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SOME HEAVY METALS CONCENTRATIONS IN WATER AND TILAPIA (*Oreochromis niloticus*) MUSCLES OF FISH FARMS SUPPLIED BY THREE DIFFERENT WATER SOURCES

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Abstract

This study was carried out on three fish farms in Sharkia governorate during the period from May to November 2016. The water supply sources of the studied farms were Nile water through the Ismailia canal, agricultural drainage water through El-Wady drain and sewage drainage water from Bahr El Bakar drain. Heavy metals concentrations of iron (Fe), copper (Cu), Cadmium (Cd), lead (Pb), zinc (Zn), and manganese (Mn), were appraisal in water and muscles of Tilapia (***Oreochromis niloticus***) collected from the three fish farms to evaluate the contamination by metals in these farms using Atomic Absorption spectrometry (AAS). The obtained results indicated significant difference between selected heavy metals in water of the three farms. The results revealed that Fe, Zn, Cu, Mn, Pb and Cd concentrations were higher in fish muscles than water in areas under investigation. There was significant difference among months for Cd, Fe, Mn, Pb and Zn metals concentrations also there was significant difference among farms for Fe, Mn, and Zn metals concentrations in water. Iron (Fe) had the highest mean concentration while Pb exhibited the lowest one in fish muscle. It is worth to mention that the concentrations of heavy metals in the fish muscle were always higher than that in water. The mean metals concentration in the fish muscle decreased in the order: Fe > Zn >Cu > Mn > Cd > Pb. The mean concentrations of all metals in water and edible muscles of fish with the exception of Fe, Zn in the farms were found below the notified permissible limits.

Keywords: Fish farms, heavy metals, *Oreochromis niloticus*, Tilapia, water, Egypt

INTRODUCTION

Due to industrialization, the number of factories and population has increased rapidly. The contamination of freshwaters and agriculture waters with a wide range of pollutants has become a matter of concern over the last few decades (Canli and Kalay 1998; Dirilgen, 2001 and Vutukuru, 2005). The natural aquatic systems have been extensively be contaminated with heavy metals released from domestic, industrial and other man- made activities (Velez and Montoro 1998) and due to the uses of pesticides and fertilizers in agriculture purposes (Santos *et al.,* 2005; Singh *et al.,* 2007). In aquatic ecosystems, heavy metals have received considerable attention due to their toxicity and accumulation in biota (Dural *et al.*, 2006). Heavy metal contaminations have devastating effects on the ecological balance of the recipient environment and a diversity of aquatic organisms (Ashraj, 2005; Vosyliene and Jankaite, 2006). Among animal species, fishes are the inhabitants that cannot escape from the detrimental effects of these pollutants (Olaifa *et al*., 2004). Fish are considered as one of the most sensible aquatic organisms to toxic substances present in water (Alibabić *et al*., 2007) and the same time considered as the major part of the human diet due to high protein content, low saturated fat and sufficient omega fatty acids which are known to support good health therefore, heavy metals load in fish has become an important worldwide concern, not only because of the threat to fish but also due to the health risks associated with fish consumption (Begum *et al.,* 2013). Fish accumulate toxic chemicals such as heavy metals directly from water and diet, and contaminant residues may ultimately reach concentrations hundreds or thousands of times above those measured in the water, sediment and food (Goodwin *et al.,* 2003; Labonne *et al.,* 2001; Osman *et al.,* 2007). Heavy metals may accumulate in fish either through direct consumption of water or by uptake through epithelia like the gills, skin, and digestive tract (Burger *et al.,* 2002). Multiple factors including season, physical and chemical properties of water can play a significant role in metal accumulation in different fish tissues (Hayat *et al.,* 2007; Romeo *et al.,* 1999) Eventually, dietary intake of these metals poses risk to human health as fish occupied a significant part of human diet (Turkmen *et al.,* 2005), for these reasons, this study was conducted to assess and compare heavy metals contamination in muscle tissues (edible part) of fish cultured in ponds received fresh, agriculture and sewage drainage water which could poses a threat to human health (consumers).

