Comparative Study Between Some Heavy Metal Levels In Fresh Water Fish From Naser Lake And Others From Nile Tributaries In Sharkia Governorate

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ABSTRACT

Fifty fresh water fish samples (Nile tilapia) were collected from Naser Lake, Aswan Governorate, and Nile tributaries, Sharkia Governorate (25 from each) for estimation and comparative of heavy metal residues between fish samples from these two localities. The mean residues of lead, cadmium, mercury, copper, zinc and manganese were 0.558, 0.1273, 0.0034, 2.926, 9.674 and 2.524 ppm respectively in fish samples from Naser Lake, while; the mean residues of these metals in fish samples from Nile tributaries were 2.954, 0.9174, 0.0036, 3.864, 7.1944 and 2.842 ppm respectively, cobalt residues were not detected in all the examined samples.

In fish samples from Naser Lake, lead and cadmium exceeded the permissible limits in 18 (72%) and 13 (52%) samples respectively, while; there were above the permissible limits in all samples from Nile tributaries. Mercury, copper and zinc were below the permissible limits in all the examined samples, while; manganese was not judged in Egyptian standard of heavy metals and the available international standards. This study indicates high levels of the calculated daily intake of both lead and cadmium from consumption of fish samples from Nile tributaries rather than those from Naser Lake. Calculated daily intake of mercury, copper, zinc and manganese from consumption of fish from both Naser Lake and Nile tributaries were low in comparing with there acceptable daily intake.

The obtained results concluded that the fish samples from Nile tributaries suffered from higher lead and cadmium pollutions than those from Naser Lake, thus; the fresh water fish from the latter source is relatively safe than those from the other source, in spite of the examined fish samples from the two examined localities had high levels of lead and cadmium and low safety levels of the other estimated metals.

INTRODUCTION

In 1970 s the construction of high dam in the utmost south Egypt was established to control the annual flood of River Nile and store this water in Naser Lake which is the widest artificial lake in the world, thus; it can produce a profuse yield of fresh water fish. The building of high dam and appearance of Naser Lake not only divided the pathway of the River Nile but also may be creating two different aquatic ecosystems in this pathway. Many studies investigate the pollutions of the pathway of River Nile and its tributaries in Egypt and their sources ***(1-3)***. Another studies detected different sources and levels of pollutions in Naser Lake ***(4,5)***. So, the water of River Nile may be exposed to patterns of environmental pollutions in the front of high dam differ than those behind them.

Because their low rate of elimination from the consumer body ***(6)*** and their widely distribute in the air, water, soil, agricultural lands and animal tissues, the heavy metals are one of the most important sources of the environmental pollution in the world. Metals are unique among pollutants that cause adverse health effect, in that they occur naturally in many instances ubiquitous in the environment. Heavy metals are divided into non essential metals which have no role in the biological processes of the human or animal body as lead, cadmium and mercury, while; essential metal are needed for human and animal bodies as copper, zinc, manganese and cobalt. Several sources of the environmental pollutions of heavy metals including the industrial sources as paints, rubber, dyes and batteries, agricultural sources as fertilizers and some pesticides and natural sources from rocks and soil ***(5)***.

Fish and other aquatic foods had been regarded as nutrition and highly desirable food due to its contribution of high quality protein, often low fat, has attracted consumers due to health benefits. Because its widespread and relative low price, Nile tilapia fish (*Oreochromis niloticus*) is the most important and public fresh water fish in Egypt and catch usually from Nile tributaries and Naser Lake.

Therefore, the aim of the present study is to compare between the levels of lead, cadmium, mercury, copper, zinc, manganese and cobalt residues in muscles of the fresh water fish in Naser Lake and those in Nile water tributaries, and study the public health importance of the detected metals.

MATRIAL AND METHODS

Collection of samples

A total of 50 fresh Nile Tilapia (*Oreochromis niloticus*) water fish samples from both Naser Lake in Aswan Governorate and Nile water tributaries in Sharkia Governorate (25 of each) were collected for detection and determination of lead, cadmium, mercury, copper, zinc, manganese and cobalt residues. The samples were placed in polyethylene bags, identified and kept frozen at -20°C till the analysis was conducted.

