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DISTRIBUTION OF SOME HEAVY METALS IN LAKE BUROLLUS, EGYPT.

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ABSTRACT

Concentrations of dissolved heavy metals (Zn, Cu, Pb, and Cd) and their variation with location and with time of year, in Lake Burollus, were determined in the period between March 1987 and March 1988.

Average values in ppb (ug/L) of these concentrations for the whole Lake were 5.50, 2.34, 1.92 and 1.61 for Zn, Cu, Pb and Cd respectively. Concentrations decreased in a westward direction across the Lake.

INTRODUCTION

Levels of heavy metals in the atmosphere, land and water (saline and fresh) are constantly on the rise, due to man's industrial processing of the environment. This widespread contamination has its obvious effects on plants, animals, and on man himself. In Egypt awareness of this danger has called for a nead to assess conditions in an effort to offset any future or imminent catastrophes.

Lake Burollus, an economically important Lake due to its rich fishery resources, lies between the two branches of the Nile Delta, and is connected to the Mediterranean Sea. The Mediterranean is itself an example of the limitation and of how essentially closed our water bodies are as a dumping ground for our polluting byproducts. It has a high level of contamination. Lake Burollus is separated from the Mediterranean by sand bars and sand dunes of different widths and heights, and is connected to the sea through a narrow opening "El-Boghaz", in the eastern part of the Lake. This connection to the sea is sometimes lost in the spring due to sediment transport and accumulation of marine sand. Within the Lake there are also many islets with varying sizes. Seawater enters the Lake through "El-Boghaz" at Borg El-Burollus, while freshwater supplies the Lake through six drains and one freshwater canal (Fig. 1). The freshwater canal joins the Lake in the westermost part. These drains bring water to the Lake that has already been used for either industrial or agricultural purposes.

The Lake has an area of about 550 Km^2. The Lake width varies between 5 and 17 Km., and its depth between 1 and 2 meters. The water depth attains its maximum during November, and reaches its minimum during February. The depth is affected by changes in the direction of the wind as well as in the water drainage into the Lake.

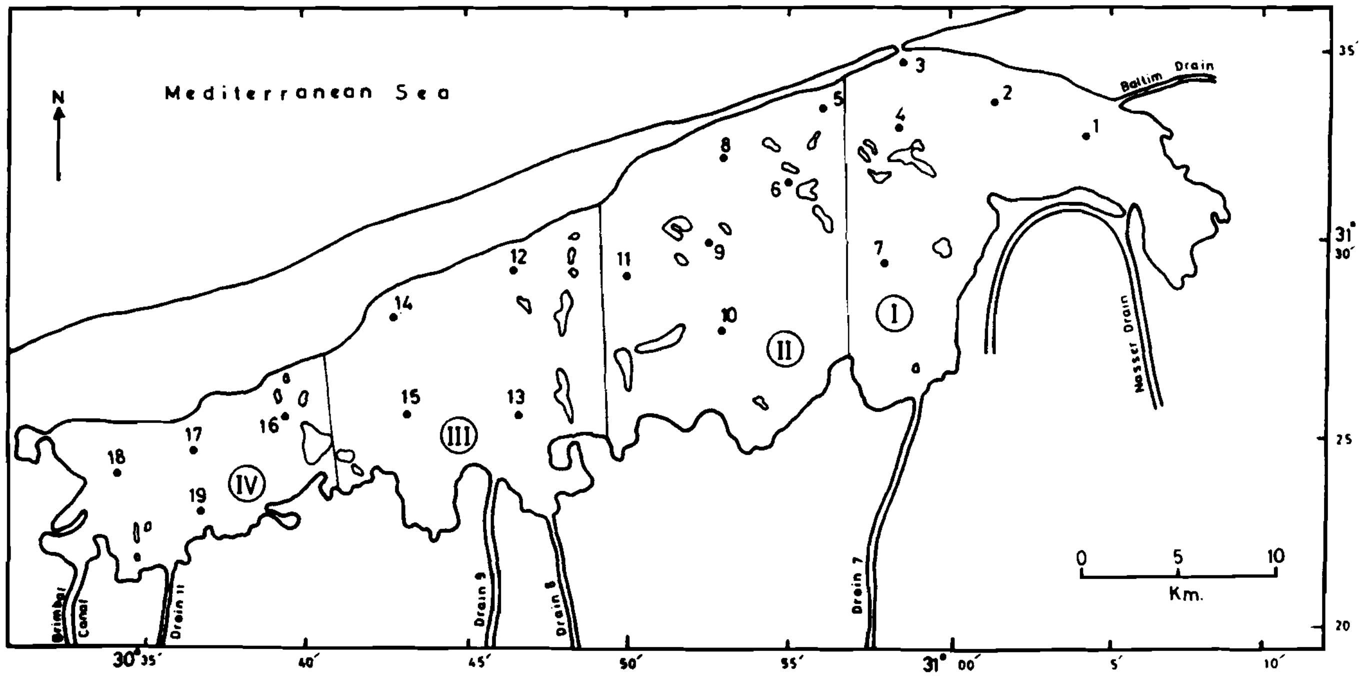

FIG. 1

Map of Lake Burollus showing the basins,
the sampling locations and the drains.

