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Oxygen studies as sewage pollution indices in a Semi-Closed Basin of Alexandria Coast

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__INTRODUCTION:__ Dissolved oxygen is one of the most important parameter for water masses identification & pollution assessment in the marine environment. Sewage pollution adversely affects aquatic life through oxygen depletion. Dissolved oxygen (D.O), biochemical oxygen demand (BOD) and permanganate value (PV) have been used as pollution indices in a heavily polluted basin; the Eastern Harbour (E.H) of Alexandria (Figure 1); receiving about $35X10^6$ m^3/yr of sewage and waste waters.

__MATERIAL AND METHODS:__ Sampling was carried out at regular bimonthly intervals from May 1985 to May 1986. D.O and H_2S (when present) were taken & analyzed according to Strickland and Parsons (1972) and Common Methods of Sea Water Analysis (1969). For determination of BOD, samples were incubated at 20°C for 5 days & analyzed according to APHA (1985). PV water samples were determined according to Carlberg (1972).

__RESULTS AND DISCUSSION:__ D.O and its related parameters 'BOD & PV' have been used as basic water criteria to assess sewage pollution. The oxygen content can be an indicator of organic loading, nutrient input & biological activity. Table 1 shows the annual average concentrations of D.O, BOD & PV for both surface and bottom water layers of the E.H. Except on rare occasions, the E.H water was well oxygenated (annual average 6.00±1.81 mg/l, corresponding to 87.2±29% saturation). However, the surface layer is oversaturated (105%), while the bottom is undersaturated (69%) which is sometimes completely deoxygenated. This dangerous phenomena occurred in May 1985 and June 1987 following a high sewage discharge load, an elevation of air & water temperatures accompanied by dense phytoplankton blooms. The primary cause of water deoxygenation is the presence of substances called oxygen-demanding wastes (mainly organic), easily broken down or decayed aerobically or anaerobically through bacterial activity (Arin, 1974). The D.O budget in the harbour is a balance between the high photosynthetic activity rate (584 g C/m^2/yr), leading to a large D.O production and a high load of organic matter that consume large amounts of D.O. Both processes occurred simultaneously in the E.H water & was demonstrated at stations I & V (Figure 1) located in front of sewage outfalls specially in summer when the bacterial activity is maximum.

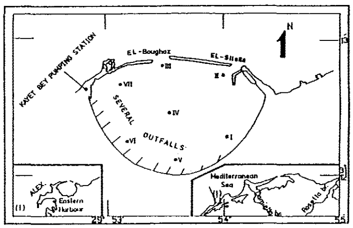

Figure 1: Sampled stations in the Eastern Harbour during 1985-86.

A BOD of 1 ppm is characteristic of nearly pure water, 3 ppm for fairly pure and 5 ppm for doubtful purity (ECPH,1975). A comparison between these levels & that observed in the present study showed that the average surface BOD values (i.e 3.86±3.32 mg/l) is comparatively higher than those of standard values. This may indicate the presence of a high load of sewage continuously discharging into the harbour and that the BOD_5 levels is still far from seriousness of severe sewage pollution as well as being within the typical BOD_5 values for domestic sewage, i.e. 250-350 g/m^3 (ECPH, 1975). The comparatively low BOD_5 in the E.H irrespective of the discharge of large amounts of sewage is mostly due to the effective exchange between fresh Mediterranean waters and the harbour water as well as its short flushing time ;i.e.5 months .The high surface D.O consumption (annual average 51.3±26%) of the available D.O is related to sewage water of lower density discharging with its high content of organic matter and bacteria.

An interesting way to point out the magnitude of the oxygen-demanding waste problem is to equate the BOD_5 of total daily nationwide wastes from specific source to the number of humans required to produce daily waste with an equivalent BOD_5. Each individual contributes to urban sewage an average BOD_5 value of about 60 gm/day (ECPH, 1975). Based on the daily discharge to the harbour (effluent having a maximum BOD_5 of 380 mg/l) the population equivalent of this effluent water will be 6.33. Based on data from the General Authority of Municipal Waste Water, the expected population equivalents during the years 1990 and 2000 will be 10.08 and 13.67, respectively. However, it is clear that the total waste water pollution loads (BOD_5) are projected to be approximately triple between now and year 2000.

Another way to assess the degree of sewage pollution in the E.H was to measure its organic matter present using permanganate value method. The PV concentrations in the E.H were remarkably low (Table 1). An excellent way to determine the type of waste water discharge, to know if it is or not biodegradable, is by calculating its BOD_5/PV ratio. A BOD_5/PV ratio of 1:1 is characteristic of pure water, 2:1-4:1 for crude domestic sewage, while carbohydrates & proteins rich wastes (food processing wastes) have ratios equal to or greater than those of sewage (ECPH,1975). The average values of BOD_5/PV ratio in the E.H varied between 0.87-2.00 and 0.73-2.35 for surface & bottom waters. Higher ratios were observed at stations directly affected by sewage discharge. Generally data may indicate that most of the sewage reaching the E.H is of biodegradable character (Aboul-Kassim,1987).

Table 1: The annual average concentrations of D.O, BOD and PV for both surface and bottom waters in the E.H during 1985-86.

	D.O(mg/l)	% oxy sat.	BOD(mg/l)	PV(mg/l)	BOD/DO(%)
SURFACE	7.24	105	3.86	3.15	51.6
BOTTOM	4.89	69	1.79	1.34	37.3

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Impact of sewage pollution on some chemico-physical characteristics of the Eastern Harbour of Alexandria

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In recent years, the problem of sewage pollution of Alexandria coastal waters has become a point of national concern. The coastal water of Alexandria receives annually about $183X10^6$ m^3 of untreated sewage. About 20% of this amount is discharged to the Eastern Harbour (E.H), rendering it highly fertile. The effect of waste water and sewage discharge on some chemico-physical characteristics of the harbour water were carefully studied and discussed.

