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ACCUMULATION OF TRACE METALS IN SOME BENTHIC INVERTEBRATE AND FISH SPECIES RELEVANT TO THEIR CONCENTRATION IN WATER AND SEDIMENT OF LAKE QARUN, EGYPT

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ABSTRACT

Concentrations of major metals (Na, K, Ca, Mg) and some trace metals (Fe, Zn, Mn, Ni, Cu, Co, Pb, Cr, Cd) were determined in water, sediment, benthos and some common fish species from Lake Qarun. Water and sediment samples were collected from seven stations where, the benthos and fish species were collected from three sites representing east, middle and west of the lake.

Distribution of studied metals showed that, east part generally had higher contamination than west one which may be attributed to the impact of pollution sources in this area which coming from El-Batts Drain and pumping station in the east part. Mollusca and Crustacea especially Barnacles have the highest concentrations of most heavy metals measured more than Polychaeta which make them suitable candidates to be used in biomonitoring surveys of Lake Qarun. The concentrations of heavy metals in fish samples indicate that *Solea* sp.and *Mugil* sp. seemed to be more contaminated than *Tilapia* sp. which attributed to their feeding behavior. Bioaccumulation factor values showed that the trend of accumulation of most metals was as follows: Mollusca > Crustacea > Annelida > *Solea* sp. > *Mugil* sp. > *Tilapia* sp.

INTRODUCTION

Studies on heavy metals in rivers, lakes, fish and sediments have been a major environmental focus especially in the last decades. Sediments are important sinks for various pollutants like pesticides and heavy metals and also play a significant role in the remobilization of contaminants in aquatic systems under favorable conditions and in interactions between water and sediment. (Klavinš, *et al*., 2000; Grosheva *et al*., 2000).

Knowledge of concentration of heavy metals is desirable for the estimation of metal concentration in lake's water, sediment and biota. Metal accumulated in benthic organisms may be further bioaccumulative in food webs. Barnacles have been shown to fulfill many of these characteristics and used to assess the bioavailability of metals in the coastal waters of many parts of the world (White and Walker, 1981; Anil and Wagh, 1988; Powell and White, 1990). In addition, the characteristics described make mussels useful indicators of the abundance and spatial distribution of metals in aquatic ecosystems (Doherty *et al*., 1993; Oertel, 1998; Sures *et al*., 1999).

The biomonitoring of pollutants using acc umulator species is based on the capacity which has some plant and animal taxa to accumulate relatively large amounts of certain pollutants, even from much diluted solutions without obvious noxious effects. The use of this type of monitoring is widespread in marine and freshwater environments also because the measuring of the pollutant content in the organism is the only way of evaluating the bioavailability of a pollutant present in the environment. This technique makes it possible to measure trace element concentrations even when their amounts in the natural environment are lower than the detection limits of the methods commonly used. In addition, the pollutant concentrations in the organism are the result of the past as well as the recent pollution level of the environment in which the organism lives, while the pollutant concentrations in the water only indicate the situation at the time of sampling. (Ravera *et al*., 2003).

Although, Lake Qarun attracts attention of many authors because of its historical and scientifically importance to study its unique ecosystem but, the studies dealt with the accumulation of heavy metals in different ecosystem components are still scarce except few studies e.g. Elewa (1994), Ibrahim (1996), Elewa *et al.* (2001), Ali (2002), Mansour and Sidky (2003) and Abdel-Satar *et al*., (2003). In fact, additional information was needed to provide a database for the ecological status of Lake Qarun that helps the policy makers to take effective decisions for proper management of the lake.

This paper focuses on the distribution of trace metals in water, sediment, some benthic groups and fishes of Lake Qarun.

MATERIALS AND METHODS

Study area

Lake Qarun is a closed saline basin located between longitudes of 30° 24\ & 30° 49\ E and latitude of 29° 24\ & 29° 33\ N in the lowest part of El-Faiyoum depression, about 80 Km south west of Cairo (Map. 1). It has an irregular shape of about 40 km length and about 6 km mean width. The average area is about 240 km^2, the lake is shallow, with mean depth of 4.2m. Nearly, most of the lake's area has a depth ranging between 5 to 8 meters. The water level of the lake fluctuated between 43 to 45 meters below mean sea level (Meshal, 1973). The lake receives the agricultural and sewage drainage water from El-Faiyoum Governorate. Most of the drainage water reaches the lake through two main drains, El-Batts and El-Wadi Drains. Since, 1973 El-Wadi drain partially delivers most of its water into Wadi El-Rayan Lakes to maintain established water level of Lake Qarun.

Sampling

During summer, 2003, samples of water and sediment were taken from seven stations covering the whole lake area (Fig. 1). At the same time, benthic invertebrate and fish species were collected from three main sectors (east, middle and west) of the lake. The water was then preserved in plastic bottles by the addition of a few drops of nitric acid. Sediments were preserved in plastic bags. Benthic fauna were collected by dredge, careful washing with lake water to remove sand and mud particles then were preserved in plastic bags. Three fish species (*Tilapia* sp., *Solea* sp. and *Mugil* sp.), the most common type of fish in Lake Qarun and widely consumed were caught. Fish weight and length were taken and samples were dissected freshly, to obtain the muscles**,** then frozen until ready for acid digestion.