METHODS

Liquid-liquid extraction of suitable complexes of the elements chosen was carried out, followed by atomic absorption measurements on the organic extracts. The dithiocarbamate methylisobutylketone, which was first suggested for seawater analysis by Sprague and Slavin (1964) was used throughout the present study. Book et al. (1967), used it for the analysis of Cu, Co, Fe, Ni, Pb and Zn. Brewer et al. (1969) simplified the standardization and applied a new blank evaluation procedure. Methylisobutylketone (MIBK) has very good burning characteristics, but its separation from the aqueous phase is slow and sometimes incomplete. Furthermore, the stability of metal complexes in the organic phase is limited and variable which means that the time lag between extraction and determination should be as short as possible. In addition, the effect of storage conditions of heavy metals has been examined in order to ascertain appropriate condition under which any change due to storage would be minimized.

Extraction, analysis and measurements of heavy metals had been carried out according to Martin (1972). Samples (1 liter each) of the Lake water were filtered. The pH of filtrate is adjusted to 4-5 with 6N HCl.

The collected sample (750 ml)of the Lake water was inserted in polyethylene bottles and 35 ml redistilled MIBK and 7 ml of APDC (ammonium pyrrolidine dithiocarbamate) solution were added to each bottle. Equilibrate by shaking on a mechanical shaker for about 30 minutes, then separate the phases by means of separating funnels.

Flame atomic absorption spectrophotometry was performed using air-acetylene on Varian Techtron model 1250.

RESULTS AND DISCUSSION

The average concentrations of dissolved heavy metals Zn, Cu, Pb and Cd in respect with salinity in the different basins (I, II, III and IV) are given in Table 1. Station 3 represents the sea-lake connection (El-Boghaz).

Zinc

In all basins tested of Lake Burollus, it is evident that the monthly concentration values of zinc fluctuated between 1.01 and 28.29 ug/L (Table 1). The highest values were recorded in basin I and the lowest values were in basin IV.

In basin I, the maximum values (28.29 and 12.28 ug/L) were recorded in December and June, 1987 coinciding with the high values of salinity which were recorded in these two months (Fig. 2). Station 3 manifested this overlapping due to higher values of salinity and dissolved zinc (Table 1 and Fig. 2). The increase in zinc concentrations in this basin seem to be from the sea. Mahmoud and Beltagy (1988),

Table 1.

Average concentration of dissolved Zn, Cu, Pb, and Cd (ug/l) in the four basins of Lake Burollus during the period from March 1987 to March 1988.

Basin	Metal	March 1987	April	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 1988	Feb.	March	Average
* Station 3	S ‰	5.77	11.15	23.52	6.58	5.53	8.63	9.54	9.57	14.79	5.74	15.28	13.31	10.78
	Zn	2.60	15.05	20.00	8.48	10.50	10.00	8.60	10.50	28.78	0.80	2.10	1.39	9.23
	Cu	2.30	1.89	3.32	1.23	2.47	0.99	2.01	1.97	6.58	1.07	4.10	2.83	2.56
	Pb	0.00	0.00	0.00	0.00	0.25	5.59	4.30	0.00	2.63	0.00	7.87	5.14	2.15
	Cd	0.00	0.00	5.20	3.51	4.10	0.00	0.00	0.50	0.00	0.00	3.76	0.37	1.46
Basin (I)	S ‰	5.99	7.95	13.39	5.29	7.10	5.64	6.07	6.42	11.10	5.18	10.66	9.60	7.93
	Zn	4.44	6.93	12.28	6.53	6.60	8.95	3.33	11.75	28.29	4.84	10.59	8.53	9.42
	Cu	2.53	1.75	2.49	2.40	2.94	2.46	2.00	2.28	6.67	2.32	5.00	2.24	2.92
	Pb	0.43	0.10	0.13	0.63	2.33	5.59	5.26	0.97	2.00	2.00	7.92	4.63	2.67
	Cd	1.38	1.82	6.93	4.22	4.56	0.63	0.54	0.54	1.51	0.63	2.74	0.72	2.11

Table 1 (cont.)

