Mansoura Veterinary Medical Journal

HEAVY METAL RESIDUES IN SOME MANZALA LAKE FISHES

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ABSTRACT

This study aimed to determine the content of heavy metals as lead, mercury, cadmium and arsenic in edible muscles of three common freshwater fishes like Nile tilapia, Flathead grey mullet and African catfish. A total of 300 freshly caught fish samples (100 each) of different weights collected from Manzala Lake, Egypt during both summer and winter seasons of 2012 have been analyzed using air acetylene flame atomic absorption spectrophotometer. The obtained results revealed that the presence of lead, mercury, cadmium and arsenic in all (100%) examined samples by means of 0.704 µg/g, 0.635 µg/g and 0.64 µg/g for Pb, 0.045 µg/g, 0.0145 µg/g and 0.017 µg/g for Hg, 0.025 µg/g, 0.006 µg/g and 0.020 µg/g for Cd and 0.511 µg/g, 0.621 µg/g and 0.568 µg/g for As in Nile tilapia, Flathead grey mullet and African catfish , respectively. heavy metal concentrations were significantly varied within and between the studied fishes. However, a significant correlation among heavy metals was observed. This study indicated that various concentrations of heavy metals exist in sampled fish species and most of those levels are within the maximum permissible limits proposed by the Egyptian standards except for Pb, its level exceeded the permissible limits in the majority of tested samples. Therefore, fish caught from Manzala Lake can be considered unsafe for human consumption.

INTRODUCTION

Fish are nutritious food that constitute a desirable components of healthy diet and considered as an excellent source of high quality protein containing a good balance of essential amino acids and having a high biological value and containing lipids with high levels of beneficial poly-unsaturated fatty acids which contributing to the enhancement of human health by reducing the risk of cardiovascular disease (**Ersoy and Celik, 2010**). Likewise, fish are characteristically tender, easily digest and good source of most B-complex vitamins and also contribute significant levels of minerals including cobalt, iron, copper, zinc, sodium, potassium, magnesium, phosphorous, iodine and fluorine (**NRC, 1998**).

Familiarity, taste, low-cost and convenience are some of the appealing factors that make fish a substitute for the red meat as a source of animal proteins. It provides an opportunity for consumers to meet their daily nutritional requirements. However, despite the recognized benefits, fish can accumulate the non-essential toxic elements like heavy metals which may pose potential health risks to human health at high concentrations (**Kalyoncu et al., 2012**). Heavy metals are natural trace components of the aquatic environment which have no known beneficial functions, but their levels have increased to toxic concentrations due to industrial, agricultural and mining activities.

Most fishes can easily be contaminated by a wide variety of toxic heavy metals like arsenic, cadmium, lead and mercury. Thus contamination may originate from various sources, including agricultural drainage, industrial effluent discharge, sewage discharge, accidental chemical waste spills, and gasoline from fishing boats (**Mishra et al., 2007** and **Satheeshkumar and Kumar, 2011**). Heavy metals reach fish flesh via the feeding on benthic species (benthic worms and crustaceans) which in role feed on the surrounding sediment having a high amount of heavy metals (**Galay Burgos and Rainbow, 2001**).

In particular, due to heavy metals cannot degrade, they can continuously persist and accumulate into environmental media including water and sediments and bio-accumulated in the aquatic organisms including fish to levels that are hazardous to the human health (**Eisler, 2010**). Heavy metal accumulation in fish depends mainly on many factors including the region and time of fishing, the feeding habits, gender, age, size, species, nutrition, their concentration in water, duration of exposure to heavy metals and other environmental factors such as salinity, pH and water temperature (**Zhang and Wong, 2007**).

The consumption of heavy metals contaminated seafood's may have a potentially health hazards for humans through induction of acute and chronic degenerative changes **(Ibrahim and El-Naggar, 2006)**, especially to the nervous system, kidneys and liver and in some cases, they also have teratogenic and carcinogenic effects in addition to immunosuppressive impact (**IARC, 1987**). The mechanism of toxicity of some heavy metals still remains unknown, although they may play a role in enzymatic inhibition and impaired antioxidants metabolism. Heavy metals produce many of their adverse health effects through the formation of free radicals, resulting in DNA damage, lipid peroxidation and depletion of protein sulfhydryls (**Valko et al., 2005**).