MATERIALS AND METHODS

Study area:

This study was carried out at three different fish farms supplied with different water sources:-

1. Farm (1): located at the world fish at Abbassa, Abou-Hammad, Sharkia governorate that is provided by Nile water through Ismailia Canal mixed

with underground water.

2. Farm (2): located at Central Laboratory for Aquaculture Research (CLAR), Abbassa, Abou-Hammad, Sharkia governorate, production fish farm which supplied with agriculture drainage water through El-Wady drain canal.

3. Farm (3): a private fish farm at El Hessania, Sharkia governorate, and it is supplied with sewage water from Bahr El- Bakar drain. Each fish farm was stocked with Nile tilapia (*Oreochromis-niloticus*).

4. Each farm was stocked with Nile tilapia (*Oreochromis niloticus*) at rate of 1.0 fish/m^2 for the three farms.

Specimens collecting and equipment

Water: Three water samples from three fish ponds were collected monthly from each farm during the study period (May –November 2016). Water samples were collected by a PVC vertical water sampler from at least five spots in the pond between 9.00 am and 12.00 pm at a depth of 30 cm below the water surface and mixed together in a plastic container according to Boyd (1990). One liter of water samples at each pond was placed in polyethylene bottles previously washed with acid (0.01 N HNO_3) and rinsed by distilled water, then placed in a cooler at 4° C and transferred to the lab for further analysis. The samples were digested by nitric acid digestion method for total metals concentration according to APHA (2000).

Fish: A number of fish samples, Nile tilapia (*Oreochromis-Niloticus*), of approximately similar size were collected monthly from each farm by a net during the study period. The fish samples were dissected and suitable weight of dorsal muscle tissues were taken placed in polyethylene bags and stored at -20° C until analysis. About 1.0 g from previously oven dried muscle tissues was ignited and digested with concentrated HNO_3 and HCl according to procedures recommended by AOAC (2005).

Finally, all samples were analyzed using Flam Atomic Absorption Spectrophotometer (Thermo Electron Corporation S Series AA Spectrometer) for cadmium (Cd), copper (Cu), iron (Fe), Manganese (Mn), Lead (Pb) and zinc (Zn) as mg/L for water and μg/g dry weight (dw) for muscle tissues.

Statistical analysis:

Two-way ANOVA was employed to evaluate the variability of the concentration of each metal with respect to different seasons and farms, using the software CoStat ver. 6.4 (CoStat, CoHort software, USA). The analyzed data were expressed as mean ± standard error (SE). The inter-elemental relationships were performed through Pearson's correlation coefficient matrix. Significant differences are stated at $P<0.05$ (Bailey, 1981).

RESULTS AND DISCUSSION

The present study assessed concentration of six heavy metals (Cd, Cu, Fe, Mn, Pb and Zn) in water collected from the three selected fish farms. The results are shown in Table (1). The results show that all the tested metals were present in all the samples of water collected from selected three farms.

Among the studied heavy metals Cadmium (Cd) was detected only in May in the three farms with concentration (0.001, 0.015 and 0.002 ppm) in farm (1), farm (2) and farm (3) respectively and detected in October and

November with concentration (0.001 and 0.002 ppm) in farm (1) respectively. These concentrations are below the permissible limits and These values are very far lower than those obtained by Authman *et al.*, (2013) in Sabal drainage canal water where they found Cd concentration varies between 0.840 mg/L at summer and 1.82 mg/L at autumn with the mean of 1.37 mg/L. Abdel-Khalek (2015) recorded a lower range of 0.0072-0.0147 mg/L. The cadmium concentration disappears in the other two farms (2 and 3) till the end of the study period as illustrated in Table (1). Cadmium concentration at farm (2), which supplied with agriculture drainage water, was detected, whereas it not detected at farm (3) which supplied with sewage water. This may be due to the fact that agriculture drainage water rich in phosphate fertilizers which is considered the main source of cadmium, as cadmium constitutes up to 35 mg /kg of phosphorous pentoxide, a component of phosphate-based fertilizers (IARC, 1993). Muntau and Baudo (1992) found that more cadmium was released from agricultural and urban run-off than from industrial and municipal sewage treatment plants. Analysis of variance showed that there is a statistically significant variation between months ($P < 0.05$).

