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LEAD AND CADMIUM CONTENTS IN NILE WATER, TILAPIA AND CATFISH FROM ROSETTA BRANCH, RIVER NILE, EGYPT.

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ABSTRACT

Lead and cadmium were determined in water and muscle of Nile Tilapia (Oreochromis niloticus)and Catfish (Clarias gariepinus) from the River Nile, Rosetta branch, Behira (Egypt) to assess the water pollution with those toxic metals. Fish samples were chosen from six sites to be analyzed. In the present investigation, Lead and Cadmium concentrations for water ranged from (1.1 to 2 µg L^{-1}) and (0.5 to 1.9 µg L^{-1}), respectively. The levels of lead and cadmium in fishes are much higher than in the water. Lead and cadmium concentrations ranged from (19.82 to 24.98) and (0.16 to 0.25) µg Kg^{-1}in wet basis for tilapia fish and ranged from (13,05 to 19.89) and (0.19 to 0.29) µg Kg-1in wet basis for catfish, respectively. Lead and cadmium were found in higher concentration than those recommended by FAO/WHO for fish.
Keywords:- lead. cadmium. Water. Fish

INTRODUCTION

Water that resides in rivers, streams, and lakes are major sources of drinking water. Thus, the pollution of these natural waters is one of the most critical environmental issues today. Inorganic compounds from natural and anthropogenic sources continuously enter the aquatic ecosystem where they pose a serious threat because of their toxicity, long time persistence, bioaccumulation, and bio magnifications in the food chain (Karadede-Akin and Ünlü, 2007; Papagiannis *et al.* 2004).

Increased industrialization and agricultural activities contribute to their elevated levels in natural waters. Inorganic compounds such as trace metal are shown to have a multitude of toxic effects such as acute syndrome and neurotoxic effects (that ultimately cause disease in brain, kidney, skin cancer, etc.). The most frequently found heavy metal contaminants include lead, cadmium. Lead and Cadmium are non-essential and toxic metals which are distributed and released into the aquatic environment by industrial sources such as mining, refining of ores (Handy, 1994). Metal contamination raises environmental concerns, such as influences on the food chain, which can be potentially harmful to humans. Cadmium and lead are two of the more toxic food chain contaminants. Cadmium damages the lungs and causes the painful Itai-Itai disease. Lead affects the blood, numerous organs, and the nervous system (Malhat, 2011).

In spite of heightened concern and pollution programs, very little is currently known about the distribution, behavior, and effects of trace metals in the River Nile. Heavy metals are a part from aerosols in the atmosphere and direct effluent discharges into waters. Although heavy metals differ widely in their chemical properties they are used widely in electronics machines and the artifacts of everyday life. Agriculture constitutes one of the very important non-point sources of metals pollutants. The main sources are impurities in fertilizers, pesticides and sewage sludge. River Nile pass through agricultural and industrial fields, since most activities in Egypt are around Nile, thus it is subjected to contamination with different pollutants. Drainage water is pumped into several major drains that finally discharged their waters into the river Nile or lakes (Malhat, 2011).

Fish is a healthy food because of its nutritional benefits related to its proteins of high biological quality, desirable lipid composition, valuable mineral compounds and vitamins (Vieira *et al.,* 2011).

Nile tilapia (*Oreochromis niloticus*) is one of the most widely and successfully cultured fresh water fish worldwide. Catfish (*Clarias gariepinus*) is one of the most abundant and widely distributed fish in the River Nile, its tributaries and lakes. It is also the principal clarid catfish in Africa. Pond reared African catfish is at particular risk of exposure to agricultural chemicals, as they are often farmed in proximity to crop-producing fields using the resulting waste water (Almeida *et al.*, 2002; Ibrahem, 2011).

Several studies has been carried out in fish pollution by Cd and Pb in Egypt especially those (Tilapia nilotica) fish of the River Nile (Awadalla *et al.,* 1985;Mohamed *et al.*, 1990; Khallaf *et al.*, 1994; Feshwi, 1994; Zaky,1995; Malhat, 2011).

Rosetta branch is a branch of the River Nile in Lower Egypt. It is the western edge of the delta before flows into the river in the Mediterranean Sea. Rosetta branch is natural barrier between Behira governorate and Monufia, Gharbia and Kafr el-Sheikh governorates. Behira governorate is consisting of 15 conservative administrative centers, six of them overlook on the Rosetta branch: Kom Hamadah, Etay El Barud, Shubrakhit, El Rahmaniyah, El Mahmoudiyah and Rosetta. Agricultural activity and fishing are the main economic activity of such centers.

