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PHYSICO-CHEMICAL CHARACTERISTICS OF DIFFERENT WATER TYPES OF EL-MEX BAY, ALEXANDRIA, EGYPT.

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ABSTRACT

Surface and bottom water samples were collected during the period from January 1988 to January 1989 to measure temperature, salinity, pH, dissolved oxygen, oxidizable organic matter, hydrogen sulphide, nitrogen compounds (ammonia, nitrite & nitrate), phosphate and chlorophyll-a.

Based on the salinity values, the water types were classified into four different categories, namely; Mediterranean Sea water (S $\%_o$: > 38.50), diluted sea water (S $\%_o$: 30 - 38.5); mixed water (S $\%_o$: 10 - 30) and mixed land drainage (S $\%_o$ < 10).

The percentage distribution of the different physico-chemical parameters in the different water types indicated that water type "L" exhibited the lowest percentage of dissolved oxygen and highest of hydrogen sulphide, oxidizable organic matter, ammonia and chlorophyll-a. In contrast, water type "S" exhibited the highest percentage of dissolved oxygen and lowest of oxidizable organic matter, hydrogen sulphide, ammonia, chlorophyll-a. Water types M and D represent the intermediate stage between water type "L" and water type "S".

The calculated amount of dissolved oxygen that presents after complete oxidation of organic matter was on the order of water type "L" < water type "M" < water type "D".

The mean annual ratio of N/P suggests that phosphorus is the most limiting factor for the growth of algae in water types "L" and "M". In water type "D" the ratio are near the optimal assimilative proportion.

INTRODUCTION

El-Mex Bay, west of Alexandria, extends for about 15 Km between El-Agamy headland to the west and the Western Harbour to the east and from the coast to a depth of about 15 meters. It has a mean depth of 10 m, surface area of about 25.2 Km^2 and a volume of 252 x 10^6 m^3. It receives the combined domestic and industrial effluents from chloro-alkali plant; tanneries and slaughterhouse, as well as brackish water (6 - 11.8 x 10^6 m^3/ day) from Umum drain.

The configuration of El-Mex Bay, its major hydrography and chemical character have been studied by several authors El-Wakeel and El-Sayed (1978); Abdallah (1979); Sabra (1979); Mahmoud (1979 & 1985); Farag (1982); Rifaat (1982), Aboul-Dahab and Halim (1986 & 1988a, 1988b), and El-Gindy et al. (1986).

The objective of the present syudy is to investigate the influences of different effluents on the physico-chemical characteristics of El-Mex Bay water types.

MATERIAL AND METHODS

Throughout the period from January 1988 to January 1989 seven trips were carried out in El-Max Bay. The physicochemical parameters; e.g. temperature, salinity, dissolved oxygen, pH, oxidizable organic matter, hydrogen sulphide, inorganic nitrogen compounds (nitrate-N, nitrite-N & ammonia-N) phosphate-p and chlorophyll-a were measured at surface and bottom from seven hydrographic stations. The positions of which are indicated in Fig. 1.

Water temperature was measured using a protected reversing thermometer attached to a plastic Niskin water sampler. Temperature corrections were made using calibration curves. Salinity determinations were carried out using the Beckman induction salinometer (Model Rs-7C). PH measurements were made using a pH-meter (Orien Research Model 201 digital pH-meter). Dissolved oxygen and nutrient salts were analysed according to Grasshoff (1976), while chlorophyll-a extraction and measurement according to Strickland and Parsons (1965). Hydrogen sulphide was determined according to the standard methods for the examination of water and waste water (Anon., 1965), and oxidizable organic matter by the method of FAO (Anon., 1975).

During the period of investigation, the monthly climatological data concerning wind speed and direction from Alexandria Meteorological Station were obtained from the Egyptian Meteorological Authority-Cairo, Egypt.

RESULTS AND DISCUSSION

Salinity which reflects changes caused by the mixing of both fresh and sea waters showed very broad regional variations. The salinity values changed widely from Mediterranean shelf water in the north to brackish water near El-Umum Drain outlet. The minimum surface salinity (4.969 $‰_o$) is observed during November in front of El-Umum Drain (St. 1) and the maximum one (38.683 $‰_o$) is found in April at the open sea stations. Bottom water, on the other hand, shows very limitted regional variations. The salinity values varied between 29.053 $‰_o$ in January 1988 and 39.656 $‰_o$ during January 1989.

