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Bioaccumulation of heavy metals in tilapia fish organs

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Abstract

The bioaccumulation of Fe, Mn, Zn, Cu, Pb and Cd in the muscle, bones and gills of Nile tilapia, Mango tilapia and Tilapia zillii collected from four Rayahs (canals) namely from El Tawfiky, El Menoufy, El Behery, and El Nasery Rayahs, River Nile were investigated during spring 2014 till winter 2015. The results indicated that, heavy metals showed differential bioaccumulation in fish organs muscle, gills and bones, and the accumulation pattern as total heavy metal residues was seasonally as follows: spring> summer> winter> autumn. Moreover, the relative accumulation of total heavy metals in the studied fish showed the following pattern: Nile tilapia <Mango tilapia <Tilapia zillii. Also, higher concentrations of heavy metals were recorded in El-Rayah El-Tawfiky followed by El-Rayah El-Behery> El-Rayah El-Menoufy> El-Rayah El-Nasery. Fe was the most abundant element in all fish organs followed by Zn> Mn> Cu> Pb> Cd. Also, results revealed that, fish muscles have much lower concentrations of all metals than bones and gills and were not significantly different from specie to others. The concentrations of the heavy metal in muscles were within the international permissible level, so fish muscles are safe for human consumption.

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Introduction

The River Nile is recognized as the longest river, and can be considered as one of the most important rivers in the world. At, the North of Cairo at Delta Barrage, the River Nile bifurcates into two branches namely Damietta and Rosetta and four Rayahs (canals) namely El-Nasery, El-Behery, El-Menoufy and El-Tawfiky (Saad and Goma, 1994 and Abdel Aziz, 2005).

The heavy metals in freshwater are a matter of concern because of their toxic potential ability to be accumulated in food chains, therefore mercury and zinc are on first list percent of dangerous substances (Svobodova *et al.* 1993; Dalman *et al.*, 2006). The most important heavy metals from the point of view of water pollution are Zn, Cu, Pb. Cd, Hg, Ni and Cr. Some of these metals (e.g. Cu. Ni, Cr and Zn) are essential trace metals to living organisms, but become toxic at higher concentrations. Other such as Pb and Cd has no known biological function, but are toxic elements (Dudka and Adriano, 1997).

Tilapia is the most familiar and popular fishes in Egypt, as well as, in the Middle East and warm climate countries (Philippart and Ruwet, 1982). Many studies concentrated on the heavy metal bioaccumulation of Tilapia fish species. These researches showed that the accumulating extent of heavy metals in fishes were by far dependent on the different metals, fish species, and the tissues, respectively. Fish are often at the top of the aquatic food chain and may concentrate large amounts of some metals, such as lead, cadmium, chromium, copper, mercury, zinc and iron. These metals accumulate differentially in fish organs and cause serious health hazards to humans. For this reason, the problem of fish contamination by toxic metals has received much attention (e.g. Harms, 1975; Ramos, *et al.*, 1979; Wiener and Giesy,1979; Lowe, *et al.*, 1985; Eisenberg and Topping, 1986; Luckas, 1987; Barak and Mason, 1990; Hernandez, *et al.*, 1990; Gomaa *et al.*, 1995; Abou- Arab *et al.*, 1996; Ibrahim, 1996; Zyadah, 2008; Yacoub and Gad, 2012, Ghannam, *et al.*, 2014). Therefore this study aimed to determine the bioaccumulation of Fe, Mn, Zn, Cu, Pb and Cd in the muscle, bones and gills of Nile tilapia, Mango tilapia and Tilapia zillii collected from four Rayahs (canals) namely El Tawfiky, El Menoufy, El Behery, and El Nasery Rayahs, River Nile from spring 2014 to winter 2015.

Materials and methods

The present study was conducted through the research project of freshwater and lakes division which belongs to the National Institute of Oceanography and Fisheries in order to identify the environmental status of the four Rayahs (canals) namely El Tawfiky, El Menoufy, El Behery, and El Nasery Rayahs, River Nile from spring 2014 to winter 2015.