The goal of this study was to determine the concentrations of two of highly toxic heavy metals namely lead (Pb) and cadmium (Cd) in water samples and muscle of two edible fish species from Rosetta branch in Behira governorate, Egypt.

MATERIALS AND METHODS

Materials

Water and fish samples were taken during October 2013 and March 2014 from six study sites on the Rosetta branch in Behira governorate. These sites are Kom Hamadah (1), Etay El Barud (2), Shubrakhit (3), El Rahmaniyah (4), El Mahmoudiyah (5) and Rosetta (6) (figure 1).

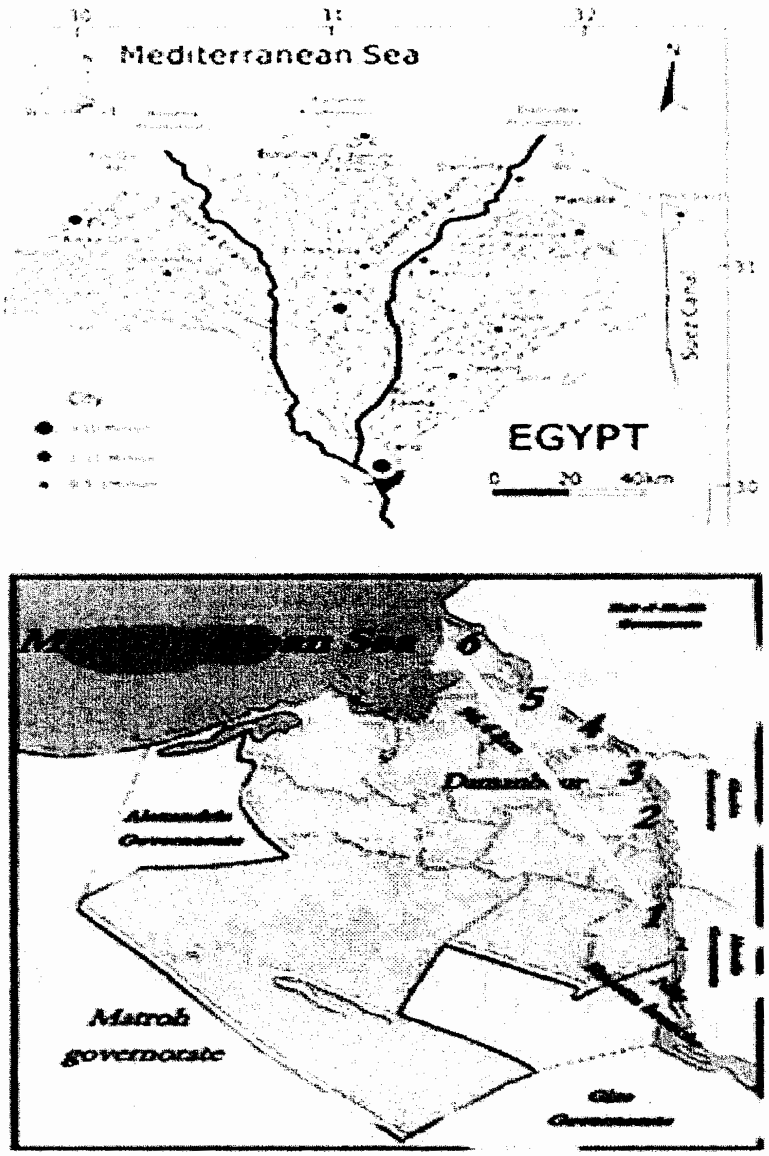

Figure 1: Map of River Nile, Rosetta branch in in Behira governorate, Egypt showing locations of study area.

Sampling procedure

Water samples

Sterilized glass bottles (300 mL) were used to collect the water samples and transported directly to the laboratory.

Fish samples

Two fish species used in this study and their ecological characteristics are shown in Table (1). Healthy and vigorous fish from each of Nile tilapia (192± 3g of weight, 18.4 ± 1.1 cm of total length) and catfish (284± 5g of weight, 31.3 ± 4.7 cm of total length) were caught by fishermen from the different sites at the same day.

