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PLANKTON OF LAKE MARYUT OUTLET, WEST FROM ALEXANDRIA

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ABSTRACT

The polluted brackish water of Lake Maryut is continuously pumped out the sea through the outlet of Max pumping station (St.3). Two canals crossing this Lake (Nubariah canal and Umum drain) mix with the Lake waters before reaching the sea.

In order to investigate the effect of mixing of Lake waters with the drain and canal waters, samples were regularly collected, immediatcly south of the Lake (before mixing sts. 1&2), from the outlet of the drain (St. 3, after mixing) and from the adjacent inshore sea water st. 4.

Drastic changes are caused by the mixing of agricultural drainage waters with the Lake waters, concerning both the water characteristics and the phyto- and zooplankton associations. Salinity increases only slightly and the pH shows little variation. Oxygen saturation is low in the agricultural drainage waters, but it is further decreased by Lake waters. The adjacent inshore sea waters show recovery in the O_2 content. Mixing raises the phosphate content to abnormally high values.

The effects of eutrophication are reflected on both the plankton biomass and composition. The composition is typically brackish, the number of species and the biomass are increased for both phyto- and zooplankton with mixing.

INTRODUCTION

Lake Maryut is the smallest of the 4 Delta lakes, situated along the Mediterranean coast, south of Alexandria.

It is a shallow brackish basin of average depth about 1 meter and of an area about15000 feddans. It differs from other Delta lakes by being with no exit with the Mediterranean Sea. But a pump station at El-Max keeps the level of water below the level of the cultivated lands at about 280 cm below sea level.

Lake Maryut receives agricultural drainage water from the surroundings cultivated lands mainly through El-Umum drain, southwest and by ElQalaa drain, southeast. Domestic and industrial sewages are discharged from Alexandria city to the northern Lake.

Mumerous limnological studies have been carried out on Lake Maryut, of which some deal with hydrobiological and pollution aspects: Abd El-Moneim (1977), Aleem and Samaan (1968, 1969 a&b), Anonymous (1978),El Hawary (1960), Elster and Vollenweider (1961), Khaleefah (1964), Saad, (1973 & 1980), Salah (1960 & 1961), Saleh (1974), Samaan (1966), Samaan and Aleem (1972 a&b), Sharkawi (1976), and Wahby et al (1978).

MATERIAL AND METHODS

Four stations (Fig. 1) were sampled monthly for 16 months (August 1986 to November 1987). Stations 1 and 2 are located in Nubariah canal and El-Umum drain respectively, immediately south of the lake. Station 3 is located at the seaward outlet of El-Umum drain. Station 4 is located in the adjacent inshore sea water.

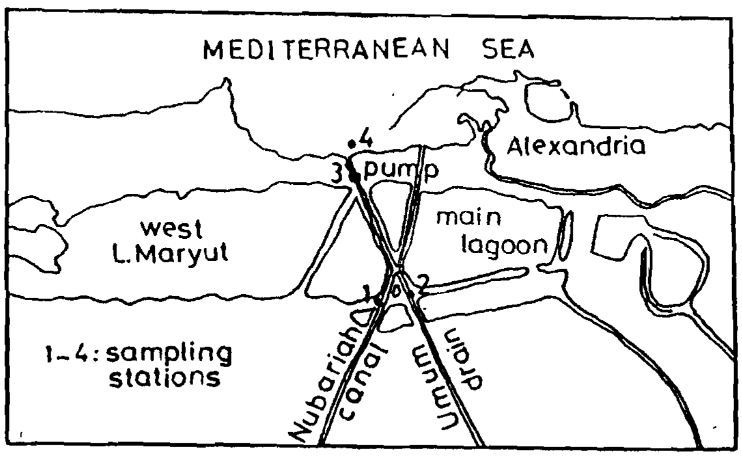

Fig. 1
Lake Maryut, showing the investigated stations 1 to 4.

In addition, El-Max and the adjacent offshore waters from El-Agamy to the Eastern Harbour were surveyed twice in April 1987 (Fig. 7).

Air and water temperature were recorded. Salinity was measured by a portable induction salinometer. Hydrogen ion concentration was measured using a portable Beckmann pH meter.

Phosphate was determined by ammonium molybdate-ascorbic acid method (Morphy and Riley, 1962). Oxygen was determined by Winkler's method.

For the plankton studies, 5 l surface water samples were collected in polyethylene bottles and left for at least 24h. after fixation with formaline. The sample volume was then reduced by siphoning of the upper supernatant water to about 1/25 (sedimentation method).

Phytoplankton was counted in a divided cell of capacity 1ecc and the zooplankton in a glass tray (Rafter cell) of 5 cc.

For qualitative study 50 l of water were filtered and surface hauls taken by means of a narrow mesh net.

The following taxonomic references and publications were used for checking the species and for identification: Cupp (1943), Dussart (1967 & 1969), Edmondson (1959), Gurney (1932 & 1933) Rottner-Kolisko (1974) and Tregouboff and Rose (1957).

