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HEAVY METALS CONCENTRATIONS IN WATER AND FISH OF SOME EGYPTIAN LAKES AND FISHPONDS

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ABESTRACT: Five heavy metals namely, cadmium, copper, iron, lead, and zinc were determined in water and fish samples obtained from three different lakes and fishponds in Egypt over nine months to assess pollution with those toxic metals. Water and fish (Tilapia sp.) samples were collected from Abbassa fishpond, Lake Qaroun, and Wadi El-Rayan Lake. The results showed that concentrations of the five metals varied significantly among sites and seasons. Concentrations of iron, copper and zinc were slightly higher than lead and cadmium concentrations in water samples from the three sites. Copper, iron, lead, and zinc concentrations in water from the three sites were within the permissible limits, while the cadmium concentration in water from the three sites exceeded the permissible limit. On the other hand, the concentrations of copper, iron and zinc in fish obtained from the three sites were very much higher than cadmium and lead concentrations, which reflect the differences between the five metals in uptake and accumulation. Mean bioconcentration factor (BCF) data revealed that iron and zinc have the highest tendency to accumulate in fish tissue (7903 and 1655.8) while copper has a medium BCF level (983.4) and cadmium and lead have the lowest BCF levels (21.7 and 28). Based on the wet weight of fish samples, the levels of the five heavy metals in fish were within the safe levels for human consumers except for the zinc levels in Wadi El-Rayan Lake.

Key words: Heavy metals, fish, tilapia, lakes, fish ponds, bioconcentration.

INTRODUTION

The contamination of aquatic ecosystems (e.g., lakes, rivers, streams, etc.) with heavy metals has been receiving increased attention all over the world. The literature offers many publications on this aspect (e.g., Ramelow *et al.*, 1989; Davis and Bastian, 1990; Bhattacharya and Sarker, 1998; Blasco *et al.*, 1999; Castiki and Strogyloudi, 1999; Part *et al.*, 1999; Rashed, 2001).

Many chemical contaminants in aquatic systems cause neurotoxicity as their major mode of action (e.g., conventional insecticides) or target the central nervous system along with other organ systems (e.g., most heavy metals). Neurotoxic injury can result in behavioral changes that may impair the subsequent survival or reproduction of exposed organisms (NRC, 1992).

Unfortunately, most Egyptian lakes and water bodies receive many kinds of chemical and biological pollutants in addition to agricultural and domestic wastes and remains. El-Rafei *et al.* (1987) reported that the waste waters from the electroplating industry in Helwan area contain higher concentrations of chromium, manganese and zinc than the permissible limits. They also reported that there are other important toxic elements in wastewaters such as mercury, lead, copper, iron and cadmium. Mercury is released from electric generating stations (Johnels *et al.*, 1967), agriculture operations and various industries (Kohler, 1989).

When heavy metals enter an aquatic ecosystem, such as a lake or river, they change its water quality, bind to sediment, especially in soils with a high clay content, and accumulate in the different compartments; causing adverse effects to the ecosystem and human health depending on their relative levels (Luckey and Venugopal, 1977; Brenner *et al.*, 1995).

For over a century, fish kills from metal pollution have occurred in the Sacramento River that receives runoff from Iron Mountain Mine (Finlayson and Wilson, 1979; CH2M Hill, 1991). Major kills of $\geq$ 25000 fish were documented in 1955, 1957 and 1967 (CH2M Hill, 1991).

Although the adverse health effects of heavy metals have been known for a long time, exposure to heavy metals continues and is even increasing in some areas. Cadmium exposure may cause kidney damage. The first sign of the renal lesion is usually a tubular dysfunction, evidenced by an increased excretion of low molecular weight proteins [such as β_2-microglobulin and α_1-microglobulin (protein HC)] or enzymes [such as N-Acetyl- ß -D-glucosaminidase (NAG)]. The symptoms of acute lead poisoning are headache, irritability, abdominal pain and various symptoms related to the nervous system. Lead encephalopathy is characterized by sleeplessness and restlessness. Children may be affected by behavioural disturbances, learning and concentration difficulties (Jarup, 2003).

The IARC (1993) has classified cadmium as a human carcinogen (group I) on the basis of sufficient evidence in both humans and experimental animals.

