JJBS

Jordan Journal of Biological Sciences

Volume 1, Number 1, Mar. 2008
ISSN 1995-6673
Pages 41 - 46

Levels of Heavy Metal Cd, Cu and Zn in Three Fish Species Collected from the Northern Jordan Valley, Jordan

S. M. Al-Weher *

Mutah University –department of biological sciences, Karak, Jordan

Abstract

Cd, Cu and Zn concentrations were determined in muscle, bone, skin, scales and gills of three fish species (*Oreochromis aureus, Cyprinus carpio* and *Clarias lazera*) collected from northern Jordan Valley (Wadi El-Arab) during March, 2006. Heavy metal concentrations varied significantly depending on the type of the tissue and fish species. Generally, *Oreochromis aureus* showed the lowest levels of both Cd, and Cu metals in all tissues except gills. The other two fish species*, Cyprinus carpio* and *Clarias lazera,* showed less difference in their heavy metal levels but it was a significant difference ($P< 0.05$). Cd and Cu recorded their lowest levels in muscle and their highest levels in gills. *Cyprinus carpio* fish species showed high values of Cu metal in all organs, except muscles. *Oreochromis aureus* accumulated the highest level of Zn in all organs particularly in their skin (432.11± 152.14 mg/ kg dry wt.). Other studied fish species showed a high values of Zn in their skin, but not as high as that in *Oreochromis aureus*. The other two fish species showed no significant difference in Zn level between all of their different organs. It was concluded that the level of heavy metals (Cd, Cu and Zn) in muscles of the three fish species were within acceptable limits by FAO standards, except for the Zn concentration in muscles of *Oreochromis aureus (*70.76± 31.21 mg/ kg dry wt.) which might be due to the increase of agricultural influx and some other anthropogenic activity in that area.

الملخص

تم قياس تركيز ثلاثة عناصر ثقيلة (الكادميوم والنحاس والزنك) في عضلات وعظام وجلد وقشور وخياشيم ثلاثة أنواع من الأسماك جمعت من سد وادي العرب في شمال وادي الأردن وهي على الترتيب البلطي والشبوط وسمك القط والتي جمعت خلال شهر مارس 2006. أوضحت الدراسة أن تراكيز المعادن الثقيلة الثلاث كانت تتغير بتغير نوع النسيج ونوع السمك. ووجد أن سمك البلطي سجل اقل مستوى لكل من الكادميوم والنحاس في جميع أنسجتها ما عدا الخياشيم . أما النوعين الآخرين من الأسماك (الشبوط والقط) فقد كانت تراكيز هذين المعدنين متقاربة أكثر منها مع البلطي ومع ذلك فقد كان الفارق الإحصائي بينهما جوهريا" (أقل من 0.05) . ووجد أيضا أن مستوى هذين المعدنين (الكادميوم والنحاس) كان الأقل في العضلات والأعلى في الخياشيم. وقد لوحظ أن سمك الشبوط قد سجل قيما عاليه من النحاس في جميع أنسجته ما عدا العضلات. لقد كان على العكس من ذلك بالنسبة لتركيز معدن الخارصين (Zn) فقد سجلت اسماك البلطي أعلى مستوى للخارصين في كل أنسجتها خاصة الجلد (432,11± 152,14 ملجم/ كغم من الوزن الجاف) ولوحظ أيضا أن جميع الأسماك تحت الدراسة سجلت مستويات عالية من الخارصين في جلدها أيضا ولكنها لم تصل إلى القدر الذي هو عليه في سمك البلطي إضافة إلى أن النوعين الآخرين (الشبوط والقط) لم يكن هناك فارق جوهري بينهما في مستوى الخارصين في جميع أنسجتهما. وعليه فقد أثبتت الدراسة إن تراكيز جميع العناصر الثقيلة موضوع الدراسة في عضلات الأسماك كان في حدود التراكيز المسموح بها عالميا وذلك حسب منظمة التغذية والزراعة ولكن المستوى العالي للخارصين في عضلات سمك البلطي (70,76 ملجم / كغم) وكذلك في الأنسجة الأخرى لأسماك تلك المنطقة يجب أخذه بعين الاعتبار وذلك لما له من تـأثير سلبي على صحة الأشخاص المستهلكين لها وصحة الأسماك نفسها حيث أن زيادة تركيز الخارصين وغيره من العناصر الثقيلة ربما يعود إلى رمي المخلفات الزراعية وغيرها من أنشطة الإنسان في تلك المنطقة.