Hydrochemical Characteristics :

Maximum air temperature (31.5°C) and water temperature (29.5°C) were recorded in August 1986 and minimum temperatures (12.5 and 11.5°C respectively) were recorded in January, 1987.

Salinity (Fig. 2, table 1)

Mixing the agricultural drainage water with Lake water increases the salinity slightly. The monthly variations showed slight fluctuations. The salinity of the three stations reached maxima in February 1987 (4.11, 5.06 and 6.41 respectively), but they differed in reaching their minimum salinity : st. 1 in June 1987 (2.03), St. 2 in October 1986 (2.09) and St. 3 in November 1986 (3.35). The mixed inshore sea water (St. 4) showed wide monthly fluctuation, with a relatively high maximum (36.05) in December 1986 and a minimum in November 1986 (3,51).

Hydrogen ion concentration (table 2).

On the average, the pH values were lower than those of sea water. It was lower in Umum drain both upstream (st. 2) and downstream (St.3), (7.68 and 7.66 respectively than at St. 1 (7.78) and St. 4 (7.81). Except for January 1987 when it was abnormally low (6.66) and for April 1987 when it exceeded 8, it was always near the average 7.68 in the drain.

Oxygen relative saturation (Table 3).

The relative saturation in oxygen on the whole is low in the agricultural

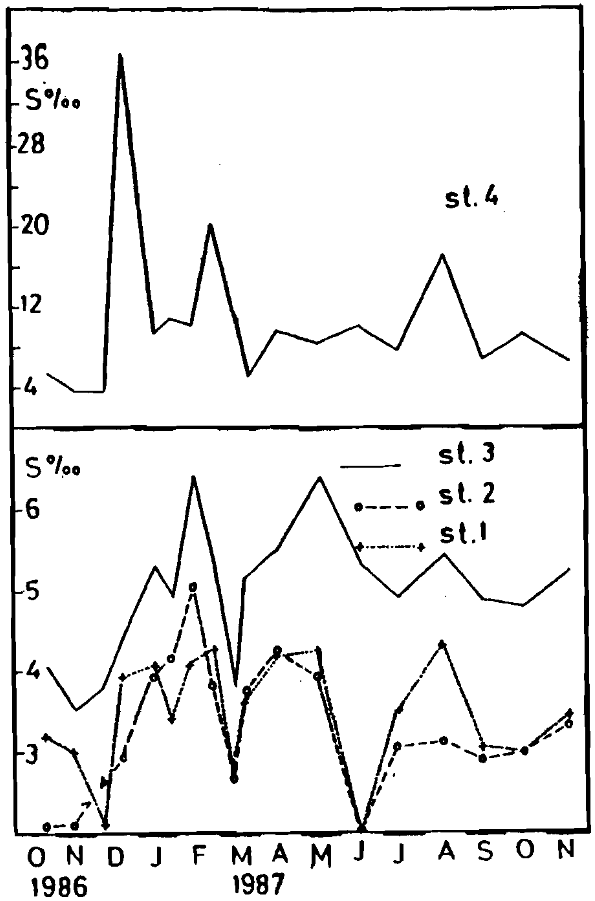

Fig. 2
Monthly variations of salinity (Stations 1 to 4)

TABLE (1)

Maximum, minimum and average salinity of stations 1 to 4.

	St.1	St.2	St.3	St.4
Maximum	4.11	5.06	6.41	36.25
Minimum	2.03	2.09	3.53	3.51
Average	3.50	3.34	4.92q	10.75

TABLE (2)

Maximum, minimum and average pH of stations 1 to 4.

	St.1	St.2	St.3	St.4
Maximum	8.55	8.32	8.24	8.36
Minimum	7.50	6.66	7.35	7.45
Average	7.78	7.68	7.66	7.81

drainage waters (av. 54.56 at St. 1 and 59.18 at St. 2) (Guerguess, 1979 and Halim and Guerguess, 1978 & 1981). But mixing with the lake waters with their high load of organic matter further decreases the oxygen content to comparatively very low values (av. 36 % at St. 3). The adjacent inshore sea waters show a recovery in the oxygen content (av. 68.1 at St. 4).

Dissolved phosphate (Fig. 3 & table 4):

The phosphate content of the drain water after mixing (St. 3) rises to abnormally high values. In the agricultural drainage water before mixing, it ranged from 0.45 to 2.75 μ ml^{-1} at St. 1, 0.25 to 3.2 μ ml^{-1} at St. 2, while at St. 3 the range was from 2.25 to 6.8 μ ml^{-1}.

It is likely that other nutrients become also enriched.