Preparation of samples

Each fresh water fish sample was represented by one gram of flesh dissected from axial muscles after removal the scales at this region, fish muscle samples were prepared according to the method previously cited ***(7).*** Each sample was transferred to a clean screw capped glass bottle and digested with 10 ml. of digestive solution (nitric acid / perchloric acid, 4 :1). Initial digestion was carried out for 4 hours at room temperature, followed by heating at 40- 45°C for one hour in water bath, then the temperature was raised to 75°C until the end of digestion . After cooling to room temperature, the digest was diluted to 30 ml. with deionized water and filtrated through 0.45 µm Whatman filter paper. The clean filtrate of each sample was kept in refrigerator to avoid evaporation.

Preparation of blank solution

Ten ml. of digestion solution (nitric/ perchloric acid 4:1) in screw capped glass bottle was subjected to digestion, dilution, and filtration as the examined samples to detect any traces of the studied metals in acids or deionized water.

Quantitative determination of metals in the examined samples

Quantitative determinations of cadmium, copper, zinc, manganese and cobalt residues were conducted using UNICAM 969 Atomic Absorption Spectrophotometer, in toxicology unit, Animal Health Research Institute. Lead residues were conducted using Atomic Absorption Spectrophotometer (Buck – MODEL 220 GF- Graphic Furance) in Faculty of Veterinary Medicine, Zagazig University. Meanwhile, mercury was determined using Perkin- Elmer mod. 2830, USA, Spectrophotometer in Faculty of Science, Mansoura University. The concentrations of metals were calculated according to the following equation: ppm metal in samples = $A \times B \div W$ where, A= ppm metal in prepared samples from the digital scale reading of A.A.S., B= final volume of prepared samples in ml. and W = weight of samples in gm.

Statistical analysis

Statistical analysis of data was conducted using "Statistic for animal and veterinary science ***(8).***

RESULTS AND DISCUSSION

The recorded results in Table 1 showed that the average of lead concentrations in the examined fresh water samples from Naser Lake, Aswan Governorate was 0.558 ±0.0937 ppm, while; in Nile tributaries it was 2.954 ±0.1243 ppm. Our findings are higher than those recorded in fresh water fish in Egypt ***(9-11),*** Greece ***(12)*** and Turkey ***(13).*** Moreover, in Naser lake fish; two previous Egyptian studies recorded lower levels of lead residues (0.095 ppm) ***(14),*** (0.33 ppm) ***(15)*** than our figures. On the other hand, another Egyptian studies estimated higher lead residues than those in the current study ***(2,3).*** The statistical analysis showed significant high lead levels in fish samples from Nile tributaries in Sharkia than those from Naser Lake in Aswan.

The mean values of cadmium residues in the examined fresh water fish samples from Naser Lake and Nile tributaries were 0.1273±0.0251 and 0.9174 ±0.1072 ppm respectively. Two studies in Egypt ***(2)*** and Turkey ***(16)*** recorded cadmium levels nearly similar with our estimations in fish of Naser Lake and lower than those in fish of Nile tributaries. On the other aspect, our figures are higher than those previously reported in fresh water fish in Egypt ***(9-11)***, Greece ***(12)***, Croatia ***(17)*** and Turkey ***(13)***. Moreover, another Egyptian studies recorded lower cadmium residues in the fish of Naser Lake than those in the current study ***(14,15)***. As detected in lead results, the statistical analysis indicates significant higher cadmium concentrations in fish from Nile tributaries than those in Naser Lake fish.

Concerning the mercury residues, it could be detected in fish of Naser Lake and Nile tributaries with the mean values of 0.0034 ±0.00024 and 0.0036 ±0.00034 ppm respectively. These findings are obviously lower than those detected in Egypt ***(2,3,9,10)***. Otherwise the results of lead and cadmium, the statistical analysis revealed absence of significant variance between mercury residues in fish from Naser Lake and those from Nile tributaries.

Our estimation showed that the mean values of copper in the examined fish from Naser Lake was 2.926 ±0.3281 ppm, while; in Nile tributaries fish it was 3.864 ±0.3229 ppm. These levels are higher than those recorded in Nile water fish ***(2,10,11)*** and in fresh water fish in Turkey ***(16)*** and Croatia ***(17)***. On the other hand, another Egyptian investigation detected higher copper levels in fresh water crayfish ***(3)***. The statistical analysis showed higher copper levels in the examined fish of Nile tributaries than those in Naser Lake.