In Egypt fish are caught and collected from either wild sources or aquacultures distributed in different localities all over the country. However, in contrast to many studies carried out in a wide variety of fish species from aquaculture in Egypt (**Abumourad et al., 2013** and **El-Moselhy et al., 2014**), little studies focused on freshwater fish from wild source like Manzala lake which occupies an important position in the national fisheries in Egypt. Nile tilapia (*Oreochromis niloticus*), Flathead grey mullet (*Mugil cephalus*) and African African catfish (*Clarias gariepinus*) are among the most popular fish species consumed widely in Egypt and are most frequently cultured in Manzala lake at Northeast Egypt. Due to the little information about the heavy metals contents in these fishes up till now and the toxic effects of these metals on public health, therefore, the aim of this study was to throw the light on determination the contents of the most toxic heavy metals like arsenic, cadmium, lead and mercury in edible muscles of three common freshwater fish species (Nile tilapia, Flathead grey mullet and African catfish) and to evaluate the risk assessment of fish consumption on human health.

MATERIALS AND METHODS

2.1. Study area

Manzala Lake is considered one of the most important fish sources in Egypt which is a brackish lake and located in north-eastern Nile Delta of Egypt near Port Said and a few miles from the ancient ruins at Tanis. It is bounded by Suez Canal from east, Damietta branch of Nile from west and Mediterranean Sea from north. Manzala Lake receives the highly polluted untreated water from Bahr El-Baqr drain (domestic and industrial sewage), Hadous, Ramsis, El-Serw and Faraskour drains (agricultural effluents), which in role contributing to the high accumulation of heavy metals in the organs and edible muscle of fish reared in this lake with subsequent great public health problems to the consumers.

2.2. Collection of samples

A total of 300 freshly caught fish samples (100 each of Nile tilapia, Flathead grey mullet and African African catfish) of different weights were collected from Manzala Lake, Egypt during both summer and winter seasons of 2012. Sampled fishes were individually packed into a clean polyethylene bag then marked and transferred at 4 °C in icebox with a minimum of delay to the laboratory of Food Hygiene and Control Department, Faculty of Veterinary Medicine, Mansoura University, Egypt, wherein the further treatments and preparation of samples were done to be ready for analysis of heavy metals. In the laboratory, each fish was weighed using a digital balance, wrapped with aluminum foil, packed separately in a clean plastic polyethylene bag, labeled with identification number and date of collection, then the fish are kept frozen at -20 °C until sample preparation and digestion.

2.3. Reagents

All Reagents used, including nitric acid (65%), perchloric acid (70 %), hydrochloric acid (37 %) and hydrogen peroxide (30 %) were of ultra-pure grade (E-Merck, Darmstadt, Germany). All laboratory wares used for storage and handling of samples were soaked in water and soap for at least 2 hours then rinsed several times with tap water, after that they were rinsed once with distilled water, once with Therands mixture (250 ml deionized water+200 ml concentrated HCL 37 %+80 ml H_2O_2 30 %), once with washing acid (900 ml deionized water+100 ml concentrated HCL 37%) and finally once rinsed with deionized water and then dried on a clean bench.

2.4. Sample preparation and digestion

Representative samples were excised from fish by dissection using stainless steel scalpel, forceps and scissors on a clean working surface previously cleaned with washing acid to minimize sample pollution. Section from axial muscle behind the head was removed from each fish. The preparation of sample prior to each analysis should be done with a special care and faults during grinding, maceration or homogenizing of a representative sample should be kept in a minimum to avoided sample contamination with metals (**Cowely, 1978**).

