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ACCUMULATION OF HEAVY METALS IN THE WATER AND SOME FISH SPECIES INHABITING LAKE MANZALA AND RIVER NILE

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Abstract

Metal concentrations in water and organs of two species of freshwater fish at (Lake Manzala and River Nile. were examined concentrations of several metals were naturally high in the water. were randomly collected from the lake. The detected heavy metals were: Fe, Pb, Cu, Cd and Zn. The obtained results indicated that the highest concentrations of heavy metals were observed in the north eastern and the southern parts of the lake and River Nile nearby drains. This could be attributed to industrial, agricultural and municipal wastes coming.

Keywords: Lake Manzala, River Nile and Heavy Metals.

1. Introduction

The contamination of freshwater with a wide range of pollutants has become a matter of great concern over the last few decades; not only because of the threats to public water supplies, but also due to the damage have they caused to the aquatic life [1]. Metals are among the most common environmental pollutants; their accumulation and distribution in soil and water are increasing to an alarming rate, causing deposition and sedimentation in water reservoirs and affecting the aquatic organisms as well [2, 3]. Metals like chromium, lead, cadmium and tin exhibit extreme toxicity even at trace levels. Rivers are a dominant pathway for metals transport [4], and metals become significant pollutants of many riverine systems [5]. The behaviour of metals in natural waters is a function of the substrate sediment composition, the suspended sediment composition, and the water chemistry. During their transport, the metals undergo numerous changes in their speciation due to dissolution, precipitation, sorption and complexation phenomena [6] which affect their behaviour and bioavailability [7]. Hence, metals are sensitive indicators for monitoring changes in the water environment. However, to assess the environmental impact of contaminated sediments, information on the total concentrations is not sufficient, and particular interest is the fraction of the total metal content that may take part in further biological processes [8].The River Nile is the principal fresh water resource for Egypt, meeting nearly all demands for drinking water, irrigation, and industry [9, 10]. Fishing, aquaculture, and navigation are in stream uses of the River Nile water. Approximately 99 percent of the population of Egypt lives within the Nile Valley and Delta, which constitutes less than 4 percent of Egypt's total area. Any disruption or impairment to these from natural or anthropogenic threats cannot be without far reaching economic and social implications. For these reasons, continuous monitoring for quality parameters is necessary. Even with the presence of relevant legislation, the Nile River receives numerous non-point and point source discharges during its transit through Egypt [11].Manzala Lake, the largest of Egypt's Mediterranean wetlands and the most productive for fisheries, is suffering from land reclamation, industrial and nutrient pollution and overgrowth by water hyacinth. In the last six decades Manzala Lake was subjected to various threats: agriculture drainage, municipal sewage and industrial waste water. These pollutants have turned the lake into polluted, unhealthy ecosystem affecting fish production and natural resources that are distributed within the lake. A total of fresh water (mostly from agricultural drainage) flow annually into Manzala Lake from nine major drains and canals. It receives and carries the greatest part of wastewater into the lake through a very densely populated area of the Eastern Delta passing through Qalubyia, Sharkia, Ismailia and Port Said Governorates, and contributing much to the deteriorating water quality of the lake [12].

2.Materials And Methods

2.1. Study Area:

Lake Manzala is the largest lake in the northern region of Egypt and the most productive for fisheries. The lake, as illustrated in Figure 1, lies between 31˚45', 32˚15'E and 31˚00', 31˚35'N. It covers an area of about 52,611 hectares. It is bordered by Suez Canal from east, Nile-Damietta branch from west and Mediterranean Sea from north. It is a shallow lagoon where about 50% of the lake area has a depth ranged between 0.5 and 1.0 m. The lake receives polluted water from different drains namely; Bahr El-Baqar, Ramsis, El-Matria, Hadous, Faraskur, El-Serw and Lissa El-Gamalia**.** The Nile is the longest river of the world, stretching north for approximately 4,000 miles from East Africa to the Mediterranean Sea. While the River Nile is often associated with Egypt, it actually flows through Ethiopia, Zaire, Kenya, Uganda, Tanzania, Rwanda, Burundi and Sudan, as well as Egypt. It flows 1,300 kilometres in Egypt before it empties into the Mediterranean Sea near Alexandria. At a distance of 25 km north of Cairo, the River Nile is divided into two branches (Rosetta and Damietta), forming a delta resting with its base on the Mediterranean Sea shore.