Methods

Preparation of Samples

Samples were transport to the laboratory in an ice box on the same day. The soft parts of fish samples were removed and a muscle tissue sample (10 g) was taken from the dorsal muscle in air tight Kilner jar foil and kept frozen (-20 °C) until analysis.

Analytical Methods

Moisture content in fish was determined by drying about 5gm sample at 105±2 °C to constant weight as described by Less (1975).

Ash content was determined by incineration of 2g of each sample in a muffle furnace (Lenton Furnaces, England) at 550°c for 2hours.

The concentration of cadmim and lead in the samples were determined after digestion by using Atomic Absorption Spectroscopy (AAS) according to the method described by (Vitosevic *et al* 2007) .

Statistical Analysis

The data were assessed statistically using SAS software (SAS Institute Inc, Carry, NC., USA). Measured data were analyzed by ANOVA. Duncan's multiple range test was used to determine differences between means. Significance was assumed at ($P \leq 0.05$) (SAS, 1996).

Table (1): Ecological characteristics of fish samples.

Common name	English name	Scientific name	Habitat*	Feeding* mode	Food* source
Bolti	Tilapia fish	*Oreochromis niloticus*	Benthopelagic	Herbivorous	Mainly algae
Quarmote	Catfish	*Clarias gariepinus*	Benthopelagic, mainly littoral	Carnivorous	Fish, aquatic insects, mollusks

* According to Dsikowitzky *et al.* (2013).

RESULTS AND DISCUSSION

Water pollution

Concentrations of the two elements measured in water samples from six sites on Rosetta River Nile (Fig 1) are shown in Table (2). Lead concentrations ranged from 11.9 to 21.5 µg L-1. Between the Nile sampling sites, the concentrations did not differ significantly. Higher concentrations of lead were recorded at sites 3 and 5. Lead concentration at all sites was 4-7 times higher than the accepted level.

Cadmium concentrations in analyzed water samples ranged from 0.5 to 1.9 µg L-1. Higher level of cadmium was recorded at site 5. In general, these values are less than guideline values for drinking water quality from the World Health Organization (WHO, 2008).

Table (2): Lead and Cadmium concentrations (µg L^{-1}) in water samples from different sites of Rosetta River Nile.

Study sites	Lead (Pb)*	Cadmium (Cd)*
1	15.8±0.0001^{c}	0. 6^{d}
2	12.0±0.0002^{d}	0. 5^{d}
3	21.4±0.0002^{a}	0. 6^{d}
4	11.9±0.0003^{d}	1.1^{c}
5	21.5±0.0002^{a}	1.9^{a}
6	18.4±0.0002^{b}	1.4^{b}
WHO	10.0	3.0
ARW	3.0	0.02

*Means in a column not sharing the superscript are significantly different at p≤0.05.

Guideline values for drinking water quality from the World Health Organization (WHO, 2008) and background values for African River Water (ARW, Burton 1976).

Lead and cadmium were detected in raw Nile and in finished drinking water of four treatment plants in greater Cairo during the period September 1993 to August1994 (Mohamed *et al.*, 1998). They found levels of 29.6 µg l^{-1} for lead and 4.15 µg l^{-1} for cadmium, but Gomaa (1995) found concentrations in Nile water 14 and 24 times greater than those obtained by Mohamed *et al.* (1998). Elsokkary and Müller (1990), Zayed *et al.* (1994), Gomaa (1995), Komy and El-Samahy (1995), Soltan and Awadalla (1995), Mohamed *et al.* (1998), Rashed (2001a), Elghobashy *et al.* (2001) and Abdel-Satar (2005) reported monitoring results from several sites of River Nile; their data are summarized in Table (3). Differences in results indicate possible point source contamination and seasonal variations.

Table (3): Lead and cadmium concentrations (µg l^{-1}) in Rosetta River Nile in comparison to other studies on River Nile.