Two grams of fish muscles were aseptically excised from each back of every sampled fishes by the aid of a sterile stainless steel scalpel and forceps then macerated and transferred into a clean and previously washed 20 ml screw capped tubes containing a mixture of 8 ml concentrated nitric acid (65 %) and 4 ml concentrated perchloric acid (70 %). The screw capped tubes were then closed and placed over night in water bath adjusted at 53°C for complete digestion. After cooling to room temperature, the digest was then filtrated using Whattman filter paper No. 42 into a clean glass beaker. The filtrate was then diluted by adding 47 ml deionized water into the beaker. The diluted filtrate was poured into a clean screw capped bottles then labeled with number, season and fish species and then stored at room temperature until heavy metal analysis. A blank digest was also carried out in the same way, without sample. The blank solution was analyzed by Atomic Absorption Spectrophotometer and if they showed any residual metals, it should be subtracted from the result. The standard solutions for the calibration curves were prepared by diluting a stock solution of 1000 mg/L of the analyzed element with acidified ultrapure water (5 % v/v HNO_3).

2.5. Heavy metals analysis:

All filtered samples were analyzed for their heavy metals content (Pb, Hg, Cd and As) using "Buck scientific USA 210 VGP Atomic Absorption Spectrophotometer equipped with an oxidizing air acetylene flame" at the central laboratory, Faculty of Veterinary Medicine, Zagazig University, Egypt. The apparatus has digital absorbance capable of operating at wavelengths of 283.3, 253.7, 228.8 and 193.7 nm for Pb, Hg, Cd and As, respectively.

2.6. Statistical analysis:

Data was analyzed using the computer program ***SPSS/PC+ (2001)*** then were arranged and summarized.

Table (1): Heavy metal residues (µg/g) in muscle tissues of different fish species (n=100 for each species)

Species		**Pb**	**Hg**	**Cd**	**As**
Nile tilapia (n=100)	**Min.**	0.021	0.0031	0.003	0.028
	Max.	2.04	0.586	0.091	1.06
	Mean	0.704	0.045	0.025	0.511
Flathead grey mullet (n=100)	**Min.**	0.021	0.006	0.002	0.146
	Max.	2.25	0.046	0.014	1.36
	Mean	0.635	0.0145	0.006	0.621
African African catfish (n=100)	**Min.**	0.09	0.01	0.004	0.017
	Max.	2.32	0.043	0.057	1.77
	Mean	0.64	0.017	0.020	0.568

Table (2): Comparison of detected of heavy metals levels in fish muscles (μg/g) to the Maximum Permissible Limit (MPL)

Heavy metals	MPL (μg/g)	Nile tilapia		Flathead grey mullet		African African catfish	
		Within MPL	Exceed MPL	Within MPL	ExceedMPL	Within MPL	Exceed MPL
Pb	0.3 [a]	22% (22/100)	78% (78/100)	42% (42/100)	58% (58/100)	28% (28/100)	72% (72/100)
Hg	0.5 [a]	84% (84/100)	16% (16/100)	100% (100/100)	0% (0/100)	100% (100/100)	0% (0/100)
Cd	0.05 [a]	94% (94/100)	6% (6/100)	100% (100/100)	0% (0/100)	94% (94/100)	6% (6/100)
As	1[b]	98% (98/100)	2% (2/100)	98% (98/100)	2% (2/100)	94% (94/100)	6% (6/100)

a = Egyptian Organization for standardization (EOS) No. 7136/2010.
b = The strictest international legislation in seafood (Munoz et al., 2000).

Table (3) Mean of heavy metal residues in muscle tissues in different fish species examined during summer and winter

Species	No.	Season	Pb	Hg	Cd	As
Nile tilapia	50	summer	0.72[a]	0.019[b]	0.037[a]	0.65[a]
	50	winter	0.69[a]	0.072[a]	0.014[b]	0.58[a]
Flathead grey mullet	50	summer	0.60[a]	0.005[b]	0. 049[a]	0.57[a]
	50	summer	0.67[a]	0.024[a]	0. 068[a]	0.67[a]
African African catfish	50	summer	0.54[a]	0.012[b]	0.056[a]	0.72[a]
	50	summer	0.75[a]	0.024[a]	0.035[b]	0.50[b]

Mean with different letters in the same column for each species are significantly different ($P < 0.05$).