Keywords: Heavy metals; Jordan Valley; Jordan; FAO; *Oreochromis; Cyprinus; Clarius*;

1. Introduction

The contamination of freshwaters with a wide range of pollutants has become a matter of great concern over the last few decades. Heavy metals are natural trace components of the aquatic environment, but their levels have increased due to domestic, industrial, mining and agricultural activities (Lelan et al., 1978; Mance, 1987; Kalay and Canli, 2000). Discharge of heavy metals into river or any aquatic environment can change both aquatic species diversity and ecosystems, due to their toxicity and accumulative behavior (Heath, 1987; Allen, 1995). Aquatic organisms such as fish and shell fish accumulate metals to concentrations many times higher than present in water or sediment (Olaifa et al, 2004, Gumgum et al., 1994). They can take up metals concentrated at different levels in their different body organs (Khaled, 2004). Certain environmental conditions such as salinity, pH, water hardness can play an important factor in heavy metals accumulation in the living organisms up to toxic

---

* Corresponding author. e-mail: sanaman@mutah.edu.jo

concentrations and cause ecological damage (Guven et al., 1999). Thus, heavy metals acquired through the food chain as a result of pollution are potential chemical hazards, threatening consumers. At low levels, some heavy metals such as copper, cobalt, zinc, iron and manganese are essential for enzymatic activity and many biological processes. Other metals, such as cadmium, mercury, and lead have no known essential role in living organisms, and are toxic at even low concentrations. The essential metals also become toxic at high concentrations (Bryan, 1976). Studies carried out on fish have shown that heavy metals may have toxic effects, altering physiological activities and biochemical parameters both in tissue and in blood of fish (Larsson et al, 1985; Nemesok and Huphes, 1988; Abel et al, 1986). The consequence of heavy metal pollution can be hazardous to man through his food. Therefore, it is important to monitor heavy metal in aquatic environments (water, sediment and biota).

In most parts of Jordan, water resources are scarce and insufficient to meet the growing demands of a rapidly increasing population. As a consequence, the water resources situation is now precarious and of great concern to the Government. All water bodies are looked upon as a source of exploitation for urban, agricultural and industrial uses. Many water bodies are affected by increasing salinity, pollution and eutrophication due to intensive agricultural practices.

A 380-kilometer-long rift valley runs from Yarmouk River in the north to Aqaba in the south. The northern part, from Yarmouk River to the Dead Sea, is commonly known as the Jordan Valley. The valley is properly known as (Al Ghawr). Northern Jordan Valley includes: Wetlands of the Yarmouk River basin (including Birket Al Rais pool), Wadi El- Arab and Wadi Ziglab (Budeiri, 1994).

This study was undertaken to investigate the levels of heavy metal in three commercially important fish species (Bolti, *Oreochromis aureus;* common carp, *Cyprinus carpio;* and cat fish, *Clarias lazera*) collected from Wadi El-Arab, Northern Jordan Valley.

2. Materials and Methods

2.1. Study Area

Wadi El- Arab is situated at 3235'N, 3540'E; in the northern highlands and north Jordan Valley, 10-25 km west-northwest of Irbid. Wadi El- Arab and its tributary wadis rise in the hills west of Irbid city and drain west into the Jordan Valley, entering the Jordan River about 10 km south of Lake Tiberias. A dam was constructed on the main wadi in 1987, with a total capacity of 20 MCM, to collect flood water and base flows for use in irrigation in the Jordan Valley area. Since its completion, the dam has filled with water originating from within its catchment area only in the very wet year of 1991/92. In other years, water has been pumped from the King Abdallah Canal during floods to increase the stored amount of water in the dam for use during the dry season. The dam is used for irrigation, and has substantial potential for fish production (Ahmad, 1989). The catchment area is under agriculture. Irbid city is expanding westwards into the catchment, and this may put increasing pressure on the quality of the water collected in the dam (Budeiri, 1994). Moreover, due to heavy agricultural, domestic activities and urbanization in the region, the wetlands of this area may receive large quantities of untreated agricultural and domestic sewage. Meanwhile, they have an economical importance for fishery. Thus, contamination in the region is an important issue regarding the health of the aquatic animals and in turn, health of the human.