Procedure

Water samples were digested using the method described in APHA (1992), sediment samples were dried at 80 ^{0}C in oven and digested according to Kouadia and Trefry (1987) method**.** Bottom fauna were classified to three main groups (Mollusca, Crustacea and Annelida), and digested after drying according to Metcalfe-Smith (1994) method. Different fish samples were digested after drying according to the methods of Association of Official Analytical Chemist (AOAC, 1995) method. The levels of Ca, Mg, Na, K, Fe, Mn, Zn, Cu, Cd, Pb, Co, Cr, and Ni in digests were determined using atomic absorption (Perkin Elemer Model 3700) with flameless graphite furnace(GA-2).

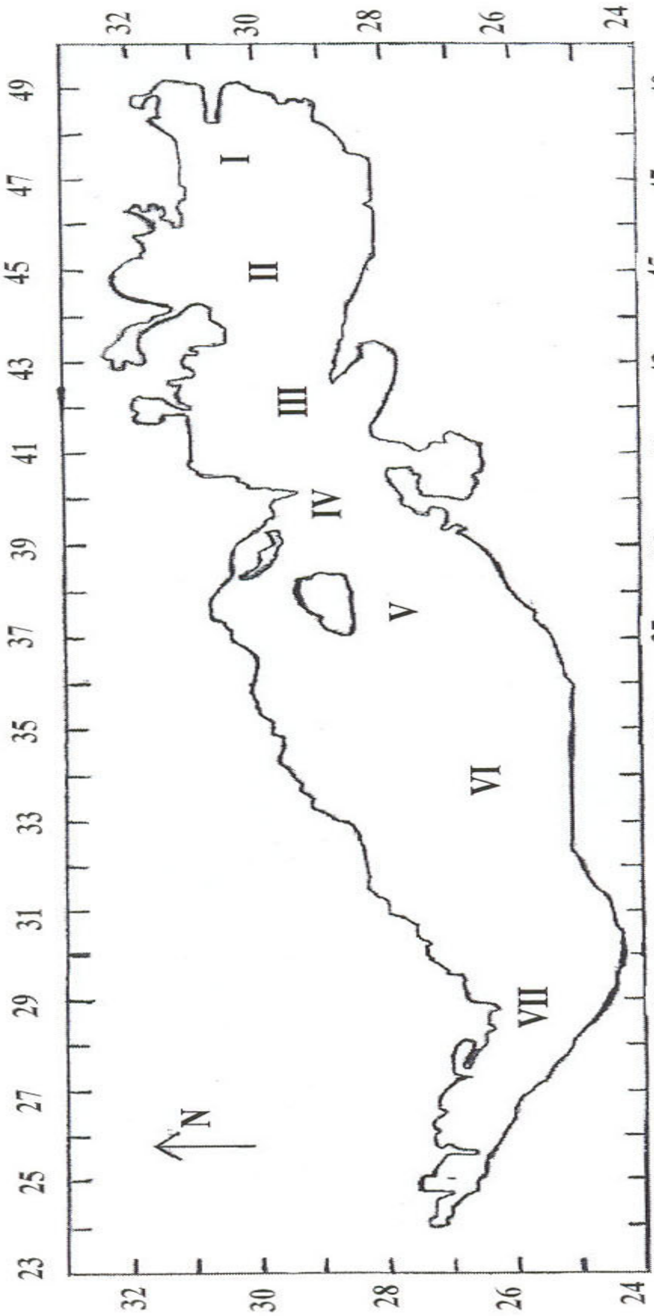

Figure (1) : Map showing the selected sampling stations

Bioaccumulation factor (BAF)

Bioaccumulation factor was calculated according to Klavinš *et al.* (1998) as follow:

$BAF = M_{\_tissue} / M_{\_sed}$

where:

$M_{\_tissue}$: metal concentration in soft tissue

$M_{\_sed}$: metal concentration in sediment

RESULTS

1. Water and sediment analyses:

Sodium and Potassium:

Sodium content in the water of Lake Qarun ranged from 8.72 g/l at station II to 9.32 g/l at station VII. Its values in sediment ranged from 33.10 mg/g in the most eastern site (station I) to 39.10 mg/g in the most western site (station VII). Concerning potassium, the maximum value of water (464 mg/l) was recorded at station VII and the lowest was (398 mg/l) at station III. At the same time, the maximum level of potassium in sediment (10.05 mg/g) was recorded at station VII and the lowest level (7.90 mg/g) was recorded at station I. It is noticed that, sodium and potassium concentrations exhibit a homogenous distribution trend in water and sediment (Tables, 1 & 2).

Calcium and Magnesium:

Calcium concentrations in water of Lake Qarun fluctuated from 641 mg/l at stations III, VI & VII to 802 mg/l at station II. In sediment, the range fluctuated from 81.88 mg/g at station IV to 35.94 mg/g at station I (Tables, 1 & 2).

The concentrations of magnesium in water ranged from 2340 mg/l at station VII to 1857 mg/l at station I. In sediment, it ranged from 19.41 mg/g at station V to 11.88 mg/g at station II (Tables, 1 & 2).