Study area

El Rayah El Tawfiky

El Rayah El Tawfiky (canal) is a fresh stream, which is used for fishing, irrigation, and navigation and other domestic uses in Egypt.Its length is about 180 km.El Tawfiky Canal begins at the Damietta branch in El Kanater (the only canal branches from Damietta Branch) towards northern which is parallel to the Damietta branch till El Mansoura city and then branched into two sub- channels. The main canal starts from El kanater to El Manzala counting two sub-main branches of El Mansoura. The main characterization of El Tawfiky canal is the existence of several of the powers and water stations on the shore contain great water stations as way station Banha water and water stations own small villages found on both sides of the canal. The First Chanel directed northern to Damietta city. The lack of water is this distinguished. Approximately water vanishes in the Fareskour city. The second Canal is directed eastern to Dekernes, El gamalia and El Manzala and finished in Lake Manzala in the past but now not. This channel has more water than the first channel. At the begging three samples were collected from at the begging, central and end of this section in the city of Manzala.

El Rayah El Behery

At west of delta Behery canal starts from Rosetta branch directed to northwestern parallel to Rosetta branch and west to Giza City. It passes through El Behira city, Koum Hamada, Damanhour city and Alx city. After Damanhour city, El Behery canal joins with El Mahmoudia canal (branched from Rosetta branch) direct to North West Alx City. Its length is about 220 km from Elkanater Elhyria to Alex.

El Rayah El Nasery

Nasery canal begins at Rosetta branch parallel to Behery canal, then directed to North West in direction of Nopareia City. It connected with Noubria canal branched from Kanater Bolin then directed to North West till reaches Mediterranean Sea through Lake Mariut. It is characterized by many huge of water and electricity stations specially after Lake Noubaria.

El Rayah El Menoufy

El Rayah El Menoufy (canal) begins from Rosetta branch through Menoufy City, El Garbia city and El Daqhlia city, then directed north till reaches Gamsa City and south of Lake El Brouls. It has many branches starting from El Monfia lie El Bagoria Canal and Tanta Navigational Canal. The Shebin Sea is the chosen branch for the selected samples which are directed from Santa town, then the El Mahala then Belqas City then El Brouls.It has low level of water in north direction as the results of its branches, till Damietta the branch in Zefta city the water level increases then decreases again after it branches at Bilqas City. It is characterized by a lot of water and electricity plants as other Canals.

Fish samples

Nile Tilapia (*Oreochromis niloticus*); Mango Tilapia (*Sarotherodon galilaeus*) and (*Tilapia zilli*) were collected directly from four Rayahs namely (El Tawfiky, El Menoufy, El Behery, and El Nasery Rayahs) during period from spring 2014 to winter 2015. The mean total lengths and total weights of fish were (25.5 ± 1.32cm and 350 ± 57.73) in Nile Tilapia, (13.5 ± 1.09 and 61 ± 13.07) in Mango Tilapia and (10.02 ± 1.41 and 52.4± 5.26) in Tilapia zilli. Fish samples transported using icebox to the pollution laboratory, National Institute of Oceanography and Fisheries. Fish samples were re-washed thoroughly with potable water then beheaded and dissection to obtain muscle, gills, and bones.

Fig. 1. Sampling area of four canals.

Heavy metals analysis

Fish from each group were dissected to separate organs (flesh, gills and bones) according to FAO methods (Dybem, 1983). The separated organs were put in petri dishes to dry at 105 °C until reaching a constant weight. The separated organs were placed into digestion flasks and then add concentrated nitric acid and perchloric acid (1:1 v/v). The digestion flasks were then heated to 300 ºC until all the materials were dissolved. Digest was diluted with double distilled water appropriately. The elements Fe, Zn, Cu, Mn, Pb and Cd were assayed using an atomic absorption reader (SavantAAS) with GF 5000 Graphite Furnace and the results were given as µg/ g dry wt.

Results and discussion

Iron (Fe)

Bioaccumulation of iron (Fe) in the muscle, bones and gills of Nile tilapia, Mango tilapia and Tilapia zillii collected from El-Nasery, El-Behery, El-Menoufy and El-Tawfiky, River Nile during spring 2014 to winter 2015 are represented in table (1). Generally, mango tilapia fish were not found during autumn in El-Rayah El-Behery.