2.2. Sampling

Three fish species (7-9 individuals of each species) namely, Bolti(*Oreochromis aureus* measuring 26± 1 cm and weighing 358± 14.42 g) , common carp (*Cyprinus carpio* measuring 20.79± 1.13 cm and weighing 202.58±12.81 g), and cat fish (*Clarias lazera* measuring 40.58± 1.29 cm and weighing 467.26± 33.81 g) were bought from northern Jordan valley (Wadi El-Arab) during March, 2006 from the local fishermen of the area. Fish were brought to the laboratory and dissected with clean stainless steel instruments on the same day. The tissues from 7-9 fish individuals of the same species were pooled to make 5 subsamples. Muscle, bone, skin, scales and gills organs were dried and put in an oven at 150°C until reaching a constant weight. Tissues were homogenized and grinded to a powder. Two grams of each dry tissue were weighed out, transferred into polyethylene tubes, 10 ml of freshly prepared nitric acid-perchloric acid (10:4) were added to the sample, and left overnight at room temperature. Then the samples were digested, digestion tubes were put in a water bath set to boiling water temperature; 100° C and the contents boiled for about 2 hours until all the tissues were dissolved. The digests were allowed to cool, filtered, transferred to 25ml volumetric flasks and made up to mark with 1% nitric acid (FAO, 1983). The digests were kept in plastic bottles and later, the heavy metal concentrations were determined using an atomic absorption flame emission spectrophotometer (Shimadzu, AA- 6200, Japan), and given as mg/ kg dry weight. The actual concentration of each metal was calculated using the formula:

$$\textit{Actual concentration of metal in sample} = \textit{ppmR} \times \textit{dilution factor}$$

Where

ppmR= AAS Reading of digest

Dilution Factor = Volume of digest used ⁄ Weight of sample digested

Working calibration standards of cadmium, copper and zinc were prepared by serial dilution of concentrated stock solutions (Merck, Germany) of 1000 mg/ l. These and blank solutions were also analyzed in the same way as for the digested samples.

2.3. Determination of Recovery

The digestion method and the atomic absorption spectrophotometry (AAS) analysis were validated by preparation of a multi-element standard solution (MESS) containing 1000 mg/ l of each metal. Two grams of randomly selected muscle sample powder were spiked with three different concentrations (Table 1) of heavy metals, each run in triplicate. This was followed by the digestion of the spiked samples and determination of metal concentration using AAS. Blank or unspiked samples were carried through the whole procedure described above. The amount of spiked metal recovered after the digestion of the spiked samples was used to calculate percentage recovery.

Table 1: Recovery (%) of Cd, Cu and Zn in muscle fish samples.

Heavy metal	Spiked concentration (mg/ kg)	Recovery concentration (mg/ kg)	Recovery (%)
Cd	0.025	0.0230	92
	0.050	0.0488	97
	0.10	0.0987	98
Cu	0.25	0.250	99
	0.50	0.489	97
	1.00	0.999	99
Zn	0.25	0.240	96
	0.50	0.480	96
	1.00	1.01	101

2.4. Statistical analysis

Statistical Analysis of data was carried out using SPSS statistical package programs. A one- way analysis of variance (ANOVA) was performed, followed by Scheffe post hoc comparisons for the source of statistically significant difference. Differences in mean values were accepted as being statistically significant if $P< 0.05$.

3. Results

Table1 shows the following % recovery: on average Cd, 95% ; Cu, 98% and Zn 97%.This shows that the digestion method used and the AAS analysis are reliable. Table 2 shows mean metal concentrations in the tissues of fishes and their standard deviations for the fishes *Oreochromis aureus, Cyprinus carpio* and *Clarias lazera*. Comparisons of the data for the three fish species, related with the heavy metal levels of organs, are also given in this table. Figure 1 shows the sampling area.

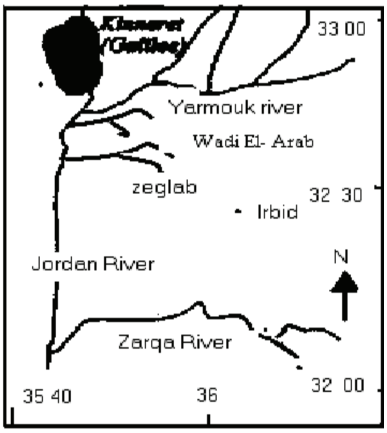

Figure1: Sampling location map of Wadi El-Arab in northern Jordan valley.

Cadmium: Concentration of Cd varied with no significant difference among all tissues of *Oreochromis aureus* except the gills that show the highest concentration of Cd (0.24± 0.12 mg/ kg dry wt.). Its distribution in both *Cyprinus carpio* and *Clarias lazera* was similar, it was in the increasing order of muscle≤ skin< bone< scales< gills with a significant differences among all organs with each other except muscle and skin which showed no significant difference in each of the two fish species. Gills also showed the highest values of Cd (about 0.7 mg/ kg dry wt.) in both fish species. There was no significant difference between *Cyprinus carpio* and *Clarias lazera* in Cd concentration values of their comparable tissues. While there was a significant difference between both of them and *Oreochromis aureus* in almost all comparable tissues. Skin of *Oreochromis aureus* and *Clarias lazera* showed no significant difference in their Cd values. Cd level in *cyprinus carpio* scales (0.66± 0.15 mg/ kg dry wt.) was significantly higher than that in *Oreochromis aureus* (0.07± 0.07 mg/ kg dry wt.). It should be noted that *Clarias lazera* has no scales. Muscles showed the lowest values of Cd in all fish species, particularly in *Oreochromis aureus*.