2.2. Determination of heavy metals

2.2.1 In water:

Water samples from each station (a total of about 180 samples; 3 samples from each station (15 station) in each season (4 season) were collected in acid washed polyethylene bottles, and acidified with HNO_3 (1 ml), kept refrigerated and transferred cold to the laboratory. The samples were digested by concentrated HCl (5 ml for each liter) according to [13].and kept refrigerated till elemental determination.

2.2.2 In fish organs:

Fish samples (a total of 160 samples; 20 specimen of each species (2) in four seasons) of the 2 fish species(*Oreochromisniloticus*, and *Clariasgariepinus*) were collected from the different regions of the lake and River Nile by fishermen. The fish were sorted and separated and all samples kept frozen until transferred to the laboratory.

The different organs were collected separately from (about 20 fish in each season) of each species and dried in an oven at 105 ºC for 24 hour to constant weight, then a pieces of 5 gm (dry wt.) from each organ were ashed at 550 ºC in a muffle furnace. After cooling, the samples were digested with 2 ml concentrated HNO_3. This treatment was repeated, if necessary, to obtain clean practically C-free ash. Finally, the ash was dissolved by 10 ml 1 N HCl before analysis [14].

All metals (except Cd) were analyzed by an air-acetylene Atomic Absorption Spectrophotometer (Model 210 VGP, Buck Scientific) using graphite furnace for water samples (and Cd) and flame for the other samples.

3. Results and Discussion

3.1: Heavy metals

3.1.1: Heavy metals in water:

Seasonal variations of heavy metals in the lake and River Nile water are shown in Tables (1-2) and are graphically represented in Figures (1,2).

Results (Table, 18 and Figure 1) revealed that, the highest average value of zinc ion concentrations in lake water was recorded during winter (0.063) and the lowest value (0.106) was observed during autumn.

The lowest concentration of Cu (0.013mg/L) was observed in autumn at station 4, whereas the highest one was detected at station 2 during the spring season.

Results (Table, 1 and Figure, 2) indicated that, the highest average value of iron ion concentrations in the lake water was recorded during spring (0.459 mg/L), it decreased gradually (0.298 mg/L) during summer, followed by autumn (0.284 mg/L) and reached its lowest value (0.231 mg/L) during winter.

Concerning stations sampled, the maximum average value of iron ion concentrations was recorded at station 3 (0.562 mg/L) at spring and the minimum values were detected at stations 3 (0.12 mg/L) at summer.

Results (Table, 1 and Figure, 2) revealed that, the maximum average value of Cadmium ion concentrations in the lake waters was recorded during spring (0.0046 and mg/L), it decreased gradually during autumn (0.004 mg/L) through winter and reached its minimum value (0.0038 mg/L) during summer and autumn. Concerning stations sampled, cadmium ion concentrations exhibited its highest average value (0.006) at station 3 and 4 the lowest values (0.006 mg/L) at station 1.4 respectively.

Lead Pb concentration ranged between 0.17mg/L at station 1 in summer and 0.096 mg/L at station 5 in winter.

In the River Nile (Table, 2), the concentration of Zn ranged from 0.051mg/L at station 1 in winter to 0.082 mg/L in summer at station 2. The lowest concentration of Cu (0.026 mg/L) was observed in autumn at station 1, whereas the highest one 0.061 mg/L was detected at the station 3 during the same season. Fe was the most common element and its concentration varied from 0.085 mg/L in winter at station 2 to 0.596 mg/L at station 3 in the summer season. Regarding Cd concentration, station 2 showed the lowest concentration (0.0031mg/L) in summer, while station 2 had the highest one (0.006mg/L) in spring and autumn. Lead Pb concentration ranged between 0.022mg/L at station 2 in spring and 0.055mg/L at the same station in summer.

3.1.2: Heavy metals in fish organs:

The concentrations of tested heavy metals (Zn, Cu, Fe, Cd and Pb) in the two studied fish species varied considerably with regards to tissues, seasons and sites. Tables, 3, 4 show the seasonal averages of studied heavy metals in different tissues of the fish species collected from the lake Manzala and River Nile. It is clear that, the concentration of metals as a whole increase in fish organs in summer and autumn and decrease in winter and spring.

a: Muscle tissues:

In muscle tissue of the two fish species collected from the lake Manzala (Table 3 and Fig 3.4). The highest values of Zn, Cu and Fe (47.55, 27.61and 82.48µg/g) were recorded in muscle tissue of *Clariasgariepinus* the lowest values were observed in muscle tissues of *Oreochromisniloticus* with (3.63, 1.22and 12.81µg/g), respectively. On the other hand, for Cd and Pb, the highest values (0.092 and 4.66) was recorded in*C.gariepinus* and the lowest(0.018 and 1.52) in *O. niloticus.* However in the River Nile, the highest values of Zn, Cu, were detected in muscle tissues of *C.gariepinus* was of 115 and 12.21 µg/g,) and the lowest value (6.21, 4.56 µg/g) was recorded in *O. niloticus.* However, the lowest value of Fe was recorded in *O. niloticus*52.8 µg/g and the highest was 224µg/g at the same fish. Results revealed that, the concentrations of Cd and Pb were fluctuated between (0.04and 1.12 µg/g) and (0.22 2.64 µg/g) respectively.

b: Gills tissue:

In the Manzala Lake fish, however, (Zn, Cu, Fe, Cd and Pb) ion concentrations was fluctuated between (10.42, 1.43, 52, 0.039 and 5.42) and (91.14, 62.44, 217, 1.19 and 9.49µg/g) during different season.

Table (3) and Figure (5.6) indicated that, the minimum value of (Zn, Cu, Fe, Cd and Pb) concentrations in the gill of different fish of River Nile (28.4,6.11,31.7, 0.16 and 1.34µg/g) in *O. niloticus,* and the maximum value was detected (137, 37.4, 411, 0.84 and 4.14µg/g).

c: Liver tissue:

Results showed that, the maximum average value of ion concentrations in the liver of *O. niloticus,* in Lake Manzala was recorded during autumn (73.76) and the minimum (23.26) during winter. In the *C.gariepinus* ,fish, however, ion concentrations showed highly increasing in the liver during autumn (83.1.) and the lowest value during winter (26.8).on other hand , the maximum average value of ion concentrations in the liver of *O. niloticus,* in River Nile was recorded during autumn (148.36) and the minimum (27.54) during winter. In the *C.gariepinus*, fish, however, ion concentrations showed highly increasing in the liver during autumn (118.44.) and the lowest value during winter (32.10)

Table (1): Seasonal average of heavy metals concentration (mg/L) in water samples collected from Lake Manzala during 2016.

St. No.	1	2	3	4	5	Av.
Winter						
Zn	0.061	0.057	0.055	0.069	0.072	0.063
Cu	0.043	0.044	0.045	0.035	0.051	0.044
Fe	0.194	0.235	0.244	0.131	0.352	0.231
Cd	0.003	0.004	0.006	0.005	0.004	0.004
Pb	0.094	0.084	0.041	0.076	0.096	0.078
Spring						
Zn	0.062	0.068	0.047	0.054	0.069	0.06
Cu	0.049	0.053	0.032	0.021	0.047	0.0404
Fe	0.172	0.393	0.562	0.447	0.723	0.459
Cd	0.002	0.005	0.003	0.006	0.007	0.0046
Pb	0.078	0.032	0.052	0.072	0.053	0.0574
Summer						
Zn	0.037	0.041	0.033	0.044	0.063	0.0436
Cu	0.12	0.113	0.124	0.016	0.046	0.0838
Fe	0.33	0.392	0.12	0.21	0.441	0.298
Cd	0.004	0.005	0.003	0.002	0.005	0.0038
Pb	0.17	0.063	0.019	0.02	0.04	0.0624
Autumn						
Zn	0.023	0.044	0.031	0.39	0.042	0.106
Cu	0.031	0.052	0.035	0.013	0.045	0.0352
Fe	0.178	0.315	0.321	0.276	0.331	0.284
Cd	0.004	0.005	0.004	0.002	0.004	0.0038
Pb	0.071	0.036	0.031	0.028	0.082	0.0496

No. = Station number. Av. Annul average

Table (2): Seasonal average of heavy metals concentration (mg/L) in water samples collected from the River Nile during 2016.

St. No.	1	2	3	Av.
Winter				
Zn	0.051	0.054	0.057	0.054
Cu	0.049	0.037	0.033	0.03967
Fe	0.191	0.085	0.186	0.154
Cd	0.0059	0.0032	0.0034	0.00417
Pb	0.035	0.037	0.041	0.03767
Spring				
Zn	0.062	0.076	0.081	0.073
Cu	0.034	0.035	0.03	0.033
Fe	0.418	0.427	0.556	0.467
Cd	0.0049	0.006	0.0062	0.0057
Pb	0.037	0.022	0.044	0.034
Summer				
Zn	0.079	0.082	0.079	0.08
Cu	0.031	0.042	0.051	0.04133
Fe	0.421	0.375	0.596	0.464
Cd	0.0057	0.0031	0.0039	0.0042
Pb	0.031	0.055	0.031	0.039
Autumn				
Zn	0.069	0.061	0.062	0.064
Cu	0.026	0.052	0.061	0.04633
Fe	0.482	0.375	0.465	0.44067
Cd	0.0052	0.006	0.0071	0.0061
Pb	0.027	0.041	0.029	0.03233