Table (4) Analysis of variance (ANOVA) comparing heavy metal concentrations among the 3 different fish species

Metal	Mean			LSD	Significance level
	Nile tilapia (n=100)	Flathead grey mullet (n=100)	African African catfish (n=100)		
Pb	0.704[a]	0.635[a]	0.646[a]	0.20	Not significant
Hg	0.045[a]	0.0146[b]	0.018[b]	0.009	P < 0.05
Cd	0.0255[a]	0.006[c]	0.0202[b]	0.004	P < 0.05
As	0.512[a]	0.621[ab]	0.568[b]	0.094	P < 0.05

Table (5): Analysis of variance (ANOVA) comparing different heavy metal concentrations in all analyzed fish species during summer and winter

Metal	summer (n=150)	winter (n=150)	LSD	Significance level
Pb	0.618[a]	0.705[a]	0.166	Not significant
Hg	0.012[a]	0.040[b]	0.0148	P < 0.05
Cd	0.0158[a]	0.0186[a]	0.003	Not significant
As	0.645[a]	0.582[a]	0.077	Not significant

Means with different letters are significantly different

Table (6): Pareson correlation between weight difference and various metals analyzed and between the weight among different metals and correlations among metals with each other (N=300)

	Wt.	Pb	Hg	Cd	As
Wt. Pareson Correlation	1	-0.185*	-293**	-0.064	-0.112
Sig. (2-Tailed)		0.023	0.000	0.435	0.173
Pb Pareson correlation	-0.185*	1	0.129	0.129	-0.109
Sig. (2-Tailed)	0.023		0.115	0.116	0.184
Hg Pareson correlation	-0.293**	0.129	1	0.159	0.052
Sig. (2-Tailed)	0.000	0.115		-0.052	0.530
Cd Pareson correlation	0.064	0.129	0.159	1	-0.029
Sig. (2-Tailed)	0.435	0.116	0.052		0.726
As Pareson correlation	0.112	-0.109	0.052	-0.029	1
Sig. (2-Tailed)	0.173	0.184	0.530	0.726	

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

RESULTS & DISCUSSION

3.1. Metal concentrations in the muscle of three fish species

Heavy metal pollution is a very serious issue in many countries and is caused by agricultural and industrial waste disposal into the sea or brackish water, where it becomes toxic for many aquatic organisms. Metal concentrations in the muscle of three fish species from Manzala Lake are shown in **Table (1)**.

3.1.1. Pb

Lead is a toxic element that has no biological role and can cause carcinogenic effects, reduced cognitive development and intellectual performance in children and also it increased blood pressure and cardiovascular diseases in adults (**Canfield et al., 2003** and **Hsu and Guo, 2002**). Lead (Pb) level in analyzed fish muscles in this study ranged from 0.021 to 2.04 µg/g with a mean concentration of 0.704 µg/g for Nile tilapia, 0.021 to 2.25 µg/g with a mean value of 0.635 µg/g for Flathead grey mullet and from 0.09 to 2.32 µg/g with a mean of 0.64 µg/g for African African catfish. The fish species can be ordered from the highest to the lowest mean levels of Pb as follows: Nile tilapia > African African catfish > Flathead grey mullet.

The tested Egyptian freshwater fish samples of this study showed higher Pb levels than those (0.12 µg/g) determined in several marine fish species samples collected from Mumbai Harbor, India (**Velusamy et al., 2014),** (0.053±0.058 µg/g) recorded in analyzed canned tuna fish in Tehran, Iran during 2012–2013 by **Hadiani et al. (2015)** and also by **Sankar et al. (2006)** who could not detect lead in the commercially important fish species they studied in India, except for J. dussumerri (0.13 µg/g), but they are in the nearly same levels (0.33 to 0.86 µg/g) of fish samples collected from the Marmara, Aegean and Mediterranean seas **(Türkmen et al., 2008)** and (0.33 to 0.93 µg/g) detected in fish of the Black and Aegean seas by **Uluozlu et al. (2007)**. Meanwhile, higher Pb level of 10.1µg/g was detected by **Saeed and Shaker (2008)** in the muscle of Oreochromis niloticus caught from Manzala Lake of Egypt and at a range of 0.33 to 7.74 µg/g that was reported by **Cheung et al. (2008)** in fish from the Pearl River Delta, South China. Lead is prevalent in aquatic environment from anthropogenic activity such as industries of batteries, paint production, and leaded gasoline (**Monteiro et al., 2011**). The difference in the lead concentrations in muscle tissue among fish species from the same area is attributed to difference in feeding level, geography, fish size and age, foraging method/location and the capability of metals to undergo bioaccumulation in the food chain **(Wei et al., 2014)**.