Copper: In *Oreochromis aureus,* the distribution pattern of copper was in the increasing order of scales≤ bone≤ muscle≤ skin< gills. Cu concentration was low in the first three tissues with no significant difference between each other, also there was no significant difference between muscle and skin, but there was a significant difference ($P< 0.05$) between skin and both scales and bone. The gills recorded the highest Cu concentration (9.32± 1.75 mg/ kg dry wt.) with a significant difference with all other tissues.

In *Cyprinus carpio* and *Clarias lazera* the distribution pattern of Cu metal was different from *Oreochromis aureus*. Its order was as follows: muscle< bone< skin< gills< scales. *Cyprinus carpio* fish recorded the highest values of Cu metal in almost all of its tissues; (Bone, skin, gills and scales with 7.99±3.04, 8.30±1.23, 9.92±2.38 and 9.93±1.74 mg/ kg, respectively) and with no significant difference between each other but with a significant difference in the comparable tissues of the other fish species; *Oreochromis aureus* and *Clarias lazera*, while muscles recorded the lowest mean concentration of copper, and with a significant difference ($P< 0.05$) when compared to the other tissues of *Cyprinus carpio*. Although Cu distribution pattern in *Clarias lazera* followed the same order as in *Cyprinus carpio* but it showed different values; bone and muscle had the lowest Cu concentrations (2.79± 0.60 and 3.04± 0.64 mg/ kg dry wt. respectively). Skin recorded a moderate concentration of Cu (6.26± 1.17) while gills recorded the highest level (9.12± 1.99 mg/ kg). There was significant differences among different tissues of *Clarias lazera* in their Cu concentratios except the difference between muscle and bone was not significant ($P> 0.05$). In general, Cu concentration was low in muscles of all fish species, and also it was low in bones and scales except those of *Cyprinus carpio* which showed a significant high Cu level. Gills in the three fish species had similar values of Cu metal (about 9 mg / kg dry wt).

Zinc: Table 2 shows that all tissues of *Oreochromis aureus* fish tend to accumulate Zn in large amounts particularly in the skin (432.11± 152.14) which was recorded the highest concentration of Zn with a significant difference ($P< 0.05$) compared with all other tissues of *Oreochromis aureus* and of other fish species. The gills recorded the lowest concentration of Zn (46.22± 22.24). Muscles recorded high concentration of Zn (70.76± 31.21) and it was higher than the acceptable values for human consumption designated by FAO (FAO, 1983). In the other fish species (*Cyprinus* and *Clarias*) the highest concentration of Zn recorded was in their skin, and with a significant difference ($P< 0.05$) compared with the other tissues. The lowest Zn value was recorded in bone and gills of *Cyprinus carpio* (25.06± 4.09 and 27.85±3.93, respectively) and in muscles of *Clarias lazera* (30.13± 3.04 mg/ kg). Zn concentration in muscles and scales of *Cyprinus carpio* showed no significant difference but there was a significant difference ($P< 0.05$) between scales and bone. No significant difference ($P>0.05$) was found between the levels of Zn in bone and gills of *Clarias lazera* but there was a significant difference ($P< 0.05$) among them and the other tissues such as muscles and skin.

In comparison of Zn level in the three fish species, it was found that *Oreochromis aureus* showed the highest Zn level with a significant difference ($P< 0.05$) among all comparable tissues, except the gills of *Oreochromis aureus* and *Clarias lazera* which showed no significant difference. While *Cyprinus carpio* and *Clarias lazera* showed no significant difference ($P> 0.05$) in the Zn level in all of their comparable tissues.

