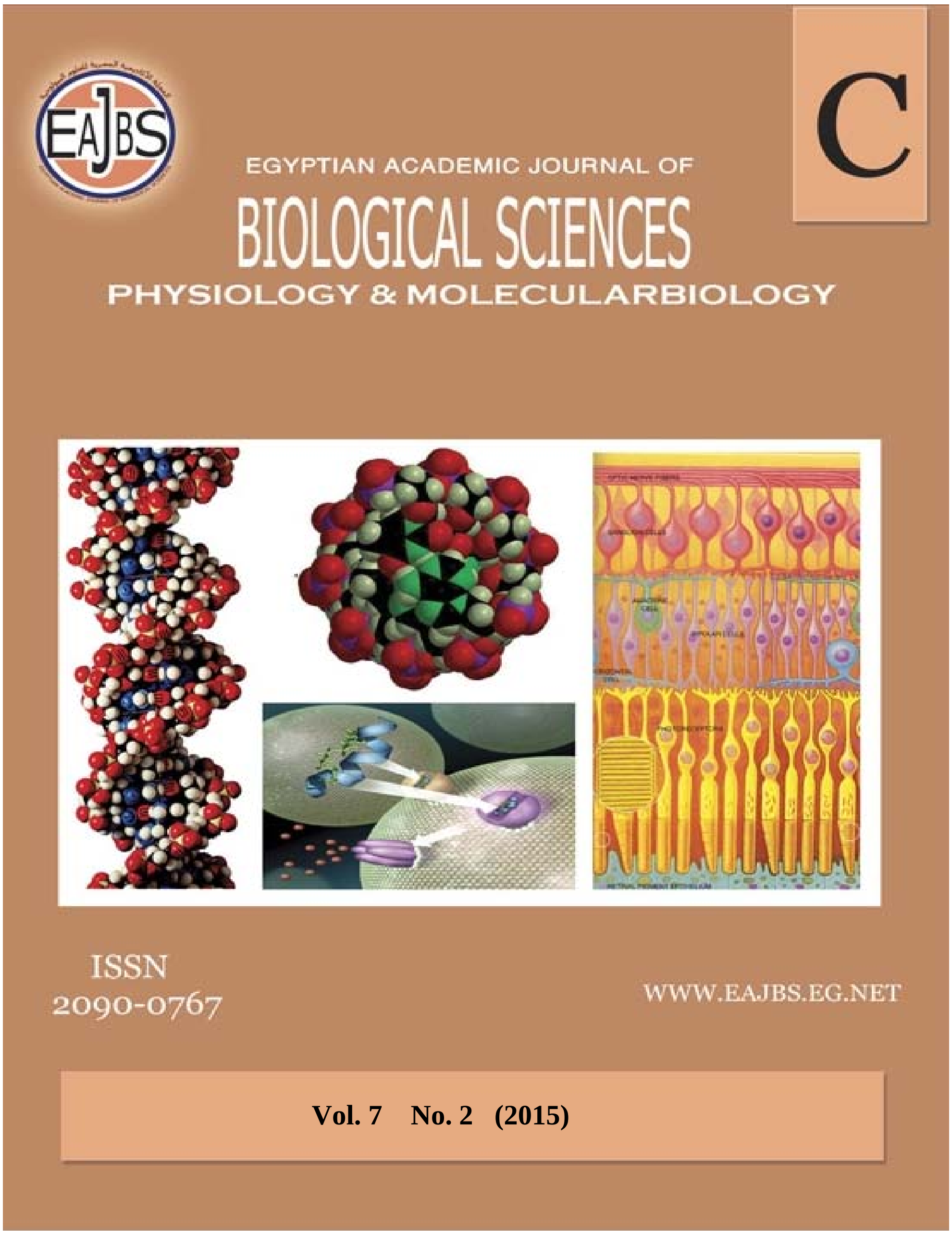

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Biomonitoring Of Some Heavy Metals In Water Of El Salam Canal using *Oreochromis niloticus* As Bioindicator

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ABSTRACT

This study was initiated to assess the levels of (Fe, Cu, Cd, Pb, Zn, Co, Mn and Ni) in water samples and *Oreochromis niloticus* tissues (muscles, gills and liver) collected from Fum El-Salam canal, Hadous drain and mixing point of El-Salam canal with Hadous drain throughout Summer 2014. Levels of physicochemical parameters of water samples (TDS, EC and ammonia) were significantly high ($P<0.05$) in Hadous drain and mixing point of El-Salam canal with Hadous than the permissible levels of the law 48/1982. The results showed that Zn, Fe, Mn and Cu recorded 1.612±0.6-<0.001-0.011±0.001,0.56±0.29- 0.479 ± 0.03- 0.075±0.01, 0.25±0.028 - 0.179±0.01 - 0.046±0.003, 0.045± 0.01 - 0.019±0.01 - 0.009±0.007 mg/l in Hadous drain, Mixing point and Fum El-Salam canal respectively, while the increase in Zn and Mn for Hadous drainage exceeded the permissible values sets by USEPA (1996). The discharging of Bahr Hadous drainage water to El-Salam canal leads to alteration in water quality of El-Salam canal as it increases heavy metals loads which implicate pollution, such deterioration showed in the studied tissues of *Oreochromis niloticus*. It is recommended to treat the different wastes before discharging to El-Salam canal.

