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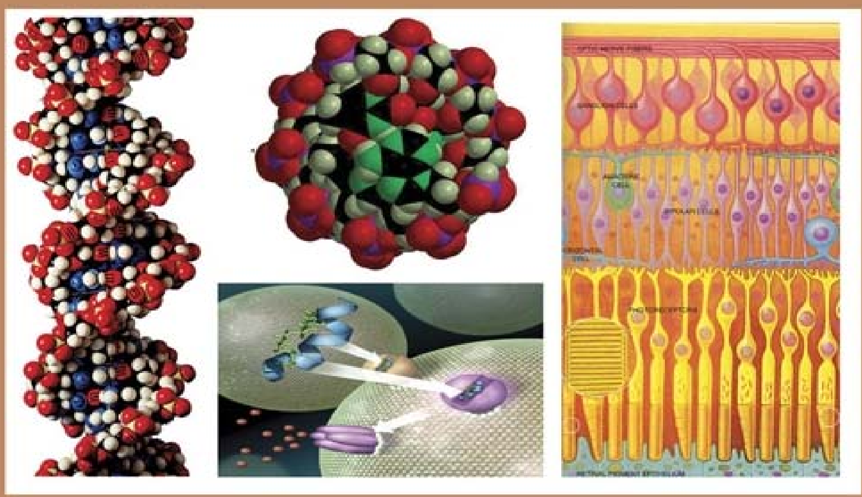
EGYPTIAN ACADEMIC JOURNAL OF

BIOLOGICAL SCIENCES

PHYSIOLOGY & MOLECULARBIOLOGY



ISSN
2090-0767

WWW.EAJBS.EG.NET

Vol. 8 No. 1 (2016)

Egyptian Academic Journal of Biological Sciences is the official English language journal of the Egyptian Society for Biological Sciences, Department of Entomology, Faculty of Sciences Ain Shams University.

Physiology & molecular biology journal is one of the series issued twice by the Egyptian Academic Journal of Biological Sciences, and is devoted to publication of original papers that elucidateimportant biological, chemical, or physical mechanisms of broad physiological significance.

www.eajbs.eg.net

Egypt. Acad. J. Biolog. Sci., 8(1): 51 - 63 (2016)

Egyptian Academic Journal of Biological Sciences
C. Physiology & Molecular Biology
ISSN 2090-0767
www.eajbs.eg.net

Seasonal Variations of Heavy Metal Accumulation in Water, Sediment and Target Organs of the Cichlid Fish, *Oreochromis niloticus* Inhabiting El-Bagouria Canal, El-Gharbia Governorate, Egypt

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ARTICLE INFO

Article History
Received: 5/5/2016
Accepted:20/6/2016

Keywords:
water quality
heavy metals
biochemical
O. niloticus
El-Bagouria Canal

ABSTRACT

Damietta Nile Branch is a continues resource for drinking water and aquatic life in Delta Governorates; however it's subjected to severe pollutants of domestic, sewage and agricultural pollutants. The present study was conducted to evaluate seasonal accumulation of some heavy metals (Cu, Fe, Mn and Zn) in water, sediment and edible organs of the cichlid fish, *Oreochromis niloticus*, inhabiting El-Bagouria Canal during the period from summer 2013to spring, 2014. on the bases of qualitative and quantitative analysis, total protein, total lipids, total carbohydrates, ASAT and ALAT activity in the target organs (liver, kidney, muscle and gonads) of this fish were determined. Results revealed that, concentrations of heavy metals in sediment were remarkably higher than in the surface water. It was followed the order: Fe>Mn>Zn>Cu in the former and Fe>Mn>Cu>Zn in the latter. In the target organs, however, it was in the rank of Fe>Zn>Cu>Mn. Biochemical analysis indicated remarkable changes in the metabolic pathways and enzymatic activities. ANOVA ($p< 0.05$) showed highly significant differences between the different organs, seasons and metals. Also, there was a highly significant difference between biochemical parameters and a slight significant difference between the different seasons and organs. Constant monitoring of the water quality in the study area is needed to record any alteration in the water characteristics and reducing the impacts on the aquatic ecosystem.

INTRODUCTION

Damietta Nile Branch receives a large amount of untreated effluents from agricultural domestic and partially treated industrial wastewater. Contamination of water is a serious environmental problem as it adversely affects the human health and the biodiversity in the aquatic ecosystem (Sabae & Rabeh, 2007). El-Bagouria Canal (Fig. 1) is diverting from El-Monofy Rayah, It extends along the middle of Kafr El-Zayat Center (El-Gamal, 2009).