To reach an understand of the extent to which the run-off water mixes with sea water and affects water quality, it is convenient to identify specific water types. As mentioned

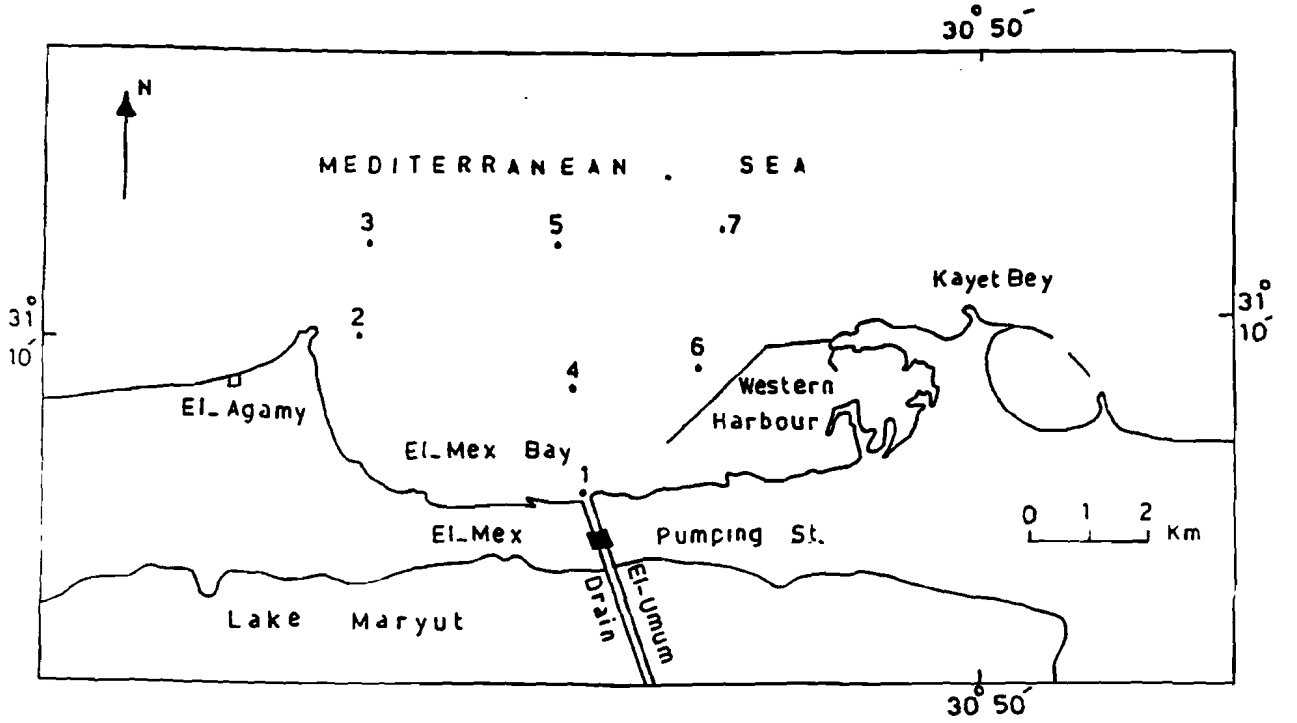

Fig. 1

El-Mex Bay area and the locations of the sampling stations.

earlier, the surface salinity ranged from undiluted sea water to undiluted drain and sewage water. Accordingly, salinity is selected as the main tool for water type identification. Based on the distribution of surface salinity in the investigated area, four types of water are identified :

1. Mediterranean Sea water "S" of salinity > 38.50 $‰_o$.

2. Diluted Sea water "D" with a salinity range from 30.00 to 38.50 $‰_o$.

3. Mixed water "M" of salinity 10.00 - 30.00 $‰_o$.

4. Mixed land drainage water "L" with a salinity < 10.00 $‰_o$.

According to El-Maghraby and Halim (1965), Said (1979) and Abdel-Moati and Said (1987), the salinity value 38.50 $‰_o$ was taken to represent the inner boundary of the neritic water off Alexandria. This value still could be generally accepted and will be used here to identify the limits within which the diluted sea water extends horizontally seawards.