Copper (Cu) concentration showed similar pattern for minimum and maximum values at the three farms. It had levels of 0.001 to 0.156 mg/L at farm (1) and 0.001 to 0.040 mg/L at farm (2) and 0.001 to 0.006 mg/L at farm (3). Moreover there are months, where Cu disappears in all farms as shown in Table (1). The mean concentrations of Cu were 0.0022, 0.008 and 0.001 mg/L in farm (1), (2) and (3) respectively. The lowest value record in farm (3). This is may be due to its high value of water hardness.

The highest concentration of Fe was (53.522, 18.77 and 14.02 mg/l) in Farm (2), farm (1) and farm (3) in July, August and May respectively. It is clear from Table (1) that the iron concentration in farm (2) (agriculture drainage water) is higher than that in farm (1) (Nile water) and the lowest mean in farm (3) (sewage drainage water) with mean value 27.98, 10.02 and 7.55 mg/L respectively. This may be due to the fact that agriculture drainage water rich in iron fertilizers. This mean concentration is higher than that obtained by Badr *et* *al*. (2014) (3.05 mg/L) in the Nile river at El Tebeen district. Analysis of variance showed that there is a statistically significant variation between months, between farms and the interaction between farms and months ($P < 0.05, 0.0001$).

On the other hand, the concentration of Mn revealed irregular variation among months, with mean concentration values (0.58, 0.37 and 0.10 mg/L) in farm (2), farm (3) and farm (1) respectively. These results are much lower than that obtained by Baidoo *et al*. (2012) at two different points in waste water-fed pond in Ghana (3.28 and 4.4 mg/L). Analysis of variance showed that there is a statistically significant variation between months, between farms and between farms and months ($P < 0.05$).

Lead (Pb) had the lowest concentration in all fish samples collected. The highest concentration of Pb (0.1 ppm) was observed in June in farm (3) and decreased gradually with months till 0.01ppm and disappear in October and November for this farm. While it disappears in all months in farm (1) except June with concentration of 0.02 ppm and it appear only in May with concentration of 0.05 ppm in farm (2).

Finally, Zinc (Zn) showed similar pattern for minimum and maximum values at the three studied farms but the range of concentration of Zn has higher levels 0.05 - 0.59 mg/L at farm (2) than the other two concentration levels at farms (1 and 3) 0.02 - 0.14 and 0.02 - 0.08 mg/L, respectively, as it is shown in (Table 1). The mean concentrations values of Zinc were 0.08, 0.26 and 0.04 in farm (1, 2 and 3) respectively. Analysis of variance showed that there is a statistically significant variation between months, between farms and their interaction ($P < 0.05$). Monthly, the results in Table (1) showed that the concentration of metals exhibited irregular pattern during different months. The order of metals concentrations in water at the three fish farms was as follows: Fe > Mn > Zn > Pb > Cu > Cd

Saeed (2013a) found the same pattern for heavy metals concentration in water at Al-Abbassa and Maruit fish farms.

Metals concentration varied significantly ($P < 0.05$) between the three fish farms through different months, except cupper (Cu) and Lead (Pb) concentration that showed no significant difference. These monthly variations may be due to the fluctuation of the amount of agricultural drainage water, untreated domestic sewage and industrial wastes discharged into the canals and drains which feed ponds (Authman *et al*., 2008). The seasonal variations of metals in water have been reported by different authors at different water bodies in Egypt: at Shanawan drainage canal (Khallaf *et al*., 1998); at Lake Manzala (Bahnasawy *et al*., 2011) and at Sabal drainage canal (Authman *et al*., 2013). Generally all mean metals concentration in water in the three farms except (Fe) and Cu in farm (1), (Zn) in farm (2) are under chronic Criterion Continuous Concentration (USEPA, 2006) for protection of freshwater aquatic life, and the Egyptian Chemical Standards (ECS, 1994) for the maximum permissible limits of heavy metals in surface water.

Heavy metals in *Oreochromis niloticus* fish muscle.