There are several categories of water pollutants, which include domestic sewage and oxygen demanding wastes, infectious agents, plant nutrients, chemicals such as insecticides, herbicides & detergents, and heavy metals.

Fig. 1: Map of Kafr El-Zayat showing study area

Fig. 2: Lateral view of the cichlid fish, *O. niloticus*, inhabiting the study area

The construction of canals in the River Nile valley including its delta has attracted farmers to locate villages onto the banks of the canals, these canals have been polluted by different pollutants from those developing communities (Zaki *et al*., 2014). Accumulation of heavy metals in aquatic organisms can pose a long lasting effect on biogeochemical cycling in the ecosphere. Heavy metals can also adversely affect the growth rate of fishes. The presence of heavy metals in different foods constitutes a serious health hazards depending on their relative levels (Mansour & Sidky 2002). Metals can be incorporated into food chains and concentrated in aquatic organisms to levels that affect their physiological state. The most effective pollutants are heavy metals, which have drastic environmental impact on all organisms. Trace metals such as Zn, Cu and Fe play a biochemical role in the life processes of all aquatic plants and animals; therefore, they are essential in the aquatic environment. In the Egyptian irrigation system, the main source of Cu and Pb are industrial wastes as well as algaecides (for Cu), while that of Cd is the phosphatic fertilizers used in crop farms (Mason, 2002).

The present study aims to estimate seasonal variations of the concentrations of some heavy metals (Cu, Fe, Mn and Zn) in El-Bagouria Canal water, sediment and the target organs of *Oreochromis niloticus* inhabiting the same canal to evaluate the effect of these metals on the metabolic contents (total protein, total lipids and total carbohydrates) in the liver, kidney, muscles and gonads, as well as the enzyme activity of ASAT and ALAT in the same organs of this fish.

MATERIALS AND METHODS

Study area:

The present work was carried out on El-Bagouria Canal, El-Gharbia Governorate. Five stations on canal banks were selected (Hesset Abar Village, Kalleeb Ebiar Village, Kafr El-Zayat City, Kasr Nasr El-Din Village and Akwa El-Hessah Village). Samples were collected during the period from summer, 2013 to spring, 2014.

Heavy metals analysis:

Determination of heavy metals in water, sediment and fish organs were done in triplicate using Atomic Absorption Spectrophotometer (model Varian AA240FS) according to the corresponding wave lengths (Cu 324.8, Fe 248.3, Mn 279.5and Zn 213.9). Samples were collected and digested as the following:

Water samples:

They were collected seasonally in cleaned polypropylene bottles and 5 ml of concentrated HNO_3 were added to one liter of each sample; then transferred in icebox at 4°C to the laboratory till examination. In the laboratory 20 ml of nitric acid was added to 500 ml of sample in a beaker, samples then were boiled slowly and evaporated on a hot plate until completed digestion (APHA, 2012).

Sediment samples:

They were collected seasonally from the bottom of canal by using Ekman dredge bottom sampler at the same time of water collection. After collection, sediment samples were transferred in icebox to the laboratory, where exact weight (1.0 g) of each sample was dried at≤ 60°C, sieved, and digested with a mixture of HNO_3 (69%), HCL (37%), and deionized water in waterbath for 2 hrs at 95ºC. The digested samples were filtered and stored in polypropylene bottles till analysis (Martin&Martin,1989).

Fish samples:

Triplicate samples of *O. niloticus* were collected seasonally from the different stations at El-Bagouria Canal. After collection, fishes were dissected and four organs (liver, kidney, muscle and gonads) were removed. An exact weight of each organ (0.5 g) was dried for several days at 70ºC to constant weight, placed in Teflon vessel and 5 ml of nitric acid (69%) was added. The vessels were tightly covered and allowed to predigest at room temperature overnight. The digested block was placed on a preheated hot plate at 80ºC for three hours, cooled at room temperature, filtered and stored in polypropylene bottles till analysis (UNEP, 1984).

Biochemical analysis:

An exact weight of each organ (0.25 g) was grinded through homogenizer in 4 ml saline solution (NaCl 0.9%), centrifuged at 4000 round for 15 minutes; the supernatants were transferred to clean wasserman tubes. Total protein, lipids and carbohydrates and ALAT & ASAT were estimated according to the methods suggested by Burtis & Ashwood (1999), Tietz (1976), Frolund *et al*. (1996) and IFCC, (1986).

Statistical Analysis

All data generated were analyzed by calculating the mean and standard deviation of the measured parameters and statistically performed using analysis of variance (ANOVA, $p<0.05$).

RESULTS AND DISSCUSIONS

Seasonal accumulation of heavy metals in water, sediment and target organs o the cichlid fish, *O. niloticus* collected from El-Bagouria Canal during the period from summer, 2013 to spring, 2014are shown in Tables (1&2).