Acute exposure to lead is known to cause proximal renal tubular damage. Long-term lead exposure may also give rise to kidney damage and, in a recent study of Egyptian policemen, urinary excretion of NAG was positively correlated with duration of exposure to lead from automobile exhaust, blood lead and nail lead (Mortada *et al.*, 2001).

Food is the most important source of cadmium exposure in the general non-smoking population in most countries (WHO, 1992). Cadmium is present in most foodstuffs, but concentrations vary greatly, and individual intake also varies considerably due to differences in dietary habits (Jarup *et al.*, 1998).

Lake Qaroun, one of the five large lakes in Egypt, is a closed basin used as a general reservoir for agriculture wastewater drainage of Fayoum Provence. Due to its unique character, the accumulation of chemical pollutants, e.g. heavy metals, in the lake ecosystem should receive considerable concern (Ibrahim, 1996).

Wadi El-Rayan is great depression located southwest of Cairo in the western desert of Egypt. In 1973, Wadi El-Rayan was connected with the agricultural waste water drainage system of El-Fayoum Governorate to provide a reservoir for the waste water that exceeded the capacity of Lake Qaroun (Saleh *et al.*, 2000).

Abbassa fish farm is a great area (1200 Acres) of fish ponds receiving their water from the Nile through the Ismailia Canal.

The objective of the present study is to monitor the levels of five heavy metals in water and fish of Lakes Qaroun, Wadi El-Rayan (Fayoum Governorate) and Abbassa fishpond (Sharkia Governorate), Egypt.

MATERIALS AND METHODS

The present work was carried out on water and fish samples collected monthly for a period of nine months (from May 2003 to Januray 2004) from three sites; Lake Qaroun, Wadi El-Rayan Lake 1 (Fayoum Governorate), and a fish pond at Abbassa fish farm (Sharkia Governorate). These sites were chosen for their importance as water resources for fisheries and aquaculture sectors in Egypt. Samples collected from the two lakes were collected from one location in each lake. For Lake Qaroun, water and fish samples were collected from the area of Ebshway. For Wadi El Rayan Lake 1, samples were collected from the area that the new established fishponds (1000 Acres) receive their water from. Water and fish samples, collected from Abbassa fish farm, were obtained from the sedimentation pond which supplies an area of 1200 Acres of fishponds with water. Abbassa fish farm receives Nile water through the Ismailia Canal.

Water Sample Analysis

Water samples were taken monthly from the three sites. Three liters were taken from three locations of each of the selected sites fifteen cm below the surface. The three subsamples were added to each other, afterwhich one liter was taken for analysis. Samples were placed in polyethylene bottles, and chilled on ice for transport to the laboratory.

The water samples were analyzed for total hardness, total alkalinity and salinity according to standard the methods described by the American Public Health Association (APHA, 1998). pH was measured using an accumet® pH meter 25.

Metal analysis was performed on 100-mL filtered samples collected from different sites. Water samples were filtered through a 0.3-µm filter, transferred to a pre-cleaned polyethylene bottles, and preserved by the addition of 1 mL nitric acid. Dissolved heavy metal (cadmium, copper, iron, lead and zinc) concentrations were determined by furnace atomic absorbance spectrophotometry (Unicam®, 969).

Fish Sample Analysis

Fish samples were collected from the preceding sites, rinsed in the ambient water immediately after collection, then wrapped in polyethylene and chilled on ice for transport to the laboratory. Samples were dried in a hot air oven (105°C) overnight, and grinded, afterwhich one gram of dry sample was digested with nitric acid. Digestates were diluted with 1% HCl. The concentrations of the preceding heavy metals were measured by furnace atomic absorbance spectrophotometry (Unicam®, 969) according to APHA (1998).

Calculation of Bioconcentration Factor (BCF)

Some inorganic pollutants are assimilated by organisms to a greater extent than others. This is reflected in the BCF, concentration of the chemical in the organism divided by concentration in the ambient water.

Statistical Analysis

The data were analyzed using statistical analysis system (SAS) software to evaluate the seasonal changes in metals levels and the differences between the studied sites in this respect.

RESULTS AND DISCUSSION

Water Quality Parameters

The data in Table 1 showed that there were variations among the sites in water quality parameters. The water pH levels were very close in the three sites and ranged from 7.9 to 9.0, which revealed that all the sites have alkaline water.