Table 1. Bioaccumulation of Fe in different tissues of tilapia fish species collected from River Nile Rayahs during spring 2014 to winter 2015.

Fish species	Fish organs	Seasons	Tawfiky	Behery	Nasery	Menoufy
Nile tilapia	Muscle	*Sp*	172.81	77.50	70.80	70.90
		Su	71.30	893.08	40.70	66.10
		Au	51.20	89.30	95.20	49.10
		Wi	66.90	207.30	66.80	51.30
	Bones	*Sp*	386.65	122.20	137.50	159.30
		Su	55.10	55.73	109.50	141.90
		Au	280.70	234.90	817.50	186.90
		Wi	52.40	140.60	76.00	72.30
	Gills	*Sp*	431.16	172.70	353.90	372.20
		Su	352.90	155.01	520.17	391.30
		Au	179.50	154.60	94.50	23.50
		Wi	95.20	415.30	255.80	195.80
Mango tilapia	Muscle	*Sp*	110.50	89.80	64.20	112.00
		Su	79.40	67.10	78.80	38.70
		Au	222.70	NF	35.90	60.40
		Wi	66.60	107.10	96.00	157.80
	Bones	*Sp*	188.10	138.30	114.30	148.60
		Su	136.10	51.30	65.90	81.50
		Au	193.90	NF	110.10	205.60
		Wi	45.50	157.90	109.00	98.10
	Gills	*Sp*	473.34	155.80	176.50	416.10
		Su	245.00	136.70	383.00	303.80
		Au	427.60	NF	59.10	101.50
		Wi	78.10	461.88	382.10	213.70
Tilapia zillii	Muscle	*Sp*	117.27	118.63	140.80	167.78
		Su	50.30	67.70	43.70	66.70
		Au	71.20	72.80	59.60	50.30
		Wi	33.90	161.10	112.10	156.20
	Bones	*Sp*	179.20	233.58	181.20	241.00
		Su	98.20	382.30	64.20	109.90
		Au	97.80	62.30	170.00	408.20
		Wi	34.60	99.50	79.40	86.70
	Gills	*Sp*	400.00	352.39	432.90	692.40
		Su	427.87	403.87	893.08	418.96
		Au	90.60	796.80	130.20	167.70
		Wi	155.30	271.30	649.00	382.90

Sp: spring; *Su*: summer; *Au*: autumn; *Wi*: winter.

The obtained results showed that, the minimum levels of Fe (33.90 µg/g dw) were recorded during winter in the muscles of tilapia zillii collected from El-Rayah El-Tawfiky, while the maximum levels (893.08 µg/g dw) of Fe during summer season in both muscles of Nile tilapia from El-Rayah El-Behery and gills of tilapia zillii from El-Rayah El-Nasery. However, the bioaccumulation of Fe was Rayahs-related as the accumulations of the heavy metals analysed in the sampled fishes were of the following trend: El-Rayah El-Tawfiky> El-Rayah El-Behery> El-Rayah El-Menoufy> El-Rayah El-Nasery, while the order of fish according to highest levels of Fe were: Mango tilapia> Tilapia zillii> Nile tilapia, also, fish organs were in the following trend: gills> bones> muscles.

El-Rayah El-Behery showed higher concentrations of Fe in the muscle of Nile tilapia during summer (893.08 µg/g dw) and winter (207.30 µg/g dw) and also, in tilapia zillii muscles during summer (67.70 µg/g dw), autumn (72.80 µg/g dw) and winter (161.10 µg/g dw). El-Rayah El-Menoufy showed higher concentrations of Fe in the muscle of Mango tilapia during spring (112 µg/g dw) and winter (157.80 µg/g dw) and also, in tilapia zillii muscles during spring (167.78 µg/g dw). El-Rayah El-Tawfiky showed higher concentrations of Fe in the muscle of Nile tilapia during spring (172.81 µg/g dw), and also, in Mango tilapia muscles during summer (79.40 µg/g dw) and autumn (222.70 µg/g dw). The highest value (95.20 µg/g dw) of Fe was recorded in the muscle of Nile tilapia during autumn in El-Rayah El-Nasery. The lowest concentrations of Fe were noticed in Nile Tilapia fish in El-Rayah El-Menoufy followed by Mango tilapia in El-Rayah El-Nasery, and Tilapia zilli in El-Rayah El-Tawfiky. Spring season showed higher concentrations of Fe in comparison with other seasons.