The study of heavy metal concentrations in fish muscles are decisive where it's the main edible part of fish and can directly influence human health (Pintaeva *et al.,* 2011). This work studied the metal contamination in Nile tilapia (*Oreochromis-niloticus*) as it's the most familiar and popular fish that represents about 75 % of freshwater farmed fishes in Egypt. The variations in the concentrations of (Cd, Cu, Fe, Mn, Pb and Zn) in muscle tissues of fish samples collected from farm (1), farm (2) and farm (3) fish farm are shown in Table (2). There is no significant ($P > 0.05$) variation for all metals concentration in the three farms. Tekin-Özan and Kir (2008) described that bioavailability of metals may influenced by physiological activities of fish during different seasons. The total mean values of Fe concentrations were 1135.4, 612.2 and 455.3 µg/g dry weight in farm (1), (2) and (3) respectively. The concentration of Fe revealed irregular variation among months, where the maximum concentration was recorded at the first four months May, June, July and August in farm (1) with concentration of 2022.47, 1548.16, 1289.94 and 2644.37 µg/g dw respectively. While in farm (2) with concentration of 583.74, 1548.16, 579.93 and 453.16 μg/g dw, respectively while in farm (3) with concentration of 568.263, 491.71, 225.11and 1154.80 μg/g dw, respectively. These results are much too higher than that obtained by Emara *et al*. (2015) at two different points in waste water-fed pond in Egypt (109.15 & 106.86 μg/g dw). Saeed (2013b) recorded Fe annual mean (61.94, 76.71 and 84.02 μg/g dw) for *O. niloticus, O. aureus*, Tilapia zillii collected from Lake Edku, Egypt, respectively. Analysis of variance showed that there is no statistically significant variation between months, between farms and between farms and months ($P > 0.05$).

The accumulation levels of metals in muscle tissues have been detected in the order: Fe > Zn > Cu > Mn > Cd > Pb > Cd which approximately agrees with those obtained by Abdel-Khalek (2015) in muscle tissues of Nile tilapia at southern part of river Nile at Shoubra El-Khaema. This also complies with (Watanabe *et al.,* 2003; Masoud *et al*., 2007) who mentioned that, bioaccumulation of metals in tissues varies from metal to metal. Moreover, Koca *et al*. (2005) postulated that the accumulation patterns of contaminants in fish and other aquatic organisms depend on both uptake and elimination rates of contaminants. Table (2) showed that the concentration mean of Mn in fish muscles was (1.56, 2.44 and 10.0 μg/g dw) for fish farms (1), (2) and (3) these levels are higher than (2.2 μg/g dw) obtained by Abdel-Khalek (2015).

Table 1. Monthly mean (±SE) of heavy metals concentration in water (mg/L) of the three studied fish farms during May-November 2016 at Sharkia government.