Heavy metals in the water:

Copper: The highest value of copper concentration was recorded during summer at Kasr Nasr El-Din Village (24.67 ± 5.51 µg/L) and the lowest (3.00 ± 1.00 µg/L) occurred during spring at Kafr El-Zayat City. Seasonal variations of copper concentrations may be due to the fluctuation of agricultural drainage water and sewage effluents discharged into this canal. Similar observations were recorded by Daifullah *et al*. (2003) and didn't match with those obtained by Moustafa *et al*. (2010) and Alawy *et al*. (2015) whom recorded the highest value of copper concentration during spring and the lowest value during autumn.

Table 1: Seasonal variations of heavy metal concentrations in water (µg/L ± SD) and sediment (µg/g dry wt. ± SD) of El-Bagouria Canal during the period from summer, 2013 to spring, 2014.

Stations	Seasons	Metals concentrations							
		Copper (Cu)		Iron (Fe)		Manganese (Mn)		Zinc (Zn)	
		Water	Sediment	Water	Sediment (mg/g)	Water	Sediment (mg/g)	Water	Sediment
Akwa El-Hessah Village	Summer	19.00 ± 1.00	46.72 ± 0.79	120.00 ± 17.32	15.39 ± 0.02	13.33 ± 3.21	0.70 ± 0.01	5.00 ± 1.00	94.55 ± 1.46
Kasr Nasr El-Din Village		24.67 ± 5.51	59.10 ± 0.89	180.00 ± 20.00	15.28 ± 0.09	23.00 ± 4.00	1.01 ± 0.01	5.00 ± 0.72	110.30 ± 1.26
Kafr El-Zayat City		18.33 ± 2.08	62.85 ± 1.46	123.33 ± 49.33	15.28 ± 0.03	21.33 ± 3.05	1.05 ± 0.00	5.00 ± 0.31	117.18 ± 1.85
Kalleeb Ebiar Village		13.00 ± 5.29	62.57 ± 1.36	176.67 ± 5.77	15.07 ± 0.30	32.60 ± 8.50	0.81 ± 0.01	4.33 ± 0.58	127.85 ± 1.74
Hesset Abar Village		18.00 ± 3.61	45.18 ± 0.94	203.33 ± 15.28	15.34 ± 0.07	29.00 ± 11.14	0.67 ± 0.01	21.00 ± 6.24	108.02 ± 1.50
Average		18.60 ± 4.15	55.28 ± 8.66	160.67 ± 37.07	15.27 ± 0.12	23.85 ± 7.43	0.85 ± 0.17	8.07 ± 7.24	111.58±12.25
Akwa El-Hessah Village	Autumn	5.83 ± 0.29	64.40 ± 5.80	63.33 ± 5.77	15.56 ± 0.16	12.16 ± 0.84	1.11 ± 0.02	4.63 ± 0.55	107.53 ± 2.82
Kasr Nasr El-Din Village		6.00 ± 0.02	134.90 ± 5.66	33.33 ± 5.77	15.66 ± 0.15	14.23 ± 0.40	1.21 ± 0.04	4.67 ± 0.29	122.38 ± 0.85
Kafr El-Zayat City		5.33 ± 0.58	198.85 ± 6.36	43.33 ± 32.15	15.66 ± 0.13	12.90 ± 2.54	1.23 ± 0.05	5.00 ± 0.50	129.60 ± 2.09
Kalleeb Ebiar Village		4.33 ± 1.53	108.92 ± 3.23	60.00 ± 10.00	15.76 ± 0.07	13.13 ± 2.71	0.74 ± 0.02	4.67 ± 0.58	108.10 ± 3.14
Hesset Abar Village		5.33 ± 0.58	48.80 ± 0.40	73.33 ± 20.82	15.55 ± 0.22	11.33 ± 2.31	0.73 ± 0.01	4.50 ± 0.87	94.00 ± 0.46
Average		5.36 ± 0.65	111.17 ± 59.86	54.66 ±16.09	15.64 ± 0.09	12.75 ± 1.09	1.00 ± 0.25	4.69 ± 0.18	112.32±13.93
Akwa El-Hessah Village	Winter	5.77 ± 0.25	29.07 ± 0.43	153.33 ± 15.28	14.30 ± 0.07	73.00 ± 5.57	0.58 ± 0.01	5.00 ± 0.92	48.07 ± 0.81
Kasr Nasr El-Din Village		5.70 ± 0.26	29.28 ± 0.20	180.00 ± 10.00	14.40 ± 0.04	85.67 ± 7.02	0.55 ± 0.01	5.17 ± 0.29	48.37 ± 1.16
Kafr El-Zayat City		5.87 ± 0.15	31.67 ± 2.87	130.00 ± 34.64	14.20 ± 0.06	80.67 ± 7.23	0.63 ± 0.00	5.33 ± 0.29	51.43 ± 1.23
Kalleeb Ebiar Village		5.37 ± 0.47	48.88 ± 0.31	186.67 ± 5.77	14.93 ± 0.04	81.00 ± 6.56	0.61 ± 0.02	5.17 ± 0.29	77.13 ± 7.70
Hesset Abar Village		5.67 ± 0.58	31.87 ± 0.46	113.33 ± 5.77	14.11 ± 0.35	70.00 ± 7.81	0.58 ± 0.04	5.43 ± 0.40	62.32 ± 0.45
Average		5.68 ± 0.19	34.15 ± 8.33	152.67 ± 31.48	14.39 ± 0.32	78.07 ± 6.40	0.59 ± 0.03	5.22 ± 0.17	57.46 ± 12.43
Akwa El-Hessah Village	Spring	4.33 ± 1.15	78.17 ± 0.32	453.33 ± 35.12	14.08 ± 0.00	102.33 ± 7.28	0.61 ± 0.01	5.30 ± 0.26	81.25 ± 0.93
Kasr Nasr El-Din Village		3.67 ± 1.15	42.23 ± 0.96	540.00 ± 10.00	14.03 ± 0.02	113.87 ± 6.61	0.70 ± 0.02	5.17 ± 0.29	71.68 ± 1.00
Kafr El-Zayat City		3.00 ± 1.00	48.55 ± 0.64	1156.67± 77.67	14.00 ± 0.01	160.50 ± 1.14	0.65 ± 0.01	5.43 ± 0.21	84.12 ± 1.33
Kalleeb Ebiar Village		5.77 ± 0.23	41.22 ± 0.60	980.00 ± 62.45	13.89 ± 0.01	178.30± 24.30	0.66 ± 0.01	5.00 ± 0.81	75.18 ± 0.36
Hesset Abar Village		6.00 ± 0.05	55.63 ± 0.94	906.67 ± 15.28	13.96 ± 0.02	164.33 ± 6.04	0.60 ± 0.00	5.30 ± 0.26	91.22 ± 0.83
Average		4.55 ± 1.31	53.16 ± 15.12	807.33± 299.38	13.99 ± 0.07	143.87± 33.56	0.64 ± 0.04	5.24 ± 0.16	80.69 ± 7.66