INTRODUCTION

Water pollution is an international problem that needs urgent attention and prevention of the many different toxic compounds present in aquatic system the heavy metals are considered by some to be the most hazardous.

Some of these metals, such as Cd and Pb, are toxic to living organisms even at low concentrations, whereas others, such as Zn and Cu, are biologically essential and natural constituents of aquatic ecosystems, and generally only become toxic at very high concentrations. Zn has a multitude of biological functions in the human body.

Accumulation of heavy metals in the food web can occur either by accumulation from the surrounding medium, such as water or sediment, or by bioaccumulation from the food source (Tulonen *et al.,* 2006).

El Salam Canal project initiated in 1987 to irrigate 650000 feddans of the newly reclaimed areas in the west and east Suez Canal by mixed water from River Nile and Hadous Drain (1:1). Hadous Drain has been constructed in 1965 and receiving principally agriculture drain water from 420000 hectares, moreover some domestic and industrial wastes are also discharged. Changes in water quality such as depletion in dissolved oxygen exert a selective action on flora and fauna which constitute the living population of water and can be used to establish biologic indices of water quality (Lebelo *et al.,* 2001).

Fish are generally one of the main protein sources for humans (Eleta *et al.,* 2003) and a useful bioindicator for the determination of heavy metal pollution in aquatic ecosystems (Anges *et al.,* 2013) and (Lamas *et al.,* 2007). To be a good indicator fish must be long living and inhibit water, making continuous monitoring of the presence of pollutants and sampling easy (Farkas *et al.,* 2003). The heavy metals concentration in fish tissues reflects the concentration in water and accumulates by fish through the food chain and water (Birungi, 2007). Heavy metals enter fish through five main routes (food or non-food particles, gills, water, and skin), follow into the blood, and are carried to either a storage point or to the liver for its transformation or storage (Jabeen and Chaudhry 2010). The liver is the main site of accumulation, biotransformation, and excretion of pollutants in fish (Shinn *et al.* ,2009). For this reason, monitoring fish tissue contamination serves an important function as an early warning indicator of sediment contamination or related water quality problems (Mansour and Sidky, (2002).

Increasing amount of agricultural, domestic and industrial drain water which discharged into El-Salam canal may exert considerable changes in the histological structures of the different organs of the fish. Several histopathological changes have been reported in the gills, liver, kidneys and gonads of fish in response to agricultural, sewage and industrial pollutants (Fatma, 2003).

Metals such as copper, zinc, chromium, and manganese, are essential metals since they play an important role in biological systems, whereas lead, cadmium and nickel are non-essential metals because they are toxic, even in traces. The essential metals can also produce toxic effects when the metal intake was excessively elevated (Türkmen *et al.,* 2008). Bioaccumulation of these heavy metals in fish tissue and measurements of water quality can provide a good indication of conditions and potential risks to the water body. Therefore, the aim of this study is to illustrate the harmful effects of El-Salam Canal heavy metals content of (gills, livers and muscles) of the commercially important fish *Oreochromis niloticus* with referred to the evaluation of the effect of Hadous drain on El-Salam Canal water.

MATERIALS AND METHODS

The program of monitoring had been planned and carried out to know the quality of water and the influence of the drained water on its aquatic life.

Water samples

Water and fish samples were collected four times during one year (May 2014 to April 2015) from three different sites as shown in Table (1).

Table 1: Locations of water and fish sampling

Sectors	No. of collected samples		Site	Coordinates
	water	Fish		
Site I	5	10	Fum El-Salam Canal (as control)	31°23'39.58"N 31°46'10.47"E
Site II	5	10	Hadous drainage (polluted)	31° 6'5.55"N 32° 0'15.05"E
Site III	5	10	El-Salam Canal after mixing with Hadous drainage (polluted)	31° 5'35.10"N 32° 0'26.73"E

Twenty water samples were collected from each site (five samples per time) in Polyethylene containers of two-liter capacity. The water samples were preserved via adding concentrated nitric acid to reduce the pH below 2 to prevent the microbial reactions. The concentrations of Fe, Cu, Cd, Pb, Zn, Co, Mn and Ni were measured using the Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) model Perkin Elmer optima 5300 DV. Water analyses were achieved according to the standard methods for examination of Water and Wastewater (APHA, 2005).

Fish samples

Twenty fish of Nile tilapia (*Oreochromis niloticus*) were caught from each of the selected study sites (five fish per time) ranged between 110-125 g in weight were collected using gill net with the help of professional local fishermen in each locations.

Muscle, liver, and gill of fishes of each site were removed and dried at 80 ^{o}C till constant weight. Then digestion was done for fish tissue using Microwave Lab station MLS- 1200 mega (reagent used were HNO_3 65% and H_2O_2 30%). Estimation of heavy metals takes place using Inductivity Coupled Plasma ICP-OES 5300 DV (Chandanshive *et al.*, 2012).