The waters of Abbassa and Wadi El-Rayan have medium hardness levels ranging from 110 to 480 mg/L (as $CaCO_3$), while Lake Qaroun water could be considered as very hard water, due to its high salinity (33.4 to 39.2 g/L). Total alkalinity in the three sites ranged from 150 to 460 mg/L (calcium carbonate and bicarbonate). It is obvious that there is a wide range in salinity (total dissolved salts) among the three sites; undetectable levels for Abbassa, 1 to 2 g/L for Wadi El-Rayan Lake, and 33.4 to 39.2 g/L. for lake Quroun water.

Table 1: Physiochemical parameters of water in the three studied sites

Sampling Site	pH	Total Hardness mg/L	Total Alkalinity mg/L	Electric Conductivity µmohs/L	Salinity g/L
Abbassa Fishpond	8.0 – 8.5	110 – 200	150 – 220	300 – 500	Un Detectable
Lake Qaroun	7.9 – 8.1	Very hard	400 – 460	35000 – 38000	33.4 – 39.2
Wadi El-Rayan	8.4 – 9.0	300 – 480	200 – 225	2100 – 2400	1.0 – 2.0

Metals in Water

The mean concentrations of cadmium, copper, iron, lead and zinc in the three studied sites are presented in Table 2. It is obvious that concentrations of copper, and iron in Abbassa and Wadi El-Rayan water were significantly lower than in Lake Qaroun. Lead concentration was similar in all three sites. Zinc showed higher levels in Abbassa water compared with the other two sites throughout the whole period of study. Cadmium levels were significantly higher in both Abbassa and Wadi El-Rayan water in comparison with Lake Qaroun water.

Regarding the seasonal variations of metals in water, considerable variation could be noticed in Lake Qaroun concerning the concentration of metals in different seasons with the exception of Zn, which did not show significant changes in this respect. Slight seasonal changes were noticed in the concentrations of the heavy metals in water for both Abbassa and Wadi El-Rayan sites with the exception of Pb in Wadi El-Rayan and Zn in both Abbassa and Wadi El-Rayan (Table 2). The data showed significant seasonal changes in the concentration of Zn in Abbassa water; Zn concentration was significantly higher in both autumn and winter than in summer. In Wadi El-Rayan water, Pb concentration showed a significant increase in summer when compared with winter, while in autumn, there were no significant differences than the other two seasons. The zinc concentration in Wadi El-Rayan water was significantly higher in winter than summer, while in autumn, Zn concentration occupied an intermediate level between summer and autumn; the differences were not significant.

Concentrations of Fe and Cu did not show any significant differences among seasons in Abbassa and Wadi El-Rayan Lake, while in Lake Qaroun Fe and Cu concentrations in water were significantly different with high levels in winter followed by autumn then summer.

The lead levels in Abbassa fishpond water did not show significant changes in this respect. In Lake Qaroun water, Pb concentrations were significantly higher in winter than in summer and autumn. On the contrary, Pb levels in Wadi El-Rayan Lake were significantly higher in summer and autumn compared with winter. It is obvious that cadmium levels in water did not change significantly among seasons in the three tested sites.

In Abbassa fishpond, water zinc concentration was higher in winter than in both summer and autumn. There was no significant difference between winter and autumn or summer and autumn. In Lake Qaroun, slight differences in the levels of zinc concentration were found in the three seasons. Zinc, in Wadi El-Rayan Lake, was significantly higher in winter than summer while zinc levels in autumn did not show any significant difference when compared with either summer or winter levels.

The permissible limits in water for Cd, Cu, Fe, Pb, and Zn are 0.01, 1.0, 0.3, 0.05, and 5.0 ppm, respectively according to World Health Organization, published by FAO (1992). The figures presented in this study reveal that Fe, Cu, Pb, and Zn concentrations in water from the three studied sites fall far below the mentioned permissible limits, while Cd concentration in water from the three sites, however, exceeded the permissible limit.

The main sources of Cu and Pb in Egyptian irrigation system are industrial wastes and algaecides (Cu), while those for Cd are the phosphate fertilizers used in agriculture (Saad and Emam, 1998).