Basin (II)	S ‰	3.02	3.47	3.16	2.86	3.27	3.13	3.00	2.84 •	6.60 ♦	3.18	4.41	6.02	3.75
	Zn	5.44	13.09	4.36	3.46	4.18	5.85	3.17	10.27	22.89 ♦	1.55 •	2.37	5.48	6.84
	Cu	1.89	2.48	2.49	2.51	3.40 ♦	1.35 •	2.11	2.46	2.56	2.13	1.81	3.26	2.37
	Pb	0.59	0.27	0.06 •	0.16	0.18	4.91	4.14	0.13	0.18	0.26	8.35 ♦	2.84	1.84
	Cd	1.70	1.61	1.56	4.30	6.67 ♦	0.26	0.23	0.18	0.18	0.24	3.61	0.37	1.74
Basin (III)	S ‰	1.79	1.85	1.44	1.39 •	1.67	1.52	1.48	1.74	1.73	2.17	2.65	2.94 ♦	1.85
	Zn	3.06	3.17	2.00	2.46	2.45	5.83 ♦	4.92	4.84	1.31 •	1.32	1.92	1.55	2.90
	Cu	2.97	3.13 ♦	2.57	1.77	2.74	1.93	1.50 •	2.48	1.93	1.58	1.51	2.94	2.25
	Pb	0.54	0.25	0.16	0.16	0.41	8.27 ♦	2.00	0.28	0.09	0.53	4.91	3.64	1.77
	Cd	1.39	1.56	1.32	4.46	4.73 ♦	0.97	0.79	0.00	0.09	0.00	1.36	1.28	1.50
Basin (IV)	S ‰	1.75	1.20	1.12	0.92 •	1.04	0.98	0.90	1.02	1.37	1.54	2.61	3.17 ♦	1.47
	Zn	2.35	2.02	2.00	1.01 •	2.09	6.99 ♦	5.99	5.46	1.20	1.58	1.60	1.65	2.83
	Cu	1.65	2.45	3.87 ♦	2.50	1.90	0.93	1.35	1.48	1.42	1.39	0.77 •	1.86	1.80
	Pb	0.20	0.00	0.00	0.00	0.00	6.11 ♦	2.93	0.00	0.16	0.60	2.93	3.93	1.40
	Cd	1.94	0.56	0.00	5.61 ♦	1.67	0.38	0.12	0.00	0.00	0.21	0.36	0.39	1.10

* N.B. : The values of station 3 without average. ♦ : The maximum values. • : The minimum values.

