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EFFECT OF ECOLOGICAL AND BIOLOGICAL FACTORS ON THE UPTAKE AND CONCENTRATION OF TRACE ELEMENTS BY AQUATIC ORGANISMS AT EDKU LAKE

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ABSTRACT

The effect of temperature, pH and trace elements concentration in the ambient water on the uptake and accumulation of Cu, Zn, Ni and Pb in various organs of fish and parts of aquatic plants of Edku Lake were studied. It was found that higher water temperature and lower pH during summer increased the rates of trace metals uptake by the most common fish species *Oreochromis niloticus*.

The concentrations of Cu, Zn, and Ni in the various organs of fish were affected by the concentrations of these elements in the water.

Cu, Zn, Ni and Pb attained higher concentrations in the roots of *Eichormia crassipes* if compared with their concentrations in the other parts of this aquatic plant. Sex of fish can be considered as an important factor affecting the accumulation of trace elements in different organs of fish. The accumulation of Cu, Zn, and Ni in the flesh, liver, gonads and bones of fish were negatively correlated with length of the fish.

INTRODUCTION

An element in trace amount (less than 0.01% of the mass of organism) is essential when the organism fails to grow or complete its life cycle in absence of that element. However the same element is toxic when its concentration exceeds the required amount for correct nutritional response by factors varying between 40 to 200 folds (Venugopal and Luckey, 1975).

The processes by which trace elements are supplied to the sea under natural conditions have been summarized by Turkian (1971). They can be placed in three categories, (a) coastal supply, which includes input from rivers and from erosion produced by wave action as well as wastes discharge, (b) deep sea supply which includes elements released by deep sea volcanism and those released from particles or sediments by chemical process, (c) supply which by-passes the near-shore environments and includes metals transported in the atmosphere as dust particles or as vapor (e.g.Hg).

In the aquatic environment, the trace elements are partitioned among the various environmental components (water, suspended solids, sediments and biota). The main processes governing the distribution of these elements in the marine environment are dilution, advection, dispersion, sedimentation and adsorption.

Biota can accumulate trace elements either from the sea water or through feeding and the relative importance of these two routes seems to be species and site specific.

Usal and Tuncer (1984) pointed out that the marine organisms accumulate the chemicals as well as the trace elements in large quantities in their body as compared with that in their surroundings sea water. This results in an increase in the trace elements levels of these organisms as well as in the fish through feeding and adsorption.

Factors influencing the uptake of trace elements from sea water were studied by many authors.

Form of element in the environment, presence of other elements, water salinity, Hydrogen ion concentration, these factors as well as biological conditions of the organism were found to be the most important factors influencing the uptake of trace elements from the marine environment (shakweer, 1993).

The present investigation deals with discussing the effect of various environmental and biological factors which influenced the uptake of Cu, Zn, Ni and Pb by the most dominant macrophytes and fish species at Edku Lake.

This study is a part of the first phase of the research plan of Fisheries Division, National Institute of Oceanography and Fisheries.

MATERIAL AND METHODS

Edku Lake is a shallow lagoon situated on the western margin of the Nile delta. This lake receives its main water budget from two drains located at its eastern and southern edges. On the other hand, the salt water enters the lake through a narrow opening at S.W part of this lake.

Three species of the aquatic macrophytes namely; *Eichormia crassipes, Potamogeton pectinatus* and *Ceratophyllum demersum* were regularly collected from eight sampling stations at Edku Lake. Collection of these samples durated from 1999 to 2001. These species are considered to be representing the most dominant macrophytes at the lake.

The collected plants were washed for several times using lake water. Samples were taken from the various parts of these plants using plastic knife in order to minimize the contamination of the collected samples. These samples were transferred into tightly covered labeled plastic bags for chemical analysis.

The sampling sites as shown in Fig.(1) represent western localities (1,2,3, 4 and 10) and eastern ones (5,6,7 and 8).

The number of samples collected from the two areas of the lake is shown in the following table:

Species	Eastern area	Western area
Eichormia crassipes	25	30
Potamogeton pectinatus	32	34
Ceratophyllum demersum	30	36

It is worth to point out that chemical analysis of the water of Edku Lake was carried out in parallel with the present work by the same authors. Water samples were collected from the same sampling stations as shown in Fig. (1) where water temperature, salinities, pH, dissolved oxygen and nutrient salts concentrations were determined. For determination of the concentrations of trace elements in these plants, wet samples were digested into a mixture of concentrated nitric and perchloric acids (4:1 v/v) (according to Sawickakapusta, 1978).