Plankton (Tables 5 & 6, Figs. 4 to 9):

The effects of eutrophication are reflected on both the plankton biomass and composition. The composition is typically brackish.

a- Phytoplankton :

Due to mixing with Lake water, the number of species increased from 26 (St. 1) and 30 (St. 2) to 35 (St. 3) and 41 (St. 4). The phytoplankton standing crop also increased from 19,000 cells l^{-1} (monthly average) at St. 1 and 1,500 cells l^{-1} at St. 2 to 210,000 cells l^{-1} at St. 3 and 222,000 cells l^{-1} at St. 4. The unusually low standing crop in the agricultural drainage water (Sts. 1 & 2) is likely to result from traces of pesticides and herbicides (Halim, 1984). The observations of April 1987 showed that the phytoplankton bloom extends to the middle of Max Bay (977,000-5000,00 cells l^{-1}). Its effects extend northward to cover all the Bay, westward to El-Agamy and eastward to the Eastern Harbour gradually decreasing to low values.

TABLE (3)

Maximum, minimum and average oxygen percentage saturation at stations 1 to 4.

	St.1	St.2	St.3	St.4
Maximum	75.74	80.7	48.1	91.6
Minimum	41.6	46.7	23.2	53.0
Average	54.56	59.18	36.0	68.12

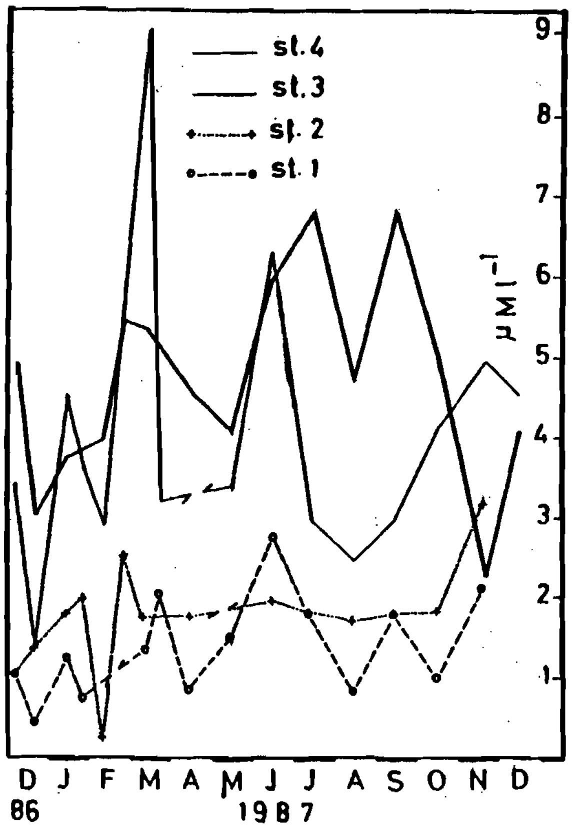

Fig. 3
Monthly variations of phosphate (stations 1 to 4).

TABLE (4)

Maximum, minimum and average phosphate (μ ML^{-1}) stations 1 to 4.

	St.1	St.2	St.3	St.4
Maximum	2.75	3.2	6.8	9
Minimum	0.45	0.25	2.25	1.5
Average	1.40	1.77	4.65	3.98

TABLE (5)

Maximum, minimum and average standing crop and number of species of sts. 1 to 4 and in Max Bay. (April 1987).

a- Phytoplankton (cells L^{-1}).

	St.1	St.2	St.3	St.4	Max Bay
Maximum	367000	20000	[illegible]	1180000	977000
Minimum	200	100	1300	1600	7000
Average	19000	1500	21000	122000	200000
No.of species	26	30	35	41	

b- Zooplankton (Organisms m^{-3}).

	St.1	St.2	St.3	St.4	Max Bay
Maximum	84000	7700	776000	387000	312000
Minimum	960	200	7000	3000	700
Average	7000	2400	90000	88000	56000
No.of species	36	20	45	36	

Composition :

Stations 1 & 2 (Upstream from the Lake).

The phytoplankton composition in both canal and drain was analogous except that Cyclotella glomerata was more frequent at St. 1 while Bacillaria

TABLE (6)

Zooplankton species composition and abundance in stations 1 to 4.

(+++ = common, ++ = frequent and + = rare)