Bioaccumulation Factor (BAF):

Bioaccumulation factor (BAF) gives an indication about the accumulation efficiency for any particular pollutant in any fish organ. BAF is the ratio between the accumulated concentration of a given pollutant in any organ and its dissolved concentration in water and it was calculated according to Neuhauser *et al.*, (1995) and Abd Allah and Moustafa (2002) using the following formula:

$$BAF = \frac{\text{Chemical concentration of a given parameter in fish organ (mg/kg)}}{\text{Chemical concentration of a given parameter in water (mg/L)}}$$

The Waste Minimization Prioritization Tool (WMPT) is a scoring system that was developed by EPA to rank chemicals based on their persistence (P), bioaccumulation potential (B), and human (HT) and ecological toxicity (ET). Chemicals are given a score of 1 (low concern), 2 (medium concern), or 3 (high concern) for P, B, and HT or ET. A score of 1 is assigned to BAF values less than 250; a score of 2 is assigned for BAF values from 250 to 1000; and a score of 3 is assigned for BAF values exceeding 1000 (Drexler et al., 2003). BAF values for heavy metals in fish muscles, gills and livers were calculated using the above equation then compared to WMPT scoring system.

Statistical Analysis

The mean ± standard deviation were calculated for each parameter of water and fish tissue in the site I, site II and site III. Analysis of variance (ANOVA – one way) were carried according to SPSS, INC. (1997).

RESULTS

Physicochemical Parameters of water samples:

The results of physicochemical parameters as shown in Table (2) and heavy metals concentration (Table 3) were compared to the permissible limits of the USEPA (1986) regarding the protection of River Nile and water ways from pollution.

Table 2: Physicochemical parameters (mean ± SD) of water samples at various sampling sites.

Property	Sites			P value	PL
	Fum El-Salam canal	Hadous drain	Hadous drain after mixing with El-Salam canal		
pH	7.96±0.6[a]	7.76±0.02[b]	7.98±0.16[a]	NS	7-8.5
Conductivity (µmohs/cm)	0.467±0.006[c]	2.08±0.0001[a]	1.18±0.006[b]	***	NA
Total dissolved solids (mg/L)	299.67±4.16[c]	1330±2.0[a]	755±3.0[b]	***	500
Dissolved oxygen (mg/L)	4.56±0.22[a]	0.69±0.1[c]	3.58±0.15[b]	***	5
Ammonia (mg/L)	5.8±4[b]	28.9±13.56[a]	10.47±1.42[b]	**	0.5

NA: Not available, permissible levels (PL) according to USEPA (1986). Letters a, b and c show differences among fish species in different ports. Data shown with different letters are statistically different at P < 0.05 level.

Heavy metals in water:

Metal concentrations in water at different sites are illustrated in Table (3). Metals concentrations in water were found in the following order: Fe >Mn >Pb >Cu >Co >Ni >Zn >Cd and in Fum El-Salam canal, whereas they follow the order of Zn >Fe >Mn >Pb >Cu >Co >Ni > Cd in Hadous drain. Where Fum El-Salam canal mixed with Hadous drain, heavy metals had the sequence of Fe >Mn >Pb >Cu >Zn >Ni >Co > Cd (Table 3 and Fig. 1).

The maximum mean values of (Fe, Pb and Cu) were recorded at Hadous drain but still less than the permissible limits while, maximum mean values of Mn and Zn exceeding these limits sets by (USEPA, 1986) as shown in Table (3).

Table 3: Mean of heavy metals concentration (mg/l) in the locations of study.

Parameter Mean ± SD	Sites			P value	PL
	Fum El-Salam canal	Hadous Drain	El-Salam canal mixed with Hadous drain		
Cd (µg/g)	< 0.001	< 0.001	< 0.001	NS	0.01
Co (µg/g)	< 0.005	< 0.005	< 0.005	NS	0.05
Cu (µg/g)	0.009±0.007[c]	0.045±0.01[a]	0.019±0.01[b]	**	1
Fe (µg/g)	0.075±0.01[b]	0.56±0.29[a]	0.479±0.03[a]	**	1
Mn (µg/g)	0.046±0.003[c]	0.25±0.028[a]	0.179±0.01[b]	***	0.05
Pb (µg/g)	0.02±0.003[b]	0.04±0.006[a]	0.036±0.001[a]	**	0.05
Ni (µg/g)	<0.001[b]	0.0035 ±0.002[b]	0.0043±0.002[a]	NS	0.02
Zn (µg/g)	<0.001[c]	1.612±0.6[a]	0.011±0.001[b]	**	1

Permissible levels (PL) according to USEPA (1986).Letters a, b and c show differences among fish species in different ports. Data shown with different letters are statistically different at P < 0.05 level.