No. = Station number. Av. Annul average

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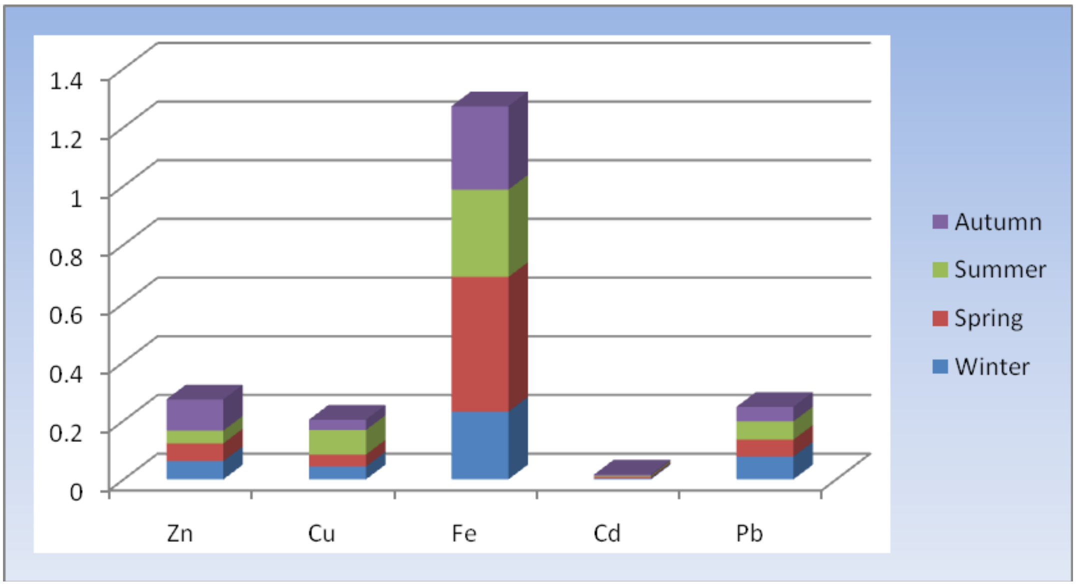
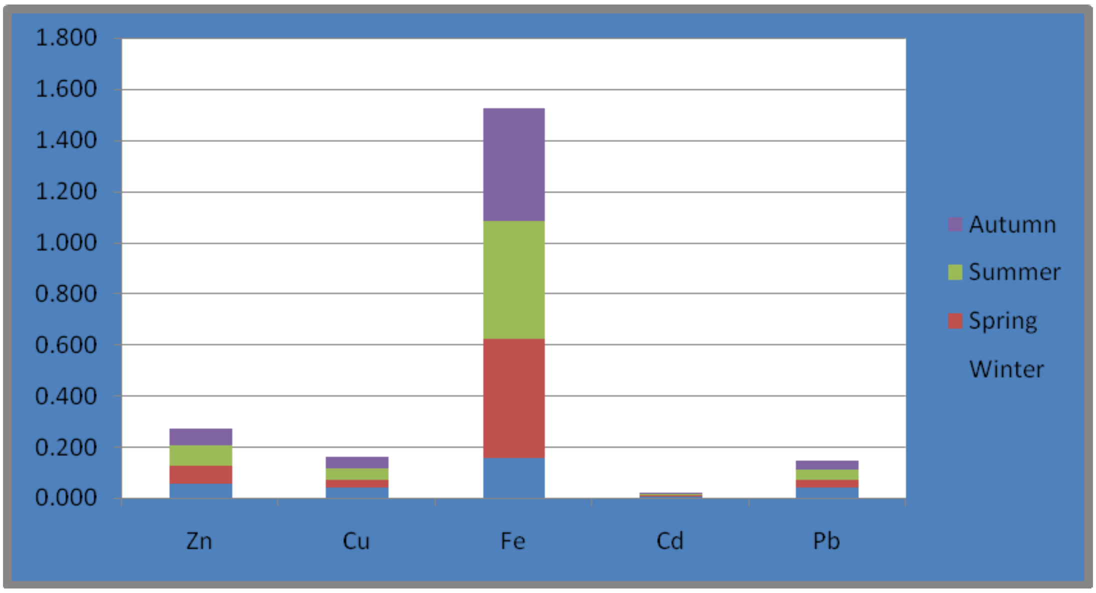


Figs. (1): Seasonal variation of heavy metals (Zn, Cu, FeCd and Pb) concentration (mg/L) in water samples collected from Lake Manzala during 2016.