Seasonal variations of the heavy metals levels in water were reported in Wadi El-Rayan Lake (Saleh *et al.*, 1988), the River Nile (Hamed, 1998) and Lake Manzala (Hamed and Said, 2000). It was found that levels of heavy metals in water were higher in winter and lower in summer and spring. The data in Table 2 show a similar trend in Lake Qaroun with the exception of zinc levels, which did not show any variation among seasons.

The low levels of most studied metals in water in summer and autumn may be attributed to the consumption of these metals by phytoplankton, which adsorb huge amounts of metals on their surface; they flourish most in spring, summer and autumn seasons. Saleh *et al.* (1988) reported that concentrations of heavy metals in plankton were found to be 4000 to 10000 times higher than those in water of Wadi El-Rayan Lake.

High concentrations of zinc in water may be due to considerable amounts of zinc leaching from the protection plates of boats containing the active Zn (Hamed, 1998).

Metals in Fish

The data presented in Table 2 show that amounts of Cu, Fe, Pb, and Zn levels in fish samples differed from location to another.

With iron, higher levels were found in fish samples obtained from Abbassa and Wadi El-Rayan compared with those found in Lake Qaroun. The corresponding average levels ranged form 182.7 to 259.7, 175.1 to 240.9 and 48.13 to 62.23 ppm. The low level of iron in Lake Qaroun samples may be due to the high salinity (33.4 – 39.29 g/L) and hardness of Lake Qaroun water which reduces the solubility of some metals in water.

Again, and as has been found with iron, Lake Qaroun samples did contain lower amounts of copper, compared with the other two sites. The differences between the three sites were significant.

Curiously enough, and in contrast with the preceding two elements, levels of lead were found to be much higher in Lake Qaroun samples compared with the other two sites, which contained either undetectable amounts or very minute amounts of lead. Levels of lead in Lake Qaroun fish were significantly higher than the other two freshwater sites and ranged from 0.807 to 0.953 ppm.

Cadmium figures refer to small variations among the studied sites. However, high Cd levels were found in fish samples obtained from Lake Qaroun and Wadi El-Rayan, compared with Abbassa fish samples. No significant differences were noticed between levels of cadmium in fish samples obtained from Lake Qaroun and Wadi El-Rayan. This may be attributed to the agricultural drain water that those two water bodies receive.

Wadi El-Rayan fish contained, however, the highest levels of zinc. Fish from Abbassa and Lake Qaroun contain Zn levels ranging from 38.5 to 68.8 and 24.2 to 48.8 ppm, respectively.

The WHO's limits for health (based on wet weight) are 30 ppm for Cu, 2.0 ppm for Pb and Cd, 50 ppm for Zn, while limits for Fe are not available. Fortunately, the obtained figures showed that concentrations of the studied metals in fish samples were found to be within the safe limits with the exception of zinc levels in all samples of Wadi El-Rayan Lake.

Table 2: Seasonal changes in metal levels and bioconcentration factor in water and fish samples from the three sites

Site	Season	Mean Concentration in Water (ppm)				
		Cd	Cu	Fe	Pb	Zn
Abbassa Fish Pond	Summer	0.030 ab	0.010 d	0.020 d	0.030 a	0.070 b
	Autumn	0.034 ab	0.010 d	0.030 d	0.027 ab	0.077 ab
	Winter	0.030 ab	0.010 d	0.027 d	0.030 a	0.090 a
Lake Qaroun	Summer	0.017 bc	0.059 c	0.183 c	0.006 c	0.036 cd
	Autumn	0.023 abc	0.160 b	0.233 b	0.010 c	0.026 d
	Winter	0.013 c	0.223 a	0.287 a	0.029 a	0.025 d
Wadi El-Rayan Lake	Summer	0.034 a	0.023 cd	0.010 d	0.030 a	0.027 d
	Autumn	0.021 abc	0.033 cd	0.013 d	0.023 ab	0.037 cd
	Winter	0.029 ab	0.023 cd	0.020 d	0.020 b	0.047 c
Permisible Limits (ppm)		0.01	1	0.3	0.05	5