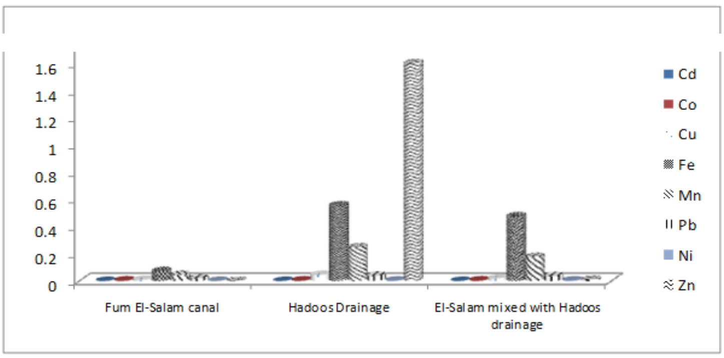

Fig.. 1: Mean of heavy metals concentrations (mg/l) in the three locations

Fish analysis:

Pollution of the aquatic environment by inorganic chemicals has been recognized as one of the major serious threats to the health and survival of fish. The present results showed that the heavy metals concentrations in fish tissue (muscles, gills and livers) of *Oreochromis niloticus* at the studied locations as follows in Table (4).

Heavy metals in fish muscles:

Comparing the average concentrations of heavy metals in the different study location (Tables 4 and Fig. 2,3 and 4) showed variations between heavy metal concentrations in fish muscle. The concentrations had the order: Cu > Zn > Cd >Mn> Co>Fe>Pb> Ni in Fum El-Salam Canal while this order was Cu > Zn >Mn>Pb>Ni >Fe > Cd > Co in Hadous drain but when both are mixed the order become Cu >Zn >Mn> Cd >Pb>Fe > Co > Ni.

Heavy metals in gills:

Comparing the average concentrations of heavy metals in the different study sites, (Tables 4 and Fig. 2,3 and 4) showed variations between heavy metal concentrations in gills. The concentration was as seen Cu> Zn >Cd > Ni >Mn>Co >Pb>Fe in Fum El-Salam canal but in Hadous drain the order was Cu >Mn> Zn >Pb> Fe > Cd > Co > Ni and this was different than when it is mixed the order become Cu >Mn> Zn > Co > Fe > Cd >Pb> Ni.

Heavy metals in fish muscles:

Comparing the average concentrations of heavy metals in the different study location (Tables 4 and Fig. 2,3 and 4) showed variations between heavy metal concentrations in fish muscle.

The concentrations had the order: Cu > Zn > Cd >Mn> Co>Fe>Pb> Ni in Fum El-Salam Canal while this order was Cu > Zn >Mn>Pb>Ni >Fe > Cd > Co in Hadous drain but when both are mixed the order become Cu >Zn >Mn> Cd >Pb>Fe > Co > Ni.

Heavy metals in gills:

Comparing the average concentrations of heavy metals in the different study sites, (Tables 4 and Fig. 2,3 and 4) showed variations between heavy metal concentrations in gills. The concentration was as seen Cu> Zn >Cd > Ni >Mn>Co >Pb>Fe in Fum El-Salam canal but in Hadous drain the order was Cu >Mn> Zn >Pb> Fe > Cd > Co > Ni and this was different than when it is mixed the order become Cu >Mn> Zn > Co > Fe > Cd >Pb> Ni.

Table 4: Average heavy metals concentrations (µg/g dry wt.) in tissues of *Oreochromis niloticus* caught from the locations of the study:

Parameter Mean ± SD	Tissue	Sites			P value
		Fum El-Salam canal	Hadous Drain	El-Salam canal mixed with Hadous drain	
Cadmium (µg/g)	**Muscles**	0.689 ± 0.012^{b} (689)	0.665 ± 0.03^{b} (664.8)	7.31 ± 0.44^{a} (7310)	**
	Gills	0.23 ± 0.031^{c} (230)	0.453 ± 0.015^{a} (453.2)	0.321 ± 0.007^{b} (321.2)	***
	Livers	0.48 ± 0.011^{b} (480)	0.598 ± 0.043^{a} (598.2)	0.462 ± 0.012^{b} (461.6)	**
Pattern		M>L>G	M>L>G	M>L>G	
Cobalt (µg/g)	**Muscles**	0.162 ± 0.016^{c} (32.4)	0.544 ± 0.047^{a} (108.8)	0.41 ± 0.01^{b} (81.92)	***
	Gills	0.1 ± 0.025^{c} (20)	0.241 ± 0.01^{b} (48.24)	1.5 ± 0.09^{a} (300)	***
	Livers	0.12 ± 0.024^{c} (24)	0.325 ± 0.004^{a} (65.08)	0.251 ± 0.012^{b} (50.2)	***
Pattern		M>L>G	M>L>G	G>M>L	
Copper (µg/g)	**Muscles**	30.51 ± 0.55^{c} (3390)	178.5 ± 3.34^{a} (3967)	111.7 ± 15.38^{b} (5880.9)	***
	Gills	1.51 ± 0.083^{c} (167.78)	35.21 ± 1.75^{a} (782.5)	27.34 ± 1.06^{b} (1439)	***
	Livers	0.25 ± 0.12^{c} (277.78)	68.71 ± 2.03^{a} (1526.9)	57.11 ± 1.94^{b} (3006)	***
Pattern		M>G>L	M>L>G	M>L>G	
Iron (µg/g)	**Muscles**	0.102 ± 0.005^{b} (1.36)	0.725 ± 0.05^{a} (1.23)	0.683 ± 0.02^{a} (1.42)	**
	Gills	0.021 ± 0.004^{b} (0.28)	0.52 ± 0.034^{a} (0.88)	0.506 ± 0.037^{a} (1.056)	**
	Livers	0.053 ± 0.007^{b} (0.707)	0.634 ± 0.08^{a} (1.075)	0.625 ± 0.03^{a} (1.30)	**
Pattern		M>L>G	M>L>G	M>L>G	
Manganese (µg/g)	**Muscles**	0.531 ± 0.01^{c} (11.54)	20.87 ± 1.49^{a} (83.5)	16.76 ± 3.9^{b} (93.61)	***
	Gills	0.13 ± 0.019^{b} (2.826)	11.24 ± 1.56^{a} (44.94)	10.23 ± 1.37^{a} (57.15)	**
	Livers	0.251 ± 0.005^{c} (5.456)	3.521 ± 0.18^{a} (14.09)	2.512 ± 0.12^{b} (14.03)	***
Pattern		M>L>G	M>G>L	M>G>L	
Lead (µg/g)	**Muscles**	0.089 ± 0.004^{c} (4.45)	2.45 ± 0.15^{a} (35)	1.02 ± 0.09^{b} (28.33)	***
	Gills	0.031 ± 0.007^{c} (1.55)	0.67 ± 0.036^{a} (9.574)	0.083 ± 0.008^{b} (2.3)	***
	Livers	0.052 ± 0.005^{b} (2.6)	1.21 ± 0.25^{a} (17.29)	0.095 ± 0.02^{b} (2.63)	**
Pattern		M>L>G	M>L>G	M>L>G	
Nickel (µg/g)	**Muscles**	0.029 ± 0.003^{c} (29)	1.73 ± 0.045^{a} (1730)	0.167 ± 0.04^{b} (167.2)	***
	Gills	0.15 ± 0.037^{a} (150)	0.035 ± 0.007^{b} (35)	0.03 ± 0.003^{b} (29.6)	**
	Livers	0.022 ± 0.002^{c} (22)	0.052 ± 0.005^{a} (52)	0.042 ± 0.006^{b} (42.4)	***
Pattern		G>M>L	M>L>G	M>L>G	
Zinc (µg/g)	**Muscles**	0.83 ± 0.09^{c} (830)	32.71 ± 0.508^{a} (20.29)	24.21 ± 0.51^{b} (24210)	***
	Gills	0.51 ± 0.039^{c} (510)	8.824 ± 0.34^{a} (5.474)	3.41 ± 0.116^{b} (3410)	***
	Livers	0.078 ± 0.037^{c} (780)	11.21 ± 1.56^{a} (6.95)	5.532 ± 0.42^{b} (5532)	***
Pattern		M>G>L	M>L>G	M>L>G	
Total	**Muscles**	32.94	238.2	162.3	
	Gills	2.682	57.19	43.42	
	Livers	4.258	86.26	66.63	

*PL: Permissible limits (wet wt.) according toFAO/WHO(1999). Letters a, b and c show differences among fish species in different ports. Data shown with different letters are statistically different at $P < 0.05$ level.

** Values between brackets are bioaccumulation factors (BAF).

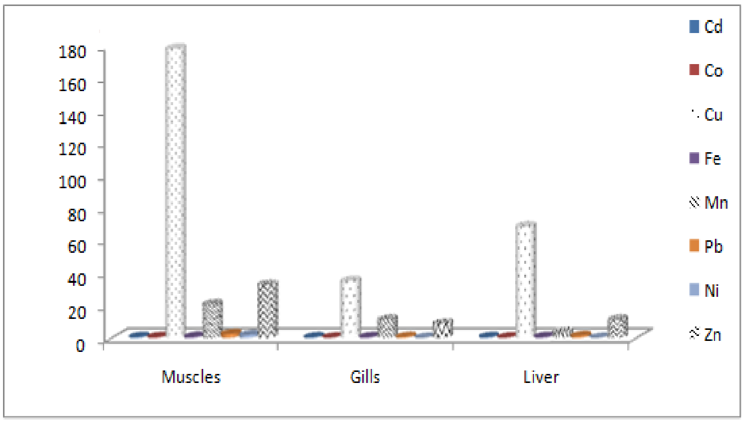

Fig. 2: Mean concentrations of heavy metals in the muscles, gills and liver of tilapia from Fum El-Salam Canal.

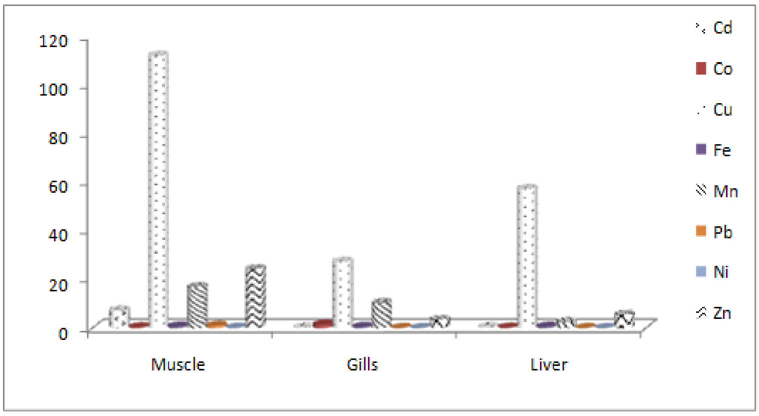

Fig. 3: Mean concentrations of heavy metals in the muscles, gills and liver of tilapia from Hadous drain.