4. Discussion

In the present study the concentration of cadmium was lowest in *Oreochromis aureus* fish and highest in *Clarias lazera* fish in all organs. There was a significant difference ($P< 0.05$) between the concentrations of Cd in all organs of the three fish species except the skin of *Oreochromis aureus* and *Clarias lazera.* Also, gills of *Cyprinus carpio* and *Clarias lazera* were not significantly different in their Cd concentrations. Gills seemed to be the organ which accumulates the highest value of Cd. The concentration of Cd in scales and bone recorded comparable values with that in gills of *Cyprinus carpio* and *Clarias lazera* which indicated that the uptake of Cd could occur through gills and other hard tissues; scales and bones. This is in agreement with the literature (El-Nemr, 2003; Khaled, 2004; Van Aardt and Endmann, 2004 and Mwashot, 2003) which reported that Cd is stored in the body in various tissues, but the main site of accumulation in aquatic organisms is in the kidney and liver, beside other tissues, notably the gills, bone and exoskeleton. It was also reported that Cd level in gills recorded higher than or comparable value with that in the liver of *Cyprinus carpio* and some other fish species (Canli et al., 1998; Khaled, 2004). There was a significant difference ($P<0.05$) between the concentrations of Cd in muscles of all collected fish species. Muscles showed the lowest levels of Cd particularly in muscles of *Oreochromis aureus;* 0.02± 0.02 mg/ kg dry wt. The highest value of Cd in muscle organ was in *Clarias lazera*; 0.24± 0.05 mg/ kg dry wt. This value is still in a permissible values of Cd; 0.5 mg/ kg that was proposed by the Food and Agricultural Organizations (FAO, 1983) to be safe for human consumption. Cadmium is rarely found in natural water (Hem, 1989). It is considered to be toxic if its concentration exceeds 0.01 mg/ L both in drinking and irrigation water (Taha, 2004). Cadmium with some other heavy metals lead and mercury are of no biological function in human system and they are potentially toxic even at trace concentrations (Robert, 1991). The effects of acute cadmium are high blood pressure, kidney damage, destruction of testicular tissue as well as destruction of red blood cells (Gupta and Mathur, 1983).

Table 2 shows that gills exhibit the highest level of Cu in addition to Cd metal while the muscle recorded the lowest level of Cu. *Oreochromis aureus* showed low level of Cu in their muscles, bones, scales and skin. Gills accumulate high level of Cu in all fish species (about 9 mg/ kg dry wt.).

Table 2. Concentrations of Cd, Cu, and Zn in mg/ kg dry wt (mean ± standard deviation) in different organs of three fish species collected from Wadi El- Arab, Northern Jordan Valley during March, 2006.

Organ	Fish species	N	Cd	Cu	Zn
Muscle	*Oreochromis aureus*	7	0.02± 0.02 ^{a}*	2.90± 0.34 ^{a}	70.76± 31.21 ^{a}
	Cyprinus carpio	9	0.14± 0.07 ^{b}	2.48± 1.00 ^{ab}	30.31± 4.16 ^{b}
	Clarias lazera	9	0.24± 0.05 ^{c}	3.04± 0.64 ^{ab}	30.13± 3.04 ^{b}
Bone	*Oreochromis aureus*	7	0.11± 0.08 ^{a}	2.33± 0.96 ^{a}	169.23± 84.66 ^{a}
	Cyprinus carpio	9	0.41± 0.06 ^{b}	7.99± 3.04 ^{b}	25.06± 4.09 ^{b}
	Clarias lazera	9	0.53± 0.06 ^{c}	2.79± 0.60 ^{a}	39.96± 2.90 ^{b}
Skin	*Oreochromis aureus*	7	0.12± 0.07 ^{a}	4.98± 1.43 ^{a}	432.11± 152.14 ^{a}
	Cyprinus carpio	9	0.27± 0.08 ^{b}	8.30± 1.23 ^{b}	46.88± 8.41 ^{b}
	Clarias lazera	9	0.15± 0.07 ^{a}	6.26± 1.17 ^{a}	65.89± 12.04 ^{b}
Scales	*Oreochromis aureus*	7	0.07± 0.07 ^{a}	2.18± 0.97 ^{a}	152.66± 157.75 ^{a}
	Cyprinus carpio	9	0.66± 0.15 ^{b}	9.93± 1.74 ^{b}	35.96± 6.45 ^{b}
	Clarias lazera	9	No Scales	No scales	No Scales
Gills	*Oreochromis aureus*	7	0.24± 0.12 ^{a}	9.32± 1.75 ^{a}	46.22± 22.24 ^{a}
	Cyprinus carpio	9	0.70± 0.16 ^{b}	9.92± 2.38 ^{ab}	27.85± 3.93 ^{b}
	Clarias lazera	9	0.77± 0.17 ^{b}	9.12±1.99 ^{ab}	40.12± 6.80 ^{ab}

* Data shown with different letters are statistically significant at the $P < 0.05$ level .

N: number of fish individuals of each fish species.