Species	St.1	St.2	St.3	St.4
Paramecium sp.	+	+	++	+
Centropyxis oculeata			+	
Globigerina sp.	+	+	+	
Favella ehrenbergi			+	+
Helicostomella subulata				+
Free living Nematods	++	+	++	++
Oligochaeta	+		+	+
Polychaeta larvae			+	+
Brachionus angularis		+	++	++
B. budapestinensis			+	+
B. calyciflorus	++	++	+++	++
B. plicatilis	++	+	++	+
B. quadridentata			+	
B. urceolaria	++	++	++	+
Brachionus sp.				+
Filinia longiseta	+		++	++
F. brachiata			+	
Filinia sp.			+	
Moraella brehmi	+		+	
Keratella quadrata			+	
Lecane bulla		+	+	+
L. depressa	+			
L. closterocerca			+	
L. luna	+			
L. ohioensis				+
Lecane sp.	+		+	+
Lepadella sp.			+	
Manfredium eudactylotum	+		+	
Polyarthra sp.			+	+
Synchaeta okai	+		+	+
Synchaeta spp.	+	+	++	++
Tricocerca sp.			+	
Unidentified Rotifers	++	+	++	++
Bosmina longirostris	+	+		
Ceriodaphnia reticulata			+	+
Chydrous ovalis	+			+
Moina micrura	+	++	++	+
Oxyurella tenuicaudis	+		+	+
Diacyclops bicuspidatus	+	+	+	
Halicyclops magniceps			+	
Mesocyclops leuckarti	++	++	++	+
Nitocera lacustris	++	++	++	++
Oithona sp.				+
Onychocamptus mohammed		+		+
Thermocyclops sp.	+		+	
Cyclops sp.	+		+	
Mesopodopsis slabberi	+	+		
Ostracoda	++	++	++	+
Gammarus sp.		+	+	+
Water insects	++	++	+	
Nauplii of Cirripeds				+
Nauplii of Copepods	++	++	++	++
Mysis of shrimps	+	+	+	
Fish larvae	+		+	
Veliger larvae of Gastropods	+	+	+	
Veliger of Lamellibranchs	+		+	+

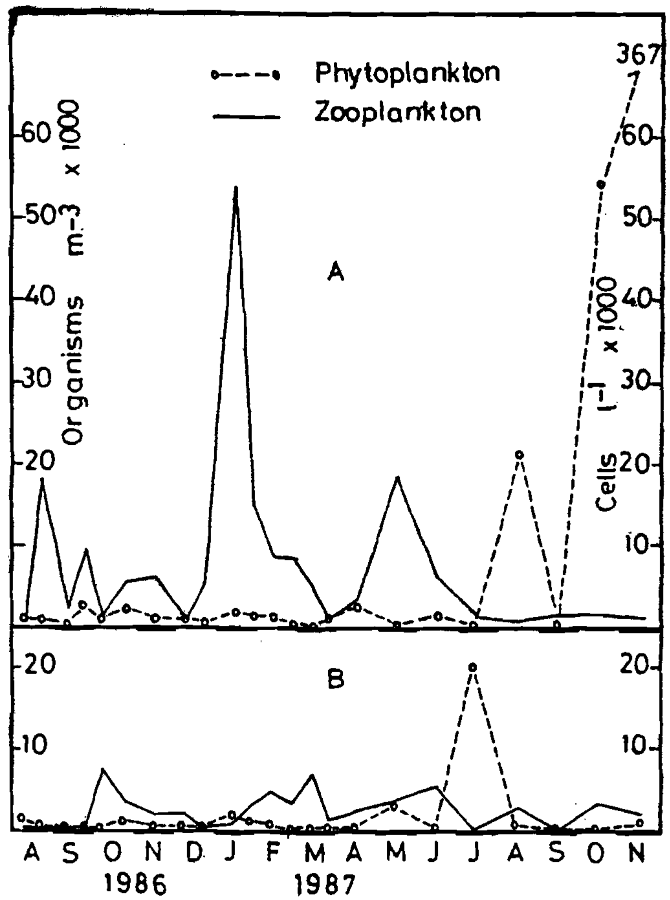

Fig. 4
Monthly variations of phytoplankton and zooplankton standing crops.
A- Station 1 B- Station 2

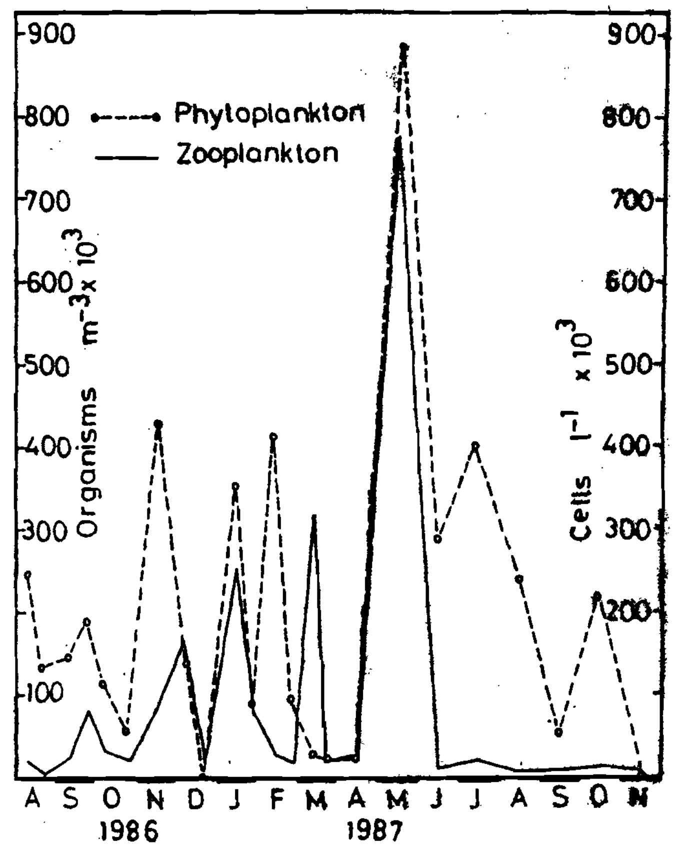

Fig. 5
Monthly variations of Phytoplankton and zooplankton standing crops (station 3).