Manganese (Mn)

Bioaccumulation of manganese (Mn) in the muscle, bones and gills of Nile tilapia, Mango tilapia and Tilapia zillii collected from El-Nasery, El-Behery, El-Menoufy and El-Tawfiky, River Nile during spring 2014 to winter 2015 are represented in table (2). Generally, higher concentrations of Mn were recorded in El-Rayah El-Tawfiky> El-Rayah El-Behery> El-Rayah El-Menoufy> El-Rayah El-Nasery. In addition, higher concentrations of Mn were observed in spring> summer> winter > autumn. Fish gills showed higher concentrations of Mn followed by bones, then muscles and Tilapia zilli were higher than others in Mn levels (Table 2). The minimum and maximum levels (0 and 98.10 µg/g dw) of Mn were recorded during summer in the muscle of Tilapia zillii from El-Rayah El-Menoufy, and in bones of Mango tilapia during spring from El-Rayah El-Tawfiky. Mn ranged from (0-56.90 µg/g dw) in muscles, (2.36-98.10 µg/g dw) in bones and (2.10-68.50 µg/g dw) in gills.

Table 2. Bioaccumulation of Mn in different tissues of tilapia fish species collected from River Nile Rayahs during spring 2014 to winter 2015.

Fish species	Fish organs	Seasons	Tawfiky	Behery	Nasery	Menoufy
Nile tilapia	Muscle	*Sp*	56.90	1.80	4.40	10.60
		Su	8.20	45.20	5.50	3.80
		Au	1.10	13.20	4.42	3.97
		Wi	6.00	8.99	5.40	9.80
	Bones	*Sp*	62.10	15.90	2.90	27.20
		Su	15.00	5.60	15.10	14.70
		Au	2.36	14.21	8.85	7.50
		Wi	5.84	8.88	5.16	26.20
	Gills	*Sp*	68.50	2.10	11.40	35.20
		Su	27.10	23.50	23.00	18.60
		Au	6.33	25.94	5.85	5.75
		Wi	7.44	11.00	3.19	30.50
Mango tilapia	Muscle	*Sp*	33.00	0.90	4.60	28.00
		Su	2.20	4.20	10.20	1.10
		Au	35.16	NF	3.52	4.63
		Wi	7.60	7.47	9.40	20.30
	Bones	*Sp*	98.10	8.80	3.70	33.60
		Su	22.50	31.00	13.70	14.90
		Au	41.90	NF	6.60	8.75
		Wi	8.36	11.00	6.13	31.10
	Gills	*Sp*	60.70	9.90	8.20	35.80
		Su	19.70	50.20	27.50	17.20
		Au	29.18	NF	4.82	10.40
		Wi	9.35	13.49	44.60	52.70
Tilapia zillii	Muscle	*Sp*	35.20	41.00	5.50	26.00
		Su	3.20	20.60	4.10	0.00
		Au	3.38	18.00	4.70	9.63
		Wi	4.84	6.34	31.00	29.40
	Bones	*Sp*	52.40	36.10	12.50	32.20
		Su	24.60	39.10	3.10	18.80
		Au	3.77	24.00	6.78	4.78

Fish species	Fish organs	Seasons	Tawfiky	Behery	Nasery	Menoufy
		Wi	7.90	20.67	5.87	6.00
	Gills	*Sp*	45.80	47.60	48.30	34.80
		Su	30.90	23.00	45.20	25.00
		Au	7.68	9.98	22.10	13.10
		Wi	6.37	8.45	41.00	18.00

Sp: spring; *Su*: summer; *Au*: autumn; *Wi*: winter.