The horizontal extension of each water type is highly variable and depends upon the pattern of circulation and the rate of outflow. The surface salinities and the corresponding water types with their volume percentage are represented in Fig.2.

During winter months (Fig. 2), the increased quantity of drainage water discharged through El-Umum Drain (Table 1) and the prevailing westward winds are probably responsible for creating this distribution pattern of the water types. In January, the diluted sea water type (salinity 30.00 - 38.50 $‰_o$) occupied almost all the area. In February, the mixed land drainage type with a salinity of less than 10 $‰_o$ spreads a considerable distance beyond the Bay to reach El-Agamy area.

In April, under the effect of the northwest prevailing wind of an average speed of about 4.62 $m.sec^{-1}$, the mixed water (salinity 10 to 30.00 $‰_o$ and the diluted sea water with a salinity range from 30 to 38.50 $‰_o$ occupied the offshore zone. The pure Mediterranean water type was found only at the eastern part of the investigated area (Fig. 2).

As a result of the increased drainage water discharge during June (1964 x 10^6 m^3), the investigated area was completly occupied by both the mixed and diluted sea water (Fig. 2). In August, by the action of the prevailing winds, the mixed water occupied the southern half of El-Mex Bay whereas the diluted sea water type occupied the northern part. The eastern part of the investigated area showed a salinity value corresponding to that of undiluted Mediterranean water (Fig. 2).

The water types referred to above, have the following characteristics (Tables 2a, 2b & 2c).

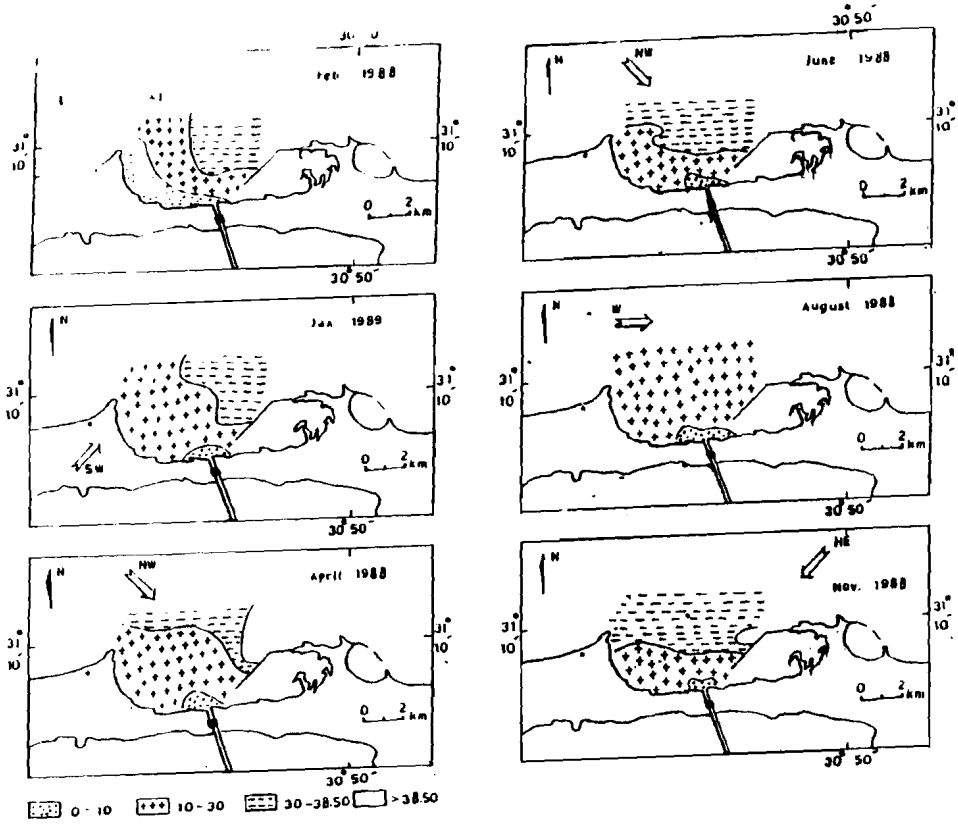

Fig. 2

Distribution of the surface water types.

Table 1.