The mean concentrations of zinc residues in fish of Naser Lake and Nile tributaries were 9.674 ±0.7591 and 7.1944 ±0.9525 ppm respectively, these levels are consistent with those recorded in fresh water fish in Egypt ***(2,3,9)***, and Croatia ***(17)***, while; another study in Greece recorded higher zinc residues in fish ***(12)***. The statistical analysis indicated significant high zinc levels in fish from Naser Lake than those from Nile tributaries.

The obtained results showed that the mean values of manganese concentrations in fresh water fish from Naser Lake and Nile tributaries were 2.524 ±0.5606 and 2.842 ±0.813 ppm respectively. These estimations are nearly the same with those recorded in fresh water crayfish in Sweden ***(18)***. On the other aspect, another studies reported lower manganese levels than those in the present study ***(9,12,17)***. The statistical analysis showed no significant variance between manganese residues in fresh water fish from Naser Lake and those from Nile tributaries.

The cobalt residues were not detected in all the examined samples.

Table 1. Heavy metal residues (ppm) in fresh water fish from Naser Lake in Aswan Governorate and Nile tributaries in Sharkia Governorate (n= 25 of each).

Locality / Metal	Naser Lake (Aswan)			Nile tributaries (Sharkia)		
	Min.	Max.	Mean ±S.E.	Min.	Max.	Mean ±S.E.
Lead	0.233	1.355	0.558 ±0.0937[b]	1.55	3.665	2.954 ±0.1243[a]
Cadmium	0.009	0.295	0.1273±0.0251[b]	0.22	1.805	0.9174 ±0.1072[a]
Mercury	0.001	0.005	0.0034 ±0.00024[a]	0.001	0.006	0.0036 ±0.00034[a]
Copper	1.30	6.350	2.926 ±0.3281[b]	1.10	6.45	3.864 ±0.3229[a]
Zinc	5.40	19.75	9.674 ±0.7591[a]	0.80	14.65	7.1944 ±0.9525[b]
Manganese	0.815	10.60	2.524 ±0.5606[a]	0.27	13.82	2.842 ±0.813[a]

N.B.: Different letters within the same category (lead, cadmium, mercury, copper, zinc and manganese) mean significant variations between the values of the metal concentrations ($P \leq 0.01$).

Regarding the comparison between the heavy metal levels in this study and the maximum permissible limits, the obtained results (Table 2) showed that the lead residues in fish samples from Naser Lake were not detected in 7 (28%) samples, while; it exceeded the permissible limits in 18 (72%) samples out of 25 samples. On the other aspect, all the fish samples collected from Nile tributaries had lead residues over the permissible limits. Concerning cadmium residues in fish samples from Naser Lake, it was not detected in 10 (40%) out of 25 fish samples, cadmium levels were below the permissible limit in 2 (8%) and exceeded this limit in 13 (52%) sample. As previously recorded in the results of lead residues, all the examined fish samples from Nile tributaries contained cadmium residues above the permissible limit. Mercury residues were within the permissible limits in all the examined samples from both Naser Lake and Nile tributaries. On the other hand, all the examined samples in the current study had copper and zinc residues below the permissible limits. Permissible limit of manganese in fish was not judged in Egyptian standard of metal and other available international standard.

Table 2. Frequency distribution of the heavy metal concentrations in the examined fresh water fish from Naser Lake and Nile tributaries with maximal permissible limits (n= 25 for each).

Metal	P.L.* (ppm)	Naser Lake (Aswan)						Nile tributaries (Sharkia)					
		Not Detected		Within P.L.*		Over P.L.		Not Detected		Within P.L		Over P.L.	
		No	%	No	%	No	%	No	%	No	%	No	%
Lead	0.1	7	28	0.0	0.0	18	72	0.0	0.0	0.0	0.0	25	100
Cadmium	0.1	10	40	2	8	13	52	0.0	0.0	0.0	0.0	25	100
Mercury	0.5	0.0	0.0	25	100	0.0	0.0	0.0	0.0	25	100	0.0	0.0
Copper	20	2	8	23	92	0.0	0.0	0.0	0.0	25	100	0.0	0.0
Zinc	50	0.0	0.0	25	100	0.0	0.0	0.0	0.0	25	100	0.0	0.0

*:P.L. = Permissible Limits *(19 – 21)*

N.B.: Permissible limit of manganese in fish meat is not judged in Egyptian standard or other available international standard.