Manganese: The maximal value of manganese in the water was recorded at Kalleeb Ebiar Village during spring (178.30 ± 24.30 µg/L) and the lowest (11.33 ± 2.31 µg/L) during autumn at Hesset Abar Village. The elevation in manganese concentrations during spring may be attributed to the effect of the drought period with probable presence of industrial effluents. Results were in agreement with Venkatesha *et al.* (2013) and differed with Ibrahim & Omar (2013) whom recorded that, the highest value of manganese was recorded during summer and the lowest occurred during winter.

Iron: The maximum value of iron concentrations was recorded at Kafr El-Zayat City during spring (1156.67 ± 77.67 µg/L) and the minimum (33.33 ± 5.77 µg/L) at Kasr Nasr El-Din Village during autumn. Variation in iron concentrations may be attributed to the direct precipitation of iron and clarity of water at Kafr El-Zayat City with high probability of industrial wastes. Results were in agreement with Daifullah *et al.* (2003) and Osman *et al.* (2012) and disagree with Khallaf *et al.* (2014) whom recorded the highest value of iron concentrations during autumn and the lowest during summer.

Zinc: Results revealed that, zinc concentrations in the water was ranged between 4.33 ± 0.58 µg/L at Kalleeb Ebiar Village and 21.00 ± 6.24 µg/L at Hesset Abar Village during summer. The disturbance in zinc concentrations may be attributed to different pollution levels at the studied areas during summer. Results were compatible with Abdel-Hamid *et al.* (2013) and incompatible with Daifullah *et al*. (2003) and Abdel-Satar (2005) whom detected the lowest concentration of zinc during winter.

Heavy metals in sediment:

Copper: The highest value of copper concentrations was recorded at Kafr El-Zayat City during autumn and the lowest value occurred at Akwa El-Hessah Village during winter; being 198.85 ± 6.36 µg/g dry wt. in the former and 29.07 ± 0.43 µg/g dry wt. in the latter. The increasing values during autumn may be due to the increasing of agricultural, domestic and industrial sewage discharged to the study areas; in addition to the increasing of organic matter in sediment at the sampling stations. The present findings were in agreement with those obtained by Daifullah *et al*. (2003) and Saeed *et al*. (2014) and differed with Abdel-Satar (2005) and Ibrahim & Omar (2013) whom observed the highest level of copper during spring.