The study area is a semi-circular shallow bay, surrounded by Alexandria city, connected to the Mediterranean through two openings. The basin is subjected annually to about $35X10^6$ m^3 of unprocessed sewage, rendering its flushing time to be 5 months.

Regular bimonthly sampling during the period 1985-1986 indicated that seasonal variations in water temperatures were directly affected by solar radiation and seasonal changes in air temperature. Thermal stratification was rarely detected. However, in period of calm weather, thermal stratification may occur to a limited extent. The occurrence of a homothermal water column is a general character, particularly in winter. This is mostly related to the effective mixing processes in this basin. The annual average temperature is 22.2°C (Table 1), with an amplitude of 11.9°C.

The transparency of the E.H was relatively high. The annual average being 2.65±0.67m. The remarkably high values at station III (Table 1) is mostly due to its low chl <u>a</u> and total suspended matter (TSM) as well as being relatively subjected to the direct effect of waste water discharged inside the harbour.

The TSM values in the E.H were remarkably high. The annual average amounted to 34.49±21.83 mg/l (Table 1). This high average are normal in such a semi-closed fertile basin, receiving large amounts of raw sewage, demonstrated by the high inverse correlation between TSM and salinity in the harbour (P<0.001).

The average Chl <u>a</u> biomass in the harbour water amounted to 5.14± 4.71 mg/m^3. This indicates that the environment of the harbour is highly eutrophic. The high Chl <u>a</u> is undoubtly due to the rich supply of nutrient salts discharged with the untreated wastes and sewage discharge disposed to the harbour as well as other sources, i.e.402 Tons nitrogen/yr (El-Nady <u>et al</u>, 1990) and 1.094 Tons phosphorus/yr (Dowidar <u>et al</u>., 1990).

The salinity of the E.H is mostly controlled by the amount of sewage water discharged into the basin and the rate of mixing and exchange of the harbour with the adjoining coastal waters of the Mediterranean Sea. During the last 10 years, salinity values of the harbour were decreasing gradually by more than 4% due to nearly doubling the amount of sewage and waste water discharged to the harbour. The distribution of salinity reveals that surplus water from the harbour flows outward as a mixed surface layer through the main openings (stations II and III), while undiluted Mediterranean water flows into the harbour as a subsurface layer near the bottom. The effect of sewage discharged into the Southern region of the harbour was clear as it lowered the values of salinity at stations I (average 36.89‰), V (36.94‰) & to a less extent station VI.

The pH of the harbour water always lies on the alkaline side. The absolutes surface values fluctuated between 7.80 & 8.58, while for bottom samples, the minimum and maximum values varied between 7.56 and 8.43, respectively. The higher surface values than those near the bottom was due to the high photosynthetic activity at the surface and relatively high organic load of the bottom water & surface sediments. Variations in total alkalinity are controlled by physical and chemical processes taking place in the water body. The annual average amounted to 2.42±0.14 meq/l. The average specific alkalinity values calculated for the E.H, i.e. 0.117±0.009 (Table 1) was slightly low compared with 0.126 accepted for oceanic water (Koczy,1956; Morcos, 1970). The relatively high pH and total alkalinity values recorded in warm months are mostly correlated (P<0.001) with the rise in water temperature. The significant correlation, between chl <u>a</u> content and pH may indicate that the pH of the environment could be used as a good indicator for production levels.

Table 1: Annual averages of some chemico-physical parameters in surface and bottom water layers in the Eastern Harbour during 1985-1986.

St. No.	Max. Dep.	Depth of sample	Water Temp. (°C)	Transp. (m)	TSM (mg/l)	Chl <u>a</u> (mg/m³)	S‰.	pH	T.Alk meq/l	sp. Alk.
I	S	0.0	22.20	2.43	47.83	13.82	36.89	8.15	2.47	0.121
	B	3.5	22.21		32.50	3.06	38.01	7.98	2.38	0.118
II	S	0.0	21.83	2.71	27.83	4.15	37.25	8.17	2.45	0.119
	B	5.0	22.50		31.20	3.51	37.84	8.22	2.42	0.116
III	S	0.0	22.15	3.79	27.50	4.35	37.48	8.22	2.43	0.117
	M	5.0	21.92		26.67	2.60	37.69	8.12	2.42	0.115
	B	8.5	21.73		24.17	1.66	38.62	8.08	2.35	0.110
IV	S	0.0	22.17	3.13	28.17	5.18	37.07	8.26	2.46	0.120
	M	3.0	21.00		18.00	2.80	38.04	8.11	2.41	0.114
	B	6.0	21.83		22.67	2.97	38.22	8.04	2.40	0.114
V	S	0.0	22.47	1.73	70.17	13.03	36.94	8.19	2.47	0.121
	B	3.5	22.37		27.50	4.07	37.38	8.12	2.40	0.116
VI	S	0.0	22.20	1.93	36.00	6.01	37.04	8.18	2.47	0.121
	B	2.0	22.67		47.67	4.07	37.03	8.19	2.45	0.119
VII	S	0.0	22.30	2.81	31.67	4.16	37.53	8.24	2.44	0.117
	B	5.0	22.10		29.83	2.33	38.40	8.06	2.37	0.117
	S		22.20	2.65	38.45	7.24	37.17	8.20	2.46	0.120
	SD±		4.60	0.67	27.55	5.98	0.91	0.16	0.15	0.009
Average										
	B		22.10		30.52	3.05	37.92	8.08	2.39	0.114
	SD±		4.20		15.87	1.55	0.42	0.07	0.15	0.008

*S=surface, M=middle, B=bottom.

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