By comparing our results of Pb levels with the maximum permissible limits **(Table 2)**, we found that 22% (22/100), 42% (42/100) and 28% (28/100) of tested Nile tilapia, Flathead grey mullet and African African catfish samples, respectively contained Pb levels within the maximum permissible limits, meanwhile, 78% (78/100), 58% (58/100) and 72% (72/100) of examined Nile tilapia, Flathead grey mullet and African African catfish samples, respectively contained Pb by levels exceeded maximum permissible limits proposed by **EOS (2010)**.

3.1.2. Hg

Mercury (Hg) is a highly toxic metal, which causes severe pollution via industrial waste discharges. Fish acquire Hg through feeding, which can be in concentration according to fish size, diet, ecological parameters, and water quality parameters. Mercury was detected in all fish samples from this study. Hg levels in fish flesh ranged from 0.0031 to 0.586 µg/g with a mean concentration of 0.045 µg/g for Nile tilapia, 0.006 to 0.046 µg/g with a mean value of 0.0145 µg/g for Mugil cephalus and from 0.01 to 0.043 µg/g with a mean of 0.017 µg/g for African catfish. The decreasing order of mean Hg content was as follows: Nile tilapia > African African catfish > Flathead grey mullet.

The Hg value in the species analyzed in this study is very close to the Hg levels reported by **Yi et al. (2008)** for fish from the Yangtze River (0.0011–0.048 µg/g) and by **Bordajandi et al. (2004)** who observed that Hg concentrations in sea fish from Spain ranged from 0.069 to 0.549 µg/g . Higher levels of Hg (0.120–0.527 µg/g) have also been reported in fish from the Persian Gulf (**Saei-Dehkordi et al., 2010**) and (3.154±1.981 µg/g) that observed by **Fard et al. (2015)** in 67 fishes caught from the Musa estuary in Persian Gulf, Iran. Lower Hg levels than that observed in the study was conducted by **Sivaperumal et al. (2007)** who could not detect Hg in 88% of the analyzed Indian marine fish tissue samples. In this study the variations in Hg concentrations in the fish species sampled is due to their feeding habits, habitat preference, distribution and seasonal variation.

It is indicated from **Table (2)** that Hg levels in 84% (84/100), 100% (100/100) and 100% (100/100) of examined Nile tilapia, Flathead grey mullet and African African catfish samples, respectively were within the maximum permissible limits, while, 16% (16/100), 0% (0/100) and 0% (0/100) of analyzed Nile tilapia, Flathead grey mullet and African African catfish samples, respectively had Hg concentration above the maximum permissible limits stated for it by **EOS (2010)**.

3.1.3. Cd

Cadmium (Cd) metals are a non-essential toxic metal and have no biological role that can accumulate in the human body and may cause kidney dysfunction, skeletal damage, and reproductive deficiencies (**Uluozlu et al., 2007**). Cd concentrations in the tested fish muscles ranged from 0.003 to 0.091 µg/g with a mean concentration of 0.025 µg/g for Nile tilapia, from 0.002 to 0.014 µg/g with a mean value of 0.006 µg/g for Flathead grey mullet and from 0.004 to 0.057 µg/g with a mean of 0.020 µg/g for African African catfish . The decreasing order of mean Hg value was as follows: Nile tilapia > African African catfish > Flathead grey mullet.