Iron and Manganese:

The concentration of iron in water and sediment showed a similar distribution trend. The highest values were recorded in the eastern sites (0.6 mg/l and 26.4 mg/g for water and sediment, respectively). On the other hand, the lowest values were recorded in the middle site at station IV; 0.33 mg/l and 11.2 mg/g for water and sediment, respectively.

Concerning manganese, its concentration in both water and sediment showed an obvious decrease from east to west (Tables, 1 & 2).

Copper and Zinc:

The concentrations of copper showed a regular distribution pattern in both water and sediment, an obvious gradual decrease from east to middle and return to increase at station V (facing El-Wadi drain) then decrease again westward (Tables 1 & 2). Zinc concentrations in water were higher in the eastern sites (38.1& 49.5 µg/l at stations I & II, respectively) than the recorded ones in the western side. On the other hand, the values of zinc in sediment showed a similar distribution trend (Tables, 1 & 2).

Cobalt and Chromium

Cobalt and chromium concentrations in water and sediment showed a similar distribution trend, since slight variation from site to another were recorded. Generally, the obvious decrease from east section to the west was observed (Tables, 1 & 2).

Cadmium:

The cadmium concentration in water showed slight fluctuation from a minimum value of 1.58 µg/l at station III and maximum one 2.21 µg/l at station I (facing El-Batts Drain). In sediment, there is a gradual decrease from east to west except at station III, an obvious increase was recorded (Tables, 1 & 2).

Lead:

Lead concentrations in water and sediment showed an irregular fluctuation from site to another. The highest value of lead in water (99.85 µg/l) was recorded at station II while the lowest one (84.5 µg/l) was recorded at station IV. The highest value of lead in sediment (24.8 µg/g) was recorded at station VI while the lowest one (17 µg/g) was recorded at station VII (Tables, 1 & 2).

Table (1): Concentrations of some major and trace metals in water of Lake Qarun during summer season, 2003

Metals	Stations						
	I	II	III	IV	V	VI	VII
Na g/l	8.9	8.7	9.0	9.0	8.8	9.2	9.3
K mg/l	421	417	398	431	430	418	464
Ca mg/l	721	802	641	721	681	641	641
Mg mg/l	1857	1930	1930	2026	2050	2098	2340
Fe mg/l	0.60	0.48	0.36	0.33	0.55	0.35	0.38
Mn µg/l	78.30	51.60	49.15	43.80	54.97	45.50	39.10
Cu µg/l	44.50	37.50	35.80	37.37	56.50	40.00	38.80
Zn µg/l	38.10	49.50	28.80	32.00	29.50	28.50	29.50
Co µg/l	91.45	96.50	88.19	90.00	73.50	70.50	83.15
Cr µg/l	60.51	63.50	61.90	64.70	85.90	68.54	61.65
Cd µg/l	2.21	2.06	1.58	2.08	2.06	2.05	2.00
Pb µg/l	95.82	99.85	89.85	84.50	93.50	85.20	92.50
Ni µg/l	44.00	42.17	40.50	39.20	39.60	40.76	38.81

Table (2): Concentrations of some major and trace metals in sediment of Lake Qarun during summer season, 2003

Metals	Stations						
	I	II	III	IV	V	VI	VII
Na mg/g	33.10	35.60	35.40	36.50	33.20	36.80	39.10
K mg/g	7.90	8.12	8.20	8.25	7.75	9.60	10.05
Ca mg/g	35.94	59.47	73.93	81.88	81.17	47.27	67.88
Mg mg/g	12.36	11.88	16.86	15.96	19.41	13.00	17.23
Fe mg/g	26.38	21.38	20.40	11.19	17.60	15.53	12.54
Mn µg/g	402.71	456.30	373.83	301.95	297.00	235.37	213.58
Cu µg/g	53.38	54.50	43.94	32.83	38.68	26.32	23.76
Zn µg/g	180.49	134.01	156.00	77.04	120.30	72.50	77.59
Co µg/g	28.56	26.29	27.16	23.15	21.19	21.89	19.75
Cr µg/g	17.81	13.50	14.49	12.86	15.00	13.77	13.65
Cd µg/g	1.38	1.20	1.80	1.24	1.16	1.04	0.97
7Pb µg/g	23.16	23.22	22.09	17.50	20.52	24.82	16.98
Ni µg/g	83.60	55.84	56.49	47.94	66.47	40.12	38.78

Nickel:

The concentrations of Nickel in water and sediment showed increasing from west to east sites of the lake (Tables, 1 & 2). Where, The lowest values of Nickel in water and sediment were recorded at station VII (38.81 µg/l and 38.78 µg/g, respectively) and the highest ones were estimated at station I (44 µg/l and 83.60 µg/g, respectively).

2. Benthos:

Sodium and Potassium:

Sodium content in benthos of Lake Qarun showed its highest values in the western part of the lake. It sharply decreased in the middle and re-increased again in east. The higher concentrations were recorded in Mollusca followed by Crustacea while the lowest concentrations were recorded in Annelida (Table, 3).