Month		Cd	Cu	Fe	Mn	Pb	Zn
May	Farm 1	0.001±0.0005	0.001±0.0008	5.82±2.72c	0.08±0.02f	0.00±0.002	0.14±0.05de
	Farm 2	0.015±0.0095a	0.040±0.0040	29.83±3.11abc	0.47±0.12bcd	0.05±0.044	0.47±0.12ab
	Farm 3	0.002±0.0015b	0.006±0.0058	14.02±2.75c	0.10±0.03f	0.00±0.000	0.05±0.02de
June	Farm 1	0.00±0.00b	0.000±0.0000	14.64±6.64bc	0.12±0.01def	0.02±0.021	0.02±0.00de
	Farm 2	0.00±0.0003b	0.000±0.0001	16.06±1.62bc	0.34±0.03bcdef	0.00±0.000	0.34±0.03bc
	Farm 3	0.00±0.00b	0.000±0.0000	12.19±5.19c	1.16±0.21a	0.10±0.098	0.05±0.02de
July	Farm 1	0.00±0.00b	0.000±0.0000	12.81±4.26c	0.10±0.00ef	0.00±0.001	0.08±0.02de
	Farm 2	0.00±0.00b	0.015±0.0065	53.522±1.24a	0.59±0.07b	0.00±0.000	0.59±0.07a
	Farm 3	0.00±0.0003b	0.000±0.0003	9.38±0.38c	1.00±0.06a	0.07±0.066	0.03±0.01de
August	Farm 1	0.00±0.00b	0.000±0.0000	18.77±8.84bc	0.15±0.01cdef	0.00±0.000	0.12±0.04de
	Farm 2	0.00±0.00b	0.000±0.0000	1.00±0.44c	0.06±0.02f	0.00±0.000	0.06±0.02de
	Farm 3	0.00±0.00b	0.000±0.0000	4.81±0.02c	0.25±0.01bcdef	0.03±0.031	0.07±0.00de
Sept.	Farm 1	0.00±0.0001b	0.003±0.0028	5.55±2.70c	0.07±0.02f	0.00±0.000	0.08±0.02de
	Farm 2	0.000±0.0000b	0.001±0.0005	24.22±3.91bc	0.23±0.04cdef	0.00±0.002	0.23±0.04cd
	Farm 3	0.000±0.0000b	0.000±0.0003	3.00±0.12c	0.45±0.06bcde	0.01±0.007	0.02±0.00de
Oct.	Farm 1	0.001±0.0004b	0.000±0.0000	8.26±0.83c	0.07±0.01f	0.00±0.000	0.07±0.01de
	Farm 2	0.000±0.0000b	0.003±0.0012	29.79±1.85abc	0.19±0.03cdef	0.00±0.000	0.11±0.06de
	Farm 3	0.00±0.00b	0.001±0.0004	3.66±0.28c	0.48±0.14bc	0.00±0.000	0.02±0.00e
Nov.	Farm 1	0.002±0.0021b	0.156±0.1558	4.30±0.70c	0.04±0.01f	0.00±0.000	0.07±0.01de
	Farm 2	0.00±0.0003b	0.002±0.0006	42.24±1.84ab	0.18±0.03cdef	0.00±0.000	0.05±0.03de
	Farm 3	0.00±0.00b	0.001±0.0001	2.92±0.49c	0.46±0.09bcde	0.00±0.000	0.08±0.01de
Mean	Farm 1	0.0006	0.022	10.02	0.1	0.002	0.082
	Farm 2	0.002	0.0087	27.98	.588	0.007	0.264
	Farm 3	0.0003	0.0011	7.55	0.372	0.03	0.045
USEPA (2006)[a] Permissible limits		0.0025	0.013	1.0	-	0.0025	0.12
ECS (1994) Permissible limits		0.01	1.0	1.0	-	0.05	5.0
Two way ANOVA		*P value*					
Month		0.019	0.458	0.026	0.0001	0.603	0.0001
farm		0.214	0.49	0.0001	0.0001	0.222	0.0001
Month × farm		0.059	0.388	0.0001	0.0001	0.64	0.0001

a = Criterion Continuous Concentration (chronic) for protection of freshwater aquatic life
ESC= Egyptian Chemical Standar

Table 2. Monthly mean (±SE) of heavy metals concentrations in *O. niloticus* muscle (µg/g dw) of three different fish farms at Sharkia government during May-November 2016.