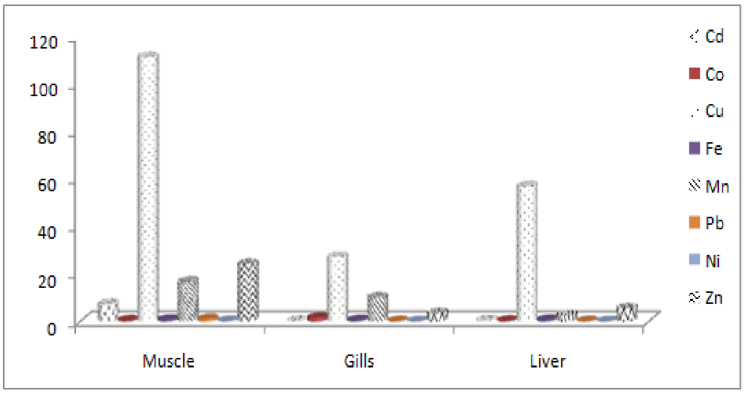

Fig. 4: Mean concentrations of heavy metals in the muscles, gills and liver of tilapia from El-Salam Canal after mixing with Hadous drain

Heavy metals in livers:

Comparing the average concentrations of heavy metals in the different study sites, (Tables 2 and Fig. 1,2 and 3) showed variations between heavy metal concentrations in liver. The concentration followed the order of Zn> Cd >Mn> Cu> Co > Fe >Pb> Ni in Fum El-Salam Canal while in Hadous drain the order was Cu > Zn >Mn>Pb> Fe > Cd > Co > Ni in Hadous drain while when mixed with El-Salam canal it was Cu > Zn >Mn> Fe > Cd > Co >Pb> Ni.

The total values of averages fish heavy metals concentrations in the studied locations showed that fish caught from Hadous drain had higher concentrations of heavy metals comparing with El-Salam canal mixed with Hadous drain than those of Fum El-

Salam Canal. The increase was significantly high ($P<0.05$) in muscles, liver compared with gills respectively as shown in Fig. (5).

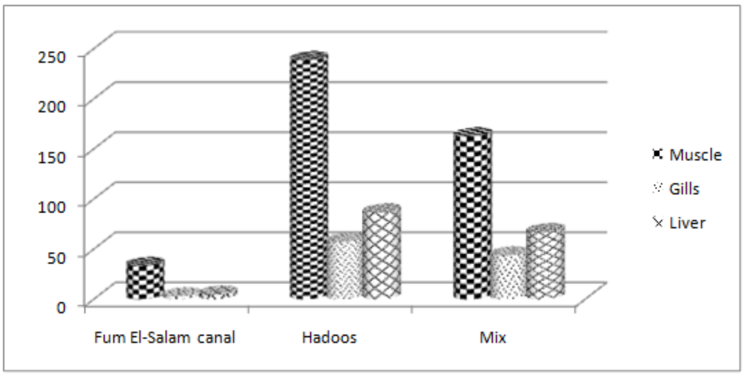

Fig. 5: Total heavy metals concentration in muscles, gills and liver of Nile tilapia in the three locations

DISCUSSION

Contamination of aquatic ecosystems with heavy metals has seriously increased worldwide attention (Yilmaz *et al.,* 2007) Concerning the water quality criteria (Table 2), the data revealed that pH was ranged between 7.76 to 7.98 as tilapia can survive at ranging between 5 and 10, while they do best in a pH range of 6 to 9 (Popma and Masser, 1999). The results recorded for electrical conductivity and Total dissolved solids in Hadous Drain and and the mixing point of Hadous Drain and El-Salam Canal were high than the limits of law 48/1982, while the value recorded for the Fum El-Salam Canal were below the permissible limits of the previous low. The high values of electrical conductivity recorded in the mixing point of Haous Drain and El-Salam Canal reflect the strong effect of the effluents discharged from Hadous Drain. The increase in the Electrical Conductivity (EC) values is related to the increase in total dissolved solids (Abdo *et al.,* 2010). Also, the increase of ammonia in the Hadous Drain and the mixing point of Haous Drain and El-Salam Canal might be related to the domestic effluents from houses and accumulations of organic matter discharges from Hadous Drain (Bolalak and Frankowaski, 2003). In addition, such increase might relate to excessive application rates of sewage discharge and agriculture wastes as well as microorganism activities in decomposition of residues and fixation of atmospheric nitrogen (Galloway *et al.,* 2003). The present results showed decrease of dissolved oxygen (DO), this depletion in oxygen content may be attributed to increase in the oxygen consumption of the decomposing organic matter and oxidation of chemical constituents (Boyd, 1990). The prolonged exposure to ammonia concentrations more than 0.5 mg/l were found to be detrimental to fish, predisposing tilapias to diseases and massive mortalities (Amal and Zamri-saad, 2011). The negative impact of Hadous Drain as sources of pollution was confirmed by the elevated values of all physicochemical parameters in the mixing point of Haous Drain and El-Salam Canal (increase of ammonia and decrease in dissolved oxygen) compared with Fum El-Salam Canal .This finding were in agreements with Shakweer (2005) who studied the chemistry of Lake Manzala and pointed out that most of chemical parameters are relatively high at the southern areas of the lake, near to the outlets of Bahr El-Baqar and Hadous drains. Highly significant decrease in dissolved oxygen in water samples collected from Hadous drain water could be attributed to the increase in the oxygen consumption of the decomposing organic matter and oxidation of chemical constituents (Tayel *et al.*, 2007).