Zinc (Zn)

The lowest value of Zn (4.70 µg/g dw) was recorded during autumn in the muscle of Tilapia zillii from El-Rayah El-Behery, while the highest value (153.03 µg/g dw) recorded during winter in the gills of Mango tilapia from El-Rayah El-Nasery (Table 3). Higher concentrations of Zn were recorded in El-Rayah El-Behery> El-Rayah El-Nasery> El-Rayah El-Menoufy> El-Rayah El-Tawfiky, while higher levels of Zn were recorded in Tilapia zillii followed by Mang tilapia and Nile tilapia and organs order were: gills> bones > muscle. The higher concentrations of Zn in the muscle, bones and gills of Nile tilapia, Mango tilapia and Tilapia zilli collected from El-Rayah El-Tawfiky were 80.30, 139.29 and 121.63 µg/g dw; 58.20, 83.70 and 142.20 µg/g dw; 61, 83.20 and 120.86 µg/g dw; respectively, while in El-Rayah El-Behery recorded 98.40, 76.30 and 86; 58.60, 85.90 and 99.80 µg/g dw; 67.30, 128.68 and 137.38 µg/g dw, respectively, also, in El-Rayah El-Nasery recorded 58.40, 117.40 and 110.73 µg/g dw, 49.40, 67.40 and 153.03 µg/g dw and 65.23, 136.46 and 133.55 µg/g dw, respectively. Finally, higher levels of Zn in El-Rayah El-Menoufy were 36.43, 76.30 and 119.91 µg/g dw, respectively, in the muscle, bones and gills of Nile tilapia, while in Mango tilapia were 64.40, 85.30 and 129.24 µg/g dw and in Tilapia zillii were 96.29, 72.20 and 151.50 µg/g dw, respectively.

Table 3. Bioaccumulation of Zn in different tissues of tilapia fish species collected from River Nile Rayahs during spring 2014 to winter 2015.

Fish species	Organs	Seasons	Tawfiky	Behery	Nasery	Menoufy
Nile tilapia	Muscle	*Sp*	80.30	39.00	58.40	34.92
		Su	49.40	98.40	43.90	32.30
		Au	20.93	10.00	21.73	9.27
		Wi	8.40	38.37	36.93	36.43
	Bones	*Sp*	139.29	76.30	72.30	57.43
		Su	76.30	44.60	80.50	76.30
		Au	112.86	58.00	117.40	24.07
		Wi	6.10	47.37	41.29	41.97
	Gills	*Sp*	121.63	73.60	62.20	119.91
		Su	94.30	86.00	110.73	87.10
		Au	47.57	15.80	8.63	7.13
		Wi	21.80	73.80	95.85	52.50
Mango tilapia	Muscle	*Sp*	41.40	51.10	46.90	64.40
		Su	45.70	58.60	49.90	48.90
		Au	58.20	NF	16.77	13.63
		Wi	9.37	33.30	34.58	52.87
	Bones	*Sp*	53.55	69.60	48.10	40.34
		Su	83.70	85.90	67.40	85.30
		Au	44.50	NF	27.40	32.17
		Wi	13.33	61.70	40.24	38.63
	Gills	*Sp*	142.20	86.60	70.00	129.24
		Su	82.70	99.80	97.40	96.10
		Au	43.20	NF	14.40	35.37
		Wi	20.77	78.90	153.03	41.23
Tilapia zillii	Muscle	*Sp*	61.00	56.66	65.23	96.29
		Su	44.10	67.30	40.60	6.18
		Au	15.03	4.70	28.47	31.67
		Wi	5.57	24.70	48.20	40.20
	Bones	*Sp*	82.05	128.68	136.46	72.18

Fish species	Organs	Seasons	Tawfiky	Behery	Nasery	Menoufy
		Su	83.20	103.40	40.20	72.20
		Au	20.10	23.90	12.50	66.27
		Wi	21.83	42.30	40.47	39.93
	Gills	*Sp*	120.86	137.38	133.55	151.50
		Su	92.90	92.00	98.40	92.10
		Au	23.37	133.90	12.90	8.70
		Wi	40.17	48.90	121.80	108.23

Sp: spring; *Su*: summer; *Au*: autumn; *Wi*: winter.