Potassium concentrations fluctuated from benthic group to another. Mollusca still maintained the highest value (4.80 mg/g) in the western section and the minimum value of 3.49 mg/g in the middle one. Crustacea recorded its highest value in eastern part (4.32 mg/g) while the highest one in Annelida (3.82 mg/g) was observed in the middle of the lake (Table, 3).

Calcium and Magnesium:

As shown in Table (3), calcium concentrations in Mollusca are higher than other component of benthos of Lake Qarun. It followed by Crustacea and Annelida. The eastern part of the lake was having the higher concentration values (128.22, 70.06 & 2.82, mg/g, respectively). Magnesium concentration showed a narrow variation among the three main benthic groups and different lake sectors (Table, 3).

Iron and Manganese:

Iron contents in benthos showed their highest values in the eastern part of the lake (78.38 µg/g for Mollusca, 73.27 µg/g for Crustacea and 68.16 µg/g for Annelida). While, the lowest values were recorded in the western part where 48.03 µg/ g for Mollusca 44.39 µg/g for Crustacea and 40.71 µg/g for Annelida (Table,3). Manganese concentration showed to less extent a similar distribution trend of all benthic component whereas, the middle sector showed the lowest values (Table, 3).

Copper and Zinc:

Copper contents in benthos groups showed an elevated values in the eastern side of the lake. Mollusca having higher concentrations of copper followed by Crustacea and Annelida. Zinc concentrations in benthic groups differ from group to another. It increased in Molusca from the east to middle and decreased again to the west. Zinc values in Annelida showed opposite trend, the highest value was observed in the eastern part and decreased from middle to west (Table, 3).

Cobalt and Chromium

Cobalt concentrations in Mollusca were higher than other benthic groups in all parts of the lake. Also, the eastern part has the highest values followed by western one, while middle section maintained the lowest values for all groups (Table, 3). The distribution of chromium in Mollusca and Crustacea showed increase towards the west. At the same time, Annelida showed higher concentrations to the east, decreased in the middle and increased again to the west (Table, 3).

Cadmium:

The values of cadmium in benthic groups were close to each other. At the same time, the highest values (0.25 µg/g for Mollusca, 0.24 µg/g for Crustacea and 0.22 µg/g for Annelida) was recorded in the eastern part of the lake (Table, 3).

Lead:

The highest values of lead in all benthic groups were recorded in the eastern part of the lake while the lowest ones were recorded in the middle. The concentrations of lead in Mollusca are usually higher than that of Crustacea and Annelida in all sampling localities (Table, 3).

Nickel

The concentrations of Nickel in benthos showed increasing pattern towards the east site of the lake. The concentrations of Nickel in Mollusca are usually higher than that of Crustacea and Annelida in all sampling localities (Table, 3).

Bioaccumulation factor (BAF) (Table 4), showed decrease trend from east to west section for most metals i.e. the eastern part of the lake has high values of most metals which can be explained on the basis of anthropogenic pollutants income to the lake via El-Batts Drain in the eastern part. Also, the BAF values showed elevated trend in case of macronutrients elements (Na, K, Ca and Mg) while they showed an obvious decrease in trace metals.

3. Fishes

Sodium and Potassium:

Sodium concentrations in common fish species of Lake Qarun fluctuated from species to another. *Tilapia* sp. showed its highest value in the middle part of the lake. *Mugil* sp. showed the highest concentration of sodium in the west and decreased towards east. At the same time, the highest concentration of sodium in *Solea* sp. was recorded in the east. Potassium concentrations showed a similar trend as sodium (Table, 3).

Calcium and Magnesium:

Calcium concentrations in *Mugil* sp. are higher than other studied fishes of Lake Qarun. It followed by *Tilapia* sp. and *Solea* sp. The eastern part of the lake was having the higher concentration values (2.56, 2.44 & 2.06 µg/g, for *Mugil* sp, *Tilapia* sp. and *Solea* sp. respectively). The distribution pattern of magnesium contents in fish species having the same trend of Calcium (Table, 3). There are no obvious variations between different parts of the lake.

Iron and Manganese:

The concentration of iron in fish species showed its highest values in the eastern part of the lake (42.39 µg/g for *Tilapia* sp., 82.35 µg/g for *Solea* sp. and 85.56 µg/g for *Mugil* sp.). On the other hand, the lowest values were recorded in the middle for *Solea* sp. and *Mugil* sp. and in the west for *Tilapia* sp. (Table, 3). Manganese contents in fishes differ from species to another. *Solea* sp. and *Mugil* sp. showed a decrease trend from the east to middle and re-increased again in the west. *Tilapia* sp. showed opposite trend where the highest manganese value was observed in the middle (Table, 3).

Copper and Zinc:

The concentration of copper in *Solea* sp. decreased from the east to middle and increased again in the west. *Tilapia* sp. contained the highest copper value in the middle while in *Mugil* sp. its concentration showed gradual decrease towards the west (Table, 3). Zinc concentrations in *Mugil* sp. increased from the east to the middle and decreased towards the west. Where it decreased from the east to the middle and increased again in the west for *Solea* sp. samples, while in *Tilapia* sp. it showed gradual decrease towards the west (Table, 3).