Figs. (2): Seasonal variation of heavy metals (Zn, Cu, FeCd and Pb) concentration (mg/L) in water samples collected from the River Nile during 2016.

Table (3): Seasonal average of heavy metals concentration (µg/g dry wt.) in tissues of some fish species collected from the Lake Manzala during 2016.

Fish		Winter			Spring			Summer			Autumn		
sp.	**Metal**	**Muscle**	**Gills**	**Liver**	**Muscle**	**Gills**	**Liver**	**Muscle**	**Gills**	**Liver**	**Muscle**	**Gills**	**Liver**
O. niloticus	Zn	3.63	10.42	12.41	5.22	23.09	14.76	18.13	68.71	58.17	17.31	25.98	78.14
	Cu	1.22	1.43	17.46	4.21	4.91	24.91	4.82	12.23	19.35	6.38	8.61	38.17
	Fe	12.81	52.11	79.68	15.73	67.83	102.16	22.12	116.14	186.9	43.17	152.2	241.4
	Cd	0.018	0.039	0.06	0.039	0.062	0.092	0.056	0.073	1.12	0.077	1.19	1.13
	Pb	1.78	6.11	6.71	2.43	5.42	4.61	1.97	7.24	12.6	1.52	6.69	9.94
	Av.	3.89	14.02	23.26	5.53	20.26	29.31	9.42	40.88	55.63	13.69	38.93	73.76
C. gariepinus	Zn	5.66	14.36	31.3	19.32	31.26	53.91	29.91	79.36	74.54	47.55	91.14	71.83
	Cu	7.93	9.26	18.14	7.29	46.62	34.42	27.61	62.44	44.13	13.31	18.37	49.21
	Fe	28.28	63	75.27	51.02	56.18	121.6	41.41	191.11	198.21	82.48	217.5	282.1
	Cd	0.17	0.39	0.49	0.19	0.49	1.16	0.092	0.94	1.35	0.39	0.69	2.10
	Pb	2.64	9.45	8.61	4.66	9.42	11.21	4.61	9.49	12.08	3.41	7.54	10.31
	Av.	8.9	19.3	26.8	16.5	28.8	44.5	20.7	68.7	66.1	29.4	67.0	83.1

Table (4): Seasonal average of heavy metals concentration (µg/g dry wt.) in tissues of some fish species collected from the River Nile during 2016.

Fish		Winter			Spring			Summer			Autumn		
sp.	Metal	Muscle	Gills	Liver	Muscle	Gills	Liver	Muscle	Gills	Liver	Muscle	Gills	Liver
O. niloticus	Zn	6.21	28.4	31.1	22.3	42.2	32.9	31	48.2	61.9	32.4	61.4	94.1
	Cu	4.95	6.11	10.27	4.56	8.45	27.32	9.46	24.2	43.14	8.53	27.5	46
	Fe	224	31.7	94	68	98.7	221	76.1	91.3	337	52.8	252	593
	Cd	0.08	0.16	0.28	0.13	0.35	0.36	0.032	0.23	0.51	0.22	0.28	0.57
	Pb	1.12	1.34	2.05	1.15	1.87	2.97	2.16	2.18	5.31	2.64	3.23	8.12
	Av.	47.27	13.54	27.54	19.23	30.31	56.91	23.75	33.22	89.57	19.32	68.88	148.36
C. gariepinus	Zn	13.14	31.18	37.14	47.19	71.25	68.41	115	137	171	68.1	87.8	91.47
	Cu	5.47	7.45	27.2	8.61	11.18	41.2	9.72	37.4	59.1	12.21	26	52.5
	Fe	83.1	87.4	92.2	141	411	201	108	394	208	98	326	438
	Cd	0.04	0.39	0.81	0.06	0.57	0.65	0.08	0.79	0.55	0.07	0.84	0.93
	Pb	1.28	2.48	3.14	2.36	2.81	4.81	1.91	3.12	8.14	2.36	4.14	9.31
	Av.	20.61	25.78	32.10	39.84	99.36	63.21	46.94	114.46	89.36	36.15	88.96	118.44