Volume of water discharged to El-Max Bay through El-Umum Drain (10^6 m^3).

Month		Total Discharge	Month		Total Discharge
January,	1988	284.187	July,	1988	168.908
February,	1988	208.529	August,	1988	188. 85
March,	1988	194.241	September,	1988	194.996
April,	1988	144.746	October,	1988	243.493
May,	1988	154.746	October,	1988	231.215
June,	1988	163.692	December,	1988	251.665

Table 2 a.

Seasonal and annual variations of the hydrochemical characteristics of average values for the land drainage water type "L" (0-10 S $‰_o$).

Parameter / Month		T ^oC	S $‰_o$	Dissolved Oxygen $ml O_2\ l^{-1}$	H_2S $mg\ l^{-1}$	Organic matter $mgO_2\ l^{-1}$	pH	Ammonia $ug\ at.l^{-1}$	Nitrite $ug\ at.l^{-1}$	Nitrate $ug\ at.l^{-1}$	Phos-phorus $ug\ at.l^{-1}$	Chlo ro-phyl -a mg/m^3
January,	1988	14.20	5.629	1.79	1.31	9.94	7.78	32.20	2.52	0.08	1.19	0.2 4
February,	1988	14.93	6.543	1.52	1.14	7.07	7.80	40.74	1.74	2.70	5.62	0.2 1
April,	1988	21.07	5.996	1.70	0.96	1.46	7.75	57.66	3.87	4.41	9.26	0.0 6
June,	1988	27.25	5.653	0.85	1.08	2.39	8.50	7.54	0.63	0.67	0.55	0.0 1
August,	1988	28.41	6.012	0.81	2.23	6.66	7.60	72.20	4.87	19.50	1.10	0.1 1
November,	1988	19.60	4.969	3.12	0.80	1.68	7.99	**	**	**	**	0.7 2
January,	1988	14.20	7.236	2.93	0.99	6.62	7.50	**	**	**	**	0.9 0
Annual average		19.95	6.00	1.82	1.22	5.12	7.84	42.07	2.73	5.47	3.54	0.3 2

** not sampled.

Table 2 b.

Seasonal variations of the hydrochemical characteristics of average values for the Mixed water type "M" (10-30) S $\%_o$).

Parameter / Month	T ^oC	S $\%_o$	Dissolved Oxygen $ml O_2\ l^{-1}$	H_2S $mg\ l^{-1}$	Organic matter $mgO_2\ l^{-1}$	pH	Ammonia $ug\ at.l^{-1}$	Nitrite $ug\ at.l^{-1}$	Nitrate $ug\ at.l^{-1}$	Phos-phorus $ug\ at.l^{-1}$	Chloro phyl-a $mg/\ m^3$
January, 1988	14.80	22.920	2.21	1.69	3.66	7.98	32.20	3.06	8.78	4.71	0.12
February, 1988	15.45	16.235	1.82	0.83	4.80	8.35	31.91	0.41	3.40	6.51	0.18
April, 1988	19.50	22.661	2.08	0.85	2.66	8.06	28.40	4.17	9.29	3.94	0.11
June, 1988	26.50	28.190	2.21	1.14	1.72	8.10	3.78	17.24	22.27	0.70	0.15
August, 1988	28.38	25.312	1.60	2.00	5.26	7.73	16.89	3.57	16.15	0.84	0.07
November, 1988	22.40	30.000	3.50	0.82	3.99	7.68	**	**	**	**	0.23
January, 1988	14.80	27.307	14.70	3.47	0.14	5.29	7.23	**	**	**	0.27
Annual average	20.26	24.66	2.41	1.07	3.91	7.88	21.01	5.69	11.98	3.34	0.16

** not sampled.

Table 2 c.

Seasonal variations of the hydrochemical characteristics of average values for the diluted water type "D" (30-38.5 S $\%_o$).