Cobalt & Chromium

Cobalt concentrations in *Tilapia* sp. were lower than in other fish species in all parts of the lake. Also, there is no obvious differences between cobalt concentrations in different parts of the lake. Chromium concentrations in *Solea* sp. are higher than that of other fish species. A slight increase was observed in the middle for *Solea* sp (5.95 µg/g) and *Tilapia* sp. (4.99 µg/g) and in the west for *Mugil* sp. (5.04 µg/g, Table, 3).

Cadmium:

Cadmium contents in *Solea* sp. were higher than other fish species in all parts of the lake. At the same time, the highest values (1.87 µg/g for *Solea* sp., 1.33 µg/g for *Tilapia* sp., and 1.16 µg/g for *Mugil* sp.) were recorded the eastern part of the lake (Table, 3).

Lead:

The highest values of lead in all fish species were recorded in the eastern part of the lake. The concentrations of lead in *Solea* sp. are usually higher than that of *Tilapia* sp.

and *Mugil* sp. in all sampling localities (Table, 3).

Nickel

Nickel contents in *Mugil* sp. decreased sharply from east to west. At the same time, the concentrations in *Solea* sp. decreased from east to middle and increased again in the west. Concerning *Tilapia* sp., there is no difference among sampling localities (Table, 3).

Table (3): Concentrations of some major and trace metals in some benthic fauna and common fish species (dry wt.) of Lake Qarun during summer season, 2003

	Annelida			Mollusca			Crustacea			*Tilapia* sp.			*Solea* sp.			*Mugil* sp.		
	East	Middle	West	East	Middle	West	East	Middle	West	East	Middle	West	East	Middle	West	East	Middle	West
Na mg/g	15.89	16.02	16.28	18.25	16.93	19.14	16.81	16.45	17.80	3.50	3.58	3.29	3.12	2.89	2.96	3.13	3.18	3.27
K mg/g	3.60	3.82	3.61	3.80	3.49	4.80	4.32	3.59	3.78	3.93	4.13	3.70	3.51	3.50	3.33	3.87	3.92	4.04
Ca mg/g	2.82	2.45	2.30	128.2	124.5	123.0	70.06	60.11	50.76	2.44	2.40	2.43	2.06	2.11	1.94	2.56	2.55	2.47
Mg mg/g	2.06	2.12	2.12	2.16	2.23	2.22	2.27	2.34	2.33	2.71	2.60	2.70	2.28	2.31	2.16	3.10	3.02	3.13
Fe µg/g	68.16	43.19	40.71	78.38	50.53	48.03	73.27	46.86	44.39	42.39	22.26	19.61	82.35	43.05	74.12	85.56	55.74	65.31
Mn µg/g	10.27	5.99	6.73	11.81	7.01	7.95	11.04	6.50	7.34	5.87	8.82	5.47	12.59	7.20	9.71	8.09	7.01	8.38
Cu µg/g	7.59	4.29	3.51	8.73	8.02	7.14	8.16	6.15	5.32	7.78	10.54	6.43	13.68	9.38	10.85	9.00	8.93	8.91
Zn µg/g	23.52	11.84	10.51	17.05	23.85	22.40	20.29	20.85	21.45	26.29	25.92	22.83	32.11	29.18	29.90	29.39	30.84	27.52
Co µg/g	4.10	2.66	2.91	4.72	3.11	3.44	4.41	2.89	3.18	4.05	4.06	4.03	4.66	4.44	4.46	4.68	4.74	4.25
Cr µg/g	2.29	1.67	1.92	1.63	1.96	2.26	1.46	1.81	2.09	4.56	4.99	4.64	5.82	5.95	5.35	4.76	4.92	5.04
Cd µg/g	0.22	0.14	0.14	0.25	0.17	0.17	0.24	0.16	0.15	1.33	1.10	1.27	1.87	1.58	1.78	1.16	1.04	1.04
Pb µg/g	3.42	2.28	2.93	3.94	2.67	3.45	3.68	2.47	3.19	7.86	6.47	5.82	8.16	6.95	6.34	6.62	6.36	6.48
Ni µg/g	9.80	6.86	5.52	11.27	8.03	6.52	10.53	7.45	6.02	5.46	5.53	5.42	6.23	5.66	6.14	6.72	6.04	4.20

Table (4): Bioaccumulation factors (BAF) for each metal of benthic fauna and common fish species with relation to their concentrations in sediment during summer, 2003.

