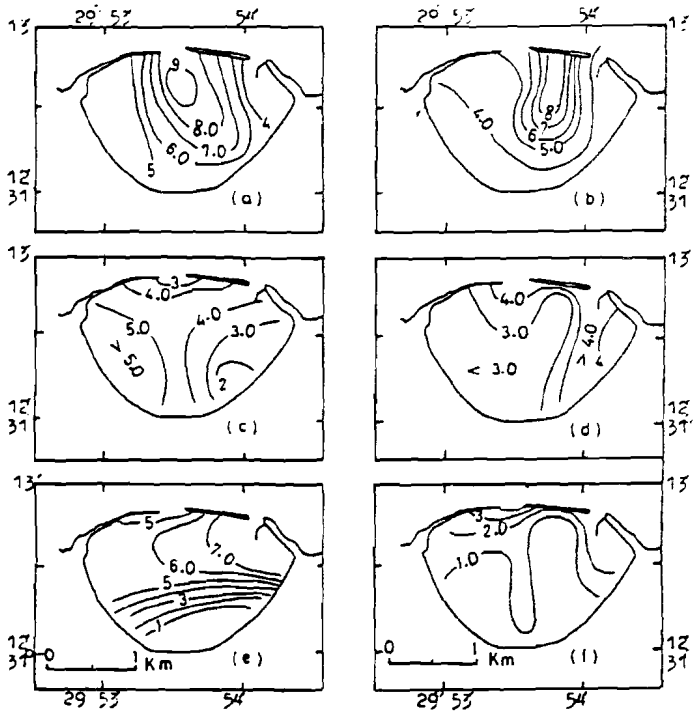

Fig. (13)
Horizontal distribution of dissolved oxygen (ml / L) during the spring months (April, May and June) of 1986. Left : surface, right : bottom.

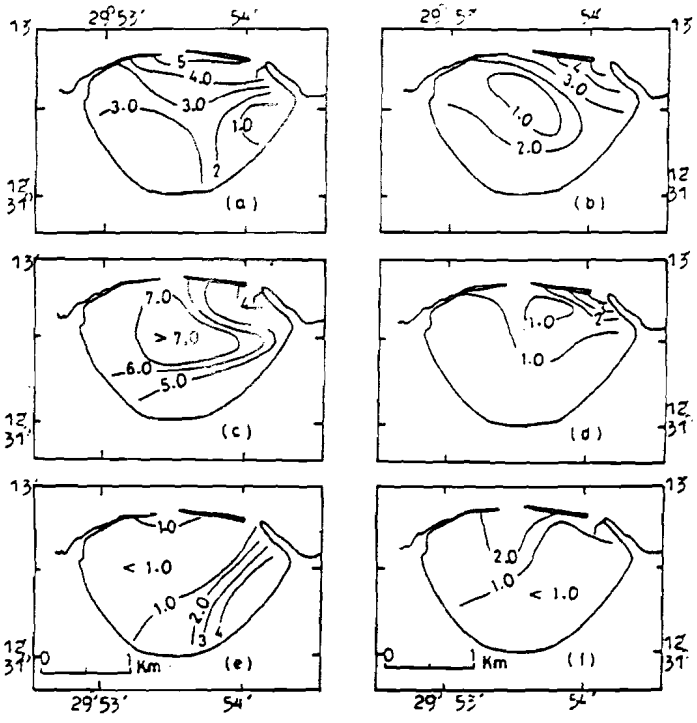

Fig. (14)
Horizontal distribution of dissolved oxygen (ml / L) during the summer months (July, August and Sebtember) of 1986. Left : surface, right : bottom.

CONCLUSION

Eleven outfalls discharge untreated sewage into the eastern harbour. These wastes affect the hydrographic characteristics of the harbour water particularly salinity and dissolved oxygen.

In the eastern harbour area, temperature variations are mostly controlled by solar radiation in the different seasons. During autumn season, the water temperature increases seaward. It varies from 18.80 to 23.50°C at the surface and from 18.75 to 23.17°C at the bottom. Lowest values of water temperature were observed during the winter months. They are between 17.20 and 18.90°C at the surface and between 16.98 and 18.40°C at the bottom. During spring season, the air temperature startes to rise and consequently the water temperature increases. During the summer months, the highest values of water temperature at both surface (30.30°C) and bottom (28.50°C) were observed.

Salinity of the eastern harbour water increases seaward in October and December, where the maximum values of salinity were observed near El-Boughaz (> 39.00 %.). In November, due to the northwesterly winds, the less saline water found near the main outfall at Kayet Bey enters the harbour, through the two openings, pushing the more saline water toward the southern border of the harbour. The effect of the polluted water from the pipelines of the domestic sewage was considerable on the surface salinity during spring and summer months. The bottom salinity distribution during the period of investigation clearly indicates that, a water of high salinity compared with the surface water, enters the harbour from the open sea through the both openings.

The discharge of sewage into the sea is an important factors that disturbs the oxygen distribution in the sea, especially inprotected areas near the outfalls. During autumn, the dissolved oxygen content in the harbour water varies between 3-5 ml/l. In November, the maximum values (9.43-9.65 ml/l) were observed at the surface. This is due to the intrusion of water of low salinity (37.20‰) rich in organic matter which causes a sort of eutrophication in the area, this resulted in an increase of diatom populations, consequently an increase in the rate of photosynthesis.

The low oxygen content starting in May, June and July in both surface and botttom water, also in August, bottom water only and September in both surface and bottom is evidently affected by two factors : 1- position of sewage outfall situated at the southern and western borders of the harbour and 2- salinity distribution, where, as in the bottom water in August. Water with high salinity at the bottom showed low oxygen content, probably due to consumption of organic matter by bacteria.

Our conclusion means that, these domestic sewages affect the physical and chemical characteristics of the harbour waters and consequently the marine life inside the harbour. Consequently, these wastes must be treated before its discharge to the open sea, in addition its discharge must be at 8-10 Km distance from the shore (outfall planning and design, 1978), or it is better to be discharged to the land.

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