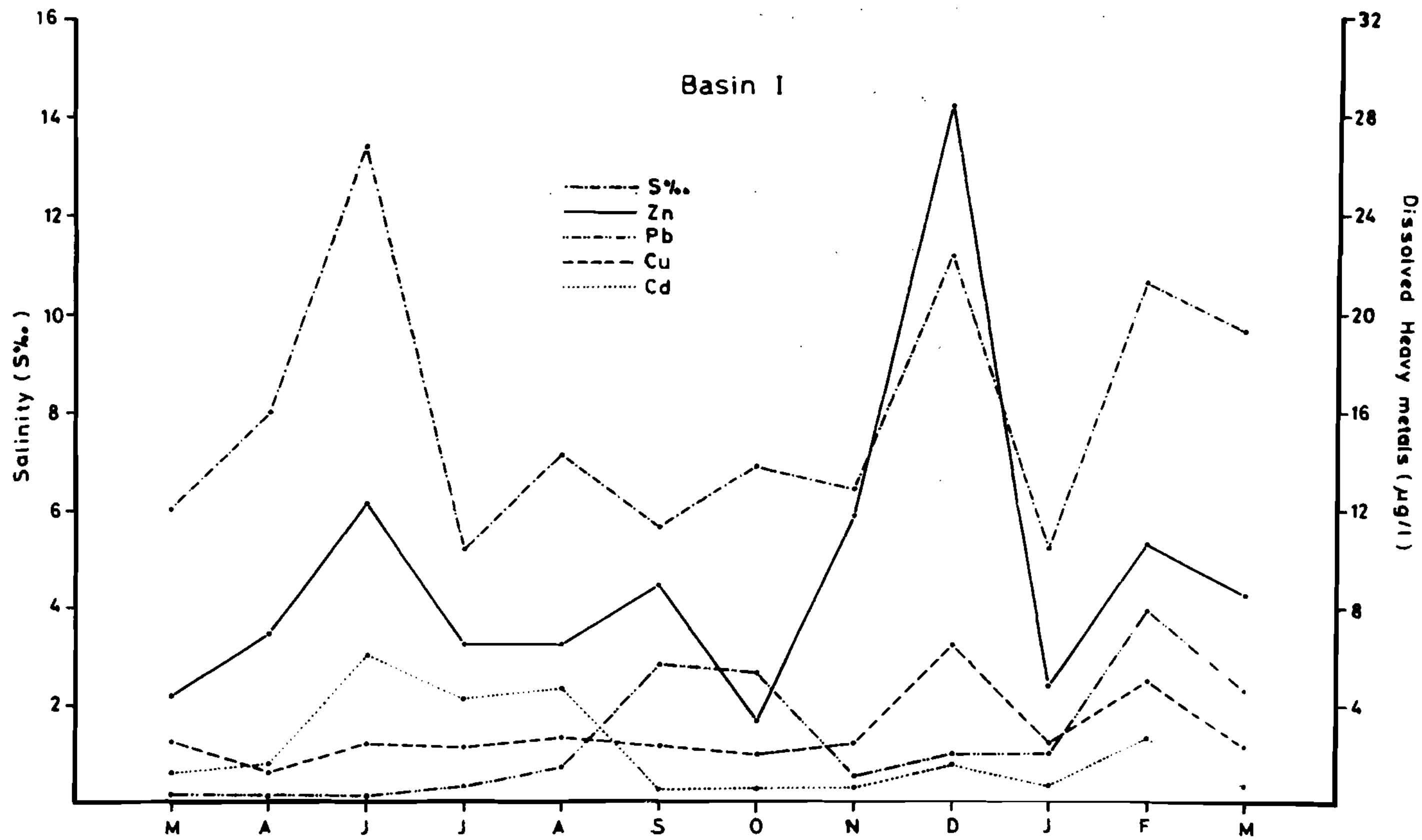

FIG. 2

The average monthly variations of dissolved heavy metals and salinity in Lake Burollus (Basin I).

pointed out this phenomenon, where the pollution by detergents in basin I mainly comes from the sea which contains more heavy metals and detergents.

From the hydrobiological point of view, the relative decrease in zinc concentration in spring and autumn may be attributed to the decrease in the decomposition rate of organic matter with lower temperatures (Aboul-Nagah, 1979; Hafez, 1982). In addition, Thompson, et al. (1932) and Salah, (1959), concluded that the consumption of zinc by phytoplankton from water is spread in spring.

In basin II, the same trend happened as in basin I, but with relatively small values (Table 1 and Fig. 3). The average maximum and minimum values of dissolved zinc are fluctuated between 22, 89 and 1.55 ug/L in December 1987 and January 1988, respectively. The high values of dissolved zinc coincided also with the high values of salinity as mentioned before. But the water of this basin may be affected by the adjacent waters from basins I and III.

In basin III, the maximum average value of dissolved zinc (5.83 ug/L was recorded in September with normal or low salinity (Table 1 and Fig. 4). In this basin, no effect of the salinity on the concentration of zinc was recorded. But the maximum average value of dissolved zinc in this month (September) may be attributed to the increase of zinc content of the drains (No. 8 & 9) which pour in the south margin of basin III (Table 2). In addition, the decay of organic matter normally occurs in late summer (September). Minimum average values of dissolved zinc (1.31 and 1.32 ug/L) were measured during winter (December, 1987 and January, 1988). This may also be attributed to the decrease in the decomposition rate during low temperature periods.

Basin IV, showed the same trend as in basin III. The maximum average value (6.99 ug/L) was measured in the same month (September), as in basin III (Table 1 and Fig. 5). Minimum average values were also measured in the same season (winter) as in basin III. Finally, it is clear that no effect of salinity on the zinc concentration in these two basins III and IV. Our data are in concordance with previous findings (Hutchinson, 1957) where zinc is usually present in higher quantities than those of copper in normal water (Tables 3 and). In general, our results as an average are lower (Table 3) and consequently Lake Burollus is less polluted than the other lakes, e.g. Lake Mariut and Lake Manzala.

Copper

Copper enters Lake Burollus mainly from drains (agricultural drainage and industrial wastes). Copper salts in our waters may also come from textile processes, pigmentation, insecticides, fungicides and antifouling paints.