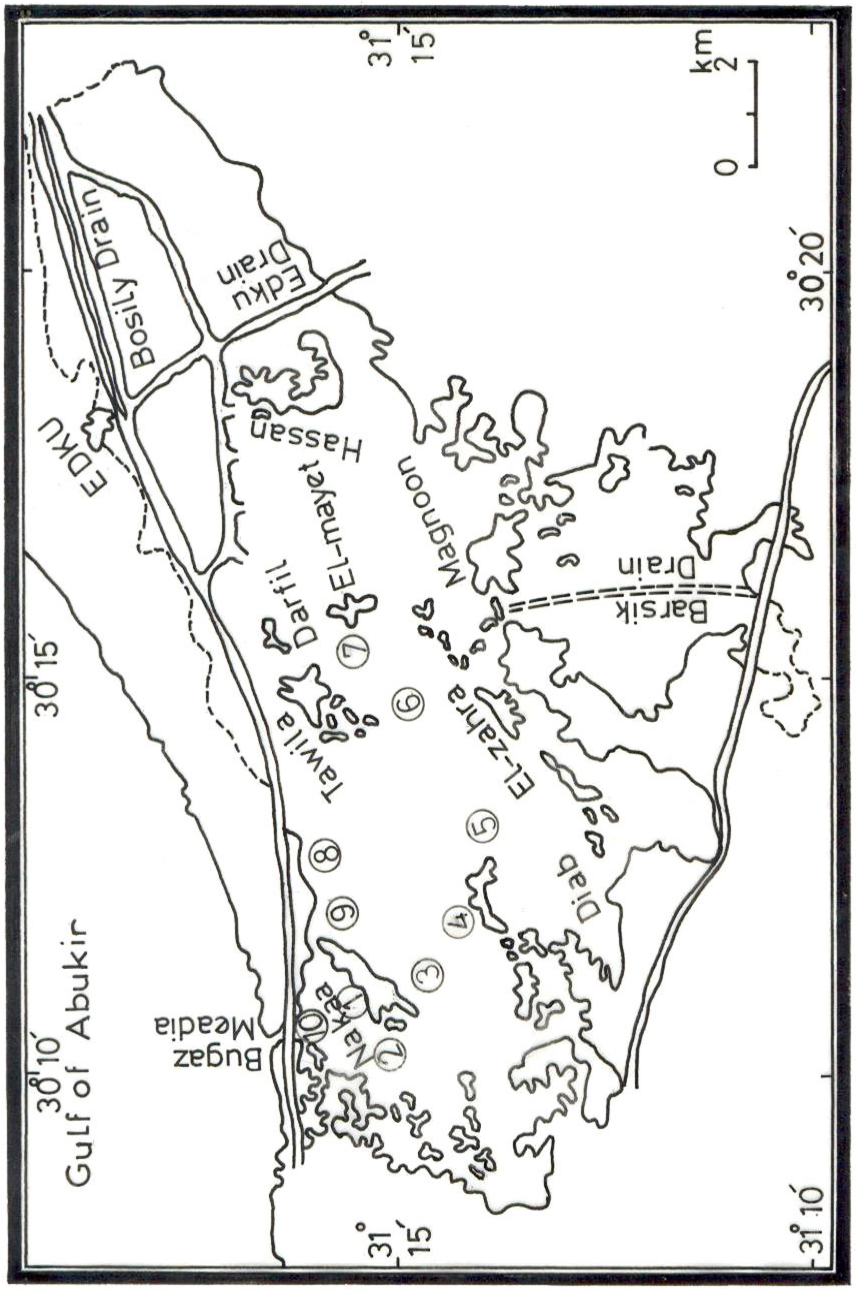

Fig.(1): The location map of sampling stations in Lake Edku.

Fish samples were collected from the experimental catch carried out at the different parts of the lake. The number of samples taken was as follows:

Species	East area		West area	
	No.	Av.L. (cm)	No.	Av.L. (cm)
Oreachromis niloticus	45	14.29	38	16.59
Oreochromis aureus	42	14.00	40	11.81
Tilapia zillii	38	9.15	38	10.35
Labeo niloticus	16	10.50	18	11.25
Bagrus bayad	24	17.80	26	17.25
Clarias lazera	21	28.25	19	31.27
Anguilla sp.	15	33.00	10	30.5

The samples were transferred iced in polyethylene bags to the laboratory for sampling their organs.

Digestion of samples was carried out using HNO3, 60% conc. at 60°C. Determinations of Cu, Zn, Ni and Pb concentrations were determined by Atomic absorption Spectrophotometer Perkin Elmer 2380.

RESULTS AND DISCUSSION

The two parameters (temperature and pH) of Edku Lake during autumn, winter, spring and summer seasons of 1999/ 2000 are given in table (1) after (Abbas *et al,* 2001). This period covered a part of the collection period for fish and macrophytes.

A. Effect of environmental parameters on the uptake and concentrations of trace elements:

1. Effect of water temperature:

Raymont and Shields (1964) indicated that trace metals are uptaken more rapidly at high temperatures by marine organisms. In unicellular algae and polychaete worms approximate doubling rate of uptake of copper was found at a 10°C rise in temperature.

Fowler and Benayoun (1974) found a marked increase in the uptake of Cd by the shrimp *Lysmata seticaudata* at higher temperature although it was not possible to observe any influence of increasing temperature on the uptake of this element by the mussel *Mytilus edulis*.

The mechanism whereby heavy metal toxicity increases with higher temperature was attributed by Lloyd (1965) to elevated respiratory activity.

It is attempted in the present study to deal with the effect of water temperature on the rate of uptake and concentrations of trace elements by fish at Edku Lake.

Table (2) shows the average concentrations of Cu, Zn, and Ni in the various organs *of O.niloticus, O. aureus* and *Tilapia* collected from the western part of Edku Lake during winter and summer seasons.

It can be observed from the data given that the concentrations of both Cu and Zn in the flesh, liver and bones of the three fish species were higher in case of fish collected during summer in comparison with those collected during winter.

It can also be indicated from table (1) that the average water temperatures at the western area of the lake stations (1,2,3,4 and 10)from which the fish samples were caught were 16.30° during winter and 26.30°C during summer. This means that there was a difference in water temperature of 10.0°C between the winter and summer seasons.

However it is believed that the increase of water temperature during summer was a main factor in increasing the uptake of Cu and Zn by fish from the lake water.

On the other hand, it can be pointed out from the data given in table (2) that such increase of water temperature did not contribute in increasing the uptake of Ni by fish. The data given indicate that the concentrations of Ni in the various organs of the three fish species were lower in summer if compared with its concentrations in winter.

Table (1): Average values of water temperature and pH at the eastern and western areas of Edku Lake.