Manganese: The maximum value of manganese concentrations in the sediment was recorded during autumn at Kafr El-Zayat City (1.23 ± 0.05 mg/g dry wt.) and the minimum value occurred during winter at Kasr Nasr El-Din Village (0.55 ± 0.01 mg/g dry wt.). The fluctuations in manganese levels may be due to the variable amounts of effluent wastes which reached to the sampling stations. The present results were adapted to those recorded by Karadede-Akin (2007) and Pandey & Singh (2015), and differed with Daifullah *et al*. (2003) who recorded the highest value of manganese during spring and Dong *et al*. (2015) whose manganese peaked during winter.

Iron: It was fluctuated between 13.89 ± 0.01 mg/g dry wt. during spring at Kalleeb Ebiar Village and 15.76 ± 0.07 mg/g during autumn at the same station. The higher iron concentrations during autumn could be caused as a result of higher dissolved oxygen which can oxidize dissolved iron into insoluble forms. Similar findings were obtained by Ibrahim & Omar (2013); and differed with Abdel-Satar (2005) who declared that, the maximal value of iron occurred during summer and the minimal during winter.

Zinc: The highest value of zinc concentrations was recorded at Kafr El-Zayat City during autumn (129.6 ± 2.09 µg/g dry wt.) and the lowest (48.07 ± 0.81 µg/g dry wt.) occurred at Akwa El-Hessah Village during winter. The elevation in zinc level during autumn may be attributed to the increasing amounts of industrial, agricultural and domestic wastes at the sampling areas with low water levels and leaching of fertilizers residues used in the agriculture operation into the aquatic environment. Results were nearly similar with that obtained by Ibrahim & Omar (2013) and Goher *et al*. (2014); and differed with Zayed *et al*. (1994) whom recorded the highest level of zinc during winter and the lowest during autumn.

Heavy metals in the different organs of fishes

Copper: Results (Table 2) revealed that, copper in the target organs of *Oreochromis niloticus* decreased from 53.41± 20.55 µg/g wet wt. in the liver during spring to 0.6± 0.28 µg/g wet wt. in the muscles during the same season. These observations were agree with that obtained by Salem *et al*. (2014) and differed with Demirak *et al*. (2006) whom reported that, copper concentration was peaked in the muscles and declined in the gills. Accumulations of copper in the different organs of *O. niloticus* showed visible variations with the highest concentration in the liver. However, muscles and gonads were tended to accumulate less level of copper. Fishes absorbed copper from their diets, sediments and surrounding contaminant waters that, probably received large amounts of industrial, domestic effluents resulting to copper accumulation in different organs of the fish. The higher accumulation in the liver may alter the levels of various biochemical parameters thereby affecting the function of its detoxification and biotransformation of foreign compounds. The differences in the level of heavy metals accumulated by the studied species could be attributed to the differences in their metabolic rates, feeding habits, age, sex and fish species in accordance with Jonathan & Maina (2009); Parvathi *et al.* (2011); Andem *et al.* (2013) and Nanda (2014).

Table 2: Seasonal variations of heavy metals and biochemical parameters in the target organs of *O. niloticus* inhabiting El-Bagouria Canal during the period from summer, 2013 to spring, 2014.