	Annelida			Mollusca			Crustacea			*Tilapia* sp.			*Solea* sp.			*Mugil* sp.		
	East	Middle	West	East	Middle	West	East	Middle	West	East	Middle	West	East	Middle	West	East	Middle	West
Na	0.48	0.44	0.42	0.55	0.46	0.49	0.51	0.45	0.46	0.11	0.10	0.08	0.09	0.08	0.08	0.09	0.09	0.08
K	0.46	0.46	0.36	0.48	0.42	0.48	0.55	0.44	0.38	0.50	0.50	0.37	0.44	0.42	0.33	0.49	0.48	0.40
Ca	0.08	0.03	0.03	3.57	1.52	1.81	1.95	0.73	0.75	0.07	0.03	0.04	0.06	0.03	0.03	0.07	0.03	0.04
Mg	0.17	0.13	0.12	0.17	0.14	0.13	0.18	0.15	0.14	0.22	0.16	0.16	0.18	0.14	0.13	0.25	0.19	0.18
Fe	0.003	0.004	0.003	0.003	0.005	0.004	0.003	0.004	0.004	0.002	0.002	0.002	0.003	0.004	0.006	0.003	0.005	0.005
Mn	0.03	0.02	0.03	0.03	0.02	0.04	0.03	0.02	0.03	0.01	0.03	0.03	0.03	0.02	0.05	0.02	0.02	0.04
Cu	0.14	0.13	0.15	0.16	0.24	0.30	0.15	0.19	0.22	0.15	0.32	0.27	0.26	0.29	0.46	0.17	0.27	0.38
Zn	0.13	0.15	0.14	0.09	0.31	0.29	0.11	0.27	0.28	0.15	0.34	0.29	0.18	0.38	0.39	0.16	0.40	0.35
Co	0.14	0.11	0.15	0.17	0.13	0.17	0.15	0.12	0.16	0.14	0.18	0.20	0.16	0.19	0.23	0.16	0.20	0.22
Cr	0.13	0.13	0.14	0.09	0.15	0.17	0.08	0.14	0.15	0.26	0.39	0.34	0.33	0.46	0.39	0.27	0.38	0.37
Cd	0.16	0.12	0.14	0.18	0.14	0.17	0.17	0.13	0.16	0.97	0.89	1.31	1.36	1.28	1.84	0.84	0.84	1.07
Pb	0.15	0.13	0.17	0.17	0.15	0.20	0.16	0.14	0.19	0.34	0.37	0.34	0.35	0.40	0.37	0.29	0.36	0.38
Ni	0.12	0.14	0.14	0.13	0.17	0.17	0.13	0.16	0.16	0.07	0.12	0.14	0.07	0.12	0.16	0.08	0.13	0.11

BAF = M_tissue / M_sed

Where

M_tissue : metal concentration in soft tissue

M_sed: metal concentration in sediment

DISCUSSION

The contamination of soils, sediments, water resources, and biota by heavy metals is of major concern especially in many industrialized countries because of their toxicity, persistence and bioaccumulative nature (Ikem, *et al*. 2003).

From above mentioned result it is clear that the distribution of heavy metals in Lake Qarun showed an increased values in the eastern sites (Sites I and II) where generally had higher contamination when compared to western ones (Sites VI and VII). The relatively higher values obtained for east part of the lake sediments and water may be due to the impact of pollution sources in this area which coming from El-Batts Drain and many anthropogenic activities in this part of the lake, these results were in agreement with those obtained by Ali (2002) for the same sites.

Iron and manganese showed a similar distribution profiles which suggests that these metals were derived from the same source. Iron and manganese are adsorbed onto the surface of suspended particles. Therefore, their concentration increased in the east lake side where the organic matter are more drained from El-Batts Drain. While their concentrations tend to decrease westwards away from the effect of the drain.

The average values of cadmium, chromium, copper and lead in this study were agreed with the corresponding values obtained by Mansour and Sidky (2003) in Lake Qarun. While the average levels of cadmium, chromium, copper, and zinc in sediments and water of Manzalah and Burullus lakes (El-Enany, 2004; Radwan & Lotfy, 2002) were higher than that obtained in Lake Qarun during this study.

The presence of trace metals in Lake Qarun is mainly of allochthonous origin due to either agricultural influx, wastes of fish farms or sewage via surrounding cultivated lands. Trace elements in waters may be undergo rapid changes affecting the rate of uptake or release by sediments, thus influencing living organisms throughout the water-sediment interaction chain (James, 1985). Although, some of these metals are classified biochemically as essential elements in the bodies of living organisms and aquatic plants when present in trace amounts e.g. (Cr, Co and Ni) but, when they present in high concentration they become toxic (Kotickhoff, 1983).

The benthic studies highlighted their ability to detect temporal changes in metal availabilities. Eastern part of the lake usually has high concentrations of most metals. Such differences were apparent for iron, nickel, cadmium, lead. These differences may well be attributable to changes in anthropogenic input of metals or to changes in physicochemical factors such as salinity which affect the uptake of many trace metals (Rainbow, 1997).

The biomonitoring of pollutants using accumulator species is based on the capacity which has some plant and animal taxa to accumulate relatively large amounts of certain pollutants, even from much diluted solutions without obvious noxious effects. The use of this type of monitoring is widespread in marine and freshwater environments also because the measuring of the pollutant content in the organisms is the only way of evaluating the bioavailability of a pollutant present in the environment. This technique makes it possible to measure trace elements concentrations even when their amounts in the natural environment are lower than the detection limits of the methods commonly used. In addition, the pollutant concentrations in the organism are the result of the past as well as the recent pollution level of the environment in which the organism lives, while the pollutants concentrations in the water only indicate the situation at the time of sampling (Ravera *et al.*, 2003).