Copper (Cu)

Bioaccumulation of Cu in different tissues of tilapia fish species collected from River Nile Rayahs in the period spring 2014 to winter 2015 are given in Table (4). The lower and higher values of Cu were (0 and 29.80 µg/g dw). Higher values of Cu were found in El-Rayah El-Nasery followed by El-Rayah El-Tawfiky> El-Rayah El-Behery> El-Rayah El-Menoufy. Mango tilapia recorded higher values of Cu followed by Tilapia zillii> Nile tilapia. Fish organs were in the order: gills> bones> muscle.

Table 4. Bioaccumulation of Cu in different tissues of tilapia fish species collected from River Nile Rayahs during spring 2014 to winter 2015.

Fish species	Organs	Seasons	Tawfiky	Behery	Nasery	Menoufy
Nile tilapia	Muscle	*Sp*	0.00	0.00	6.10	0.99
		Su	7.70	6.00	6.70	8.60
		Au	8.30	6.10	5.10	5.90
		Wi	1.30	3.30	18.30	18.60
	Bones	*Sp*	2.10	2.20	4.10	1.10
		Su	11.80	2.80	8.10	6.40
		Au	8.20	12.40	8.50	6.90
		Wi	0.30	2.80	22.20	23.60
	Gills	*Sp*	5.40	1.10	4.80	0.86
		Su	9.70	4.90	7.00	6.40
		Au	6.50	7.30	6.20	5.50
		Wi	2.30	6.40	22.70	29.80
Mango tilapia	Muscle	*Sp*	0.00	5.20	2.80	1.21
		Su	7.80	10.20	11.80	4.10
		Au	7.10	NF	6.20	6.00
		Wi	0.20	1.50	18.00	26.20
	Bones	*Sp*	0.87	3.00	4.10	3.40
		Su	5.00	6.40	10.80	6.60
		Au	8.60	NF	6.80	7.50
		Wi	0.70	2.80	22.40	28.20
	Gills	*Sp*	0.92	5.40	6.40	0.56
		Su	7.80	9.30	15.60	6.80
		Au	10.00	NF	5.20	5.40
		Wi	3.70	4.70	26.80	25.70
Tilapia zillii	Muscle	*Sp*	1.00	0.80	1.53	0.00
		Su	7.50	7.50	2.70	0.00
		Au	7.90	8.30	4.70	8.20
		Wi	0.60	1.40	21.20	26.40
	Bones	*Sp*	2.68	0.90	2.13	1.80
		Su	5.60	7.80	3.30	4.90
		Au	8.80	7.50	5.80	5.90
		Wi	4.60	2.90	22.70	26.60
	Gills	*Sp*	1.14	3.00	2.67	9.40
		Su	9.20	10.30	6.00	3.50
		Au	8.80	5.40	7.00	6.00
		Wi	2.10	3.10	19.10	28.40

Sp: spring; *Su*: summer; *Au*: autumn; *Wi*: winter.

Nile tilapia showed lowest values (0.00 µg/g dw) of Cu in the muscle collected from El-Rayah El-Tawfiky during spring season, while the highest value (29.80 µg/g dw) were recorded in gills collected from El-Rayah El-Menoufy during winter season. Mango tilapia showed lowest values (0.00 µg/g dw) of Cu in the muscle collected from El-Rayah El-Tawfiky during spring season, while the highest value (28.20 µg/g dw) were recorded in bones collected from El-Rayah El-Menoufy during winter season. Tilapia zillii showed lowest values (0.00 µg/g dw) of Cu in the muscle collected from El-Rayah El-Menoufy during spring season, while the highest value (28.40 µg/g dw) were recorded in bones collected from El-Rayah El-Menoufy during winter season.

Lead (Pb)

Bioaccumulation of Pb in different tissues of tilapia fish species collected from River Nile Rayahs in the period spring 2014 to winter 2015 are given in Table (5). The minimum and maximum of Pb concentrations in different tissues of tilapia fish species were (0.00 and 36.90 µg/g dw). Higher values of Pb were found in El-Rayah El-Menoufy> El-Rayah El-Nasery> El-Rayah El-Tawfiky> El-Rayah El-Behery>. Mango tilapia recorded higher values of Pb followed by Nile tilapia> Tilapia zillii. Fish organs were in the order: gills> bones> muscle.

Table 5. Bioaccumulation of Pb in different tissues of tilapia fish species collected from River Nile Rayahs during spring 2014 to winter 2015.