Metals / Seasons	Organs	Metals (µg/g wet wt.)				Metabolic analysis (g/mg wet wt.)			Enzymes activity (U/mg wet wt.)	
		Cu	Fe	Mn	Zn	Protein	Lipids	Carbohydrates	ASAT	ALAT
Summer	Liver	26.31 ± 25.41	28.48 ± 2.0	5 ± 2.49	4.28 ± 3.93	44.80 ±4.54	128.40 ±6.26	7.25 ±0.91	68.80 ±2.71	20.80 ±1.27
Autumn		39.15 ± 12.43	39.33 ± 4.15	9.83 ± 2.47	10.95±0.98	96.0 ±21.78	133.60 ±12.32	24.38 ±2.33	163.73 ±43.24	139.73±33.77
Winter		40.8 ± 16.62	104.18±27.24	10.17±3.33	25.25±3.93	60.80 ±5.21	147.60 ±42.10	16.67 ±5.53	183.47 ±59.14	98.13 ±20.83
Spring		53.41 ± 20.55	103.76 ±54.2	13.5 ± 3.00	11.03±1.37	73.60 ±9.30	120.00 ±13.80	12.06 ±2.59	92.80 ±11.34	38.40 ±5.56
Annual average		39.92 ± 11.08	68.94 ± 40.69	9.62 ± 3.50	12.88±8.84	68.8± 21.62	132.40 ± 11.58	15.09 ± 7.29	127.20 ± 55.06	74.27 ± 54.77
Summer	Kidney	1.81 ± 0.30	28.07 ± 0.15	0.72 ± 0.02	4.65 ± 0.15	81.60 ±8.61	104.40 ±9.20	9.61 ±0.97	180.80 ±12.99	99.20 ±4.98
Autumn		3.71 ± 0.20	44.98 ± 1.90	0.5 ± 0.09	7.25 ± 0.25	99.2 ±20.27	187.20 ±24.53	19.35 ±3.38	331.20 ±18.10	318.4 ±34.12
Winter		5.4 ± 3.10	93.25 ± 16.25	0.86 ± 0.14	14.85± 1.90	96.48±43.99	189.60 ±37.89	12.69 ±0.58	649.60 ±176.02	556.8 ±146.28
Spring		4.01 ± 0.40	43.52 ± 1.50	2.49 ± 0.20	18.16± 1.05	108.8±20.68	97.20 ±17.93	9.57 ±1.25	612.80 ±28.43	502.4 ±43.42
Annual average		3.73 ± 1.48	52.45 ± 28.25	1.14 ± 0.91	11.23± 6.33	96.52±11.26	144.60 ± 50.67	12.81 ± 4.60	443.60 ± 225.66	369.2 ± 206.9
Summer	Muscle	1.25 ± 0.82	4.66 ± 2.46	1.34 ± 0.57	0.58 ± 0.54	50.13 ±5.98	99.60 ±8.40	7.16 ±1.65	242.67 ±43.62	41.60 ±10.91
Autumn		0.73 ± 0.14	11.49±2.77	0.53 ± 0.03	4.67 ± 2.06	93.87±19.29	122.40 ±19.20	5.50 ±3.48	685.87 ±26.20	36.27 ±23.31
Winter		0.85 ± 0.09	14.01±1.32	0.71 ± 0.26	4.77 ± 0.80	55.47 ±7.56	154.80 ±17.68	3.03 ±1.32	3044.80 ±641.78	152.13±73.92
Spring		0.6 ± 0.28	13.99±1.73	4.03 ± 0.76	4.68 ± 1.76	90.13±33.73	172.00 ±53.16	2.42 ±1.23	1055.47 ±392.37	27.73 ±0.92
Annual average		0.86 ± 0.28	11.04±4.41	1.65 ± 1.62	3.67 ± 2.07	72.4 ± 22.79	137.20 ± 32.42	4.53 ± 2.20	1257.2±1237.19	64.43 ± 58.74
Summer	Gonads	1.02 ± 0.36	15.14 ± 9.3	5.16 ± 2.75	12.72±6.21	80.0 ±5.40	85.20 ±5.17	1.25 ±0.16	27.20 ±4.79	25.60 ±4.28
Autumn		1.13 ± 0.12	20.99±2.49	3.5 ± 3.00	18.8 ± 2.40	64.80 ±0.80	120.60 ±5.33	15.43 ±2.70	16.80 ±8.80	34.40 ±2.40
Winter		1.31 ± 0.14	19.32±2.93	2.4 ± 1.65	20.88±1.07	66.4 ±13.6	205.80 ±21.00	12.36 ±0.64	65.60 ±12.80	55.20 ±4.00
Spring		1.11 ± 0.30	13.49±1.01	0.72 ± 0.02	23.63±0.92	91.20 ±9.87	127.20 ±24.53	5.92 ±0.84	59.20 ±13.00	68.80 ±14.24
Annual average		1.14 ± 0.12	17.24±3.51	2.95 ± 1.87	19.01±4.63	75.6 ± 12.44	134.70 ± 50.86	8.74 ± 6.37	42.20 ± 23.85	46.00 ± 19.62

Manganese: Results showed that, manganese concentrations exhibited its highest value in the liver during spring and the lowest value in the kidney during autumn; being 13.5 ± 3.0 µg/g wet wt. in the former and 0.5 ± 0.09 µg/g wet wt. in the latter. The present findings were agree with Monferrán *et al.* (2015) and disagree with Meche *et al.* (2010) whom obtained the highest level of manganese during autumn and the lowest during summer. The concentrations of manganese in the different organs of *O. niloticus* showed remarkable variations with highest peak in the gonads and liver. It could be also due to the greater tendency of the elements to react with the oxygen carboxylate, aminogroup, nitrogen and/or sulphur of the mercapto group in the metallothionein protein, which concentrate in the liver due to the fact that, manganese is naturally abundant in the soil which represented the main source of metals in the surrounding water of the fish samples as it is generally accepted that heavy metal uptake mainly from food, sediment and water that might be polluted with industrial and agricultural effluents discharged directly into the canal.