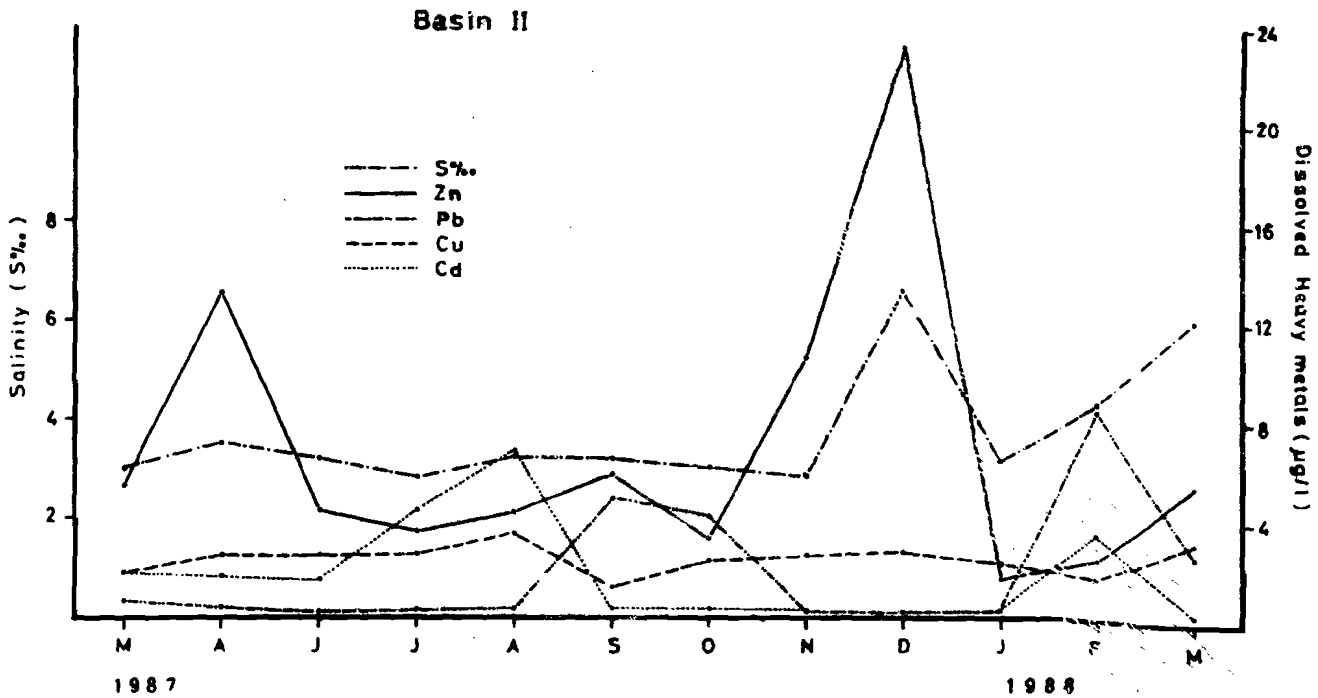

FIG. 3.

The average monthly variations of dissolved heavy metals and salinity in Lake Burollus (Basin II).

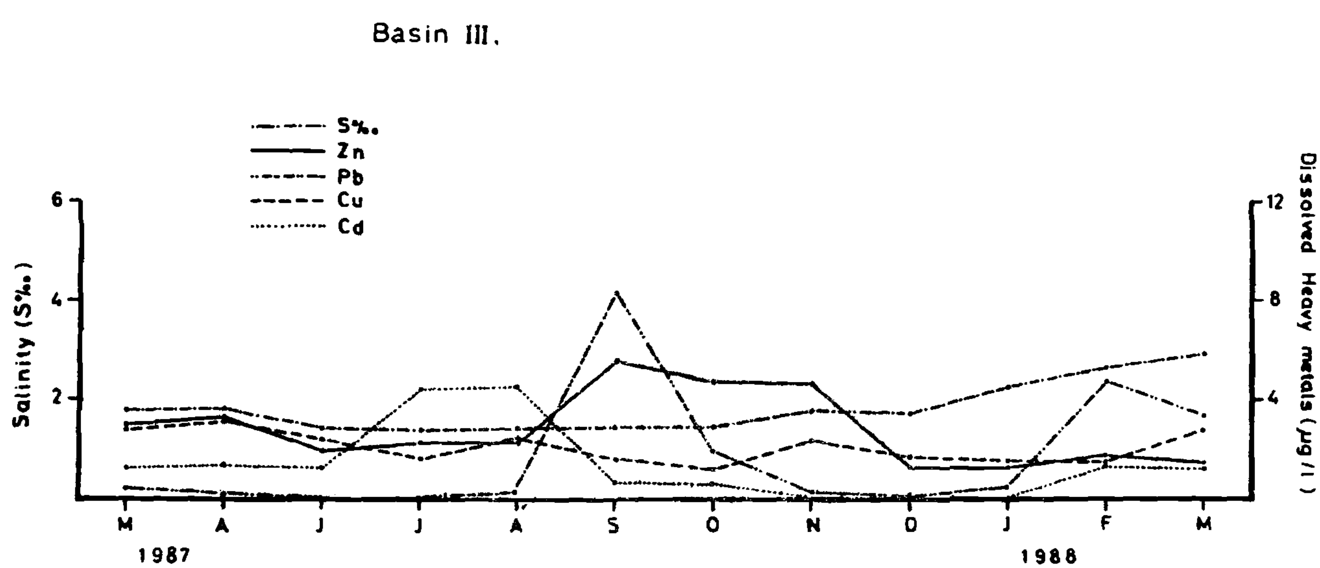

FIG. 4.

The average monthly variations of dissolved heavy metals and salinity in Lake Burollus (Basin III).

Table 2.

Heavy Metals Concentration in Drains of Lake Burollus.