Site	Season	Mean Concentration in Fish (ppm) dry weight				
		Cd	Cu	Fe	Pb	Zn
Abbassa Fish Pond	Summer	0.213 d	16.697 b	182.667 de	UD* c	68.820 c
	Autumn	0.293 cd	18.603 b	210.667 c	UD c	57.473 d
	Winter	0.480 bc	19.420 b	259.667 a	UD c	38.523 e
Lake Qaroun	Summer	0.443 bc	4.407 c	48.133 f	0.807 b	48.767 d
	Autumn	0.530 ab	4.593 c	52.067 f	0.917 a	34.433 e
	Winter	0.597 ab	5.030 c	62.233 f	0.953 a	24.233 f
Wadi El-Rayan Lake	Summer	0.510 b	20.667 b	175.133 e	0.007 c	103.633 ab
	Autumn	0.730 a	30.933 a	199.567 cd	0.007 c	112.033 a
	Winter	0.483 bc	33.590 a	240.933 b	UD c	101.567 b

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Site	Season	Bioconcentration Factor (BCF)				
		Cd	Cu	Fe	Pb	Zn
	Summer	7.10	1669.70	9133.35	---	983.14
Abbassa Fish Pond	Autumn	8.62	1860.30	7022.23	---	746.40
	Winter	16.00	1942.00	9617.30	---	428.03
	Summer	26.06	74.69	263.02	134.50	1354.64
Lake Qaroun	Autumn	23.04	28.71	223.46	91.70	1324.35
	Winter	45.92	22.56	216.84	32.86	969.32
	Summer	15.00	898.57	17513.30	0.23	3838.26
Wadi El-Rayan Lake	Autumn	34.76	937.36	15351.31	0.30	3027.92
	Winter	16.66	1460.43	12046.65	---	2161.00
Mean		**21.46**	**988.26**	**7931.94**	**51.92**	**1648.12**

Site	Season	Mean Concentration in Fish (ppm) wet weight									
		Cd		Cu		Fe		Pb		Zn	
	Summer	0.125	d	9.817	b	107.408	de	UD		40.466	c
c	Autumn	0.172	cd	10.938	b	123.872	c	UD		33.794	d
c	Winter	0.282	bc	11.419	b	152.684	a	UD	c	22.651	e
	Summer	0.26	bc	2.591	c	28.302	f	0.475	b	28.675	d
Lake Qaroun	Autumn	0.312	ab	2.701	c	30.615	f	0.539	a	20.247	e
	Winter	0.351	ab	2.958	c	36.593	f	0.56	a	14.249	f
	Summer	0.299	b	12.152	b	102.978	e	0.004	c	60.936	ab
Wadi El-Rayan Lake	Autumn	0.429	a	18.189	a	117.345	cd	0.004	c	65.875	a
	Winter	0.284	bc	19.75	a	141.668	b	UD	c	59.721	b
Permisible Limits (ppm)	2			30		not defined		2		50	

Means with the same letter in the same column are not significantly different. * Undetectable

High bioaccumulation levels of Fe and the low ones for Pb and Cd (Table 2), were also reported by Lasheen (1982), Shakweer and Abbas (1997), Zyadah (1997), Hamed (1998), El-Moselhy (1999) and Abdel-Sattar and Shehata (2000).

Variation in the concentrations of heavy metals levels in most fish samples between freshwater sites and saltwater sites was also reported by Saleh (1982) who found that fish living in polluted freshwater accumulate greater concentrations of heavy metals than those in brackish or saline water.

Among aquatic animals, variables such as water quality, diet composition and foraging behavior, physiological processes, and body weight or age of the individual can influence the body burden of metals. In addition, animals (including insects and fish) require certain metals (e.g., Cu and Zn, but not Cd) for growth and survival (N.R.C 1979, 1993; Roseijadi 1992). Low concentrations of Cu and Zn in the ambient water and food (but not below critical threshold concentrations) trigger symptoms of nutrient deficiency. Physiological mechanisms may allow animals to accumulate required amounts of essential micronutrients by decreasing excretion rates and increasing absorption efficiencies (N.R.C, Loc.Cit.). On the other hand, when ambient concentrations are high, animals may reduce their body burdens of these metals by increasing excretion rates and decreasing absorption efficiencies. Exposure to very high concentrations of metals (including Cd) can also stimulate production of metallothioniens (metal-binding proteins) that protect cellular function until the metals are cleared from the tissue (Richards 1989; Roesijadi 1992).

Seasonal Variations of Metals in Fish Samples

In most cases, metals levels in fish obtained from the three studied sites showed considerable seasonal variations (Table 2).