Location	Lead	Cadmium	Source
Rosetta branch	11.9-21.5	0.5-1.9	This study
Cairo	14–327	0.09–11.8	Elsokkary and Müller (1990)
Cairo	4–20	0.2–0.4	Zayed *et al.* (1994)
Aswan – Sahag	22	0.8	Komy and El-Samahy, 1995
Cairo, El-Malek El-Saleh	ND–1100	ND–80	Gomaa (1995)
Aswan	16–40	1.0–4.0	Soltan and Awadalla (1995)
Great Cairo	9.6–26	4.5–7.1	Mohamed *et al.* (1998)
Nasser Lake	ND–0.005	ND–10	Rashed (2001a)
Shoubra El-Kheima, Cairo sector	2	3	Elghobashy *et al.* (2001)
River Nile from Idfo to Cairo	61	nm	Abdel-Satar (2005)

ND= not detectable, NM= not measured

Ash, lead and cadmium in fishes:

The results of total ash content in Nile fish muscles were shown in Table (4). Total ash content in Nile tilapia muscles ranged between 0.83 and 1.22% (wet basis), while the values in catfish muscles ranged from 0.96 to 1.56% (wet basis). The variations in these values for the same kind of fish from different regions may be due to the difference in food chain components in the aquatic environment, which depend on the common manner of pollution in every region. Heavy metal pollution affects water quality and the distribution and diversity of phytoplankton (Ali and Abdel-Salam, 1999). In general, Catfish from all sites had high concentrations of ash compared to Nile Tilapia fish. Chemical composition is known to vary in fishes depending on various factors such as its habitat, feeding behavior and migration even in the same area (Andres *et al.*, 2000; Canli and Atli, 2003).

Table (4): total ash concentration (gm/100 gm wet basis) in Nile tilapia and catfish muscles.

Study sites	Nile tilapia		Catfish	
	Ash %	Moisture%	Ash %	Moisture%
1	0.964 ± 0.012^{c}	78.82 ± 0.78^{b}	1.059 ± 0.009^{d}	78.75 ± 0.74^{a}
2	0.895 ± 0.01^{cd}	79.15 ± 0.52^{a}	1.242 ± 0.008^{c}	78.71 ± 0.86^{a}
3	1.224 ± 0.009^{a}	80.06 ± 0.86^{a}	1.392 ± 0.009^{b}	77.05 ± 0.81^{b}
4	1.021 ± 0.009^{b}	79.16 ± 0.62^{a}	0.957 ± 0.009^{e}	76.54 ± 0.42^{b}
5	1.062 ± 0.012^{b}	77.92 ± 0.48^{b}	1.558 ± 0.008^{a}	78.52 ± 0.35^{a}
6	0.8334 ± 0.006^{d}	76.05 ± 0.73^{d}	1.069 ± 0.009^{d}	78.97 ± 65^{a}

Means ± SD in a column not sharing the same superscript are significantly different at $p \leq 0.05$.

Fish pollution

The concentrations of lead and cadmium in two studied fish species from the six investigated sites are shown in Table (5). It is clear from the present results that the levels of two metals under study in fishes are much higher than in the water. The higher values of lead were detected in both species muscles from site 6, whereas the lower values were detected in tilapia and catfish muscles from site 3. The average lead concentrations were detected in the following ascending order: 3<4<5<1<2<6. In general, cadmium concentrations in tilapia and catfish ranged from 0.16 to 0.25 µg Kg^{-1}, from 0.19 to 0.29 µg Kg^{-1} (wet weight), respectively. Higher cadmium concentrations were detected in fishes from site 1, while the lower values were detected in fishes from site 4.

Various forms of metals in the sediment and in water are taken up by aquatic life and accumulated in very high concentration factors with respect to the environment. However, not all metals are accumulated, within organs and tissues, in the same manner (Adham *et al.*, 1999).

Table (5): Lead and cadmium concentration (µg Kg^{-1} wet basis) in Nile tilapia and catfish muscles.

Study sites	Nile tilapia		Catfish	
	Pb	Cd	Pb	Cd
1	21.87 ± 0.021^{b}	0.25 ± 0.0003^{a}	17.76 ± 0.009^{c}	0.29 ± 0.0001^{a}
2	22.12 ± 0.029^{b}	0.20 ± 0.0005^{bc}	18.52 ± 0.015^{b}	0.26 ± 0.0002^{b}
3	$19.82 \pm .0018^{d}$	0.23 ± 0.0002^{ab}	13.05 ± 0.036^{f}	0.24 ± 0.0001^{b}
4	20.67 ± 0.022^{c}	0.16 ± 0.0003^{d}	14.55 ± 0.032^{e}	0.19 ± 0.0002^{c}
5	21.23 ± 0.041^{c}	0.22 ± 0.0002^{b}	16.55 ± 0.011^{d}	0.28 ± 0.0001^{a}
6	24.98 ± 0.031^{a}	0.19 ± 0.0002^{c}	19.89 ± 0.012^{a}	0.28 ± 0.0001^{a}

- **Means ± SD in a column not sharing the same superscript are significantly different at $p \leq 0.05$.**

The concentrations of lead and cadmium in fish muscles from some other parts of the Egyptian aquatic environment that are published in this respect, are given in Table 6. Comparison with our data revealed that the levels are generally comparable.