Season	Area	Average	
		Temperature	P H
Winter	Western *	16.3	8.97
	Eastern *	16.6	8.43
Spring	Western	24.4	8.50
	Eastern	24.9	7.97
Summer	Western	26.3	8.65
	Eastern	26.5	7.93
Autumn	Western	23.6	7.56
	Eastern	22.8	7.57

- western area : Stations 1,2,3,4,9 and (10)
- Eastern area : Stations 5,6,7 and (8)

Table (2): Average concentrations of trace element in (mg/kg) wet weight during winter and summer season at the western area of the lake.

Species	Season	Cu concentration			Zn concentration			Ni concentration		
		Flesh	Liver	Bone	Flesh	Liver	Bone	Flesh	Liver	Bone
O.niloticus	*Winter*	5.76	52.65	16.20	7.53	25.51	33.16	21.33	31.72	55.12
	Summer	12.44	88.69	16.66	25.16	61.56	54.28	7.76	28.74	15.07
O.aureus	*Winter*	4.98	70.17	10.06	17.81	39.35	41.41	15.51	24.69	32.03
	Summer	19.33	55.41	17.27	27.93	89.08	61.45	8.07	12.28	16.57
T.Zillii	*Winter*	4.47	25.10	14.34	6.11	40.26	16.53	17.67	17.70	8.83
	Summer	5.31	53.12	15.65	26.17	70.60	31.82	7.58	30.41	53.48

2. Effect of pH:

The pH of water has a major influence on the physical and chemical forms of metal and metal compounds in the aquatic environment because it controls the solubility and concentrations of major metal species. Increasing the acidity of solution increase the concentrations of free metal ion in that solution. This is due to competition between H^+ and metal ions for binding sites on inorganic and organic ligands. Because of the relationship between pH and concentration of free metal ions it has been assumed that metals are more likely to be toxic to biota in acidic than in neutral waters (Hare and Tessier, 1996). Drummond *et al.* (1974) found that the uptake of some heavy metals into the gills and blood cells of brook trout is greater at pH 6.0 than at pH 9.0. Bryan (1976) pointed out that Cu and Cr are more uptaken at low pH to the goby *Chaenogobius beptancbus*. The pH values at stations 1,2,3,4 and 10 (western area) of the lake ranged between 8.22 and 9.20 during the summer season. On the other hand, these values ranged between 8.74 and 9.36 in winter.

The higher concentrations of Cu and Zn in the various organs of fish during summer in comparison with their concentrations in the same organs of fish during winter can therefore be attributed to the decreased values of pH during summer.

3. Effect of concentration of trace elements in the ambient water:

It was pointed out by several authors that the concentration of trace elements in water is a main factor affecting their concentration in the marine organisms where these organisms uptake the trace elements either through adsorption from the water or from their food. Bryan (1976) indicated that it has been found in general that the concentrations of heavy metals in bivalve molluscs change with those in environment. The concentrations of Pb in *Crassostrea virginicia* was closely related to those in sea water.

Similarly Phillips (1976) exposed mussels to 10 and 20 µg Pb l^{-1} for 35 days, he found accumulations of 10.7 and 13.7 mg Pb/kg wet weight respectively. This may indicate that the rate of direct uptake of Pb by marine organisms from the ambient water is affected by increasing metal concentrations in such water. The concentrations of Zn, Cu and Ni at the different areas of Edku Lake during the period of the present study are given according Shakweer *et al.* (unpublished data) in table (3).

In this concern the concentrations of trace elements in the various organs of the different fish species caught from the western and eastern areas of the lake are shown in table (4). In general, it can be observed from the data given that higher concentrations of Cu and Zn were found in the organs of fish caught from the western area in comparison with their concentrations in fish caught from the eastern part of the lake.

It can be also observed that the concentration of these two elements were higher in the water of the western area than that at the eastern part of this lake. On the other hand it was found that Ni has been accumulated in opposite direction where its concentrations in the organs of fish caught from the eastern area were higher than those caught from the western region. At the same time the concentrations of Ni in water were higher in the eastern areas than those at the western part of the lake (Table 3).

This means that the concentrations of Cu, Zn and Ni in the various organs of fish caught from either the eastern or western parts of the lake were greatly dependant on the concentrations of these elements in the ambient water.

In agreement with that Grimains *et al.* (1976) in their study on trace elements concentrations in some fish species collected from polluted and unpolluted areas of Aegean sea, indicated that higher levels of some trace elements were found in the flesh of *Sargus anularis* and flesh and liver of *Gobius niger* from the polluted areas of the sea than that found in fish collected from the unpolluted areas. Similar collusions were achieved by different authors in various countries. Among these authors was Portman (1972) who indicated that the rate of accumulation of heavy metals in the aquatic organisms is passively coverlet to heavy metals concentration in the marine environment. Saleh *et al*. (1983) noticed that the rates of heavy metals accumulation in the gills of *Tilapia zillii* living in the highly polluted locations of Mariut Lake were more than those present in the gills of fish living in the less polluted areas. These authors stated also that analysis of heavy metals content of the gills and flesh of fish caught from different locations of Mariut Lake showed strong relationship with their content in the water and tested organ.

Shakweer (1998) in her study on the concentrations of some trace metals in *Oreochromis niloticus* at highly and less polluted areas of Mariut Lake indicated that the concentrations of Zn , Cu, Mn and Pb in the muscle tissues, gonads and liver of fish living at the highly polluted areas of the lake were higher than their concentration in the organs of fish living at the less polluted areas. This agrees to a large extent with the data obtained in the present investigation.