In the current study, some heavy metals (Cd, Co, Cu, Fe, Mn, Ni, Pb, and Zn) were determined in water and in the muscles, livers and gills of *Oreochromis niloticus* and compared to permissible limits as recommended by FAO/WHO (1999).

The obtained results of heavy metals concentration (Zn, Fe, Mn, Ni and Cu) of water samples were significantly high (P<0.05) in Hadous drain followed by mixing with El-Salam Canal comparing with Fum El-Salam Canal which showed normal levels of these metals, and considered within the limits of law 48/1982. This finding is in agreement with (Koussa, 2000 and Moussa, 2004) and the (4^{th} Conference of Central Laboratory for Aquaculture Research 2014) which reported that the heavy metals concentrations significantly increase and were out of the permissible limits in all locations near the mouths of the drains specially Hadous, Ramsis and Baher El-Bakar. These increases may be due to comes from raw sewage, agricultural and industrial wastewater discharged into the Lake (Abdel-Moati and El-Sammak, 1997). Maduabuchi *et al.* (2006) mentioned that the major sources for manganese in air and water are iron and steel manufacturing and the burning of diesel fuel in the motor cars. So, using of fuel by irrigation pump or the engine of fishing boats in Hadous drain could be a reason for increasing the lead and manganese in the water.

Lead concentration was significantly high (P<0.05) in Hadous drain and slightly decreased when mixing with El-Salam canal comparing with Fum El-Salam Canal. These values of lead concentration were higher than the permissible limits of FAO and WHO (1999). The high levels of lead in water can be attributed to industrial and agricultural discharge (Mason, 2002). Also, (Adakole, 2012) mentioned that, the high level of lead in water of aquaculture pond may be attributed to various types of pollutants from sewage and untreated effluents discharged from dairy processing factory, as well as from spill of leaded petrol from fishing boats and dust which holds a huge amount of lead from the combustion of petrol in automobile cars. On the other hand cadmium, cobalt, and nickel are within the permissible limits in the studied location as shown in Table (3) and Fig.ure (1).

The concentrations of heavy metals (Cd, Co, Cu, Fe, Mn, Ni, Pb, and Zn) determined in fish muscles, liver and gills of *Oreochromis niloticus* collected from the sampling sites are given in Table (4) and Fig.s. (3- 5). The highest concentrations of the heavy metals in fish muscles were Cu (30.5±0.55, 178.5±3.34 and 111.7±15.38) mg/L, Mn (0.531±0.01, 20.87±1.49 and 16.76±3.9), Zn (0.83±0.09 , 32.71±0.508 and 24.21±0.51) and Cd (0.689±0.012, 0.665±0.03 and 7.31±0.44) mg/l in Fum El-Salam Canal, Hadous Drain and mixing point respectively. Gills recorded lower concen-trations Cu (1.51±0.083, 35.21±1.75 and 27.34±1.06) mg/l, Mn (0.13±0.019, 11.24±1.56 and 10.23±31.37), Zn (0.51±0.039, 8.824±0.34 and 3.41±0.116) and Cd (0.23±0.031, 0.453±0.015 and 0.321±0.007) mg/l in Fum El-Salam Canal, Hadous Drain and mixing point respectively. Livers recorded Cu (0.25±0.12, 68.71±2.03 and 57.11±1.94) mg/l, Mn (0.251±0.005, 3.521±0.18 and 2.512±0.12), Zn (0.078±0.037 , 311.21±1.56 and 5.532±0.42) and Cd (0.48±0.011, 0.598±0.043 and 0.462±0.012) mg/l in Fum El-Salam Canal, Hadous Drain and mixing point respectively.

Comparing the calculated BAF in Table (4) with WMPT tool it shows that Mn, Fe, Pb,Co and Ni (muscles, gills and liver) for the three studied sites, Cu and

Cd (gills) site 1 were given score 1 since their BAF values were less than 250, except for Co in gills (300) in site 3 and Ni in muscles (1730) in site 2,while Cd (muscle and liver) for site 2 , (muscles, liver and gills) in site 2 and (liver and gills) in site 3 also, Cu (liver) site 1 and (gills) site and Zn (muscle, liver and gills) in site 1 given score 2 as it is fall between 250 and 1000. The highest bioaccumulation factor of score 3 which is more than 1000 was recorded for Cd (muscle) site 3, Mn (muscles) site 2, Cu (muscles) in the three studied sites while gills in site 3 and in livers in sites 2 and 3. Zn also given score 3 for site 3 (muscle, liver and gills).The bioaccumulation factor of Zn and Cu (muscles, gills and livers) in site 3 indicates the high effect of Hadous drain on El-Salam Canal pollution and reflects that the pollution highly affect the fish organs and indicates that the affinity of various metals to fish organs may differ.