Iron levels in the fish of Abbassa fishpond varied significantly. The highest level of Fe in fish was found in winter (259.7 ppm) followed by autumn (210.7 ppm); the lowest level (182.7 ppm) in summer. Lake Qaroun fish did not show any seasonal differences in the rate of Fe bioaccumulation in their bodies

(Table 2). The highest amounts of iron in the fish of Wadi El-Rayan were found in winter (240.9 ppm) followed by autumn (199.6 ppm) then summer (175.1 ppm).

Copper levels in fish from both Abbassa fishpond and Lake Qaroun did not show any significant differences. A seasonal variation in fish samples was found only in Wadi El-Rayan site; levels of Cu in fish samples were, however, significantly lower in summer when compared with both autumn and winter.

Lead levels in both Abbassa and Wadi El-Rayan fish for the three seasons were either undetectable or very slight. Significant variations in lead levels in fish samples among seasons was found only in Lake Qaroun site; the levels were higher in both winter and autumn than in summer.

Cadmium levels in fish behaved vacillatingly during seasons. In Lake Qaroun, there were no significant seasonal variations in Cd levels, whereas in Abbassa fishpond and Wadi El-Rayan Lake, Cd levels in fish varied significantly from season to another. In the Abbassa site, Cd levels in fish were significantly higher in winter compared with summer. In autumn, levels occupied an intermediate position. Cadmium in Wadi El-Rayan's fish samples was significantly higher in autumn compared with summer and winter. No significant difference in cadmium levels was found in fish samples collected in summer and winter.

Levels of zinc concentration in fish samples of all studied sites, however, varied significantly from season to another. In contrary with the preceding four metals, the ranking of zinc levels in fish during the three seasons differed greatly. The lowest amounts of zinc were found during winter. Fish from Abbassa fishpond contained higher amounts of Zn in summer (68.8 ppm) followed by autumn (57.5 ppm) then winter (38.5 ppm). The same trend of seasonal variation of Zn was found also in Lake Qaroun fish samples. This is may be due to the feeding behaviors of fish in summer and autumn when the algae, which are the main natural fish food, abundance reach its maximum rate. In Wadi El-Rayan fish samples, Zn levels were significantly higher in autumn than in winter, but no significant difference found between summer and winter and between summer and autumn.

In conclusion, the figures presented in Table 2 show that fish uptake higher amounts of Fe, Cu, Pb and Cd during winter and lower amounts during summer. These results are contrary to those of Saleh *et al.* (1988) and Mussa (2004).

Fish are capable of maintaining and balancing the levels of several elements in their bodies and in the surrounding environment by a mechanism such as the mechanism for balancing the salts in the body even when they move from fresh to seawater. Lin *et al.* (2001) described how tilapia larvae are capable of adapting to environmental salinity changes even when transferred from freshwater to seawater or vice versa.

Bioconcentration Factor (BCF)

The bioconcentration factor is obtained by dividing the residue of a chemical in test organism by its concentration in the ambient environment. This factor measures the tendency for a chemical to accumulate in organism's tissues. The bioconcentration factors of the five tested elements are compiled in Table 2 and Fig. 1. It is obvious that the bioaccumulation levels of the five metals differed greatly. The metal, the location, and season of inspection play obvious roles in this respect. The bioconcentration factors for the three sites could be descendingly arranged as follows: iron > copper > zinc > cadmium in Abbassa fishpond; zinc > iron > copper > cadmium > lead in Wadi El-Rayan Lake; and zinc > iron > lead > copper > cadmium in Lake Qaroun. There was no factor for lead in Abbassa fishpond and the winter season of Wadi El-Rayan Lake since the levels of this metal were undetectable. These figures show that iron was the metal most likely to accumulate in fish tissues obtained from Abbassa fishpond and Wadi El-Rayan Lake. In Lake Qaroun, zinc ranked first.

The studied heavy metals could be descendingly arranged according to their mean BCF values for different studied sites and seasons in fish as follows: Iron (7931.94 folds), zinc (1648.12 folds), copper (988.26 folds), lead (51.92 folds) then cadmium (21.46 folds).

In conclusion, the data presented in Table (2) show that fish are capable of accumulating iron, copper and zinc in their bodies. It is of great interest to note that, the rate of accumulation of the risky metals (cadmium and lead) in fish bodies is extremely low.