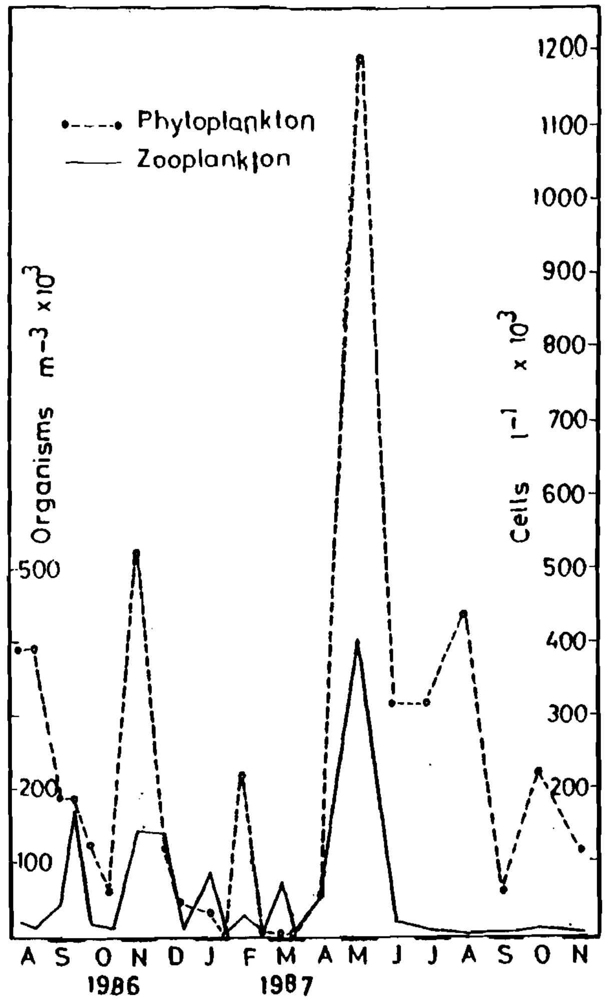

Fig. 6
Monthly variations of Phytoplankton and

paradoxa was more frequent at St. 2. Diatoms were dominant : **Biddulphia** sp., **Gyrosigma** sp., **Nitzschia minutissima, N. longissima, Nitzschia** spp., **Navicula** spp., **Campylodiscus** sp. and **Surirella striatula.** In addition, **Pediastrum boryanum** (Chlorophyta), **Spirulina** sp. (Cyanophyta) and **Euglena** spp. (Euglenophyta) were also intermittently recorded in both canal and drain.

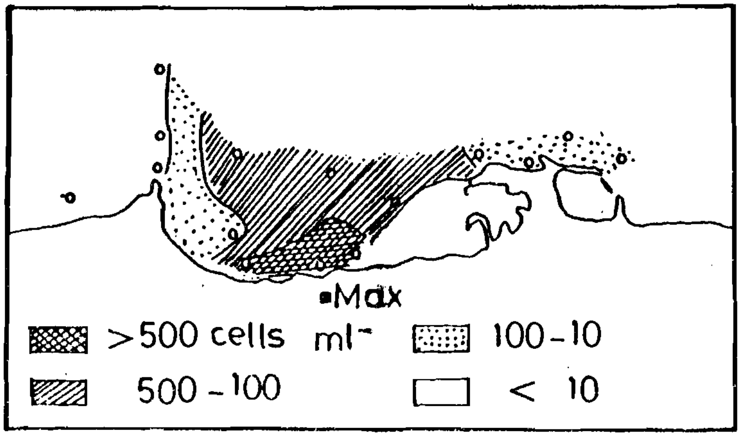

Fig. 7
Monthly variations of Phytoplankton and zooplankton standing crops (Station 4).

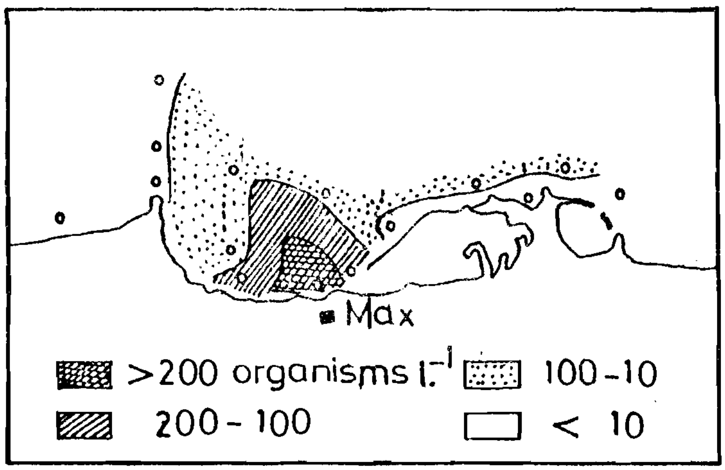

Fig. 8
Distribution of zooplankton in Max Bay (April, 1987).