Cyprinus carpio accumulated high concentrations of Cu in all of its tissues except muscles, while *Clarias lazera* had no scales and they tend to accumulate Cu only in their gills and skin (9.12± 1.99 and 6.26± 1.17 mg/ kg dry wt. respectively), while bone and muscle recorded low levels (2.79± 0.60 and 3.04± 0.64 mg/ kg dry wt. respectively). Most copper minerals are relatively insoluble and hence little copper is found in natural water. Copper is available in surface water and ground water due to the extensive use of pesticides sprays containing copper compounds for agricultural purposes. It is an essential element in human metabolism but can cause anemia, disorders of bone and connective tissues and liver damage at excessive levels. The toxicity of copper depends upon the hardness and pH of the water, and therefore, it is more toxic in soft water and in water with low alkalinity (Taha, 2004). This study shows that the most uptake of Zn metal was through the skin tissue not gills and which showed the lowest level of Zn if compared to the other organs of *Oreochromis aureus.* Generally all the studied organs showed high level of Zn in bone, scales and even the muscles particularly in *Oreochromis aureus.* The other two fish species *Cyprinus carpio* and *Clarias lazera* also showed high level of Zn in their skin but lower level than in *Oreochromis aureus* skin. *Cyprinus carpio* showed the lowest values of Zn in their organs. Zinc concentration in muscles was the highest in *Oreochromis aureus* (70.76± 31.21 mg/ kg dry wt). This value is higher than the acceptable value for Zn in edible fish (30 mg/ kg dry wt) (FAO, 1983). *Cyprinus carpio* and *Clarias lazera* fish showed similar values of Zn in their muscles (30 mg/ kg dry wt). Zinc is one of the essential elements as copper, and cobalt for both animals and humans. A deficiency of zinc is marked by retarded growth, loss of taste and hypogonadism, leading to decreased fertility. Zinc toxicity is rare, but at concentrations in water up to 40 mg/ l, may induce toxicity, characterized by symptoms of irritability, muscular stiffness and pain, loss of appetite, and nausea (NAS-NRC, 1974). Zinc appears to have a protective effect against the toxicities of both cadmium (Calabrese et al., 1985) and lead (Sanstead, 1976).

This difference in the pattern of heavy metals distribution in the three fish species might be a result of their difference in many factors such as; feeding habits, habitats, ecological needs, metabolism, biology and physiology (Arellano et al., 1999). Generally, heavy metal uptake occurs mainly from water, food and sediment (Canli et al., 1998). However, the efficiency of metal uptake from contaminated water and food may differ in relation to ecological needs, metabolism, and the contamination gradient of water, food and sediment, as well as other environmental factors such as salinity, temperature and interacting agents (Heath, 1987 and Pagenkopt, 1983). *Cyprinus carpio* is a benthic, burrowing species and their heavy metal concentrations especially Cu, can indicate the bioavailability of them from sediments (Luoma, 1983). On the other hand, *Clarias lazera* usually feeds near the bottom in natural waters but they take some food from the surface, besides the nature of diet of their youngs differ from that of adults. While *Oreochromis aureus* is a benthopelagic, feeds on plants and zoobenthos which might accumulate heavy metals from their food. This is agreed with the literature which reported that some plant and animal taxa such as crustacea and mollusca have high potential for accumulation of metals and other pollutants even from much diluted solutions without obvious noxious effects (Ali and Fishar, 2005). Although fish muscle is the most important part to be used for human consumption, fish skin and liver may also be consumed to some extent. Target organs such as liver, kidney, gonads and gills, have a tendency to accumulate heavy metals in high values, as shown in many species of fish in different areas (Kargin, 1996; Yilmaz, 2003; Yilmaz, 2005 and Abdel-Moniem, et al., 1994). It is generally accepted that muscle is not an organ in which metals accumulate (Legorburu et al., 1988). Similar results were reported from a number of fish species showing that muscle is not an active tissue in accumulating heavy metals (Karadede and Unlo, 2000). This is agreed with the present study. Skin is not much studied in previous works, although it is a consumed part of the fish. Yielmaz (2003) indicated that concentrations of heavy metals were higher in all of the skin samples than in muscles. This is agreed with the present study. The reason for high metal concentrations in the skin could be due to the metal complexion with the mucus that is impossible to be removed completely from the tissue before the analysis. The present results indicated that the lowest concentrations of the heavy metals were usually recorded in muscle rather than the skin, while the higher values were recorded in the gills and sometimes in bones and scales. This study indicated that gills accumulate more Cd and Cu metals than skins and muscles, but this is reversed in case of Zn metal. The levels of heavy metal in fish vary in various species and different aquatic environments (Canli and Atli, 2003). The presence of trace metals, particularly Zinc in Wadi El-Arab might due to the agricultural influx and sewage via surrounding cultivated lands