Concentrations of Cu, Zn, Ni and Pb in macrophytes in relation to their concentration in water:

The macrophytes are considered as an important component of the food cycle in the aquatic habitates. The chemical composition of these plants reflects the status and mineral uptake from water and sediments in the marine environment.

The most common macroflora of Edku Lake are represented by aerial, floating and submerged plants. The hydrophytes *Potamogeton* spp. and *Ceratoplyllum* sp. represent the most abundant plants in the lake. The floating hydrophyte *Eichormia crassipes* forms a yellowish green thin material on the surface of the stagnant water.

It is a matter of fact that the flora of Edku Lake represent good shelter and spawning areas for fish in the lake. However, it is attempted in the present study to compare between the concentrations of some trace elements in the various parts of macrophytes and their concentrations in the water of the lake. Table (5) shows the concentrations of Cu, Zn, Ni and Pb in the different parts of the three common macrophytes collected from the western and eastern parts of Edku Lake. It can be pointed out from the data given in table (5) that:

1. Cu, Zn, Ni and Pb attained higher concentrations in the roots of *Eichormia crassipes* in comparison with their concentrations in either the leaves or stems of this floating macrophyte.
2. Higher concentrations of Cu and Zn were detected in the various parts of the different macrophytes collected from the western part of this lake as indicated in table (5). These higher concentrations can be attributed to the higher concentrations of the two elements in the water at the western part of this lake as indicated in table (3).
3. It is difficult to indicate direct correlation between the concentrations of Ni in the plants and its concentrations in the ambient water.
4. Pb exhibited higher concentrations in the plants collected from the western area of the lake near the lake sea connection where the lake exchanges some of its water with Abu Qir Bay.
5. The higher concentrations of Zn and Cu in the eastern area of the lake may be resulted from their higher concentrations in the drainage water of El-Khairy and Barsik drains as shown in table (3). On the other hand, the main source of Ni to the lake is believed to be from Abu Qir water which enters the lake through lake sea connection.

B. Effect of the biological factors on the uptake and concentrations of Zn, Cu, and Ni

1. Variation of trace elements concentration between fish species:

It has been pointed out by various authors that the rate of uptake of trace elements differs from one species to another in the aquatic habitats.

Grimanis *et al.* (1980) determined the concentrations of copper in the flesh of different fish species taken from three gulfs in Greece water. They demonstrated that in general, there is a high variability in copper concentration among the species examined. Usal (1978) related the differences of copper concentrations in the flesh of five fish species living in Azmir Bay to their mode of living with special reference to their feeding habits.

The concentrations of Zn, Cu, and Ni in the various fish species caught from Edku Lake are indictated in table (4). It can be observed from the data that these concentrations differed from one fish species to another.

The concentrations of Zn in the muscle tissues are varied from 7.77mg/kg in case of *Labeo niloticus* to 26.90 mg/kg in the tissues of *Anguilla.* It was also found that the concentrations of Cu and Ni in the different organs of seven fish species caught from the lake varied from one organ to another. Their lowest detected concentrations were found in the muscle tissues of *Bagrus bayad* as 6.62 mg/kg for Cu and 8.59 mg/kg for Ni. On the other hand, the highest concentrations of these elements were found to be 15.50 mg/kg for Cu in the tissues of *Anguilla* and 30.04 mg/kg in the muscles of *Labeo niloticus*.

In agreement with that of Shakweer (1993) in her study on the concentrations of trace elements in 15 fish species caught from the Mediterranean water found that the concentrations of these elements vary significantly from one species to another. As for the variations of Cu, Zn, Ni and Pb concentrations from one species of the macrophytes to another, it can be observed that these concentrations varied from 2.85 mg/kg in the stems of *E. crassipes* to 4.84 mg/kg in *Ceratophyllum* in case of Cu. Ni concentrations varied from 2.47 mg/kg to3.73 mg/kg and from 8.73 mg/kg to 12.84 mg/kg for Zn in its stem and roots (Tables 5). The concentrations of Pb ranged from 1.68 mg/kg in case of *Potamogeton* to 2.01 mg/kg for *E. crassipes.*

<u>2. Variation of trace elements concentrations in the internal body organs</u>:

The concentrations of various elements in the organs of fish, (Table 4) showed that:

(1) The least concentrations of trace elements were found in the muscle tissues of all investigated species. In agreement with Plaskett and Potter (1979) who found that the lowest concentrations of trace metals existed in the flesh of 12 fish species collected from Western Australia, in comparison with their concentrations in the other organs of fish.

(2) The highest concentrations of Zn were found in the gonads of fish. This agrees with Fisher (1973) who indicated that high zinc accumulation may occur in the gonads of fish. It was found also by Windom *et al*. (1973) through their study on zinc concentrations in 35 fish species from the North Atlantic that the gonads of fish accumulated elevated levels of zinc in comparison with the other internal organs.

(3) The maximum concentrations of Cu were detected in the liver of all species collected from the lake. These concentrations reached 86.10, 86.33 and 75.08 mg/kg in the liver of *O. niloticus*, *O. aureus* and *C. lazera* respectively. It is worth to mention that many authors pointed out that Cu accumulates with high concentrations in the liver of fish. Buckley *et al.* (1982) indicated that in fish, the liver is the major storage organ for copper. It has also been mentioned by Salanki (1982) that in fishes, the liver is the selective organ for storage of copper. Accumulation in the liver can be the result of detoxicating mechanisms and may originate from metal in the food.

(4) High concentrations of Ni were detected in the gonads and bones of most fish species caught from the lake.