It is evident in Table 3 that the previously mentioned average concentrations of lead, cadmium, mercury, copper, zinc and manganese in the examined fish samples from Naser Lake gave a daily intake of about 0.0558, 0.0127, 0.00034, 0.292, 0.967 and 0.252 mg/ person/ day of the mentioned metals respectively for fish meat consumers (100 gm/ person) and this contribute of about 11.16, 18.14, 0.68, 0.834, 1.381 and 5.04 % of the acceptable daily intake (ADI) recommended by FAO/ WHO respectively, whereas; the mean values of lead, cadmium, mercury, copper, zinc and manganese residues in the examined fish samples from Nile tributaries gave a daily intake of about 0.295, 0.0917, 0.00036, 0.386, 0.719 and 0.284 mg/ person, and this contributed to about 59, 131, 0.72, 1.102, 1.027 and 5.68 % of the acceptable daily intake (ADI) recommended by FAO/ WHO respectively. In Egypt a study of the calculated daily intake of lead, cadmium, mercury, copper and zinc from consumption of 100 gm prawn ***(24)*** were recorded lower calculated daily intake of the most of metals than those from Nile tributaries in the present study. It could be concluded that the daily intake of lead and cadmium from consumption of fish from Nile tributaries in Sharkia Governorate are obviously higher than those from consumption of fish from Naser Lake. Moreover, the daily intake of cadmium from consumption of fish from Nile tributaries exceeded the maximum tolerated daily intake of this metal from all types of food.

Table 3. Comparison of acceptable daily intake (ADI) values of the detected metals with calculated daily intake from the examined fish from Nser Lake and Nile tributaries.

Metal	ADI* mg/70kg person	Mean conc. of the metals in the present study (mg/kg)		Calculated daily intake from consumption of 100 gm fish meat daily**			
				Naser Lake fish		NileTributaries fish	
		Naser Lake fish	Nile Tributaries fish	mg/day/ person	%	mg/day/ person	%
Lead	0.50	0.558	2.954	0.0558	11.16	0.295	59
Cadmium	0.07	0.1273	0.9174	0.0127	18.14	0.0917	131
Mercury	0.05	0.0034	0.0036	0.00034	0.68	0.00036	0.72
Copper	35.00	2.926	3.864	0.292	0.834	0.386	1.102
Zinc	70.00	9.674	7.1944	0.967	1.381	0.719	1.027
Manganese	5.0	2.524	2.842	0.252	5.04	0.284	5.68

** (22) ** (23)*

From public health point of view, the lead inhibits the biosynthesis of heme, and affects the membrane permeability of kidney, liver and brain cells which reduce the function or complete breakdown of these tissues ***(25).*** Therefore, CNS, kidney, liver and hematobioetic system are important target of lead toxicity, thus chronic lead poisoning characterized by anemia. On the other hand, CNS is the target of lead toxicity in children, while, adults usually manifested peripheral neuropathy *(26)*. Furthermore, chronic lead exposure leads to chromosomal aberration ***(27).*** On the other aspect, chronic cadmium toxicity had a significant role in the incidence of renal dysfunction ***(28),*** human hypertension ***(29),*** osteomalacia and pathological fractures ***(30).*** Moreover, cadmium was classified as class one human carcinogen ***(31)*** Mercury is an extremely toxic metal due to the high affinity of tissue ***(32)***. Consumption of fish polluted with mercury leads to neurotically damage, loss of vision, paralysis and death of people as occurred in Minimata, Japan, 1953. Furthermore, it passed through placenta causing chromosomal disorder ***(33)***. In spite of copper, zinc and manganese are essential elements for animal and human, these metals can exhibit toxic effects on consumer health if exceeded the permissible limits, chronic exposure to copper caused vomiting, epigastric pain, diarrhea and jaundice ***(34).*** Although, zinc toxicity from excessive ingestion is uncommon, gastrointestinal distress and diarrhea have been reported following ingestion of polluted food by zinc ***(35).*** Exposure to manganese indicates that "Abnormal and toxic concentrations of manganese in the brain especially in the basal ganglia are associated with neurological disorder similar to Parkinson ´s disease ***(36).***