Parameter / Month	T ^oC	S $\%_o$	Dissolved Oxygen $ml O_2\ l^{-1}$	H_2S $mg\ l^{-1}$	Organic matter $ml O_2\ l^{-1}$	pH	Ammonia $ug\ at.l^{-1}$	Nitrite $ug\ at.l^{-1}$	Nitrate $ug\ at.l^{-1}$	Phosphorus $ug\ at.l^{-1}$	Chlorophyl-a $mg/\ m^3$
January, 1988	15.27	36.924	2.28	0.76	4.80	7.92	4.97	0.59	0.17	7.39	0.32
February, 1988	16.00	35.827	3.37	0.90	2.40	7.79	8.83	0.77	3.58	3.67	0.12
April, 1988	19.70	33.121	2.55	0.60	1.20	8.08	21.71	2.66	17.49	1.74	0.08
June, 1988	26.28	36.335	2.00	0.99	1.94	8.30	5.46	7.62	16.71	3.56	0.06
August, 1988	--	--	--	--	--	--	--	--	--	--	--
November, 1988	22.72	35.162	3.68	0.81	0.95	7.98	**	**	**	**	0.14
January, 1988	15.27	34.032	3.35	0.30	4.31	7.70	**	**	**	**	0.16
Annual average	19.54	35.234	2.87	0.73	2.6	7.96	7.99	2.91	9.49	4.08	0.15

** not sampled.

1. Mixed land drainage water type "L" is of low brackish. It is characterized by its very low salinity (4.97-7.24; av. 6.00 $‰$), low dissolved oxygen content (0.81-3.12; av. 1.82 ml/l), high concentration of hydrogen sulphide (0.80-2.23; av. 1.22 mg/l) and high amount of oxidizable organic matter (1.46-9.94; av. 6.12 mg O_2/l). It exhibited the highest concentration of chlorophyll-a (0.06-0.90; av. 0.32 mg/m^3), the highest concentration of dissolved ammonia (7.54-72.20, av. 42.07 ug at/l). The levels of temperature, hydrogen ion concentration, nitrite-N,nitrate-N, phosphate-P scattered in the ranges (14.20-28.41, av. 19.95° C), (7.50-8.50; av. 7.84), (0.63-4.87; av. 2.73 ug at/l), (0.08-19.50; av. 5.47 ug at/l) and (0.55-9.26; av 3.54 ug at/l) respectively.

2. Mediterranean water "S" represents pure Mediterranean water free from the effects of land drainage. It is characterized by its highest oxygen content (2.74-3.70 ml/l), lowest of hydrogen sulphide (0.76 mg/l), oxidizable organic matter (0.21-2.26 mg O_2/l) and chlorophyll-a (0.07-0.14 mg/m^3). Concentration of ammonia-N (4.3 ug at/l), nitrite-N (0.43 ug at/l), nitrate-N (18.58 ug at/l) and phosphate-P (0.84 ug at/l) were also very low compared with their concentration at water type "L". The temperature and hydrogen ion concentration levels scattered in the ranges (18.6-25.5° C) and (7.90-8.01) respectively.

3. Water types "M" and "D" are the intermediate stage between water types "S" and "L". Water type "M" had higher salinity than water type "L" but still lower than that of water type "S". The levels of temperature, salinity, hydrogen ion concentration scattered in the ranges (14.8-28.38; av. 20.26° C), (16.24-30.00; av. 24.66 $‰$), (7.23- 8.35; av. 7.88). Comparing water types "M" and "L", it appears that the concentration of dissolved oxygen (1.60-3.50, av. 2.41 ml/l) is still low but hihger than that of water type "L". The hydrogen sulphide concentration (0.14-2.00, av. 1.07 mg/l), amount of oxidizable organic matter (1.72-5.29, av. 3.91 mg O_2/l) and chlorophyll-a (0.07-0.27; av. 0.16 mg/l) are decreased in this water type than in water type "L". The concentration of ammonia-N (3.78-31.91; av. 21.01 ug at/l), nitrite-N (0.41-17.24 av. 5.69 ug at/l), nitrate-N (3.40-22.27; av. 11.98 ug at/l) and phosphate-P (0.70-6.51; av. 3.34 ug at/l) are generally lower than those in type "L".

4. Water type "D" which represents the diluted sea water is characterized by high oxygen content (2.00-3.68; av.2.87 ml/l), low hydrogen sulphide (0.30- 0.99; av. 0.73 mg/l), low amount of oxidizable organic matter (0.95-4.80; av. 2.60 mg O_2/l), low concentration of dissolved ammonia-N (4.97-12.71; av. 7.99 ug at/l), low concentration of chlorophyll-a (0.06 -0.32; av. 0.15 mg/m^3). The levels of temperature, salinity, hydrogen ion concentration, nitrite and nitrate are scattered in the ranges (15.27-26.28; av. 19.54° C), (33.12-36.92; av. 35.23 $‰$), (7.70-8.30, av. 7.96), (0.59-7.62; av. 2.91 ug at/l) and (0.17- 17.41, av. 9.49 ug at/l) respectively.