(Kalfakakon and Akrida-Demertai, 2000; Bashir *et al.,* 2013) reported that Ca, Mg, Fe, Cu, Zn and Pb exhibited bioaccumulation from water to fish demonstrated that metal concentrations in fish are higher than in water, which indicates the bioaccumulation.

Very high doses of Cu can cause damage to the liver and kidneys and can even cause death (ATSDR, 2011).

Mn also show high concentrations in the fish parts and the highest concentration observed in the gills and livers than in muscles. The high heavy metal content in gills of fish collected from the three sources of water can be related to accumulation of such heavy metals from the water primarily through fish gill where metallothionine enhances that bioaccumulation in gills and its uptake could be controlled by the amount of water passing through the gills (Saeed, 2000).

Pb concentration increases only in Hadous drain fish samples in all edible parts while it is not exceeding the permissible limits in other two sites. Ayotunde and Offen (2012) found a level of (0.02 to 0.04 mg/kg) of lead in muscle tissues of some species of freshwater fish from Cross River in Nigeria were below the permissible limits.

Since the concentrations of Ni, Co and Fe in fish samples are below the permissible level it means that their accumulation does not pose any health risk. On contrast to our findings Yilmaz *et al.* (2007) reported maximum accumulations of cadmium, cobalt and copper in the liver and gills of *Leuciscus cephalus* and *Lepornis gibbosus*, while these accumulations were least in the fish muscle. However, as could be shown from our study, the muscles accumulate more of these metals. Both Cd and Co are toxic elements which have no known biological function and show their carcinogenic effect on aquatic biota and humans.

Determined heavy metals recorded highest concentrations in the muscles compared to the gills and livers of fish samples collected from all points and the levels were higher in Hadous drain followed by mixing points than El-Salam canal than El-Salam canal. The accumulation patterns of contaminants in fish depend on both uptake and elimination rates. Although, the concentrations of heavy metals, Cu, Pb, Fe, Co and Cd determined were very low and below the detection limit in Fum El-Salam Canal, the continuous discharge from Hadous Drain might be the contributor of heavy metals accumulation and other possible pollutants in the fish samples. Heavy meals are one of the more serious pollutants in our natural environment due to their toxicity, persistence and bioaccumulation problems, thus fish species will not be safe for human consumption.

Previous studies reported that El-Salam canal is contaminated with heavy metals, bacteria indicative of sewage pollution and ammonia (Abdel-Baky, 2001, Bahnasawy, 2001, Rabeh, 2001 and Sabae and Abdel-Satar, 2001). Therefore, the increasing amount of agricultural, domestic and industrial drain water which discharged into El-Salam Canal may exert considerable changes in the histological structures of the different organs of the fish.

These high levels of heavy metals in fish samples can be attributed to the deterioration of water quality. Exceeding the permissible levels in the fish sample means it is approaching toxicity levels. Although Copper as a micro nutrient is essential to the human body, high levels of it can be harmful. This findings is in agreement with a study done by Ismaniza and Saleh (2012) in Turkey and Malaysia, where they found that concentration of heavy metals in fish was high even the concentration of heavy metals in the water was low.

The main reason is the long-term disposal of sewage-treated water into the Nile, which results in the accumulation of toxic heavy metals in river water, and may adversely affect the growth of various aquatic vertebrates and invertebrates including fishes.

Fish may uptake heavy metals from water, food or sediment and therefore can easily enter or transported to the food chains (Kalfakakon and Akrida-Demertzi, 2000). When fish are exposed to elevated metal levels in an aquatic environment, they can absorb the available metals directly from the environment via the gills and skin or through the ingestion of contaminated water and food, thus accumulates them in their tissues and enter the food chains and extent to many other problems to humans (Ahmad and Othman, 2010).

The recommended daily intake for an adult is 43.0, 60.0, 3.0, 2.0-9.0, and 0.214 mg/day wet weight for Fe, Zn, Cu, Mn and Pb respectively according to FAO/WHO (1999). While, the permissible daily intake of Cd is 0.1 µg/g wet weight. The concentrations of metals in the edible parts of this fish species in the investigated sites at the time of the research is unfortunately unsafe for consumers. However, the muscle tissue of fish collected from the studied area may pose health risk to consumer, as concentrations of heavy metals exceeded those of the international limits.

CONCLUSION AND RECOMM-ENDATION

From the present results, it can be concluded that Bahr Hadous agriculture drain has the major effect on increasing total dissolved solids and heavy metals down stream in El-Salam Canal which lead to deterioration of its water quality. Environmental conditions of El-Salam Canal induce biological changes in the muscles, gills and liver of *Oreochromis niloticus*. Fish from Bahr Hadous Drain and the mixing point as well as El-Salam Canal during study period are not safe for human consumption since the heavy metal analysis pose health risk to consumer as the quality of fish grown in such water did not comply with the standards levels recommended by FAO/WHO (1999). Therefore, it is recommend to subject the drain water discharged into El-Salam Canal to technical treatment that fulfill its safety and to monitor the quality of El-Salam Canal water periodically to discover the reason of its poor quality at this time.

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