Zn (ug/L)

Basin	Name of Drain	March 1987	Sep. 1987	Dec. 1987
I	Baltim Drain	4.95	15.05	13.23
	Nasser Drain	6.36	11.31	14,04
	Drain No. 7	0.00	9.39	12.60
II	Drain No. 8	2.59	4.48	1.69
	Drain No. 9	9.42	6.16	1.83
IV	Drain No. 11	2.33	7.12	1.50

Cu (ug/L)

Basin	Name of Drain	March 1987	Sep. 1987	Dec. 1987
I	Baltim Drain	5.10	3.79	4.53
	Nasser Drain	2.39	3.69	5.18
	Drain No. 7	2.65	4.12	5.20
III	Drain No. 8	2.47	3.87	6.09
	Drain No. 9	2.06	1.65	6.58
IV	Drain No. 11	2.47	4.16	1.62

Pb (ug/L)

Basin	Name of Drain	March 1987	Sep. 1987	Dec. 1987
I	Baltim Drain	0.63	7.53	0.75
	Nasser Drain	0.88	8.53	0.00
	Drain No. 7	0.00	8.15	0.37
III	Drain No. 8	0.00	11.27	0.25
	Drain No. 9	0.88	6.89	0.00
IV	Drain No. 11	0.00	0.40	0.00

Cd (ug/L)

Basin	Name of Drain	March 1987	Sep. 1987	Dec. 1987
I	Baltim Drain	2.58	0.50	-
	Nasser Drain	2.94	0.35	-
	Drain No. 7	1,88	0.35	-
III	Drain No. 8	1.29	0.23	-
	Drain No. 9	3.87	0.47	-
IV	Drain No. 11	1.41	0.32	-

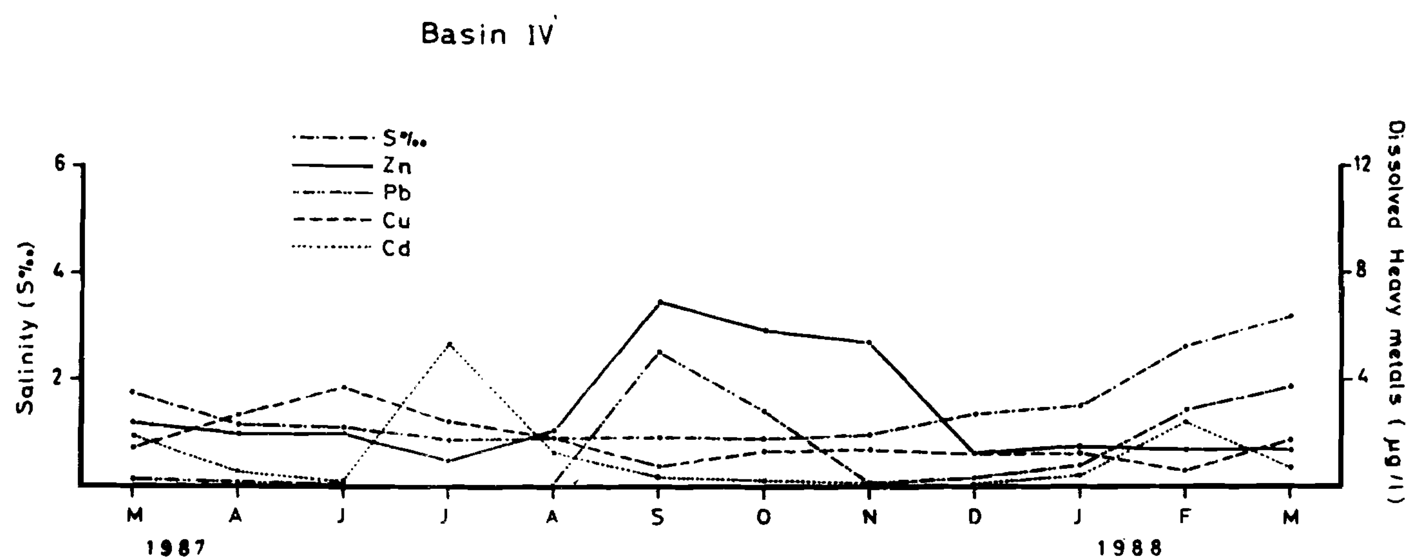

FIG. 5.

The average monthly variations of dissolved heavy metals and salinity in Lake Burollus (Basin IV).

Table 3.

Concentrations of Zinc in different ecosystems.