Table (3): Concentrations of Zn, Cu and Ni (µg/l) in the Water of Edku Lake (Shakweer *et al.*) (Under Publication)

Area	St.	Zn			Cu			N		
		Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer
East	5	10.3	10.2	17.3	22.0	3.7	8.3	1.2	10.6	3.5
	6	9.5	6.2	51.9	19.5	4.5	24.6	3.5	21.2	2.4
E	7	11.6	4.5	10.2	19.5	4.5	4.1	3.5	3.5	2.4
	8	16.1	3.7	8.9	3.7	2.9	11.6	2.4	1.2	3.5
Average		11.98	6.15	22.08	16.18	3.90	12.15	2.65	9.13	2.95
West	1	28.8	27.0	15.2	29.9	4.9	9.9	0.0	5.9	0.0
	2	16.9	12.6	19.9	23.7	7.0	11.6	1.2	2.4	9.4
	3	15.2	16.0	14.1	3.7	3.7	7.0	0.0	2.4	1.2
	4	16.4	14.1	6.9	2.9	3.3	17.0	4.7	0.0	1.2
W	9	17.3	4.6	20.7	14.1	4.1	29.5	4.7	3.5	3.5
	10	9.8	3.8	17.6	4.9	7.9	24.9	2.4	4.7	1.2
Average of East drain		13.40			10.74			4.91		
Average of West drain		15.38			11.67			2.69		
Barsik drain		--	4.7	--	--	19.9	--	--	4.7	--
El-Khairy drain		17.0	5.60	--	25.8	3.7	--	2.7	3.5	--

Table (4): Trace elements in the various organs of fish species collected from different areas of Edku Lake.

Sp.	Organz / Area	Zn				Cu				Ni			
		Flesh	liver	Gonad	Bone	Flesh	liver	Gonad	Bone	Flesh	liver	Gonad	Bone
O. niloticus	East	8.39	32.3	43.41	35.23	5.61	73.94	18.39	13.57	19.53	36.5	35.01	55.12
	west	22.26	53.1	57.09	45.31	9.31	98.25	18.04	12.76	17.3	49	81.17	24.29
	Average	13.94	40.6	48.88	39.2	7.46	86.1	18.22	13.17	16.1	33.2	55.05	41.5
O. auveus	East	14.51	35.6	47.06	41.98	5.6	102.7	9.32	9.92	18.66	28.8	29.05	26.33
	west	24.83	69.1	69.76	69.81	13.98	69.95	16	10.45	9.38	12.7	13.37	17.9
	Average	19.67	52.3	58.41	55.89	7.79	86.33	12.66	13.19	14.11	25	24.1	23.38
T. zillii	East	9.06	34.2	62.07	25.21	9.06	34.22	62.07	25.21	24.42	41.2	73.69	28.54
	west	20.11	41	-	52.18	20.11	41.01	-	41.7	8.85	31.3	-	38.35
	Average	14.58	36.5	62.07	38.69	14.59	37.62	62.07	33.46	15.52	35.5	73.69	34.15
B. bayad	East	6.19	37.8	-	32.76	6.27	38.91	-	8.16	11.17	49.4	-	41.76
	west	14.54	-	-	27.18	6.97	-	-	8.05	6.01	29.2	-	20.88
	Average	10.37	37.8	-	32.76	6.62	38.91	-	8.11	8.59	39.3	-	31.32
L. niloticus	East	7.69	-	-	44.67	9.94	-	-	16.73	28.72	-	-	127.6
	west	7.85	-	-	54.73	10.38	-	-	23.55	31.36	-	-	101.75
	Average	7.77	-	-	49.7	10.16	-	-	20.14	30.04	-	-	114.3
C. lazera	East	16.38	29.2	18.24	19.12	20.65	83.16	4.7	5.75	25.13	46.4	3.86	40.24
	west	13.24	32.4	74.28	42.47	8.28	67	8.35	10.62	7.2	10.1	13.83	15.6
	Average	14.81	30.8	46.26	30.8	14.47	75.08	6.53	8.19	16.17	28.3	17.69	27.92
Anguilla	East	16.17	20.1	-	-	22.41	-	-	9.85	13.25	14.6	-	17.67
	west	37.62	29.1	-	51.47	8.58	8.74	-	26.7	6.63	10.6	-	70.72
	Average	26.9	29.1	-	51.47	15.5	8.74	-	15.28	9.94	12.6	-	44.2

Table (5): Concentrations of Trace elements in the Macrophytes collected from various areas of Edku Lake (concentrations of element in mg/Kg wet weight).