From the obtained results, it could be concluded that the examined fish in the current study from both Naser Lake and Nile tributaries suffered from lead and cadmium pollutions, the same result was reported by many previous Egyptian studies ***(2,3,10).*** On the other hand, the fish samples from Nile tributaries polluted with significant high levels of lead and cadmium than those collected from Naser Lake. This result may be explained by the industrial and agricultural effluents which spilt and polluted the Nile stream across the dense industrial and agricultural areas in Egypt. Meanwhile, the water of Naser Lake passes across low dense population in African countries which also had a lower industrial activities compared with those in Egypt. Concerning the other tested metals, mercury, copper and zinc were detected in relative low safe levels below the permissible limits. Although, the manganese permissible limits in fish is not judged by Egyptian standard, the calculated daily intake of this metal represented low ratio compared with the acceptable daily intake of manganese from all types of food.

CONCLUSION AND RECOMMENDATIONS

1- The industrial effluents in Nile water should be treated before spilling and kept under official control.

2- Application of fungicides, herbicides, phosphate fertilizers and sewage sludge should be kept under control

3- Further studies should be enhanced to investigate the probable indistinctive sources of lead and cadmium pollutions in our feed and environment.

4- Because the examined fish from Naser Lake had relatively lower heavy metal pollutions than those in the Nile tributaries, thus; more attention to the economic development of Naser Lake and its fish production is recommended.

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الملخص العربي

دراسة مقارنة بين مستويات بعض المعادن الثقيلة في أسماك المياه العذبة ببحيرة ناصر و فروع النيل بمحافظة الشرقية

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أجريت هذه الدراسة للمقارنة بين مستويات بعض المعادن الثقيلة بين أسماك البلطي في كلا من بحيرة ناصر بمحافظة أسوان و فروع النيل بمحافظة الشرقية. تم تجميع خمسين عينة من تلك الأسماك من المصدرين المذكورين (٢٥ عينة من كل مصدر)، و تم إعدادهم للقياس بجهاز الإمتصاص الذري و قد أسفرت الدراسة عن النتائج التالية.

كان متوسط تركيزات الرصاص، الكادميوم، الزئبق، النحاس، الزنك و المنجنيز في أسماك بحيرة ناصر ٠,٥٥٨، ٠,١٢٧٣، ٠,٠٠٣٤، ٢,٩٢٦، ٩,٦٧٤، ٢,٥٢٤ جزء في المليون علي التوالي في حين كانت متوسطات تلك المعادن في أسماك فروع النيل بمحافظة الشرقية ٢,٩٥٤، ٠,٩١٧٤، ٠,٠٠٣٦، ٣,٨٦٤، ٧,١٩٤٤، ٢,٨٤٢ جزء في المليون علي التوالي في حين لم يتواجد الكوبالت في كل العينات المختبرة.

كانت مستويات الرصاص و الكادميوم أعلي من الحدود المسموح بها في ١٨ (٧٢%) ، ١٣ (٥٢%) عينة من أسماك بحيرة ناصر علي التوالي، و كانت تلك المستويات أعلي من الحدود المسموح بها في كل العينات المأخوذة من فروع النيل بالشرقية، من ناحية أخري كانت مستويات الزئبق، النحاس، الزنك أقل من الحدود المسموح بها في كل العينات، ولم تذكر المواصفات القياسية المصرية الحدود المسموح بها للمنجنيز.

كان المأخوذ اليومي لكلا من الرصاص و الكادميوم الناتج من استهلاك أسماك فروع النيل أعلي من المأخوذ اليومي لهذين العنصرين الناتج من الإستهلاك اليومي لأسماك بحيرة ناصر ، و قد كان المأخوذ اليومي للمعدنين المذكورين بصفة عامة مرتفع مقارنة بالمأخوذ اليومي المسموح به لهما. في حين كان المأخوذ اليومي لباقي العناصر المختبرة منخفض بالنسبة للمستويات المسموح بها يوميا. و قد أوضحت الدراسة أن عينات الأسماك من فروع النيل بالشرقية أكثر تلوثا بكلا من الرصاص و الكادميوم مقارنة بتلك المأخوذة من بحيرة ناصر بأسوان في حين كانت مستويات باقي العناصر المختبرة في الحدود الآمنة.

و علي ذلك نوصي بزيادة الاهتمام بتنمية بحيرة ناصر و ثروتها السمكية مع محاولة الكشف عن مصادر التلوث و تقليلها في مياه البحيرة و مجري النيل.