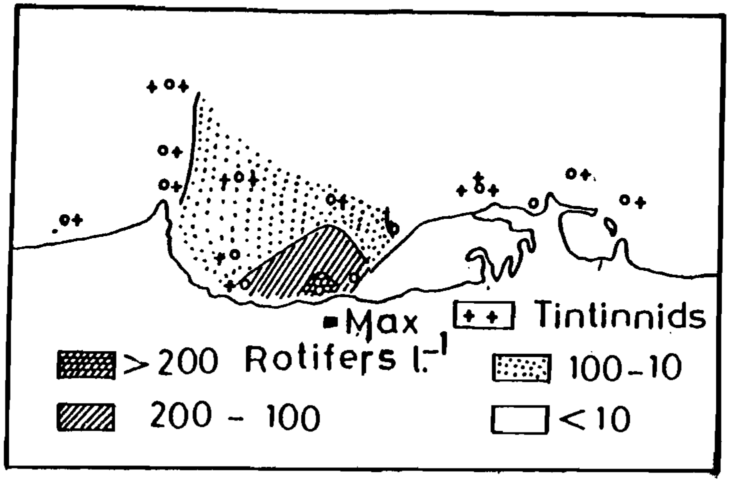

Fig. 9
Distribution of Rotifers and Tintinnids (+ = less than 5 org. l^{-1}, ++ = 5-10 and +++ = more than 10 org. l^{-1})

Station 3 :

Outlet of Umum drain, downstream from the Lake, The composition is still brackish. The abrupt increase in the phytoplankton standing crop after mixing is due to the abundance of the diatom **Cyclotella glomerata.** This species contributed a monthly average of 65.5 % to the total phytoplankton, rising to a maximum of 97 % in August 1986 and dropping to 8 % in February 1987. It is followed by Euglena spp. (0-87 %), **Biddulphia** sp., **Gyrosigma** sp., **Nitzschia minutissima, N. longissima, Nitzschia** spp., **Thalassiosira** sp., **Campylodiscus** sp., **Spirulina** sp. and to a less extent by **Scenedesmus opoliensis, Closterium** sp., **Bacillaria paradoxa, Navicula** spp., **Mastogloia sp., Amphiprora alata, Melosira moniliformis, Chaetoceros decipiens** and the Cyanophyta **Oscillatoria** sp.

Station 4 :(Mixed inshore sea water) :

Cyclotella glomerata is still the main component of the phytoplankton. It contributed 98 % to the total phytoplankton in November 1986 but was at a minimum in December 1986 (0.4 %). The species was then replaced by **Chaetoceros decipiens,** this is due to piling up of sea water. The latter species appeared in FebruaryMarch, July-August and October 1987. The increased abundance of **Chaetoceros decipiens** coincided each time with a rise in salinity (Fig. 2) **Euglena** spp. contributed from 0 to 87 %. Otherwise the composition is analogous to that in the upstream Sts. 1 & 2 including **Spirulina** sp., **Biddulphia** sp., **Campylodiscus** sp., **Nitzschia minutissima, N. seriata, N. longissima, Nitzschia** spp., **Navicula** spp., **Mastogloia** sp. and the Chlorophyta **Scenedesmus quadricauda.**

Max-Bay :

As mentioned above two surveys were carried out in April 1987. The dominant species were the Dinoflagell **Prorocentrum micans** (0-95 %) and the Diatom **Chaetoceros decipiens** (0-85 %). The two species, very rare inshore, spread in the Bay in an increasing trend towards the offshore. **Scenedesmus opoliensis** (0-60 %) and **S. bijugatus** (0-20 %), **Euglena** spp. (0-25 %) and **Cyclotella glomerata**, abundant inshore, decrease in the same direction.

Less abundant were **Leptocylindrus danicus**, **Mastogloia** sp. **Nitzschia minutissima**, **N. dissipata**, **Thalassiosira** sp. and **Melosira moniliformis**.

b- **Zooplankton**

The number of species and the standing crop of zooplankton also increased after mixing with the Lake water. Stations 1 and 2 yielded respectively 35 and 28 species. The number of species increased to 45 at St. 3. Again the monthly average standing crop increased from 7,000 org. m^{-3} at St. 1 and 2,400 org. m^{-3} at St. 2 to 90,000 org. m^{-3} at St. 3.