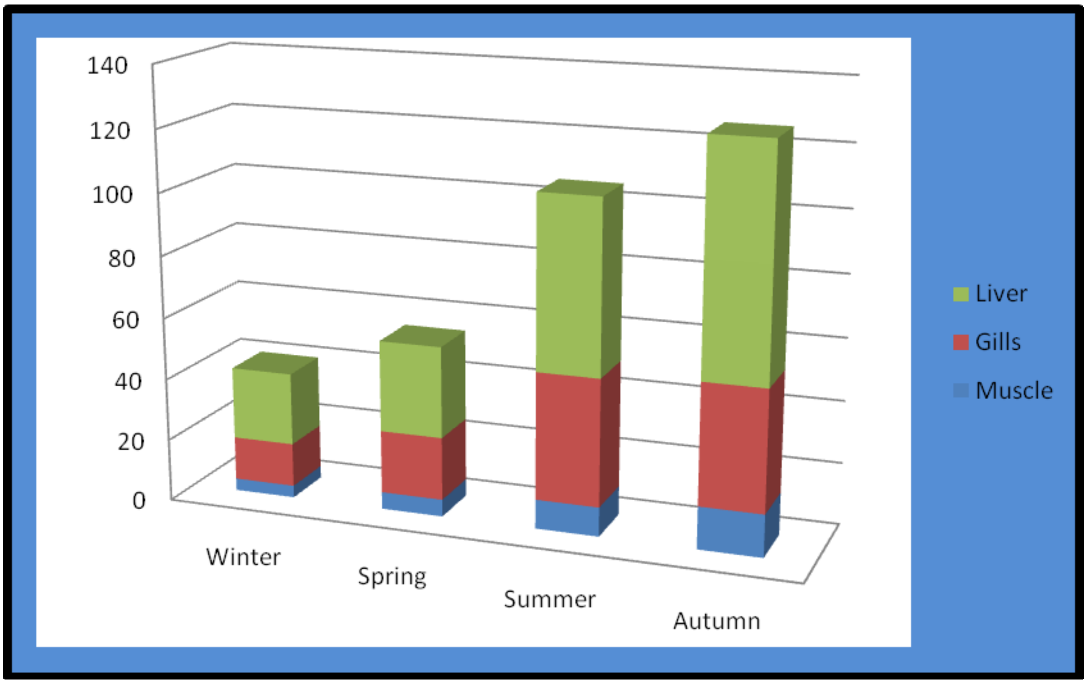


fig (3): Seasonal average of heavy metals concentration (µg/g dry wt.) in tissues of *O.niloticus* collected from the Lake Manzala during 2016.

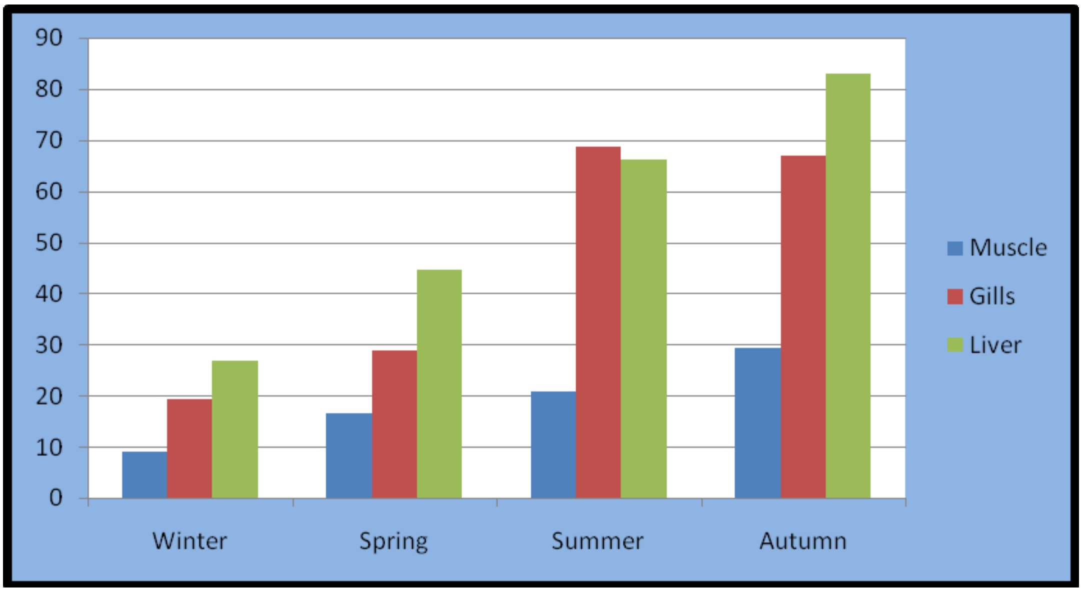


fig (4): Seasonal average of heavy metals concentration (µg/g dry wt.) in tissues of *C.gariepinus* collected from the Lake Manzala during 2016.