Element		Station No.	Eastern area					Western area					Whole
		Species	5	6	7	8	Av.	1	2	3	4	Av.	Av.
Cu	*E.crassipes*	Leaves	2.67	3.21	3.74	2.01	2.91	4.05	4.25	3.37	4.57	4.11	3.51
		Stem	5.35	2.48	1.37	1.32	2.63	2.85	2.65	2.8	4	3.08	2.85
		Roots	8.85	5.19	4.24	5.51	5.95	6.09	4.87	6.36	5.68	5.75	5.85
	Potamogeton		3.85	3.98	4.25	4.51	4.08	4.8	4.2	5.77	6.09	5.22	4.65
	Ceratophyllum		--	4.37	4.63	--	4.5	5.11	5.35	5.36	4.91	5.18	4.84
Zn	*E.crassipes*	Leaves	--	7.76	4.43	15.8	9.33	11.49	9.66	8.66	13.55	10.48	10.09
		Stem	--	9.84	3.05	5.93	6.27	14.3	14.65	8.44	7.31	11.18	8.73
		Roots	--	13.27	5.62	14.15	11.01	15.39	14.1	20.42	11.73	14.66	12.84
	Potamogeton		4.43	8.75	11.83	13.8	9.7	11.65	11.07	15.46	16.15	13.58	11.64
	Ceratophyllum		--	11.7	10.97	--	11.34	12.32	12.95	11.3	12.9	12.37	12.03
Ni	*E.crassipes*	Leaves	--	2.52	2.02	1.97	3.17	2.45	1.45	2.21	1.82	1.98	2.49
		Stem	--	2.52	0.86	2.48	1.95	3.02	3.511	3.58	2.48	3.15	2.64
		Roots	--	2.85	2.26	3.76	2.96	1.63	2.3	1.7	2.75	2.1	2.47
	Potamogeton		1.68	2.65	2.41	3.9	2.66	1.08	3	2.12	5.01	3.55	3.73
	Ceratophyllum		--				2.01	3.23	3.79	3.6	3.81	3.61	3.08
Pb	*E.crassipes*	Leaves	--	1.43	1.51	1.56	1.56	1.65	1.42	2.15	2.32	1.881	1.74
		Stem	--	1.81	2.32	1.96	1.96	1.94	1.85	2.06	2.35	2.05	2.01
		Roots	--	4.37	--	4.27	4.24	4.35	5.14	4.92	5.11	4.88	1.68
	Potamogeton		---	1.36	1.73	1.54	1.46	1.73	1.81	2.05	1.92	1.88	1.7
	Ceratophyillum		---	1.61	1.78	1.54	1.64	1.92	1.85	1.85	2.25	2.04	1.87

3. Effect of fish sex on trace element concentration:

The data for Cu, Zn and Ni concentrations in the muscle tissues, liver, gonads and bones of the males and females of *O. aureus* are indicated in table (6).

The following points can be demonstrated from the data given in this table.

Zinc concentrations:

It is obvious that the concentrations of zinc were higher in the females in comparison with those of the males in all organs tested. In agreement with Shakweer *et al.* (1993) and Shakweer and Abbas (1996) pointed out that the concentrations of zinc in the various organs of females were higher than those in males. Miller *et al*. (1992) in their study on Zn accumulation in the tissues of white sucke` pointed out that there was a large difference between sexes in concentrating Zn in gonads tissues.

Copper concentrations:

It can be pointed out that the concentrations of Cu were mostly higher in the organs of males of *O. aureus* if compared with its concentrations in the females. On the other hand, the concentrations of this element in the liver of both sexes were much higher than its concentrations in the other organs.

Nickel concentrations:

The data given shows that the concentrations of Ni were higher in the organs of females than those in males with the exception of gonads where the males accumulated higher concentrations of this element.

4. Effect of size of fish on the uptake of trace elements:

According to Bryan (1980) when a marine organism absorbs metals proportional to the environmental concentration there are at least three possible types of relations between the concentration achieved by different organs and those of the environment:

(1) The organism exerts the metal at a rate proportional to the body burden and therefore the concentration in the body is proportional to environmental availability and usually remains fairly constant or tends to fall with increasing length which is related to its age.
(2) The organism has limited powers of excretion and tends to store the absorbed metals. In this case the concentration in the organism may be still directly proportional to environmental availability but unless it grows fast enough to dilute the metal the level in the body tends to increase with age.
(3) The organism is able to increase the efficiency of excretion in response to increase the absorptions and therefore the concentrations in the body does not increase in proportion to environmental availability.

It appears therefore that there is an evidence that concentration of certain element sometimes either increase or decrease with body length.

However, it is aimed in the present study to indicate the relationship between fish length and concentrations of Cu, Zn and Ni in the various organs of *O. niloticus* the most dominant species at Edku Lake. Tables 7,8,9, and 10 show the coefficient of correlation between the concentrations of Cu, Zn and Ni in the flesh, liver, gonads and bones of *O. niloticus*. On the other hand, linear fuction relationship were calculated to describe the relations between these variables as shown in these tables. The equations are given in the form:

$Y = ax + b$

Y= concentration of element (mg\ kg)

X = Fish length in cm.

(a) And (b) are constants.

It can be pointed out from the data given that:

(1) The concentration of Cu in the fish flesh, liver, gonads and bones decrease with length mostly.

(2) With the exception of fish flesh, the concentration of Zn decrease with increasing fish length.

(3) The concentration of Ni decreased with length in all organs in case of fish having a length of 15.0 cm. when the fish attains a length of 15.0 cm or more the concentration of Ni tended to increase with length.

In agreement with Papadopoulos *et al*. (1976) who found that zinc content is a function inversely related with the age and length of fish. The decrease of this element in the older fish was attributed to metabolic factor differences, to food intake of larger fish or to fish movement. Evans *et al.* (1993) indicated that Zn, Fe and some other essential elements do not increase in concentrations with age or size because they are thought to be under homeostatic control.

Table (6): concentrations of Cu, Zn and Ni the various organs of females and males of *Oreochromis aureus*.

Element	Sex	Concentration			
		Flesh	Liver	Gonads	Bones
Cu	Female	10.74	84.47	10.03	10.45
	Male	7.91	163.74*	23.97*	28.08*
Zn	Female	27.46*	83.74*	54.22*	54.90*
	Male	18.24	46.98	48.25	50.91
Ni	Female	19.16*	32.58*	25.53	28.97*
	Male	11.15	22.28	57.45*	20.62

Table (7): Linear equations expressing the relation and concentrations of trace elements in fish flesh

