



Research Article

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Heavy Metals Profile Assessment in the Liver and Muscle Tissues of Nile Tilapia at The End of Production Cycle



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Abstract

The present study was conducted to evaluate the heavy metals profile in liver and muscle tissues of Nile tilapia at the end of the production cycle. To determine the concentration of 10 heavy metals in liver and muscle tissues of Nile tilapia (*Oreochromis niloticus*) cultured in natural and tap water, the samples of fish cultured for ten months were randomly collected and analyzed for Cadmium, Zinc, Lead, Copper, Manganese, Iron, Nickel, Chromium, Mercury, and Arsenate by Spectrophotometric method. The results revealed that the concentrations of heavy metals in fish samples collected from natural water were higher than that of samples collected from tap water. This concluded that, the concentrations of heavy metals in liver and muscle tissues of Nile tilapia reflect their concentrations in culture water and confirm its possibility to be an aquatic friendly environment.

Keywords: Nile tilapia; Heavy metals; Liver; Muscle; Water

Introduction

The high protein content, essential amino acids, vitamins, and minerals make fish a very good candidate as a human food [1,2]. Unfortunately, the aquatic life is at a continuous risk of exposure to pollutants such as heavy metals, pesticides, and other organics that leak to their water habitat [3]. Disposal of dredge spoil, sewage sludge, and industrial effluents in water bodies introduces various pollutants such as metals to the aquatic ecosystems. Deposition of metals suspended in air, leaching, runoffs, agriculture, industries, and other anthropogenic activities continuously elevate the levels of heavy metals at a frightening rate in the environment and the aquatic ecosystems in particular causing a global problem [4]. Most elements even essential trace elements are not toxic unless they reach a concentration high enough to cause pathological changes [5]. Due to their non-biodegradable nature, those metals accumulate in high concentrations in the bodies of aquatic organisms causing toxicity.

The persistence of heavy metals in the food chain and the difficulty of their elimination from the environment is the major problem [5]. Minimal concentrations of Mercury (Hg), Cadmium

(Cd), Arsenic (As), Chromium (Cr), and Lead (Pb) normally exist in the environment and even act as essential micronutrient for plants, animals, and humans, but they cause toxicity at high levels. Copper, Nickel, Manganese, Lead, Cadmium, and Iron at high levels lead to deleterious effect on human body such as hypertension, nausea, sporadic fever, and renal injury [6]. Determination of heavy metals is useful and important in the environmental pollution. World Health Organization (WHO) set maximum permissible levels of heavy metal in the environment that should not be exceeded.

Fish are at the top of aquatic food chain and can accumulate high concentrations of heavy metals from water which can easily ascend through the food chain to higher organisms like human beings [7]. Therefore, it is essential to assess heavy metals concentration in fishery products from various environments to guarantee that they are safe for human consumption. Owing to its capacity to store heavy metals and other organics, fish are believed to be a fascinating bio-indicator [8]. *Oreochromis niloticus* is an important species in commercial fisheries that readily responds to environmental alterations. The present study

was conducted to use Nile tilapia as a bioindicator for evaluating the water resources in terms of heavy metals.

Materials and Methods

Fish Collection and Area of Study

Twenty fish of Nile tilapia (*Oreochromis niloticus*) were randomly collected from circular plastic tanks supplied with tap water in the fish farm that belongs to the Faculty of Veterinary Medicine, Alexandria University and from hapas in an earthen pond supplied with natural water located at Edko, Beheira Governorate, Egypt after ten month of growth in tanks and hapas. Growth period began in September 2015 to June 2016. The muscle and liver tissues of Nile tilapia were isolated and transported in ice box to the laboratory. Water samples were manually collected in triplicates from each of the studied areas at 30 cm underneath the surface of the water and stored at 4°C in sterile glass bottles, preserved with concentrated hydrochloric acid (HCl).

Detection of Metals in Fish Organs and Water

The muscle and liver samples were extracted by digestion using a modified method described by Seymore *et al.* [9]. Briefly, 1 g of fresh tissue, 20 ml nitric acid, and 5 ml perchloric acid were placed in a 200 ml flask. The samples were heated at 225°C for 12 h (The temperature was gradually increased) on a hotplate and evaporated to ~5 ml. Upon forming a clear liquid, 0.2 ml lanthanum chloride (100 g La/L solution) was added. 2% HNO₃ was then added to make the volume up to 20 ml. The same procedure was used to make a reagent blank. Atomic absorption spectrophotometer (AAS) Analyst 800 (Perkin Elmer Instruments, USA) with an acetylene flame (Cu and Zn) or an argon non-flame (Cr, Hg, Cd, Pb, Fe, Mn, Cr, As and Ni) was used to measure the concentration “Cadmium (Cd); Zinc (Zn); Lead (Pb); Copper (Cu); Manganese (Mn); Iron (Fe); Nickel (Ni); Chromium (Cr); Mercury (Hg) and Arsenate (As)” after preparation of the calibration standard. The concentrations of heavy metals were expressed as µg/gram dry weight for fish organs. Determination of heavy metals in water was measured by the same method, but concentrations of all heavy metals in water are expressed as mg/l (ppm).