Cd contents found in this study were consistent with those previously reported in the literature, including 0.003–0.021µg/g for fish from Taihu Lake of China (**Chi et al., 2007**) and 0.01 to 0.04 µg/g for two cultured marine fish species in the Fujian Province of China (**Onsanit et al., 2010**). Lower Cd levels were reported by **Juresa and Blanusa (2003)** at mean of 0.002±0.001 µg/g in the analyzed muscle of hake fish from the Adriatic Sea, Croatia. Higher Cd contents were recorded by **Saeed and Shaker (2008)** at level of 10.36 µg/g of the tested muscle of Oreochromis niloticus caught from Manzala Lake of Egypt. The accumulation of Cd in larger fish could be explained by the omnivorous feeding habit of tilapia with sediment-ingestion being the primary feeding behavior of the species (**Zhou et al., 1998**).

Our finding showed that the obtained levels of Cd were within the maximum permissible limits in 94% (94/100), 100% (100/100) and 94% (94/100) of examined Nile tilapia, Flathead grey mullet and African African catfish samples, successively and were above the maximum permissible limits regulated by **EOS (2010)** in 6% (6/100), 0% (0/100) and 6% (6/100) of the tested Nile tilapia, Flathead grey mullet and African African catfish samples, respectively (**Table 2).**

3.1.4. As

Arsenic (As) levels in fish muscle ranged from 0.028 to 1.06 µg/g with a mean concentration of 0.511 µg/g for Nile tilapia, from 0.146 to 1.36 µg/g with a mean value of 0.621 µg/g for Flathead grey mullet and from 0.017 to 1.77 µg/g with a mean of 0.568 µg/g for African African catfish . The fish species can be ordered from the highest to the lowest mean levels of Pb as follows: Flathead grey mullet > African African catfish > Nile tilapia.

Our findings of arsenic are in agreement with that stated in an Iranian article in which arsenic level in edible muscle of different fish species ranged from 0.156 to 0.834 µg/g (**Saei-Dehkordi et al., 2010**). Higher arsenic levels were recorded by **Schaeffer et al. (2005)** who could detect arsenic level between 0.84 and 10.2 µg/g (mean: 4.3 µg/g) of five seafood species of in Greece, at a range. Lower As concentrations (0.096) were recorded by **Qin et al. (2015)** in three farmed cyprinid fish species (common carp, crucian carp and grass carp) from Northeast China**.**

The difference in heavy metals contents among various fish species may be attributed to the variance in fish habitats and ecological needs, metabolic capability and feeding habits (**Chi et al., 2007** and **Singh et al., 2007**). Alongside, the accumulation rate of heavy metals in fish species varies based on the elements extracted, accumulation time from sources and the rate of scale formation (**Patin, 1984**). In addition, the efficiency of heavy metals uptake by fish from polluted water and food varies depending on ecological needs, body metabolic rate and water salinity and temperature (**Pagenkopf, 1983** and **Satheeshkumar and Kumar, 2011**).

It is obvious from **Table (2)** that As levels in 98% (98/100), 98% (98/100) and 94% (94/100) of examined Nile tilapia, Flathead grey mullet and African African catfish samples, respectively were within the maximum permissible limits, meanwhile, 2% (2/100), 2% (2/100) and 6% (6/100) of analyzed Nile tilapia, Flathead grey mullet and African African catfish samples, respectively had As metal by levels above the maximum permissible limits proposed for it by the strictest international legislation (**Munoz et al., 2000**).

3.2. Statistical analysis

3.2.1. Mean of heavy metal residues in muscle tissues in different fish species examined during summer and winter (Table 3)

Lead (Pb) concentrations showed no significant difference between summer and winter among all fish species examined. Mercury (Hg), however showed significantly higher values during winter in comparison with summer in Nile tilapia (0.072 Vs 0.019), Flathead grey mullet (0.024 Vs 0.005) and African African catfish (0.024 Vs 0.012).

No significant difference was found in Cd concentrations between summer and winter in Flathead grey mullet. In both Nile tilapia and African African catfish, however, Cd concentrations in summer were significantly higher than in winter (0.037 Vs 0.014) and (0.056 Vs 0.035), respectively.

Arsenic (As) showed only significant difference between summer and winter in African catfish (0.72 Vs 0.50), meanwhile, there is no significant difference of As concentration between summer and winter in both Nile tilapia and Flathead grey mullet.