Element	Fish length (cm)	Function equation	Correlation coefficient (r)
Cu	**Below 15.0 cm**	Y = - 0.373 X + 11.9621	- 66.17
	More than 15.0 cm	Y = - 1.0951 X + 30.1256	- 57.15
	Total	Y = - 0.2299 X + 11.3734	- 22.05
Zn	**Below 15.0 cm**	Y = 1.597 X + 11.043	+ 55.22
	More than 15.0 cm	Y = - 1.455 X + 44.987	- 42.64
	Total	Y = 0.3276 X + 74.685	+ 15.74
Ni	**Below 15.0 cm**	Y = - 0.088 X + 20.61	- 1.84
	More than 15.0 cm	Y = 0.698 X – 1.008	+ 59.78
	Total	Y = - 0.956 X + 33.84	- 60.22

Table (8): Linear equations expressing the relation and concentrations of trace elements in fish liver

Element	Fish length (cm)	Function equation	Correlation coefficient (r)
Cu	Below 15.0 cm	Y = 12.8826 X -78.9284	+ 62.30
	More than 15.0 cm	Y = - 15.7503 X + 418.9978	- 55.89
	Total	Y = - 2.0949 X + 130.8337	- 12.95
Zn	Below 15.0 cm	Y = 0.748 X + 30.759	+ 9.19
	More than 15.0 cm	Y = -5.186 X + 142.26	- 62.93
	Total	Y = - 1.479 X + 64.0719	- 30.39
Ni	Below 15.0 cm	Y = - 12.468 X + 227.24	- 74.00
	More than 15.0 cm	Y = 1.246 X + 5.694	+ 36.81
	Total	Y = - 1.620 X + 66.014	- 32.72

Table (9): Linear equations expressing the relation and concentrations of trace elements in Fish gonads

Element	Fish length (cm)	Function equation	Correlation coefficient (r)
Cu	Below 15.0 cm	Y = -1.0232 X + 33.7339	- 25.48
	More than 15.0 cm	Y = - 2.4470 X + 67.3705	- 47.18
	Total	Y = - 0.8667 X + 32.9782	- 25.53
Zn	Below 15.0 cm	Y = - 9.445 X + 243.707	- 65.75
	More than 15.0 cm	Y = -0.822 X + 61.33	- 11.44
	Total	Y = - 2.607 X + 98.336	- 31.34
Ni	Below 15.0 cm	Y = - 0.738 X + 228.07	- 18.81
	More than 15.0 cm	Y = - 4.187 X + 139.556	- 39.87
	Total	Y = - 7.970 X + 223.147	- 51.83

Table (10): Linear equations expressing the relation and concentrations of trace elements in fish bones

Element	Fish length (cm)	Function equation	Correlation coefficient (r)
Cu	Below 15.0 cm	Y = - 2.7389 X + 53.4585	- 88.42
	More than 15.0 cm	Y = - 0.1576 X + 13.0377	- 32.30
	Total	Y = - 0.9808 X + 30.0528	- 76.93
Zn	Below 15.0 cm	Y = - 2.127 X + 73.681	- 64.20
	More than 15.0 cm	Y = + 1.534 X + 30.660	+ 59.81
	Total	Y = - 0.744 X + 45.085	- 19.78
Ni	Below 15.0 cm	Y = - 16.485 X + 292.90	- 78.49
	More than 15.0 cm	Y = 1.720 X – 8.996	+ 67.68
	Total	Y = - 1.58 X + 75.99	- 25.30

SUMMARY AND CONCLUSIONS

It can be concluded from the present investigation that:

(1) The concentrations of both Cu and Zn in the flesh, liver and bones of *O. niloticus, O.aureus,* and *T. zillii* were higher in fish collected during summer in comparison with those collected during winter. The higher water temperature during the summer season can be considered as a main factor for increasing the uptake of trace elements by fish. The lower pH values recorded in summer was also the second factor for increasing this rate.

(2) The concentrations of Cu, Zn and Ni in the various organs of fish caught from either the eastern or western parts of the lake were greatly dependant on the concentrations of these elements in the ambient water.

(3) Cu, Zn, Ni and Pb attained higher concentrations in the roots of *Eichormia crassipes* in comparison with their concentrations in either the leaves or stems of this floating macrophyte.

(4) Pb exhibited higher concentrations in the plants collected from the western area of the lake near the lake sea connection where the lake exchange some of its water with Abu Qir Bay water. The industrial wastes discharge in Abu Qir increase the concentration of Pb in this Bay.

(5) The concentrations of trace elements in the various organs of fish or macrophyte varies from one species to another. The accumulation of these elements in the bodies of marine organisms depends on their ability to regulate these elements in their bodies.

(6) Sex of fish can be considered as a main factor affecting the concentration of trace elements in fish where higher concentrations of zinc were found in various organs of females with special reference to their gonads while higher concentrations of Cu accumulated in these organs in case of males.

(7) It is possible to point out that the concentrations of Cu, Zn, and Ni in the flesh, liver, gonads and bones of fish mostly decreased with increasing fish length. Negative correlations between the length of fish and concentration of trace elements were investigated in most of the cases.

REFERENCES

Abbas, M., L.M. shakweer and D. Hassan (2001): Ecological and Fisheries management of Edku Lake I. Hydrochemical characters of Edku Lake. Bull. Nat. Inst. Ocean. Fish. Vol. 27: 65-93.

Bryan, G.W. (1976): Heavy metal contamination in the sea (Marine pollution Ed. R. Johnson, Academic press, London): 185-302.

Bryan G.W. (1980): Recent trend in search on heavy metal contamination in the sea. Helgalander Meeresuntersuchungen -33, 6-25.

Buckley, J.T., M. Roch, C.A. Rendell and M.T. Matheson (1982): Chronic exposure of coho salmon to sublethal concentrations of copper. 1. Effect on growth, accumulation and distribution of copper and on copper tolerance. Comp. Biochem. Physiol. 72 (c) :15-19.