The range of variation at St. 2 is relatively small, from 200 to 7,000 org. m^{-3}, but St. 1 showed wider fluctuations from 550 to 54,000 org. m^{-3}. After mixing, there were many wider fluctuations ranging from 7,000 to 776,000 org. m^{-3} at St. 3 and from 3000 to 397000 org. m^{-3} at St. 4.

This pronounced increase in the zooplankton standing crop extends to the Max Bay nearly in the same manner as described for the distribution of the phytoplankton standing crop (Fig. 8).

Composition :
Stations 1 & 2:

There were some difference in the zooplankton composition between stations 1 and 2, but in both, there is no leading species. The species either share dominance or alternate with each other : Species common in both canal and drain : **Brachionus calyciflorus**, **B. urceolaris** and **B. plicatilis** (Rotifers), **Moina micrura** and **Bosmina longirostris** (Cladocera), **Mesocyclops leuckarti**, **Nitocera lacustris**, **Diacyclops bicuspidatus** and **Mesopodopsis slabberi**; free living Nematods, **Paramecium** sp., **Globigerina** sp., Ostracods, larvae of water insects, shrimp mysis and veliger larvae of Gastropods.

Species of less frequent appearance in St. 1 : Oligochaeta, **Filinia**

longiseta, Horaella brehmi, Lecane depressa, L. luna, Lecane sp., **Manfredium eudactylotum** and **Synchaeta okai,** (Rotifers), **Chydorus ovalis** and **Oxyurella tenuicaudis** (Cladocera), **Thermocyclops** sp. and **Cyclops** sp. and fish larvae.

Species of less frequent appearance in St. 2 : **Brachionus angularis, Lecane bulla, Diacyclops bicuspidatus, Onychocamptus** mohammed and **Gammarus** sp.

Station 3 :

Rotifers become the leading group in this locality, ranging from 20 to 97 of the total zooplankton, followed by Cladocera (0-33 %), Copepoda (0-25 %) and free living Nematods (0-10 %).

Species were common to canal and drain in decreasing order, they were : **Brachionus calyciflorus, B. urceolaris, B. plicatilis,** free living Nematods, **Moina micrura, Mesocyclops leuckarti, Nitocera lacustris** and **Paramecium** sp., and to a lesser extent **Globigerina** sp., Oligochaeta, **B. angularis, Horaella brehmi, Lecane bulla, Lecane** sp., **Manfredium eudactylotum, Oxyruella tenuicaudis, Diacyclops bicuspidatus, Thermocyclops** sp. and **Cyclops** sp.

Species appeared in station 3 : **Centropyxis oculeata, Favella ehrenbergi,** polychaeta larvae, **Brachionus budapestinensis, Filinia brachiata, Filinia** sp., **Keratella quadrata, Lecane closterocerca, Lepadella** sp., **Polyarthra** sp.,**Tricocerca.** sp., **Ceriodaphnia reticulata** and **Halicyclops magniceps.**

Species appeared in St. 1 or St 2 and absent from St. 3 : **Lecane luna,** Chydorus ovalis, **Onychocamptus** mohammed and **Mesopodopsis slabberi.**

Station 4 :

Any increase or decrease in the zooplankton populations at st. 3 is followed by a rise or a fall in the zooplankton population at st. 4, but may be not of the same order of magnitude. Their respective composition showed some differences.

Species absent from st. 4 : **Centropyxis oculeata, Globigerina** sp., **Brachionus quadridentata, Filinia** sp., **Lecane closterocerca, Lepadella** sp., **Trichocerca** sp., **Diacyclops bicuspidatus, Halicyclops magniceps** and **Thermocyclops** sp.,

Species only recorded from st. 4 absent from st. 3 **Chydorus ovalis, Onychocamptus mohammed** (both recorded in either st. 1 or st. 2 and must be present at times in St. 3), **Otthona** sp. and **Helicostomella subulata.**

Species common to both localities : **Paramecium** spp. **Favella ehrenbergi,** free living Nematods, Polychaeta larvae. **Brachionus angularis, B.**

budapestinensis, B. calyciflorus, B. plicatilis, B. urceolaris, Filinia brachiata, F. longiseta, Lecane bulla, lecane sp., **Manfredium eudactylotum, Polyarthra** sp., **Synchaeta okai, Synchaeta** spp., nauplii of cirripeds, **Mesocyclops leuckarti, Nitocera lacustris** and **Gammarus** sp.

Max Bay (April 1987) :

The zooplankton standing crop decreased from the inshore northward. It retains its characteristics several miles eastward, abruptly decreasing to the west. . The maximum population density reached 312000 org. m^{-3} at the inshore of the drain outlet, decreasing westward to 2000-4000 org. m^{-3} at El-Agamy, Northward to 5000-7000 org. m^{3} to the east until Western Harbour to 7000 org. m^{-3} (near the W.H.), and east of the Eastern Harbour to 3000-7000 org. m^{-3}.