Ecosystem		Valuss ug/L	References
Seawater of Bombay Harbour	(range)	2.70-22.70	Matkar and Pillal, 1975
	(mean)	14.50	
Open water of Lake Michigan	(range)	4.00-10.00	Nienke, 1977.
	(mean)	5.00	
Seawater of the Ligurian Sea	(range)	1.00-2.00	Veglta and Vaissiere, 1984.
Damietta Branch	(mean)	12.00	Fahmy, 1981.
El-Max Bight	(mean)	19.00	El-Nady, 1981.
Lake Mariut	(mean)	10.60	Hafez, 1982.
Nozha Hydrodrome	(mean)	8.10	Hafez, 1982.
Lake Manzala	(mean)	12.70	Dowidar et al., 1984.
El-Max Bay inshore	(meam)	16.50	Aboul-Dahab et al., 19[illegible]
El-Max Bay offshore	(mean)	7.50	Aboul-Dahab et al., 198[illegible]
Lake Burollus Basin I	(range)	3.30-28.30	Present study
	(mean)	9.42	
Basin II	(range)	1.60-22.90	Present study
	(mean)	6.84	
Basin III	(range)	1.30-5.80	Present study
	(mean)	2.90	
Basin IV	(range)	100.7.00	Present study
	(mean)	2.83	
Average of the whole Lake		5.50	Present study

In basin I, the minimum average values of dissolved copper (1.75 ug/L) were recorded in April (Table 1 and Fig. 2). This may be attributed to the decrease in the decomposition rate of organic matter. On the other hand, with increasing temperature, phytoplankton consumes copper during spring bloom. Maximum average value (6.67 ug/L) was measured in December. This also coincides with the high salinity values in this month. On the other hand, Station 3 manifested this correspondence as it contains high values of dissolved copper and salinity (Table 1). Also, the drains, which pour in basin I contains high values of dissolved copper (4.53 - 5.20 ug/L), Table (2).

In basin II, there is a gradual increase from March, 1987 to reach a maximum average value (3.40 ug/L) of dissolved copper in August to again decrease and increase to reach another peak in March, 1988. This nearly coincides with increasing or decreasing of average salinity except in December. Minimum values were measured in autumn. This may be attributed to the decrease in the rate of decomposition of the accumulated organic matter and consequently decrease in the liberation of such heavy metal like copper and vice versa (Aboul-Nagah, 1979).

In basins III and IV, the correlation between dissolved copper and salinity is not closed to each other, as prevailed in basins I and II (Table 1 and Figs. 4 and 5).

Many studies have been done on the dissolved copper in lakes (Table 4). By comparing our results with those of Lake Mariut, Lake Manzala and Damietta Branch of the River Nile, it is clear, that Lake Burollus is less polluted.

Lead

In basins I and II, the monthly average values showed high concentrations of dissolved lead during the period from September to October, 1987 (Figs. 2 and 3). Maximum values (7.92 and 8.35 ug/L) were recorded in February, 1988, coinciding with high values of metals and salinity in this month. However, it is clear that no correlation between lead concentration and the decrease or increase of salinity could be detected. But, the relatively high lead concentration measured in September for the two basins may be attributed to the effect of the drains (Baltim, Nasser and No. 7), Table (2). Minimum average values of dissolved lead were measured in these two basins in March, 1987, also coinciding with low values which measured in the same drains (Table 2).

The average concentrations of dissolved lead in basins III and IV, are nearly the same (Figs. 4 and 5). Maximum average values of dissolved lead (8.27 and 6.11 ug/L were measured in the same month (September), (Table 1). This also coincides with the high values of dissolved lead measured in drains No. 8 , 9 and 11 (Table 2). On the other hand, the average low values of dissolved lead measured in

Table 4.

Concentrations of Copper in different ecosystems.

Ecosystem		Values (ug/L)	REFERENCES
Total amount discharged to Lake Mariut from industrial wastes during the period from May, 1974-May, 1975.	(mean)	26.00	El-Sharkawy and Hamza, 1977.
Damietta Branch	(mean)	3.10	Fahmy, 1981.
El-Max Bight	(mean)	3.20	El-Hady, 1981.
Lake Mariut	(mean)	4.00	Hafez, 1982.
Nozha Hydrodrome	(mean)	4.20	Hafez, 1982.
Lake Manzala	(mean)	3.850	Dowidar et al., 1984.
El-Max inshore	(mean)	1.99	Aboul-Dahab et al, 1984.
offshore	(mean)	0.88	Aboul-Dahab et al, 1984
Seawater of the Ligurian sea	(range)	0.40-0.80	Vegita and Vaissier [illegible]95[illegible]
Lake Burollus Basin I	(range)	1.75-6.67	Present study
	(mean)	2.92	
Basin I	(range)	1.35-3.40	Present study
	(mean)	2.37	
Basin III	(range)	1.50-3.13	Present study
	(mean)	2.25	
Basin IV	(range)	0.77-3.87	Present study
	(mean)	1.80	
Average of the whole lake		2.34	Present study

December, 1987 also coincide with the low values of dissolved lead in the same drains No. 8, 9 and 11, (Table 2).

Results do point to the fact that the origin of pollution by lead is from the drains. On the other hand, there is no correlation between the dissolved lead concentration and increasing or decreasing salinity.