From the large volume of water they filter, molluscs uptake and accumulate in their bodies toxic metals without noxious effects (e.g. Lobel *et al*., 1990; Metcalfe-Smith *et al*., 1992; Byrne and Vesk, 2000). The results of current study indicate that Mollusca have the highest concentrations of most trace metals measured. These accumulation of several metals is due to the low capacity of these molluscs for discriminating among metals which are similar in some characteristics such as ionic radius (Metcalfe-Smith, 1994; Jeffree *et al*., 1993). Molluscs also possess a variety of effective detoxification mechanisms to reduce the toxicity of the metal uptaken (Byrne 2000; Byrne and Vesk 2000).The microphagous feeders, such as barnacles (which form the main component of Crustacea) may ingest many potentially metal-rich particles they also pass large volumes of water across the permeable surfaces of the cirri and which could facilitate further uptake at high rates (Rainbow and Moore, 1986). Barnacles have, therefore, a high potential for accumulation of metals.

The polychaete *Nereis diversicolo*r (which form the major component of Annelida in this study) used in many studies as a useful indicator for Ag, Cd, Cu and Hg. The concentration of metals in this species are small compared with other benthic groups. The bioaccumulation factor (Table, 4) showed that, Annelida maintained the lowest values among the other groups followed by Crustacea then Mollusca. These values declared that, Annelida contain less metals concentrations than other benthic groups. These results were in concordant with the findings of Al-Edreesi *et al.* (2002) who reported that, Mollusca in Al-Hodeidah region (Yemen) appears to be useful tool as a bio-indicator for most of the metals. Therefore, it is concluded that the Mollusca and the Crustacea are suitable candidates to be used in biomonitoring surveys of Lake Qarun.

Trace metals tend to accumulate in different body organs. These metals are dangerous for fish and in turn they lead to serious problems in both man and animals (Marzouk, 1994). Fishes may absorb dissolved elements and trace metals from its feeding and surrounding water, these metals accumulate in various tissues in significant amounts and are eliciting a toxicological effects at target criteria (McCarthy and Shugart, 1990). The concentrations of trace metals in fish samples indicate that *Solea* sp. seemed to be more contaminated than other fish species followed by *Mugil* sp. and *Tilapia* sp. These observations are mainly due to different fish habitat (*Solea* sp. is bottom feeder fish while other species are filter feeder) and surrounding ecosystem status. These results agree with that obtained by Ibrahim (1996) in the same lake.

It is must to protect Lake Qarun from anthropogenic sources of pollution to reduce environmental risks and this study may provide preliminary database for future research on trace metals of the lake.

REFERENCES

Abdel-Satar, A.M.; A.A. Elewa,; A.K.T. Mekki, and M.E. Gohar, 2003. Some aspects on trace elements and major cations of Lake Qarun sediment, Egypt. Bull. Fac. Sci., Zagazig Univ., 25(2): 77 – 97.

Al-Edreesi, M.A.; M.A. Abdel-Monem,; H.T. Al-Saad, and H.M. Heba, 2002. Heavy metal contents of some Molluscs and Crustaceans along Al-Hodeidah Red Sea coast of Yemen. Bull. Nat. Inst. of Oceanogr. and Fish., A.R.E. 28: 319 – 331.

Ali, M.H.H. 2002. Impact of agricultural and sewage effluents on the ecosystem of Lake Qarun, Egypt. Ph.D. Thesis, Fac. Sci., Al-Azhar Univ., 307 pp.

American Public Health Association (APHA) 1992. Standard methods of the examination of water and waste water. 17th edition, AWWA, WPCF, 1015P.

Anil, A.C. and A.B. Wagh, 1988. Accumulation of copper and zinc by *Balanus amphitrite* in a tropical estuary. Marine Pollution Bulletin 19, 177-180.

AOAC 1995. Official Methods of Analysis of AOAC International. 16th ed., Vol. 1 (Cunnif, P. Ed.), AOAC Int. Arlington, Virginia, USA.

Byrne, M. 2000. Calcium concretions in the interstitial tissues of the Australian freshwater mussel *Hyridella depressa* (Hyriidae). In: E.M. Harper, J.D. Taylor and J.A. Crame (Eds). The Evolutionary Biology of the Bivalvia. Geological Society, London, Special Publications, 177: 329-337.

Byrne, M. and P.A. Vesk, 2000. Elemental composition of mantle tissue granules in *Hyridella depressa* (Unionida) from the Hawkesbury – Nepean River system, Australia: 2: 51-56.

Doherty, F.G.; D.W. Evans, and E.F. Neuhauser, 1993. An assessment of total and leachable contaminants in zebra mussels (*Dreissena polymorpha*) from Lake Eire. Ecotoxicol. Environ. Saf., 25: 328-340.

El-Enany, H.R. 2004. Ecological and biological studies on lake El-Manzalah with special reference to their water quality and sediment productivity. M.Sc. Thesis, Fac. Sci., Al-Azhar Univ. 386pp.

Elewa, A.A. 1994. Studies on some heavy metals distribution in the sediments of Lake Qarun, Fayioum, Egypt. Bull. NRC, Egypt 19 (3): 225 – 233.

Elewa, A.A.; M.B. Shehata; A.M. Abdel Satar; M.H.H. Ali and M.E. Gohar, 2001. Effect of the drainage water on lake Qarun ecosystem, Egypt. Presented in 9th international Conference on the Conservation and Management of Lakes 11 – 16 November, 2001. Shigha Prefectural Government – Japan.