Composition :

Rotifers were dominant in Max Bay and remained so as long as the standing crop exceeded 114000 org. m^{-3}, contributing more than 80 % to the total population. In other localities they were mostly absent or rarely reached 50 %. **Brachionus calyciflorus** is the leading species, followed by **Synchaeta** spp., **B. urceolaris, B. angularis** and **Brachionus sp.**

Of lesser importance were the Ciliate **Paramecium spp., The Tintinnids, Favella ehrenbergi, F. markuzowskii, Helicostomella subulata,** free living Nematods, Copepods, **Acartia latisetosa, Nitocera lacustris** and Copepod nauplii. The appendicularian **Oikopleura** sp. and the Cladoceran **Podon polyphemoides** were rare.

In the peripheral localities of lower population density (less than 14000 otg. m^{-3}), the Rotifers are replaced by Tintinnids, Copepod nauplii and adult copepods **Favella markuzowskii, F. ehrenbergi, Helicostomella subulata, Tintinnopsis beroidea, T. campanula, T. butschlii, Eutintinnus lusus-undae,** free living Nematods, the copepods **Canuella perplexa, Nitocera lacustris, Mesocyclops leuckarti** and the Cladocerna **Podon polyphemoides.**

DISCUSSION

Rotifers which are associated with organically rich environments are also observed in oligotrophic habitats. Clean water showed the least variation in its Rotifer population, as well as in the number of species, whereas eutrophic areas sustain the greatest number of species and of individuals.

Arora (1966) listed the Rotifers Species, he considers as indicators to each type of water. As an example **Brachionus angularis, B. Calyciflorus** and **Filinia longiseta,** which have wide zoogeographical distribution, were found to be associated with mixotrophic waters.

Species like **B. quadridentata** and **B. falcatus** occur in greater abundance in clean water.

The same observations were recorded in Lake Menzalah by Guerguess (1979).

In the present observations, wt. 3 waters showed the least oxygen percentage saturation owing to the presence of a heavy load of organic matter, the highest phosphate concentration, a dense phytoplankton standing crop and a maximum production of zooplankton with the greatest number of species (Table 7).

The phytoplankton species, **Cyclotella glomerata, Euglena** spp. and **Spirulina** sp. were leading in both st. 3 or st. 4.

Rotifers are the most important zooplankton components contributing more than 65 % to the total zooplankton in both st. 3 or st. 4. **Brachionus calyciflorus** is the most important species, followed by **B. angularis, B. ureolaris, B. pliccatilis, synchaeta** spp. and **Filinia longiseta.**

The association of Rotifer with organically rich water was previously observed by Arora (loc. cit) and also by Guerguess (loc. cit). The plankton, especially rotifers of both El-Nubariah Canal (st. 1) and El-Umum drain (St. 2) increased in biomass and in number of species after mixing with the lake water (st. 3), with its load of organic matter.

TABLE (7)

Number of species of Rotifera, Cladocera, Copepoda; others and total in stations 1 to 4.

	Rotifera	Cladocera	Copepoda	Others	Total
Station 1	13	4	5	13	35
Station 2	8	2	5	13	28
Station 3	20	3	6	19	45
Station 4	18	4	4	10	36

The mixotrophic species **Brachionus colyciflorus** becomes the most important species of the zooplankton and also the presence of **Filinia longiseta** in frequent abundance at Sts. 3 and 4 (table 6). The clean water form **B. falcatus** was completely absent and **B. quadridentatus** was rarely observed at st. 3 only.

. The Index (I) of Biotal (B) Dispersity (D) (Fig. 10) of Koch (1957, in Green, 1971) was applied to test the dispersity between zooplankton associations in these localities.

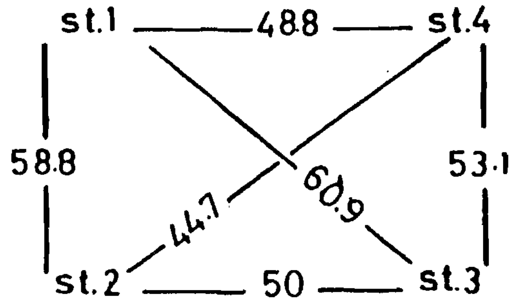

Fig. 10
Index of Biotal despersity (I.B.D)
between stations 1 to 4.

$$IBD = T - S / S (n-1) \times 100$$

Where,

T is the arithmetical sum of species living in each of n compared associations,

S is the number of species in compared associations. If each locality had a completely different set of species, IBD = 0 and if identical, IBD = 100,

IBD between st. 1 and st. 2 is 58.8, St. 2 and St. 3 is 50, St. 3 and St. 4 is 53.1, St. 1 and St. 4 is 48.8, St. 1 and St. 3 is 60.9 and St. 2 and St. 4 is 44.7.

It is clear from the IBD study that the composition of zooplankton of El-Max outlet (St. 3) is more similar to the composition of zooplankton of El-Nubariah canal St.1, (60.9) than with El-Umum drain St. 2, (50).

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