Iron: The maximal value of iron in the target organs of *O. niloticus* was recorded in the liver during winter (104.18 ± 27.24 µg/g wet wt.) and the minimal value (4.66 ± 2.46 µg/g wet wt.) occurred in the muscles during summer. The study indicated that, the highest concentrations of iron were accumulated in the liver followed by kidney. Results may be due to the influence of surrounding ecosystem or may be attributed to the abundance of iron metals in the water and sediment in addition to the amount of pollutants in the aquatic environment. Fish liver is directly proportional to the degree of pollution by heavy metals, as liver is a target organ of accumulation for metals and highly active in the uptake and storage of heavy metals while, muscle is not an active tissue in accumulating heavy metals. The elevation of iron in the metabolic organs confirm that, the surrounding environment contaminated with industrial wastes, sewage and agricultural effluents that poured into canals stream without any treatments to find their way inside the fish organs through their food. The present observations were nearly similar to those obtained by Yehia & Sebaee (2012) and differ with Eneji *et al*. (2011) whom recorded the maximum value in the gills and the minimum one in the intestine.

Zinc: The maximum value of zinc concentrations was recorded in the liver during winter and the minimum value in the muscles during summer; being 25.25 ± 3.93 µg/g wet wt. and 0.58 ± 0.54 µg/g wet wt. respectively. The present findings were in agreement with Osman (2012) and in contrast with Adeyeye *et al*. (1996) whom recorded the higher level of zinc in the muscles of *Tilapia sp.* Results revealed that, the highest concentrations of zinc were accumulated mainly in the gonads followed by liver. The elevation of zinc in the fish gonads may be attributed to decomposition of organic matter and agricultural wastes that contain residual zinc and/or may be also associated with reproductive processes.

Biochemical analysis in the different organs of the fish:

Total protein: The highest value of total protein was detected in the fish kidney during spring (108.8 ± 20.68 mg/g wet wt.) and the lowest (44.8 ± 4.54 mg/g wet wt.) occurred in the fish liver during summer. Depletion of total protein may be explained on the basis of energy production during the pollutant toxicity through metabolic utilization of the ketoacids to gluconeogenesis pathway for the synthesis of glucose. Results were similar to those obtained by Yacoub & Gad (2012) and El- Nabarawy (2014) whom attributed low protein to other several pathological processes including impairment in protein synthesis machinery, renal damage and elimination in hepatic blood flow or plasma dissolution. Unlike, El-Naggar *et al*., (1998) and Zaghloul *et al*. (2000), reported elevation in the total proteins in soft fish tissues exposed to heavy metals.

Total lipids: It was increased gradually from 85.2 ± 5.17 mg/g wet wt. in the gonads during summer to 205.8 ± 21.0 mg/g wet wt. in the same organ during winter.

Results showed low concentration of lipids in the different organs of *O. niloticus* especially in the muscles; this may be attributed to poor storage mechanism and the use of fat reserves during spawning activity or imposition of high energy demands to counter the toxic stress beside other factors such as seasonal effect, different provisioning origins and a reproductive period. The present results were nearly similar to those obtained by Yacoub & Gad (2012) and Mohanty *et al*. (2013) and disagree with Adebola *et al*. (2013) and Javed & Usmani (2015) whom recorded increasing in the lipids content in the internal organs of fish exposed to heavy metals.

Total carbohydrates: It was increased gradually from 1.25 ± 0.16 mg/g wet wt. in the gonads during summer to 24.38 ± 2.33 mg/g wet wt. in the liver during autumn. Total carbohydrate contents showed remarkable elevation in the fish liver and depletion in the fish muscles. Results explained that, heavy metals increase the glucose content in the blood; due to the intensive glycogenolysis and the synthesis of glucose from extra-hepatic tissue proteins and aminoacids (Almeida *et al*., 2001). It is assumed that, the decreasing in glycogen content in the fish muscles may be due to the inhibition of hormones which contribute to glycogen synthesis. Results were in agreement with Sobha *et al*. (2007) and Maharajan *et al*. (2012), and disagree with Mohanty *et al*. (2013) and Kavidha & Muthulingam (2014) whom observed a decline in the carbohydrate contents, due to its rapid utilization to meet the reduced energetic efficiency under the impact of the exposure to heavy metals regarded to fish tissues.