Fish species	Organs	Seasons	Tawfiky	Behery	Nasery	Menoufy
Nile tilapia	Muscle	*Sp*	8.80	4.70	6.70	15.40
		Su	1.60	13.60	0.90	13.90
		Au	11.10	1.40	0.00	0.00
		Wi	9.20	12.00	5.20	0.00
	Bones	*Sp*	2.30	2.80	10.80	15.90
		Su	2.80	16.90	0.50	7.80
		Au	0.00	0.00	3.30	12.00
		Wi	9.70	29.50	3.30	0.00
	Gills	*Sp*	3.40	7.00	10.00	12.00
		Su	5.70	5.40	3.90	7.70
		Au	3.30	2.80	0.00	0.00
		Wi	7.60	10.30	13.50	3.50
Mango tilapia	Muscle	*Sp*	7.50	6.50	0.00	10.70
		Su	6.80	7.20	19.40	2.40
		Au	NF	9.00	11.50	0.50
		Wi	6.60	14.00	4.80	12.70
	Bones	*Sp*	12.80	2.60	0.00	8.30
		Su	6.00	0.10	11.30	6.60
		Au	NF	0.00	6.30	0.00
		Wi	36.90	17.60	13.70	0.90
	Gills	*Sp*	1.50	17.80	0.00	14.80
		Su	5.40	8.10	10.10	4.30
		Au	NF	0.00	0.00	6.50
		Wi	9.70	29.00	6.00	13.80
Tilapia zillii	Muscle	*Sp*	6.90	2.10	15.00	9.40
		Su	3.50	6.00	3.10	16.30
		Au	1.30	0.00	0.00	2.30
		Wi	2.70	0.00	0.00	0.00
	Bones	*Sp*	3.20	5.50	13.50	7.10
		Su	0.60	1.30	10.10	1.80
		Au	0.00	0.00	0.00	0.00
		Wi	0.00	3.70	0.00	0.00
	Gills	*Sp*	3.80	5.00	13.70	14.20
		Su	5.90	2.60	1.60	4.30
		Au	0.00	0.00	0.00	0.00
		Wi	0.00	0.00	15.70	0.00

Sp: spring; *Su*: summer; *Au*: autumn; *Wi*: winter.

El-Rayah El-Tawfiky showed higher concentration of Pb (36.90 µg/g dw) in the bones of Mango tilapia during winter, while lower values (0.00 µg/g dw) were recorded in bones and gills of Tilapia zillii during autumn and winter. El-Rayah El-Behery showed higher concentration of Pb (29.50 µg/g dw) in the bones of Nile tilapia during winter, while higher concentration of Pb (19.40 µg/g dw) in the muscle of Mango tilapia during summer. The higher value of Pb (16.30 µg/g dw) in the muscle of Tilapia zillii during summer

Cadmium (Cd)

From table (6) cadmium in general was not detected in most fish organs samples except in El-Rayah El-Nasery during autumn in collected three tilapia fish species and ranged from (0.30-3.30 µg/g dw) in muscle of mango tilapia and the highest in the gills of Nile tilapia. Cd was detected only in bones of Nile tilapia collected from El-Rayah El-Tawfiky during autumn and recorded (1.40 µg/g dw). However, in El-Rayah El-Behery it was recorded in two samples during autumn, the first (1.50 µg/g dw) was the muscle of Nile tilapia and the second (0.30 µg/g dw) was the gills of tilapia zillii. El-Rayah El-Menoufy recorded higher levels of Cd only in the muscle of Nile tilapia and gills of Mango tilapia and recorded (2 and 2.60 µg/g dw), respectively. On the other hand, the muscle, bones and gills of Tilapia zillii recorded 1, 1.90 and 1.70 µg/g dw, respectively, during autumn.

Table 6. Bioaccumulation of Cd in different tissues of tilapia fish species collected from River Nile Rayahs during spring 2014 to winter 2015.