Consequently, it can be concluded that the levels of heavy metals in muscle are at acceptable levels for all of the studied samples in this region. Only the zinc level in muscle of *Oreochromis aureus* was higher than the acceptable values for human consumption designated by the FAO, 1983. Absorbed zinc and other heavy metals can be distributed quickly to the other tissues and organs (e.g. bone, gills, kidneys, muscle) rather than accumulating in the liver (Yilmaz, 2005) and in the skin as in the present study. Accumulation of heavy metals in fish viscera and other organs may be considered as an important warning signal for fish health and human consumption. The present study shows that precaution measures need to be taken in order to prevent future heavy metal pollution.

Acknowledgments:

I am grateful to Prof. Jeries for his help and valuable suggestions. I would like also to thank Dr Al- Edeili for his help in the statistical analysis. Many thanks are also due to Dr. Al- Khleifat, Head of Dead Sea studies Center, Miss. Dmour assisted in the analytical work and Dr. Batarseh for his insightful suggestions. Finally, I will never forget the assistance of Mr. Edinat, Mr. Saraireh and Miss Abd El-Khalek through their willingness to offer unconditional help and support.

References

[1] Abdel moniem M and Khaled A Iskander M. 1994. A study on levels of some heavy metals in El-Mex bay, Alexandria, Egypt. In: Proceeding of the fourth conference on Environmental Protection Must, Alexandria, Egypt.155-174.

[2] Abel PD and Papoutsouglou SE. 1986. Lethal toxicity of cadmium to *Cyprinus carpio* and *Tilapia aurea*. Bull. Environ. Contam. Toxicol. 37: 382-386.

[3] Ahmad AA. 1989. Jordan Environmental Profile: Status and Abatement. Amman, Jordan. Privately published. 273 pp.

[4] Arellano JM, Ortiz JB, and Capeta Da Silva D Gonzalez de Canales ML, Sarasquete C and Blasco J. 1999. Levels of copper, zinc, manganese and iron in two fish species from salt marshes of Cadiz Bay (south west Ibrian Peninsula). Bol. Inst. Esp. Oceonogr., 15/1-4: 485-488.

[5] Ali M and Fishar M. 2005. Accumulation of trace metals in some benthic invertebrate and fish species relevant to their concentration in water and sediment of lake Qarun, Egypt. Egyp. J. Aq. Res., 31/ 1: 289-301

[6] Bryan GW. 1976. Some effects of heavy metal tolerance in aquatic organisms. In: Lockwood A.P.M. (ed.) Effects of pollutants on aquatic organisms. Cambridge University Press. Cambridge, England. pp.7

[7] Budieri A. 1994. Hashemite kingdom of Jordan. A Directory Of Wetlands in the Middle East

[8] Calabrese EJ, Canada AT, and Sacco C.1985. Trace elements and public health. Annual Review of Public Health, 6: 131-146.

[9] Canli M and Atli G. 2003. The relationships between heavy metal (Cd, Cr, Cu, Fe, Pb, Zn) Levels and the size of six Mediterranean fish species. Environment. Poll. 121: 129-136.

[10] Canli M, Ay O and Kalay M. 1998. Levels of heavy metals (Cd, Pb, Cu, Cr and Ni) in tissues of *Cyprinus carpio*, *Barbus capito* and *Chondrostoma regium* from the Seyhan river, Turkey. Turk. J. of Zool. 22:149-157.

[11] El-Nemr A. 2003. Concentrations of certain heavy metals in imported frozen fish in Eygpt. Eygpt. J. Aquat. Biol. Fish. 7: 139-154.

[12] Food and Agricultural organization (FAO) 1983. Compilation of legal limits for hazardous substances in fish and fishery products. Fisheries circular No. 764. FAO, Rome.

[13] Food and Agricultural Organization (FAO) 1983**.** Manual of Methods in Aquatic Environmental Research, part 9. Analyses of metals and organochlorines in fish. FAO Fisheries Technical Paper, 212.

[14] Gumgum B, Unlu E, and Tez Z. Gulsun Z. 1994. Heavy metal pollution in water, sediment and fish from the Tigris river in Turkey. Chemosphere. 29: 111-116

[15] Gupta BN and Mathur AK. 1983. Toxicity of heavy metals. Ind. J. Med. Sci. 37: 236-240.

[16] Guven K, Ozbay C, Unlu E and Satar A. 1999. Acute lethal toxicity and accumulation of copper in *Gammarus pulex* (L.) (Amphipoda).Turk. Jour. Boil. 23: 513-521.