Month		Cd	Cu	Fe	Mn	Pb	Zn
may	Farm 1	0.401±.064	3.165±.47	2022.47±1344.47	1.96±.23	0.07±.05	179.35±57.33
	Farm 2	0.34±.11	2.26±.172	583.74±201.26	1.64±.02	0.47±.16	87.84±9.74
	Farm 3	0.00±.00	2.29±.47	5682.63±5408.24	1.94±.06	0.00±.00	126.57±47.01
June	Farm 1	0.00±.00	2.13±.427	1548.16±248.50	1.88±.37	0.00±.00	104.03±18.35
	Farm 2	0.015±.015	3.52±1.12	1205.57±610.99	8.86±7.68	0.00±.00	157.74±15.20
	Farm 3	0.00±.00	1.65±.16	491.71±272.01	1.06±.24	0.047±.047	68.74±22.08
July	Farm 1	0.078±.039	2.14±.23	1289.94±196.05	1.57±.18	0.00±.00	85.54±16.26
	Farm 2	0.078±.039	3.60±.302	579.93±207.38	1.07±.02	0.00±.00	92.92±14.30
	Farm 3	0.011±.011	1.63±.136	225.11±18.29	.98±.03	0.00±.00	70.66±9.61
August	Farm 1	0.00±.00	1.78±.23	2644.37±2528.52	1.92±.40	0.00±.00	125.17±62.90
	Farm 2	.233±.23	2.51±.34	453.16±219.25	1.74±.25	0.00±.00	70.04±12.40
	Farm 3	.125±.125	1.954±.303	1154.80±917.03	1.38±.67	0.00±.00	147.74±64.30
Sept.	Farm 1	0.00±.00	11.16±10.13	286.63±156.85	1.16±.139	0.01±.01	90.20±9.26
	Farm 2	0.00±.00	4.94±1.77	538.08±168.28	1.57±.11	0.00±.00	108.50±11.65
	Farm 3	0.00±.00	1.62±.34	198.97±50.98	1.09±.07	0.00±.00	60.21±5648
Oct.	Farm 1	0.022±.006	9.78±8.50	118.33±23.99	.86±.09	0.00±.00	54.78±7.95
	Farm 2	0.004±.004	1.84±.425	401.24±60.57	.77±.06	0.00±.00	72.79±9.21
	Farm 3	0.00±.00	1.22±.132	242.002±38.46	.58±.10	0.00±.00	48.96±1.15
Nov.	Farm 1	0.543±.543	17.63±15.67	166.66±20.07	1.57±.11	107.6±107.6	88.87±35.12
	Farm 2	0.012±.012	1.85±.59	527.54±72.40	1.40±.25	.00±.00	145.39±4.91
	Farm 3	0.003±.003	.98±.05	306.33±68.26	.96±.04	.00±.00	97.16±11.92
Mean	Farm1	0.15	6.83	1153.52	1.56	0.01	103.99
	Far^{m2}	0.10	2.93	612.75	2.44	0.07	105.03
	farm3	0.02	1.62	478.93	1.14	0.007	88.58
***PL (mg/day) wet wt.**		0.05	50	50	10	0.214	30
Two way ANOVA				*P value*			
Month		0.177	0.774	0.281	0.359	0.439	0.066
farm		0.211	0.092	0.679	0.352	0.378	0.492
Month × farm		0.339	0.744	0.718	0.542	0.465	0.203

*Permissible limits (average daily intake in wet wt.), Fe, Cd and Pb according to guidelines in WHO, 2011. Cu as in IPCS (1998), Zn and Mn as in (SCF, 1993).To compare with PL: Wet weight conc. = dry wt. x (100 -% moisture) / 100.

Wide monthly variation in copper (Cu) concentrations was recorded; where it was varied between 1.78–17.63 µg/g dw at farm (1), 1.84–4.94 µg/g dw at (2) and 0.98- 2.29 µg/g dw in farm (3) during study period. This range was higher than those (1.73 and 3.06 µg/g dw) obtained by Al-Kahtani (2009), where the seasonal Cu concentration fluctuated between autumn and summer. The mean concentration of Cu was 6.83, 2.93 and 1.62 µg/g dw in fish muscles in farm (1), (2) and (3) respectively. Abdel-Khalek (2015) found Cu average concentration value of 11.9 µg/g dw in fish muscles. There is no statistically significant variation among Cu levels ($P > 0.05$).

Zinc (Zn) concentration showed wide variation at the three farms, it ranged between 54.78 –179.35 µg/g dw at farm (1), 70.04 –157.74 µg/g dw at farm (2), and 48.96 – 147.74 µg/g dw at farm (3). Taweel et al. (2013) recorded lower Zn concentration values (20.85-26.13 µg/g dw) in muscle tissues of Nile tilapia at Langat River and Engineering Lake in Malaysia. The results showed that there's no significant ($P>0.05$) difference in the mean concentrations (103.99, 105.03 & 88.58 µg/g dw) of Zn in fish muscles between the three farms (1, 2 and 3), respectively. Abdel-Khalek (2015) recorded a value of 63.7 µg/g dw for Zn in muscle of Nile tilapia at southern part of river Nile at Shoubra ElKhaema.