Table (6): Lead and cadmium concentrations (µg kg^{-1} wet basis) in fish muscles reported in some studies.

Location / fish species	Lead	Cadmium	Source
River Nile, Rosetta branch (*O. niloticus*)	19.82-24.98	0.16-0.25	Present study
River Nile, Rosetta branch (*C. gariepinus*)	13.05-19.89	0.19-0.29	Present study
Suez fish farm (*O. niloticus*)	1.65	NM*	Shereif and Mancy (1995)
Fish farm in Lake Manzala (*O. niloticus*)	11.25	NM	Shereif and Mancy (1995)
Shanawan drainagecanal,Al MinufiyaProvince(*O. niloticus*)	48.7	5.3	Khallaf *et al.* (1998)
High Dam Lake, Aswan	130	18	Rashed (2001b)
River Nile (Shoubra El-Kheima, Cairo sector) (*O. niloticus*)	1.22	0.04	Elghobashy *et al.* (2001)
Private fishfarmatFayoumGovernorate,Egypt (*Tilapia sp*).	6.381	0.096	Mansour and Sidky (2002)
El-Shoura fishfarminEl-FayoumProvince,Egypt (*Tilapia sp*).	6.5	2.2	Ali and Abdel-Satar (2005)
Sabal DrainageCanal,Al-MinufiyaProvince (*O. niloticus*)	31.95	3.4	Authman (2008)
Illegal fishfarm in Sabal drainage canal (*O. niloticus*)	3.023	4.354	Authman *et al*, 2012
Permissible limits	2.0	0.5	WHO (World Health Organization) (1993)

NM= not measured

Muscles represent the edible part of fish. Rashed (2001b) found that cadmium and lead were higher in the scale and vertebral column than in the other tissues (muscle, gill, stomach, intestine and liver), while low cadmium and lead levels found in muscle.

The FAO/WHO has set a limit for heavy metal intake based on body weight. For an average adult (60 kg body weight), the provisional tolerable daily intakes (PTDI) for lead and cadmium are 214 and 60µg, respectively (Joint FAO/WHO Expert Committee on Food Additives, 1999). Finally, it can be concluded that the consumption of average amounts of studied tilapia and catfish does not pose a health risk for the consumer.

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تركيز الرصاص والكادميوم فى سمك البلطى والقرموط من فرع رشيد، نهر النيل، مصر

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تم تقدير الرصاص والكادميوم في الماء وعضلات سمك البلطي وسمك القرموط المصاد من نهر النيل فرع رشيد بمحافظة البحيرة؛ لتقييم التلوث في المياه بهذين العنصرين من المعادن الثقيلة.

وقد تراوح تركيز الرصاص في مياه نهر النيل من ١,١ إلى ٢'ميكروجرام / لتر، ٠,٥ ، والكادميوم من ٠,٥ إلى ١,٩ ميكروجرام/ لتر. وأما تركيز الرصاص في عضلات سمك البلطي فتراوح من ١٩,٨٢ إلى ٢٤,٩٨ ميكروجرام/ كجم، وفي عضلات سمك القرموط تراوح من ١٣,٠٥ إلى ١٩,٨٩ ميكروجرام/ كجم على أساس وزن رطب. وأما الكادميوم فقد تراوح في عضلات سمك البلطي من ٠,١٦ إلى ٠,٢٥ ميكروجرام / كجم، وفي سمك القرموط من ٠,١٩ إلى ٠,٢٩ ميكروجرام/ كجم على أساس وزن رطب.

وبصفة عامة؛ فإنّ تلك التركيزات أقل من الحدود الحرجة التي أشارت اليها منظمة الأغذية والزراعة، ومنظمة الصحة العالمية.