Fish species	Organs	Seasons	Tawfiky	Behery	Nasery	Menoufy
Nile tilapia	Muscle	*Sp*	0.00	0.00	0.00	0.00
		Su	0.00	0.00	0.00	0.00
		Au	0.00	1.50	1.40	2.00
		Wi	0.00	0.00	0.00	0.00
	Bones	*Sp*	0.00	0.00	0.00	0.00
		Su	0.00	0.00	0.00	0.00
		Au	1.40	0.00	2.90	0.00
		Wi	0.00	0.00	0.00	0.00
	Gills	*Sp*	0.00	0.00	0.00	0.00
		Su	0.00	0.00	0.00	0.00
		Au	0.00	0.00	3.30	0.00
		Wi	0.00	0.00	0.00	0.00
Mango tilapia	Muscle	*Sp*	0.00	0.00	0.00	0.00
		Su	0.00	0.00	0.00	0.00
		Au	0.00	NF	0.30	0.00
		Wi	0.00	0.00	0.00	0.00
	Bones	*Sp*	0.00	0.00	0.00	0.00
		Su	0.00	0.00	0.00	0.00
		Au	0.00	NF	2.20	0.00
		Wi	0.00	0.00	0.00	0.00
	Gills	*Sp*	0.00	0.00	0.00	0.00
		Su	0.00	0.00	0.00	0.00
		Au	0.00	NF	0.60	2.60
		Wi	0.00	0.00	0.00	0.00
Tilapia zillii	Muscle	*Sp*	0.00	0.00	0.00	0.00
		Su	0.00	0.00	0.00	0.00

Fish species	Organs	Seasons	Tawfiky	Behery	Nasery	Menoufy
		Au	0.00	0.00	1.10	1.00
		Wi	0.00	0.00	0.00	0.00
	Bones	*Sp*	0.00	0.00	0.00	0.00
		Su	0.00	0.00	0.00	0.00
		Au	0.00	0.00	2.10	1.90
		Wi	0.00	0.00	0.00	0.00
	Gills	*Sp*	0.00	0.00	0.00	0.00
		Su	0.00	0.00	0.00	0.00
		Au	0.00	0.30	0.60	1.70
		Wi	0.00	0.00	0.00	0.00

Sp: spring; *Su*: summer; *Au*: autumn; *Wi*: winter

The obtained results revealed that, fish muscles have much lower concentrations of all metals than bones and gills and were not significantly different from specie to others. Our results are in agreement with the findings of others elsewhere (Coetzee *et al*., 2002; Farkas, *et al*., 2002, Ghannam, *et al*., 2014). This is particularly important because muscles contribute the greatest mass of the flesh that is consumed as food.

The results indicated that, Fe was the most abundant element in all fish organs followed by Zn> Mn> Cu> Pb> Cd. The order of bioaccumulations of these metals might be as a result of the fact that different metals tend to accumulate differently in the tissues of different species of fish. The difference in the levels of accumulation in the different organs/tissues of a fish can primarily be attributed to the differences in the physiological role of each organ. Regulatory ability, behavior and feeding habits are other factors that influence the accumulation differences in the different organs (Marzouk, 1994). The increase of Fe accumulation in fish in all examined tissues was higher than the other metals possibly due to the increase of total dissolved Fe in Nile water and consequently increases the free metal Fe concentration and there by lead to an increase in metal uptake by different organs (Tayel *et al*., 2008). According to FAO/WHO (2006), the maximum permissible limit for Cu is 30, for Pb it is 0.5, and for Zn it is 40 mg/g.

The adsorption of metals onto the gills surface, as the first target for pollutants in water, could also be an important influence in the total metal levels of the gill (Hemens and Connell, 1975). Higher metal concentrations in the gills could be due to the element complexion with the mucus that is impossible to completely remove from the gill lamellae before tissue is prepared for analysis (Khalil and Faragallah, 2008). Many authors indicated that, metals show different affinity to various organs. The major part of total body loads accumulated at different concentrations of metals in the water, and at various exposure times are found in liver, kidney and gills (Al-Mohanna, 1994; Kock *et al*., 1998; Giguere *et al*., 2004).

Conclusion

Fish muscles recorded lower values of all tested metals, and spring season showed a slightly increase in all metals in comparison with other seasons. River Nile Rayahs showed significant differences in bioaccumulation of heavy metals and El-Rayah El-Nasery showed higher values of Cd.

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