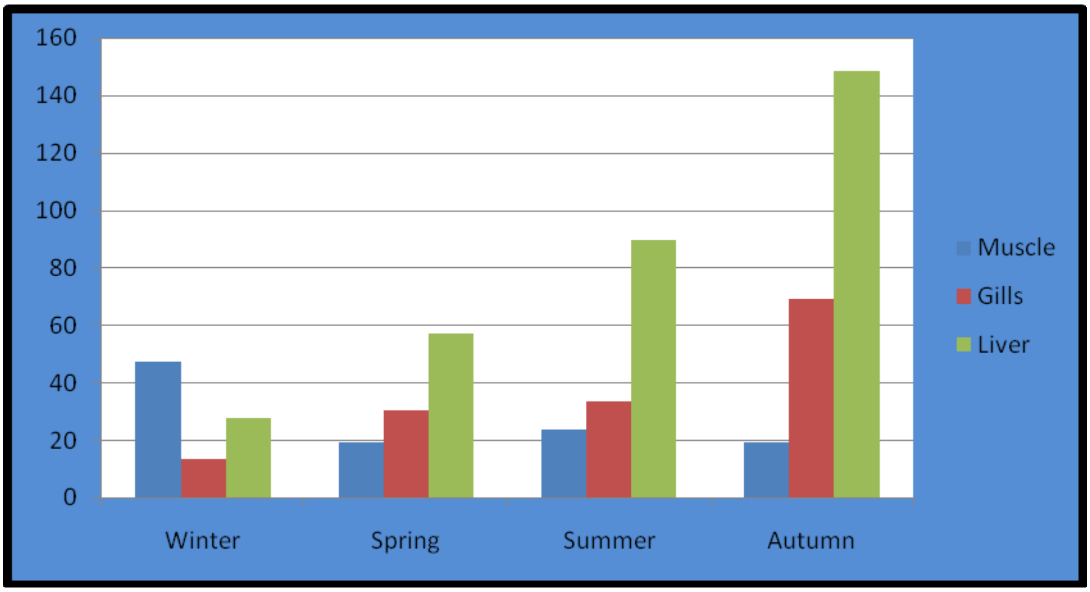


Table (5): Seasonal average of heavy metals concentration (µg/g dry wt.) in tissues of *O.niloticus* collected from the River Nile during 2016.during 2016.

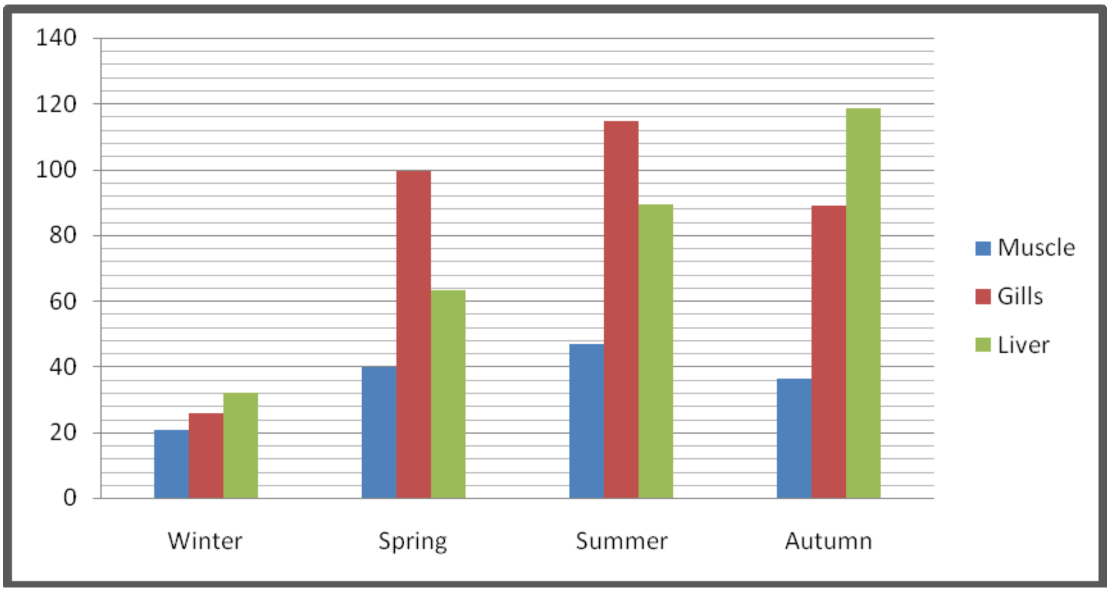


Table (6): Seasonal average of heavy metals concentration (µg/g dry wt.) in tissues of *C.gariepinus* collected from the River Nile during 2016.during 2016.