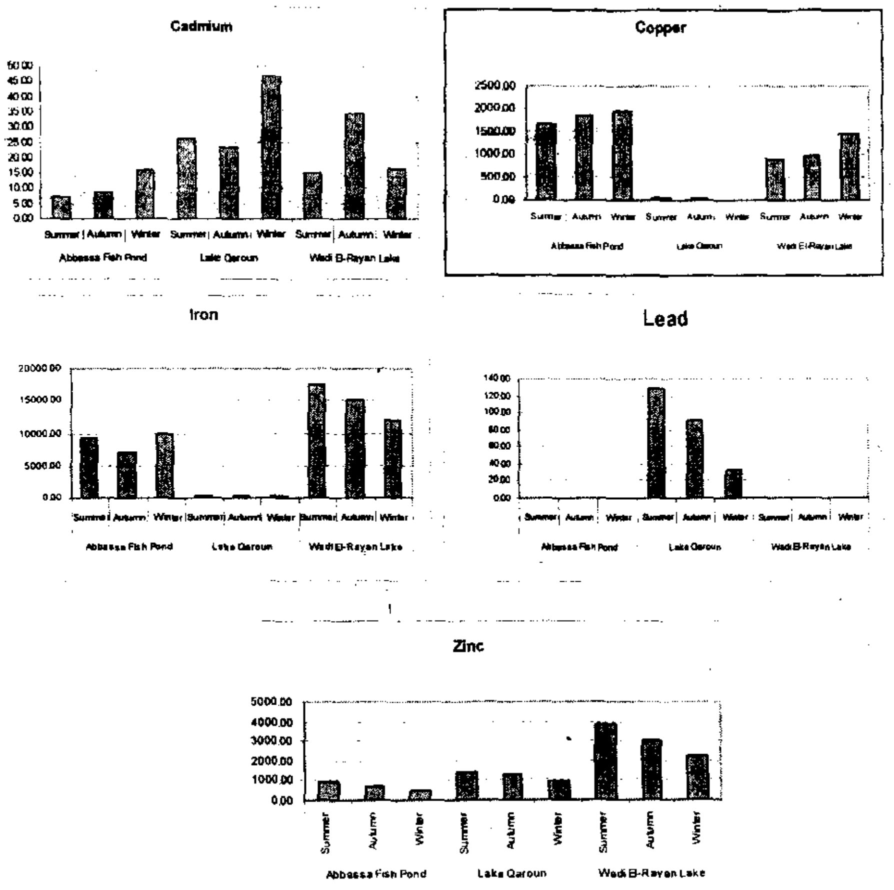

Fig. 1: Bioconcentration factor (folds) of the tested metals in fish obtained from the three sites in different seasons

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مستويات العناصر الثقيلة في الماء والأسماك ببعض البحيرات وأحواض الأسماك في مصر

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تمت دراسة تتبع مستويات خمسة من العناصر الثقيلة هي الحديد، النحاس، الرصاص، الكادميوم والزنك لمدة تسعة أشهر في عينات مياه وأسماك البلطي مأخوذة من ثلاث مصادر مائية مختلفة في مصرهي: حوض أسماك بمزرعة أسماك العباسة، محافظة الشرقية، وبحيرة قارون وبحيرة وادي الريان الأولى بمحافظة الفيوم. أوضحت النتائج أن مستويات الحديد والنحاس والزنك في المياه كانت الأعلى في جميع عينات المواقع الثلاثة في حين كان مستوى كل من الكادميوم والرصاص منخفضاً في جميع العينات. وجد أن مستويات جميع العناصر(باستثناء الكادميوم) كانت أقل من الحدود المسموح بها في المياه طبقاً لمعايير منظمة الصحة العالمية. وجد أن مستويات العناصر بالأسماك في جميع المناطق كانت أقل من مستوى الحدود المسموح بها باستثناء الزنك في بحيرة وادي الريان.

أوضحت النتائج أيضاً، أن كل من الحديد والزنك لهما القابلية الأعلى على التراكم في أنسجة الأسماك في حين كان النحاس متوسط التراكم. وكان الرصاص والكادميوم اقل العناصر الخمسة قابلية للتراكم في الأسماك.