[17] Heath AG. 1987. Water pollution and Fish physiology. CRC press, Florida, USA, 245 pp.

[18] Hem JD.1989. Study and interpretation of the chemical characteristics of natural water. U. S. Geological Survey, Water Supply, pp 1473 & 2254

[19] Kalay M and Canli M. 2000. Elimination of essential (Cu, Zn) and nonessential (Cd, Pb) metals from tissue of a freshwater fish *Tilapia zillii* following an uptake protocol. Tukr. J. Zool. 24: 429-436

[20] Karadede H and Unlu E. 2000. Concentrations of some heavy metals in water, sediment and fish species from the Ataturk dam lake (Euphrates), Turkey. Chemosphere, 41: 1371-1376.

[21] Kargin F. 1996. Seasonal changes in levels of heavy metals in tissues of *Mullus barbatus* and *Sparus aurata* collected from Iskanderun gulf (Turkey*)*. Water*,* Air Soil Pollut*.* 90: 557- 562.

[22] Khaled A. 2004. Heavy metal concentrations in certain tissues of five commercially important fishes from El-Mex Bay, Al-Exandria , Egypt. pp 1- 11 .

[23] Larsson A, Haux C, and Sjobeck M. 1985. Fish physiology and metal pollution: Results and experiences from laboratory and field studies. Ecotox. Environ. Safe. 9: 250- 281.

[24] Legorburu I, Canton L, Millan E and Casado A. 1988. Trace metal levels in fish from Unda river (Spain) Anguillidae, Mugillidae and Salmonidae. Environ. Technol. Lett., 9: 1373-1378.

[25] Leland HV, Luoma SN, and Wilkes DJ. 1978. Heavy metals and related trace elements. J. Wat. Poll. Control Fed. 50: 1469-1514.

[26] Luoma SN. 1983. Bioavailability of trace metals to aquatic organisms, a review. Sci. Total Environ. 28: 1- 22.

[27] Mance G. 1987. Pollution threat of heavy metals in aquatic environment. Elsevier. London

[28] Mwashot BM. 2003. Levels of cadmium and lead in water, sediments selected fish species in Mombasa, Kenya. Western Indian Ocean. J. Mar. Sci. 2/ 1: 25-34.

[29] National Academy of Sciences-National Research Council (NAS-NRC) 1974. Food and Nutrition Board. Recommended Dietary allowances. Washington DC: National Academic press.

[30] Nemesok JG and Huphes ZGM. 1988. The effects of copper sulphate on some biochemical parameters of rainbow trout. Environ. Poll., 49: 77-85.

[31] Olaifa FE, Olaifa AK, Adelaja AA, and Owolabi AG. 2004. Heavy metal contamination of *Clarias garpinus* from a lake and Fish farm in Ibadan, Nigeria. Afric. J. of Biomed. Res. 7: 145-148.

[32] Pagenkopf GK. 1983. Gill surface interaction model for trace metal toxicity to fish. Role of complexation, PH, water hardness. Environ. Sci. Technol. 17/ 6: 342-347

[33] Robert G. 1991. Toxix effects of metals. In: Casarett and Doull's toxicology. Pergamon Press, pp 662-672.

[34] Romeo M, Siau Y, Sidoumou Z, and Gnassia Barelli M.1999. Heavy metal distribution in different fish species from the Mauritania coast. Sci. Total Environ., 232: 169-175.

[35] Sanstead HH. 1976. Interaction of cadmium and lead with essential minerals. In G. F. Nordberg (Ed.), Effects and dose-response relationships of toxic metals (pp.511-525). Amesterdam: Elsevier.

[36] Taha AA. 2004. Pollution Sources and Related Environmental Impacts in The New Communities, Southeast Nile Delta, Egypt. Emirat. J. Eng. Res. 19/ 1: 44.

[37] Van Aardt WJ and Erdman R. 2004. Heavy metals (Cd, Pb, Cu, Zn) in mudfish and sediments from three hard-water dams of the Mooi river catchment, south Africa. Water. 30: 211-218.

[38] Yilmaz AB. 2003. Levels of heavy metals (Fe, Cu, Ni, Cr, Pb and Zn) in tissue of *Mugil cephalus* and *Trachurus mediteraneus* from Iskenderun bay, Turkey. Environ. Res., 92: 277-281.

[39] Yilmaz AB. 2005. Comparison of heavy metal levels of Grey Mullet (*Mugil cephalus* L.) and sea bream (*Sparus aurata* L.) caught in Iskendrun Bay (Turkey).Turk. J. Vet. Anim. Sci., 29: 257-262..