Drummond, R. A., F.G. Olsen and A.R. Batterman (1974): Cough response and uptake of mercury by brook trout Salvelinus fontinalis exposed to mercuric compounds at different hydrogen ion concentration. Trans. Am. Fish. Soc. 103. 244 pp.

Evans, D.W.; D.K. Dodoo and P.J. Hanson, (1993): Trace elements concentrations in fish livers. Implications of variations with fish size in pollution monitoring. Marine pollution Bulletin, Vol. 26. No. 6: 329-34.

Fisher, W. (1973): FAO species identification sheets for fishery purposes. Mediterranean and Black Sea (Fishing area 37) Vol. I. FAO Var. 244 pp.

Fowler, S.W. and G. Benayoun (1974): Influence of environmental factor on (Cd) and (Se) flux in two marine invertebrates Mar. Biol. 37: 59-68.

Girmains, A.P., D. Zafiropoulos and M.Grimani (1976): Trace elements in *Sargus anularis* and *Gobius niger* from polluted and unpolluted areas of the Aegean sea. IIIes Journees Etud. Pollutions: 55-61.

Grimanis, A.p., D. Zafiropoulos, C. Papadopoalou and M. vassilakigrimani (1980): Trace elements in the flesh of different fish species from three gulfs of Greece. Ves Journee Etud. Pollutions Cagilari. C.I.E.S.M : 407-12.

Hare, L. and A. Tessier (1996): Predicting animal cadmium concentrations in lakes. Chapman and Hall, New York. 380pp.

Lloyd, R. (1965): Factors that affect the tolerance of fish to heavy metal poisoning. Boil. Problems in water pollution, 3rd seminar, 1962. U.S. Dept. Health, Education and welfare. 181 pp.

Miller, P.A., K.R. Munkittrick and D.G. Dixon (1992): Relationship between concentrations of copper and zinc in water, sediment, benthic invertebrates and tissues of white sucker (Catostomus commersoni) at metal contaminated sites. Can. J. Fish. Aquat. Sci. vol. 49: 978-84.

Papdopoulou, G., G. Knias and E. Morailopoulou-Kassimati (1976): Zinc content in otoliths of *Scomber japonicus colias* from the Aegean sea, Versus age and total body length IIIe Journees. Etud pollutions pp. 69-73, Split, C.I.E.D.M.

Philips, D.J.H. (1976): the common mussel *Mytillus edulis* as an indicator of pollution by Zn, Cd, Pb and Cu. 1. Effects of environmental variables on uptake of metals. Mar. Biol. Vol. 38: 59 – 69.

Plaskett D, and I.C. Potter (1979): Heavy metal concentrations in the muscle tissue of 12 spcies of teteost from Cockburn South Western Australia. Aust. J. Mar. Freshw. Res. 30: 607-16.

Portman, S.E. (1972): The levels of certain metals from coastal waters around England and Wales. J. Aquaculture N: (1): 91-96.

Raymont, J.E.G. and J. Shields (1994): Advances in Water Pollution Research. Pergamon press. London, Oxford. 290 pp.

Salanki, I., V.B. katalin and E. Berta (1982) heavy metals in animals of Lake Balaton. Water Res. Vol. (16): 1147 – 52.

Saleh, H., A.Hamza and B. El-Boghdady (1983): Effect of water pollution on fish pollution at Maruit Lake. Bull. High. Inst. Pub. Health of Alex. Vol. 13. No. 5: 233-47.

Sawicka – Kapusta, K.(1978): Estimation of the content of heavy metals in antlers of roe-deer from Silesian wood. Arch. Ochr. Sord. 1:107-21.

Shakweer, L.M. (1993): Effect of waste disposal on the chemical composition of some aquatic organisms along Alexandria coast. Ph.D. Thesis. Azhar Univ. 272 pp.

Shakweer, L.M., M. Abbas and A. Al-Sayes (1993): Heavy metals content in some fishes in lake Edku. Bull. Fac. Sci. Alex. Univ. Vol. 33(A): 130-64

Shakweer, L. and M.Abbas (1996): Effect of sex on the concentration levels of some trace elements in *Oreochromis niloticus* of Lake Edku and Sardinella aurratus of the Mediterranean water, Egypt. Bull. Nat. Inst. Ocean. Fish. A.R.E vol. 22: 121-41.

Shakweer, L.M. (1998): concentration levels of some trace metals in *Oreochromis niloticus* at highly and less polluted areas of Maruit Lake. J. Egypt. Ger. Soc. Zool. Vol. 25 (A). comparative physiology: 125-44.

Turekian, k.k. (1971): Impingement of man on the Oceans (D.w. Hood, ed.). Wiley inter science: 9-73.

Usal, H. (1978): Accumulation and distributions of heavy metals in some marine organisms in the Bay of Izmir and in Aegean coasts. IV Journee Etud. Pollutions. C.I.E.S.M. Antalya : 213 – 17.

Usal, M. and S. Tuncer (1984): A comparative study on the heavy metals concentrations in some fish species and the sediments of Izmir Bay. VIIes Journee Etud. Pollutions. Lucerene. CIESM. 443-90.

Venugobal, B. and T.D. Luckey (1975): Toxicity of non-radioactive heavy metals and their salts. In: heavy metal toxicity, safety and Hormology. Luckey T.D.m B. Venugobal and Hutcheson, D. (edit). Stuttgart: Thieme 1975: 4-73.

Windom M., R. Strikeny, R. Smith, D. White, and F. Taylor (1973): Arsenic, Cadmium, Copper, Mercury and Zinc in some species of North Atlantic finfish. J. Fish. Res. Bd. Can. 30: 275-79.