In order to get a clear picture about the effect of different effluents upon the physico-chemical characteristics of different water types, the percentage of distribution of some parameters in different water types was calculated (Table 3).

Table 3.

Percentage distribution of some physico-chemical parameters in each water type.

Parameter / Water type	Dissolved oxygen	Hydrogen sulphide	Oxidizable organic matter	Ammonia-N	Nitrite	Nitrate	Phosphate-P	Chlorophyll-a
	%	%	%	%	%	%	%	%
Water type "L"	25.63	40.40	44.02	59.20	24.10	20.30	32.30	50.79
Water type "M"	33.94	35.43	33.62	29.56	50.20	44.47	30.47	25.40
Water type "D"	40.42	24.17	22.36	11.24	25.68	35.23	37.23	23.81

In general, water type "L" which is greatly affected by El-Umum drain and represents only 0.77 % of the total volume (Fig. 3), exhibited the lowest percentage of dissolved oxygen (25.6 ml/l), highest percentage of hydrogen sulphide (40.40 %), oxidizable organic matter (44.02 %), ammonia-N (59.20 %) and chlorophyll-a (50.79 %). Water type "M" which is less affected by El-Umum drain and represents 52.30 % of the total volume exhibited 33.95 % of dissolved oxygen, 35.43 % of hydrogen sulphide, 33.62 % of oxidizable organic matter ; 60.20 % of nitrite and 25.40 % of chlorophyll-a. The percentage distribution showed that water type "D" which represents 46.93 % of the total volume and relatively far from the effect of El-Umum drain exhibited high percentage of dissolved oxygen (40.42 %), low percentage of hydrogen sulphide (24.17 %), low percentage of oxidizable organic matter (22.36 %), low percentage of ammonia-N (11.24 %) and low percentage of chlorophyll-a (23.81 $\%_o$).

To get more clear insight about the effect of different effluents upon the physico-chemical characteristics of different water types, the amount of oxygen necessary for complete oxidation of orgainc materials in each water type was calculated according to Richards (1965) (Table 4). The percent of oxygen that presents after complete oxidation of orgainc matter was on the order of : water type "L" < water type "M" < water type "D".

Fig. 3

Percentage distribution of the volume of each water type in Different Months.