Statistical Analysis

Data were analyzed by Student’s “t” test to compare the different parameters by SPSS (2010) statistical package version. The data values were presented as mean ± standard error of mean (SEM).

Results

Heavy metal concentration in water samples collected from natural water showed significantly increased compared to tap water (Table 1). Concentrations of heavy metals in liver tissues had the following order Fe > Ni > Cr > Cu > As > Hg > Zn > Pb > Mn and Cd. Heavy metal concentration in liver tissues of fish culture in natural water revealed significantly higher compared to fish

cultured in tap water (Table 2). Heavy metal concentration in muscle tissues of fish culture in natural water revealed significantly higher compared to fish cultured in tap water (Table 3). Level of heavy metal residues was assessed in edible muscles and non-edible liver of fish obtained from natural and tap water; results are illustrated in Table 2 and 3. The recorded data confirmed the presence of heavy metals traces in all fish tissues under the study. In addition, the prevalence of each element was not the same in the two sampling sites.

Table 1: Means ± standard error for concentrations of trace elements (mg/l) in natural and tap water.

Element	Natural water (Hapas)	Tap water (Tanks)
Manganese	0.0388 ± 0.002 ^a	0.0028 ± 0.0002 ^b
Zinc	0.230 ± 0.005 ^a	0.168 ± 0.008 ^b
Iron	2.0400 ± 0.1005 ^a	0.2185 ± 0.0015 ^b
Copper	0.0032 ± 0.0005 ^a	0.0008 ± 0.0002 ^b
Cadmium	0.0144 ± 0.0003 ^a	0.0029 ± 0.0003 ^b
Chromium	2.0810 ± 0.1001 ^a	0.4211 ± 0.0020 ^b
Arsenic	0.410 ± 0.003 ^a	0.274 ± 0.006 ^b
Lead	0.2941 ± 0.0070 ^a	0.0075 ± 0.0001 ^b
Mercury	0.0188 ± 0.0004 ^a	0.0035 ± 0.0002 ^b
Nickel	3.0510 ± 0.1200 ^a	0.3112 ± 0.0013 ^b

Means within a row with the different superscripts differ significantly (P≤ 0.05)

Table 2: Means ± standard error for concentrations of trace elements in liver tissues of Nile tilapia cultured in natural and tap water (µg / gram dry weight).

Element	Natural water (Hapas)	Tap water (Tanks)
Manganese	1.85 ± 0.42 ^a	1.12 ± 0.22 ^b
Zinc	18.45 ± 1.71 ^a	15.25 ± 1.42 ^b
Iron	88.45 ± 10.52 ^a	43.31 ± 3.25 ^b
Copper	28.41 ± 4.55 ^a	20.05 ± 2.46 ^b
Cadmium	0.19 ± 0.07 ^a	0.08 ± 0.03 ^b
Chromium	38.30 ± 5.21 ^a	31.41 ± 4.35 ^b
Arsenic	26.66 ± 3.24 ^a	19.12 ± 2.23 ^b
Lead	5.22 ± 1.06 ^a	3.24 ± 0.22 ^b
Mercury	18.75 ± 2.25 ^a	13.65 ± 1.88 ^b
Nickel	63.28 ± 5.21 ^a	49.52 ± 4.29 ^b

Means within a row with the different superscripts differ significantly (P≤ 0.05)

Table 3: Means ± standard error for concentrations of trace elements in muscle tissues of Nile tilapia in natural and tap water (µg / g of dry weight).

Element	Natural water (Hapas)	Tap water (Tanks)
Manganese	1.68 ± 0.14 ^a	0.47 ± 0.13 ^b
Zinc	65.21 ± 4.20 ^a	33.12 ± 5.63 ^b

Iron	65.65 ± 3.98 ^a	21.56 ± 1.55 ^b
Copper	3.9 ± 0.36 ^a	2.24 ± 0.28 ^b
Cadmium	0.34 ± 0.037 ^a	0.15 ± 0.04 ^b
Chromium	0.79 ± 0.029 ^a	0.61 ± 0.042 ^b
Arsenic	0.75 ± 0.035 ^a	0.43 ± 0.044 ^b
Lead	0.4 ± 0.06 ^a	0.16 ± 0.05 ^b
Mercury	0.67 ± 0.07 ^a	0.21 ± 0.02 ^b
Nickel	54.31 ± 3.6 ^a	32.17 ± 2.4 ^b

Means within a row with the different superscripts differ significantly ($P \leq 0.05$)

Discussion

Nowadays, water pollution is regarded as a major environmental and public health issue facing Egypt and the Middle East. *Oreochromis niloticus* is important species in commercial fisheries that is readily affected by environmental modifications. Owing to the disparity in content of metal and chemical characteristics of water from which fish are obtained, their ecological needs, feeding patterns, and metabolism, heavy metals in freshwater fish appear in various concentrations in different studies [10-12]. Heavy metals diffused through the gills or the gut wall. The data of the present study indicated the accumulation of ten heavy metals in muscle tissues of *O. niloticus* in the order of Fe > Zn > Ni > Cu > Mn > Cr > As > Hg > Cd > Pb for samples of fish and liver tissues in the order of Fe > Ni > Cr > Cu > As > Hg > Zn > Pb > Mn and Cd. Meanwhile, the heavy metals concentration in water showed that Ni had the highest mean level in natural water, followed by Cr, Fe, Pb, Zn, As, Hg, Cd, Mn, and Cu.