Grosheva, E.I.; G.N. Voronskaya, and M.V. Pastukhove, 2000. 'Trace element bioavailability in Lake Baikal. Aquat. Ecosys. Health Manage. 3: 229–234.

Ibrahim, H.T.M. 1996. Detection and identification of some pesticides residues and heavy metals in Qaroun Lake and River Nile fish. M.Sc. Thesis, Fac. Agr. Cairo Univ. 212pp.

Ikem, A.; N.O. Egiebor, and K. Nyavor, 2003. Trace elements in water, fish and sediment from Tuskegee Lake, Southeastern USA. Water, Air, and Soil Pollution 149**:** 51–75

James, M.C. 1985. Accumulation of lead in fish from Missouri streams impacted by lead mining. Bull. Environ. Contam. Toxicol. 34: 736 – 774.

Jeffree, R.A.; S.J. Markich, and P.L. Brown, 1993. Comparative accumulation of alkaline-earth metals by two freshwater mussel species from the Nepean River, Australia: consistencies and a resolved paradox. Aust. J. Mar. Freshwater Res., 44: 609-634.

Klavinš, M.; A. Briede,; E. Parele,; V. Rodinov, and I. Klavina, 1998. Metal accumulation in sediments and benthic invertebrates in Lakes of Latvia. Chemosphere, 36 (15): 3043 – 3053.

Klavinš, M., A. Briede,; V. Rodinov,; I. Kokorite,; E. Parele, and I. Klavina, 2000. Heavy metals in rivers of Latvia. Sci. Total Environ. 262: 175–184.

Kotickhoff, S.W., 1983. Pollutant sorption in environmental systems. EPA- 600ID, 80 – 83, NTTS, Spring Field, VA.

Kouadia, L. and J.H. Trefry, 1987**.** Saline trace metal contamination in the Ivory Coast west Africa. Air, Water and Soil Pollution. 32: 145 - 154.

Lobel, P.B.; S.P. Belkhode,; S.E. Jackson, and H.P. Longerich, 1990. Recent taxonomic discoveries concerning the mussel Mytilus: Implications for bio-monitoring. Arch. Environ. Contam. Toxicol., 19: 508-512.

Mansour, S.A. and M.M. Sidky, 2003. Ecotoxicological Studies. 6. The first comparative study between Lake Qarun and Wadi El-Rayan wetland (Egypt), with respect to contamination of their major components. Food Chem., 82: 181 – 189.

Marzouk, M. 1994. Fish and environment pollution. Vet. Med. J., 42: 51 – 52.

McCarthy, J.F. and L.R. Shugart, 1990. Biomarkers of environmental contamination. Lewis Publishers. New York. 475pp.

Meshal, A.H. 1973. Water and salt budget of Lake Qarun, Fayum, Egypt. Ph.D. Thesis. Alexandria University, 109 pp.

Metcalfe-Smith, J.L. 1994. Influence of species and sex on metal residues in freshwater mussels (family Unionidae) from the St. Lawrence River, with implications for biomonitoring programs. Environ. Toxicol. and Chem., 13: 1433-1443.

Metcalfe-Smith, J.L., J.C. Merriman, and S.P. Batchelor, 1992. Relationships between concentrations of metals in sediment and two species of freshwater mussels in the Ottawa. River. Water Poll. Res. J. Canada, 27: 845-869.

Oertel, N. 1998. Molluscs as biomonitors of heavy metals in a side-arm system of the River Danube disturbed by engineering activities. Verh. int. Ver. Limnol., 26: 2120-2124.

Powell, M.1. and K.N. White, 1990. Heavy metal accumulation by barnacles and its implication for their use as biological monitors. Marine Environmental Research 30: 91-118.

Radwan, A.R. and I.H. Lotfy, 2002. On the pollution of Burullus Lake water and sediments by heavy metals. Egypt. J. Aquat. Biol. and Fish., 6(4): 147 - 164.

Rainbow P.S. 1997. Ecophysiology of trace metal uptake in crustaceans. Est. Cstl. Shelf Sci. 44: 169-175.

Rainbow P.S. and P.G. Moore 1986. Comparative metal analyses in amphipod crustaceans. Hydrobiologia 141: 273-289.

Ravera, R.C, G.M. Beone, M. Dantas, and P. Lodigiani, 2003. Trace element concentrations in freshwater mussels and macrophytes as related to those in their environment J. Limnol., 62(1): 61-70.

Sures, B.; W. Steiner,; M. Rydlo, and H. Taraschwski, 1999. Concentrations of 17 elements in the zebra mussel (*Dreissena polymorpha*) in different tissues of perch (*Perca fluviatilis*) and in perch intestinal parasites (*Acanthocephalus lucii*) from the subalpine Lake Mondsee, Austria. Environ. Toxicol. Chem., 48: 2574-2579.

White, K. N. and G. Walker, 1981. Uptake, accumulation, and excretion of zinc by the barnacle, *Balanus balanoides* (L.). Journal of Experimental Marine Biology Ecology 51: 285-298.