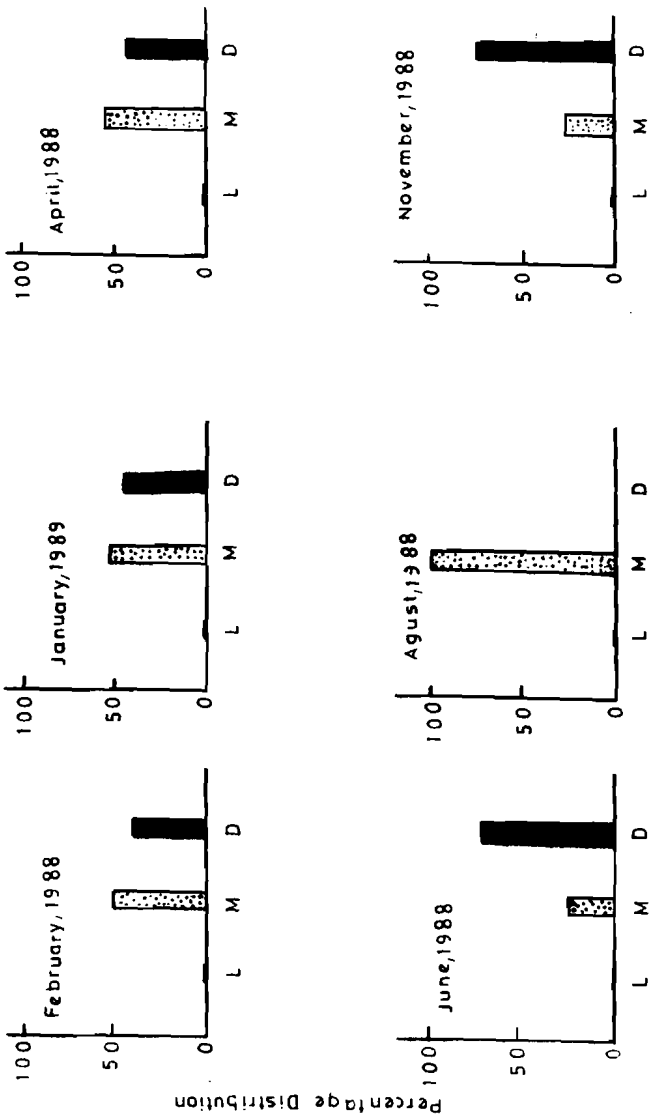

Table 4.

Concentration of oxygen necessary for complete oxidation of organic matter and the concentration present after complete oxidation.

Water type	Organic matter (mg O_2 L^{-1})	Oxygen present ($mg.L^{-1}$)	Oxygen necessary for complete oxidation ($ng.L^{-1}$)	Original oxygen concentration ($mg.L^{-1}$)	% of Oxygen present after oxidation
Water type "L"	5.12	2.60	6.36	8.96	29.0 %
Water type "M"	3.91	3.45	4.86	8.31	41.5 %
Water type "D"	2.60	4.10	3.23	7.33	55.9 %

In order to get another clear picture about the effect of different effluents upon the physico-chemical characteristics of different water types, the N/P ratio for each water type was calculated. The N/P ratio (Table 5) is lower than the normal ratio found by Richards (1958) in the north Atlantic (16:1). Chiaudani and Vighi (1978) stated 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 4.5-6.0 the ratios of nutrient elements are near the optimal assimilative proportion. The mean annual ratio for each water type reported here (Table 5) suggests that phosphorus is the most limiting factor for the growth of algae in water type "L" and water type "M"; while in water type "D" the ratio is near the optimal assimilative proportion. The seuence of the N/P ratio was on the order : water type L > water type M > water type D.

The calculated N/P ratio revealed that the intrusion of El-Umum drain water in El-Mex Bay elevated the inorganic nitrogen compounds in water types "L" and "M". Consequently, the N/P ratio (14.2 & 11.6 respectively) increased (14.29 & 11.6). In water type D, which is less affected by El-Umum drain waters, the ratio decreased to 5 as a result of the high rate of consumption of nitrogen compounds than phosphorus.

CONCLUSION

As El-Mex Bay receives considerable amount of agricultural drains and waste waters (2.4×11^{8} m^3/year), the need to pay much attention to the potential effects of anthropogenics upon the water types and the hydrochemical characteristics of the Bay is obvious.

Table 5.

Mean concentration of nutrient salts (ug at.l^{-1}) and the estimated N/P ratio in the different water types.

Water type	Ammonia-N	Nitrite-N	Nitrate-N	Phosphate-P	N/P ratio
Water type L	42.07	2.73	5.47	3.54	14.20
Water type M	21.01	5.69	11.98	3.34	11.60
Water type D	7.99	2.91	9.49	4.08	5.00

Our study revealed that the hydrochemical characteristics as well as the water types of the Bay are greatly affected by these different effluents.

Based on the salinity values, the water types could be classified into four different categories; namely: mixed land drainage water "L", Mediterranean water "S", mixed water "M" and diluted water "D".

The most important features which distinguish water type "L" from other types are the low salinity, low oxygen content and high concentration of hydrogen sulphide, organic matter, chlorophyll-a and nutrient salts (which is mainly present in the ammonia form). In contrast, water type "S" free from the effects of drainage water has high salinity value and relatively high oxygen content but low hydrogen sulphide, organic matter, chlorophyll-a and nutrient salts. The study pointed out also that water types "M" and "D" are affected to a certain extent by land drainage water which is indeed more clear in "M" water type than in "D" water type.

The calculated amount of dissolved oxygen that present after complete oxidation of organic matter was on the order of water type "L" < water type "M" < water type "D".

The mean annual ratio of N/P suggests that phosphorus is the most limiting factor for the growth of algae in water types "L" and "M". In water type "D" the ratio is near the optimal assimilative proportion.

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