4. Discussion

Pollution of the aquatic environment by inorganic chemicals has been recognized as one of the major factors posing serious threat to the survival of aquatic organisms including fish. The agricultural drainage wastewater could lead to increased concentration of pollutants from agricultural wastes including pesticides, and fertilizers as well as effluents of industrial activities and runoffs that certainly pass into the biotic elements of the ecosystems [15]. Also, [16] stated that, the agricultural drainage water, industrial and sewage effluents supply the water bodies with huge quantities of inorganic anions and heavy metals. Metal ions can be incorporated into food chains and concentrated in aquatic organisms to a level that affects their physiological state. Of the effective pollutants are the heavy metals which have drastic environmental impact on all organisms. Trace metals such as Zn, Cu and Fe play biochemical role in the life processes of all aquatic plants and animals, therefore, they are essential in the aquatic environment in trace amounts. In the Egyptian irrigation system, the main source of Cu and Pb are industrial wastes as well as algaecides (for Cu), while that of Cd is the phosphatic fertilizers used in crop farms [17] The result of the present work concluded higher mean concentrations of nearly all the detected heavy metals in water samples collected from sampling sites downstream River Nile compared to those collected from upstream river Nile. The permissible limits for Zn, Cu, Fe, Cd and Pb in water are 5.0, 1.0, 0.3, 0.01 and 0.05 ppm respectively according to WHO[18]. So, heavy metals concentration in River Nile and Lake Manzala are over the legal limits.

From this study, the concentrations of heavy metals increase in areas near the out fall of drains. This was related to the richness of drainage water with organic matter which chelates these metals. The same observation was recorded in the River Nile estuary, which receive huge amounts of drainage water [19,20]

Higher levels of both, essential and nonessential metals can damage cell membranes, alter enzyme specificity, disrupt cellular functions, bind with greater affinity to thiolcontaining groups and oxygen sites than the essential metals do, and damage the structure of DNA [21].

The heavy metals concentrations in surface water of the River Nile [20] and lake Manzala[22], increased in winter and decreased in spring and summer seasons due to the consumption of these metals by phytoplankton. In winter, trace metals may increase in water due to the release of a certain part of the adsorbed metals from the bottom sediments into the interstitial water and hence the overlying water due to stirring up of water by wind.

The high concentration of Zn in water samples may be due to considerable amounts of zinc leached from protection plates of boats containing the active zinc as mentioned by[22].

The study of fish muscle tissues is one of the means for investigating the amount of heavy metals reaching man by food chain, whereas gills and liver tissues could be analyzed to determine the potential effects of a contaminant on fish health.

The WHO's health limits were 50 µg/g. for Zn, 30 µg/g. (for Cu), 2.0 µg/g. for Cd and Pb**.** Fe was not available. So, it is worth to mention that, the concentration of heavy metals in muscle tissues of the studied cichlid species lies within safe limits, while their concentration in gills and liver tissues exceeded these limits.

From this study, it is conspicuous that, Fe was the highest accumulated metal in fish tissues while Cd was the lowest one. Similar findings were reported by [23,24 and 25] Liver and gills had a high tendency to accumulate high concentrations of heavy metals, while muscle tissue tends to retain lower concentrations of such metals. Similar observations were reported by[26-31]The present results revealed an accumulation of heavy metals in fish tissues in spring, summer and autumn might be due to the intensive feeding of these fishes on phytoplankton and animal organisms during these seasons correlated with water temperature. This agrees with some other workers [32,27 and 28] **,**whereas the low feeding activity in winter may reflect a slowing down of the metabolism and digestive process at lower temperature as well as a reduction in the amount of food eaten.

In conclusion, the present work reckoned higher mean concentrations of nearly all considered metals in water samples collected from sampling sites downstream River Nile and

Lake Manzala, more domestic and industrial effluents have been released into the Nile Lake Manzala without adequate treatment.

5. References

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