***Aspartate aminotransferase*:** The enzyme activity in the target organs of *O. niloticus* exhibited its maximum level (3044.8 ± 641.78 U/mg wet wt.) in the muscles during winter and its minimum level (16.8 ± 8.8 U/mg wet wt.) in the kidney during summer. Results suggested that, the pollutants of canal water may be toxic to fish cells; such toxic effects could be lipolytic in nature as a result the cell organelles releasing the enzymes into the blood. Hence, the increased ASAT activity in the present investigation may be a result of liver cell damage. The obtained results were relatively compatible with those obtained by El-Seify *et al*. (2011) and Abumourad *et al*. (2013) and were incompatible with those observed by Abou El-Naga *et al*. (2005) and Mohamed & Gad (2008) whom recorded decline in ASAT activity as a result of heavy metals stress.

***Alanine aminotransferase*:** The highest activity of ALAT in the target organs of *O. niloticus* was observed in the kidney during winter (556.8 ± 146.28 U/mg wet wt.) and the lowest (20.8 ± 1.27 U/mg wet wt.) in the liver during summer; such elevation may be attributed to the toxicity of heavy metals which led to production of mitochondrial enzymes which were subsequently released into the blood as a result of tissues damage. The present findings were nearly agree with Younis *et al*. (2012) and Thyagarajan *et al*. (2015) and disagree with Mohamed & Gad (2008) and Hedayati & Safahieh (2011) whom recorded falling in ALAT activity, due to heavy metals stress.

Analysis of variance (ANOVA, at $p<0.05$):

Analysis of variance (ANOVA, at $p<0.05$) revealed a highly significant differences between heavy metals in water and sediment. However, there are significant differences between the seasons on the values of heavy metals in the sediment and highly significant in the water samples. Non-significant differences were exhibited between the different stations on the values of heavy metals in the water and sediment. Two ways of ANOVA on the values of heavy metals in water and sediment provided significant differences between seasons and metals at the same stations. While, non-significant differences were showed at the interactions between seasons and sources at the same metals and between sources and metals at the same seasons.

One way analysis on the measured values of heavy metals and biochemical parameters in the target organs of *O. niloticus* during the different seasons showed that, there were highly significant differences between the parameters. However, differences between the different seasons and between target organs were highly significant for heavy metals and slight significant for biochemicals. Moreover, two ways of ANOVA on the values of heavy metals and biochemical parameters provided highly significant differences between organs and parameters at the same seasons. While, non-significant differences were showed at the interactions between seasons and organs at the same parameters and between seasons and parameters at the same organs (Table 3).

Table 3: Analysis of variance (ANOVA) performed on the values of heavy metals in water, sediment, target organs and biochemical analysis of *O. niloticus* inhabiting El-Bagoria Canal, Egypt.

Sources of variance	**D. F.**	**Soft tissues of *Oreochromis niloticus***			**Sources of variance**	**D. F.**	**Heavy metals**	
		F-value	**D. F.**	**F-value**			**F-value**	
		Heavy metals		**Biochemical's**			**Water**	**sediment**
Total	63		79		Total	139		
Seasons	3	4.81**	3	3.98*	Seasons	3	34.61**	2.90*
Organs	3	33.71**	3	3.59*	Stations	4	1.21 **n.s.**	0.33 **n.s.**
Parameters	3	71.93**	4	11.24**	Metals	6	71.62**	21.41**
Season * Organs	9	1.75 **n.s.**	9	0.88 **n.s.**	Season * Stations	12	1.25 **n.s.**	1.42 **n.s.**
Season * Parameters	9	1.19 **n.s.**	12	1.96 **n.s.**	Season * Metals	18	25.54**	2.89**
Organs * Parameters	9	16.86**	12	4.52**	Stations * Metals	24	0.94 **n.s.**	0.76 **n.s.**
Error	27		36		Error	72		

Note: * = significant at $p<0.05$. ** = highly significant at $p<0.01$. **n.s.** = non-significant

CONCLUSION

From the above findings, it can be concluded that, water quality of El-Bagouria Canal is characterized by medium to high status. This means that, the Nile water is within the standard approved for raw water. The study confirmed on the presence of a continuous degradation of the water quality in the River Nile, due to many impediments that reduce the effective implementation of environmental legislation.

Heavy metal concentrations in the sediments were remarkably higher than that of surface water as a result, a large portion of elements in sediment are likely to release back into the water column. The concentrations of heavy metals in the different organs of *O. niloticus* proved that, the liver exhibited the highest tendency to accumulate Cu, Fe, Mn and Zn, while the accumulation of these metals was very limited in fish muscles.

The biochemical analysis indicated that, the fish samples had visible elevation in ALAT and ASAT activity under stress of heavy metals accumulated in the different fish organs. There were remarkable depletions in the values of total proteins and total lipids unlike, total carbohydrates which showed remarkable elevation.

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