Iron (Fe) is a naturally occurring element in the soil, but agricultural activities add up to the iron level found in the sampled fish. Iron level in the samples was below the permissible level of 107 µg/g set by World Health Organization [13] thus not posing any threat to fish consumers. The drop of iron level in human body results in iron deficiency anemia. Zinc (Zn) is a naturally occurring fundamental element in organisms and in the earth crust and is clearly not dangerous to fish or its shoppers. Fish diet and its water habitat are the main source of zinc accumulated in fish tissues [14]. Its concentration in the samples was below the National Contaminant Bio-monitoring Program (NCBP) maximum contaminant level of 34.2: g/g. High levels of zinc cause death, reproductive impairment, and growth retardation [15]. The interaction between zinc and various elements is antagonistic, additive, or synergistic [16].

Nickel (Ni) concentration in the samples was below the dangerous level of 0.7 g/g thus not jeopardizing the health of fish consumers [16]. Excess copper (Cu) is toxic to fish though the exact effect is not yet well [17]. Once combined with ammonia, mercury, and zinc, its toxicity increases [18]. The concentration of copper (3.9 µg / g dry weight in hapas and 2.24 µg / g dry weight

in tanks) in the fish samples slightly exceeded the maximum contaminant level as reported by Schmitt and Brumbaugh [19] probably due to leaching and runoff of naturally occurring copper in the soil. It is an essential micronutrient but may cause nausea, vomiting, and diarrhea when approaching high concentrations. Hepatic and renal damage even death is reported with very high levels of copper [20].

Manganese (Mn) in fish came from naturally occurring manganese in the soil, leaks through leaching and runoff, or released from Agro chemicals as herbicides and pesticides. In this study, its concentration was below the permissible level of 5 µg/g in hapas and tanks according to the World Health Organization [13]. It's a fundamental trace element whose deficiency may lead to skin diseases, neurological symptoms, or coagulation disorders. High level may cause nerve damage, hallucinations, forgetfulness, pulmonary embolism, bronchitis, and Parkinsonism. Chromium (Cr), though essential, is lethal to fish and wildlife at high levels [21]. No maximum level of chromium in fish and wildlife was set as a guideline value [22]. In the current study, its concentration was far below (53.8: g/g) the level set by United States Environmental Protection Agency (USEPA) as contaminant to fish.

Naturally occurring arsenic (As) in the soil leaching into the water is the major source of arsenic in sampled fish. In this study, its level in hapas and tanks was below (0.5 g/g dry weight) which according to Walsh *et al.* [23] leads to deleterious effects on fish when exceeded. The recorded results of Mercury (Hg) level in the present study were lower than those obtained by Sohsah- Madiha [24] (0.81 ± 0.05 for *Tilapia nilotica*) while the concentration of Mercury in the present study was higher than the results recorded by El-Zahaby- Dina [25] (0.013 ± 0.001 ppm in *Tilapia nilotica*). Mercury is normally present in the environment in low concentrations, mainly because of industrial activities [26]. Methyl mercury is not excreted so it is more dangerous to human health than inorganic one. In addition, it acts as accumulative poison and can cross blood-brain barrier causing progressive and irreversible cerebral damage [27].

Land preparation and application of Agro-chemicals are believed to be the main source of Cadmium (Cd) in the sampled fish. Fertilizers as phosphate fertilizers which are annually applied on farmlands contain an average of 13.4 g/g of cadmium as reported by Modaihsh *et al.* [28]. Cadmium is a non-essential trace metal; it has potentially deleterious effect on most fish, wildlife, and freshwater organisms [21]. The highest cadmium levels in fish samples were below the 0.5g/g threshold but are still harmful to fish and other predators [23]. Automobile exhaust, industrial wastewater, wastewater sludge, and pesticides are the major sources of Lead (Pb) in the environment [29]. The global mean lead concentration in lakes and rivers ranges approximately between 1.0 and 10.0 µg/L [30]. Lead gained access to the 15 aquatic environments through erosion and leaching from soil, dust fallout, gasoline combustion, and industrial wastes, runoff

of fallout deposit from streets and other surfaces as well as precipitation [9]. In this study, the concentration was lower than the estimated level in lakes and rivers [31-35].

Conclusion

The concentrations of heavy metals in muscle and liver tissues of Nile tilapia (*Oreochromis niloticus*) were higher in fish samples culture in natural water compared to fish collected from tap water, and this is due to nature of water resources where in tanks was tap water while in natural water was Nile water mixed with agriculture water drainage. This means that rearing and growth of fish in tap water is better than natural water for human health and human consumption, although these elements did not reach the toxic levels. Written culture where a letter d is added to this quantity and becomes cultured

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