Cadmium (Cd) and lead (Pb) are toxic at low concentrations, non-biodegradable, non-essential heavy metals and have no role in biological processes in living organisms. Thus, even in low concentration, it could be harmful to fish (Badr *et al.,* 2014). The obtained data (Table 2) illustrated that maximum (Cd) concentration was (0.543, 0.233 and 0.125 µg/g dw) in fish muscles at farm (1), (2) and (3) in November and in August for farm (2) and (3), respectively. The mean value concentrations of Cd in fish muscles were 0.149, 0.097 and 0.0198 µg/g dw in farm (1), (2) and (3) respectively. Higher value (10.84 µg/g dw) were obtained by Authman *et al*. (2013). Saeed (2013) recorded values of Cd between 0.13 and 0.49 µg/gdw in autumn and winter in Nile tilapia. The results showed that there's no significant ($P>0.05$) difference in the mean concentrations between the three farms.

Maximum lead (Pb) concentrations were recorded in Maywith values of 0.07, 0.47 µg/g dw in farm (1) and (2) respectively and recorded 0.047 µg/g dw for farm (3) in June, and disappear through time period of study. The results showed that there's no significant (P>0.05) difference in the mean concentrations (0.01, 0.07and 0.007 μg/g dw) of Pb in fish muscles between the three farms (1, 2 and 3), respectively. These concentrations are lower than that (10.20 μg/g dw) obtained by Authman *et al.* (2013).

From Table (2) it exhibits that the mean concentrations of all metals in edible part of fish with the exception of Fe, Zn and Cd in farm (1) and (2) in the farms under studied were found below the notified permissible limits according to WHO 2011. It is worth to mention that the essential metals, such as iron, zinc, copper and manganese are in higher concentrations, presumably due to their function as co-factors for the activation of a number of enzymes and regulated to maintain a certain homeostatic status in fish. On the other hand, the non-essential metals such as cadmium and lead has no biological function or requirement and its concentrations in fishes are generally low (Kumar *et al.*, 2011).

Correlation of metals in fish muscle tissues.

The Pearson's correlation coefficient matrix for the metals was done to determine the correlation between the metals pairs in muscle tissues. Table (3) showed various degrees of correlations between the elements.

There were positive significant correlations (P<0.05) among, Cu and Cd, Pb and Cd, Pb and Cu and Zn and Fe with correlation coefficients (r values) were 0.59, 0.80, 0.76 and 0.47 respectively. On the other hand, there was negative correlated among Cu and Fe; Cu and Zn; Fe and Pb; Zn and Pb with no significant variation (P>0.05) were found between the paired of metals. The correlations between the different metals may be result from the similar accumulation behavior of the metals in fish and their interactions (Rejomon *et al.*, 2010). Also, noted significant correlations among metals which may reflect a common source of occurrence and indicative of similar biogeochemical path ways for subsequent accumulation in the muscle tissue of fishes (Kumar *et al.*, 2011).

Table 3. Correlation coefficient matrix (r) between concentrations of paired metals in *O. niloticus* muscle tissues.

Metal	Cd	Cu	Fe	Mn	Pb	Zn
Cd	1.00					
Sig.						
Cu	0.594**	1.00				
Sig.	0.00					
Fe	0.00	-0.068	1.00			
Sig.	0.99	0.597				
Mn	0.018	0.03	0.03	1.00		
Sig.	0.89	0.79	0.81			
Pb	0.80**	0.762**	-0.047	0.003	1.00	
Sig.	0.00	0.00	0.716	0.98		
Zn	0.019	-0.102	0.471**	0.16	-0.095	1.00
Sig.	0.88	0.43	0.00	0.203	0.459	

** is significant at ($P<0.01$).

The Pearson's correlation coefficient matrix for the metals was done to determine the correlation between the metals pairs in water and muscle tissues. Table (4) showed various degrees of correlations between the elements. It's clear from the Table data that most metals had no significant ($P>0.05$) relationship between their concentration in water and muscle tissues, while Cu has a significant positive ($P<0.05$) correlation between its concentration in water and muscle tissues and also with Cd and Pb with correlation coefficients (r values) were 0.828, 0.747 and 0.987 respectively. The non-significant correlation of metals concentra-tion (with the exception of Cu As mentioned before) may be due to higher concentration in muscle tissues than water and this indicate the metals accumulation in muscles and biomagnification, this agree with the findings of Saleh *et al*. (1985), who reported that aquatic animals can accumulate high and ultimately lethal concentrations of metals over long periods from extremely low water concentrations. Fish accumulate toxic chemicals such as heavy metals directly from water and diet, and contaminant residues may ultimately reach concentrations hundreds or thousands of times above those measured in the water, sediment and food (Goodwin *et al*., 2003; Labonne *et al*., 2001; Osman *et al*., 2007).