*3.2.2. Analysis of variance (*ANOVA*) comparing heavy metal concentrations among the 3 different fish species (Table 4)*

It is evident from **Table (4)** that, there is no significant difference was detected for Pb concentration among the 3 fish species analyzed.

Significant differences, however, were found for each of Hg, Cd, and As among 3 fish species examined. The highest concentration of Hg and Cd were found in Nile tilapia, while the highest of As was found in Flathead grey mullet.

3.2.3. Analysis of variance (ANOVA) comparing different heavy metal concentrations in all analyzed fish species during summer and winter (Table 5)

No significant differences in Pb, Cd, and As concentrations were found among fish species analyzed during summer and winter, although, higher significant difference was found in Hg concentration in winter (0.040) than in summer (0.012).

3.2.4. Correlation between weight difference and various metals analyzed and between the weight among different metals and correlations among metals with each other (N=300) as shown in Table (6)

There was a significant negative correlation between fish weight and each of Hg and Pb concentration in the tested muscles of 3 fish species and the decrease in Hg concentration was associated with increasing in Pb concentration.

There was positive correlation between fish weight and Cd concentration and the increase in Cd concentration in the tested muscles of all fish species was associated with the increase in Pb and Hg concentrations.

There was positive correlation between fish weight and As concentration and the increase in As concentration in the analyzed muscles of 3 fish species was associated with the decrease in each of Pb and Cd concentrations, but was associated with the increase in Hg concentration.

CONCLUSION

It can be concluded that fish species caught from Manzala Lake particularly, Nile tilapia, Flathead grey mullet and African African catfish may carry a potential health hazards for humans due to the majority of these examined samples contained heavy metals by levels exceeded the maximum permissible limits regulated for them. Therefore, a strict control measures should be followed to prevent pollution of seafood's with heavy metals and to ensure that their levels did not exceed the recommended limits for human consumption.

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الملخص العربي

بقايا المعادن الثقيلة في بعض اسماك بحيرة المنزلة

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تناولت الدراسة تقدير بقايا المعادن الثقيلة مثل الرصاص والزئبق والكادميوم والزرنيخ فى اجمالى عدد ٣٠٠ عينة من الأسماك المختلفة (١٠٠ عينة من كل من البلطى النيلى والبورى الأصيل والقرموط اللازير) المصطادة حديثا من بحيرة المنزلة خلال فصلى الصيف والشتاء من عام ٢٠١٢ م. استطاع جهاز مقياس الطيف الضوئى و الامتصاص الذرى تحديد كميات كل من الرصاص والزئبق والكادميوم والزرنيخ فى كل العينات المفحوصة بمتوسطات ٠,٧٠٤ و٠,٦٣٥ و ٠,٦٤ ملليجرام/كيلوجرام بالنسبة الرصاص، ٠,٠٤٥ و٠,٠١٤٥و ٠,٠١٧ ملليجرام/كيلوجرام بالنسبة للزئبق، ٠,٠٢٥ و ٠,٠٠٦ و ٠,٠٢٠ ملليجرام/كيلوجرام بالنسبة للكادميوم، ٠,٥١١ و ٠,٦٢١ و ٠,٥٦٨ بالنسبة للزرنيخ فى كل من البلطى النيلى والبورى الأصيل والقرموط اللازير على التوالى. وقد تباينت تركيزات المعادن الثقيلة بشكل كبير داخل وبين الأسماك التي تم دراستها. ومع ذلك، لوحظ وجود ارتباط كبير بين المعادن الثقيلة. وبمقارنة كميات تلك المعادن الثقيلة الموجودة فى العينات المفحوصة بالحدود المسموح بها لتلك المعادن، تبين ان معظم العينات المفحوصة احتوت على المعادن الثقيلة بمستويات اقل من تلك المسموح بها فيما عدا عنصر الرصاص والذى تواجد بكميات تخطت تلك المسوح بها فى معظم العينات المختبرة ومن هنا يتضح لنا ان الأسماك التي يتم صيدها من بحيرة المنزلة قد تعتبر غير آمنة للاستهلاك الآدمى.