There is a lack of adequate data on the analysis of lead in the Egyptian Lakes (Table 5), yet the data suggest that Lake Burollus is cleaner (less polluted) than Lake Manzala.

Cadmium

The average values of dissolved cadmium gave the lowest concentrations of all heavy metals in this study on Lake Burollus.

In basin I, the average value of dissolved Cd varied between a maximum (6.03 ug/L) in summer and minimum of (0.54 ug/L) in autumn. Maximum or minimum values in this basin correspond with increasing or decreasing salinity. Moreover, station 3 manifested the same correlation as it has a high concentration of dissolved cadmium and salinity during this month (Table 1). Zirino and Yamamoto (1972), indicated that cadmium interacts primarily only with the chloride ion. Pollution by Cd may arise partially from the sea. Mahmoud and Beltagy (1988) observed when the values of salinity increased during certain months, detergents also increased. Dissolved cadmium, particularly in station 3 was always associated with high salinity (Table 1). We also observed higher values of dissolved Cd during summer months (Fig. 2). Relatively high values of dissolved Cd were observed in March, 1987 than in September, 1987. This is attributed to the effect of the drains (Baltim, Nasser and No. 7) in both months (Table 2).

For basins II, III and IV, nearly the same pattern was recorded (Figs. 3, 4 and 5). There are small values of dissolved cadmium during winter season with increasing temperature in spring, the average values of dissolved Cd increase to reach a maximum during summer months followed by a decrease in autumn and winter with a small peak in February, 1988. Threr is no correlation between dissolved Cd and salinity in these basins, and the pollution in these basins may originate from drains.

When compared to other Egyptian lakes, Lake Burollus is higher with respect to Cd, and this may be attributed to the connection to the Mediterranean in basin I (Table 6).

CONCLUSION

Lake Burollus is not heavily polluted with heavy metals, but the increase in lead and cadmium concentrations, especially in basins I and II, draws attention to a need for further watch of pollution and its possible increase within the Lake.

Table 5.

Concentrations of Lead in different ecosystems.

Ecosystem		Values (ug/L)	References
Lake Manzala	(mean)	2.45	Dowidar et al., 1984.
El-Max Bay			
inshore	(mean)	0.07	Aboul-Dahab et al., 1984.
offshore	(mean)	0.04	Aboul-Dahab et al., 1984.
Lake Burollus			Present study
Basin I	(range)	0.10-7.92	[illegible]
	(mean)	2.67	
Basin II	(range)	0.06-8.35	Present study
	(mean)	1.84	
Basin III	(range)	0.00-8.27	Present study
	(mean)	1.77	
Basin IV	(range)	0.00-4.93	Present study
	(mean)	1.40	
Average of the whole lake.		1.92	Present study

Table 6.

Concentrations of Cadmium in different ecosystems.

Ecosystem		Values (ug/L)	References
River Avon Estuary	(mean)	4.20	Abdullah et al., 1972.
Irish Sea	(range)	0.00-0.20	Abdullah et al., 1972.
Total amount discharged to Lake Mariut from industrial wastes during the period from May, 1974 - May, 1975.	(mean)	3.95	El-Sharkawy and Hamza, 1977
Damietta Branch	(mean)	0.80	Fahmy, 1981.
El-Max Bight	(mean)	0.20	El-Nady, 1981.
Lake Mariut	(mean)	0.57	Hafez, 1982.
Nozha Hydrodrome	(mean)	0.65	Hafez, 1982.
Lake Manzala	(mean)	0.23	Dowidar et al., 1984.
El-Max Bay Inshore	(mean)	0.17	Aboul-Dahab et al., 1984.
El-Max Bay offshore	(mean)	0.09	Aboul-Dahab et al., 1984.
Lake Burollus			
Basin I	(range)	0.51-6.03	Present study
	(mean)	2.11	
Basin II	(range)	0.18-6.67	Present study
	(mean)	1.74	
Basin III	(range)	0.0-4.73	Present study
	(mean)	1.50	
Basin IV	(range)	0.0-5.61	Present study
	(mean)	1.10	
Average of the whole Lake		1.61	Present study

Basin I, of Lake Burollus, the eastern most part of El-Boghaz which is the connection to the sea contained higher concentrations than any other parts of the Lake.

The average values of these metals amounted, respectively to 5.50, 2.34, 1.92 and 1.61 ug/L for Zn, Cu, Pb and Cd for the whole Lake, respectively.

Results indicated that the source of pollution by heavy metals is mainly from the drains, which pour in the Lake also. Results also showed that there is no correlation between lead concentration and salinity. The pollution by lead in the Lake mainly originated from the drains. For Zn and Cu, a good correlation is observed with salinity only in basins I and II. For basins III and IV, no correlation is detected. However, a good correlation is found between Cd and salinity in basin I. No significant correlation is detected for Cd and salinity in the rest of the Lake.

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