Table 4. Correlation coefficient (r) and probability (P) showing the relation among the concentration of heavy metal in water and in fish muscles of *Oreochromis-niloticus*.

parameter	**Cd** Muscle	**Cu** Muscle	**Fe** Muscle	**Mn** Muscle	**Pb** Muscle	**Zn** Muscle
Cd water	0.217	0.107	-0.021	0.022	0.152	-0.010
Sig.	0.09	0.403	0.872	0.862	0.235	0.935
Cu water	0.828**	0.747**	-0.057	-0.002	0.987**	-0.107
Sig.	0.00	0.00	0.66	0.989	0.00	0.405
Fe water	-0.048	-0.106	-0.043	0.029	-0.087	0.049
Sig.	0.709	0.409	0.739	0.819	0.499	0.705
Mn water	-0.135	-0.195	-0.160	-0.075	-0.113	-0.198
Sig.	0.291	0.126	0.210	0.559	0.378	0.120
Pb water	0.042	-0.068	0.001	-0.019	-0.032	0.006
Sig.	0.745	0.598	0.996	0.885	0.801	0.963
Zn water	0.164	-0.018	-0.067	0.132	-0.050	0.082
Sig.	0.200	0.890	0.600	0.302	0.695	0.522

** is significant at ($P<0.01$).

CONCLUSION

This study gives valuable information on the heavy metals in Water and fish muscles (edible tissues) in the three farms. The results of this study indicated no significant accumulation of heavy meals in the fish musculature of the three farms. This study confirms previous reports on the altered water quality of water bodies as a result of discharging the industrial, agricultural and sewage effluents, which affect directly water quality and fish health and might represent a risk for human health indirectly. Some of the measured parameters exceeded the permissible limits recommended by regulatory agencies. It is recommended to treat different wastes before discharging to the natural water sources to avoid the negative effects of pollutants on aquatic life.

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تركيز بعض العناصر الثقيلة فى عضلات أسماك البلطى فى المزارع التى تروى بمصادر مياه مختلفة

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الملخص العربي

أجريت هذة الدراسة ببعض المزارع السمكية فى منطقة العباسة والحسينية بمحافظة الشرقية خلال موسم الاستزراع من مايو– نوفمبر 2016 للتعرف على دور نوع المياه التى تروى بها المزارع السمكية فى تراكم بعض العناصر الثقيلة فى عضلات أسماك البلطى وتركيز هذه العناصر فى المياه أيضا حيث تم اختيار 3 مزارع بمحافظة الشرقية.

المزرعة الأولى تروى بمياه عذبة من النيل ومياه ارتوازية وتقع فى المركز الدولى للأسماك بالعباسة، المزرعة الثانية تروى بمياه صرف زراعى وتقع فى المعمل المركزى لبحوث الثروة السمكية أما المزرعة الثالثة تروى بمياه صرف صحي وتقع فى منطقة الحسنية.

وأوضحت النتائج وجود فارق معنوى فى تركيز العناصر الثقيلة تحت الدراسة فى مياه المزارع السمكية .وأوضحت النتائج أيضا أن تركيز العناصر الثقيلة أعلى فى عضلات السمك من تركيزها فى مياه المزارع. وأكدت النتائج على وجود فروق معنوية بين تركيزات العناصر شهريا فيما عدا النحاس فى عضلات الأسماك، بينما ظهر فرق معنوى فى كلا من عناصر الحديد والمنجنيز والزنك بين المزارع الثلاثة جئاتنلا تحضوؤ أن تركيز العناصر الثقيلة فى عضلات الأسماك كان ترتيبها من الأعلى إلى الأقل كالآتى الحديد –الزنك –النحاس –المنجنيز –الكادميوم –الرصاص وكان متوسط تركيز جميع العناصر فى الماء وعضلات السمك ماعدا الحديد والزنك أقل من الحدود المسموح بها عالميا.