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HEAVY METALS POLLUTION IN RIVER NILE WATER AND *Clarias gariepinus* MUSCLE AT GREATER CAIRO

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ABSTRACT

The aim of study is to determine pollution of water by heavy metals at greater Cairo and its changes during four seasons at six selected stations extended from El-Hawamdyia region to El-Kanater El-Khyria, Egypt, which have different kinds of pollutants and to study its effects on *Clarias gariepinus* health. Samples of Water and fish were collected seasonally from the selected stations during the year 2009. Heavy metals (Fe, Cu, Pb, Mn, Zn, and Cd) in water and *Clarias gariepinus* muscles were determined during the four seasons; winter, spring, summer and autumn. Biochemical parameters glucose, total protein, albumin, globulin, ALT, AST, uric acid and blood urea were determined. The results showed that, the water heavy metals (Pb, Mn, and Cd) were in high concentrations at El-Hawamdyia station than the WHO limits while (Fe, Zn, and Cu,) where within the WHO limits in all selected stations. The changes in water pollutants at El-Hawamdyia have negative impact on blood parameters of *Clarias gariepinus* fish. That related to the waste water and sewage from sugar factory, iron and steel factory and human activates in El-Hawamdyia which affected fish production and human health.

Key words: Heavy metals, water pollution, *Clarias gariepinus*, serum glucose, liver function, kidneys function.

INTRODUCTION

The River Nile is the life of Egypt throughout the known Egyptian history. The River has dominating influence on the economy, culture, public health, social life and political aspects (APRP, 2002). There are 234 factories discharge their industrial wastes into the water ways along the extent of the river from Aswan to its outlet. The main types of industries are food (93), chemicals (51), textiles (29), metals (22) and (39) factories of other types (Ahmed, 1986). The River Nile from Aswan to Delta Barrage receives waste water discharge from 124 point sources, of which 67 are agricultural drains and the remainders are industrial sources (APRP, 2002).

Frank *et al.* (2013) decided that the degradation of aquatic ecosystems in the Lake Victoria basin and the rest of East Africa has elicited concern because of its bearing on social and economic development. Rapid population growth, industrialization and its associated urbanization, agricultural intensification and habitat loss have increased pressure on the integrity of water resources. Costs associated with traditional approaches to monitoring water quality have become prohibitive while not giving reliable early warning signals on resource condition to aquatic resource managers.

Fish is one of the most important aquatic organisms greatly affected by the toxicant. This is reflected in the blood properties, function and structure of different organs (Mahmoud *et al.*, 2008). *Clarias gariepinus* is a bottom feeder and is economically important species of the family Siluridal that is well represented in Egypt in land water. It is the most abundant fish next to Tilapia in the River Nile and is considered as an important food source of protein in Africa and some areas of the world (Tayel, 2003; Mahmoud and El-Naggar, 2007).

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El-Naggar *et al.* (2009) mentioned that the liver of *Oreochromus niloticus* living in the Damietta and Rossetta branches showed several pathological alterations including: degeneration, fatty degeneration and edema. Congestion, hemorrhage, hemolysis, hemosidrin and parasitic worms were also seen in blood vessels. It was noticed that the liver of fish collected from Shoubra El-Khema and El-Rahawy drain showed much more damage than that collected from the other stations receives more drainage water loaded with industrial and sewage wastes.

Clarias gariepinus is increasing in importance as a global aquaculture species with a 100 fold increase in production over the past decade but this species still remains one of the most important wild harvested freshwater food fish throughout rural Africa. However, this species has been shown to accumulate metals from contaminated inland waters. The metal concentrations in muscle tissue of *C. gariepinus* from two main-stem impoundments in the Oliphant's River, Limpopo Basin (Antoinette *et al.*, 2015).

The present work aimed to investigate the pollutants levels including the accumulation of some heavy metals (Iron, Zinc, Copper, Manganese, Lead and Cadmium) in water and *Clarias gariepinus* muscles in River Nile.

MATERIALS AND METHODS

Area Under Investigation

Six field sites were selected to follow up the seasonal changes in water heavy metals pollution during 2009, Details of surface water sampling location along with their longitude and latitude are presented in Table 1 and Fig. 1.

Water Samples

Three water samples from each site were taken seasonally during winter 2009 and continued till autumn 2009 from the surface (about 30 cm) by using polyvinyl Van Dorn plastic bottle. These samples were kept in polyethylene bottles of one liter capacity in ice box. The bottles were stored in a refrigerator and analysis was carried out within 24 hr., after collection.

Heavy Metals in Water

The heavy metals (Fe, Zn, Cu, Mn, Pb and Cd) were determined using atomic absorption model (Perkin Elmer 3110 USA) with graphite atomizer HGA-600, according to the method described by APHA (1998). The results were expressed in $\mu g l^{-1}$.

Heavy Metals in Fish Muscles

Samples of *Clarias gariepinus* were collected seasonally during the period of study from El-Hawamdyia and El-Kanater El-Khyria stations, Egypt. Fish specimen's muscles were done according to the method described by Goldberg *et al.* (1963).

Biochemical Studies

Sampling and preparation of blood serum

Clarias gariepinus were dried from excess external water with filter paper. Blood samples were taken by severance of the caudal peduncle of fish and collected into small sterilized vials, part of blood samples were collected into tubes with EDTA as un anticoagulant and then centrifuged at 3000 rpm for 15 minutes to obtains plasma, which was kept frozen until analysis. The other part of blood samples were left to coagulate at 37°C for 30 min and then centrifuged at 3000 rpm for 15 minutes to obtain serum, which was kept frozen until analysis.

Liver function and glucose assays

Serum glucose, alanine aminotransferase (ALT) and aspartate aminotransferase (AST), total protein, and albumin were determined according to (Trinder, 1969; Reitman and Frankel, 1957; Henry, 1964; Doumas *et al.*, 1971) using kits obtained from DIAMOND diagnostics Egypt, Serum globulin was calculated by difference between total protein and albumin according to Reinhold (1953).

Kidneys function assays

Serum uric acid and while blood urea were determined according to Gochman and Schmitz, (1971) and Patton and Crouch (1977).

Statistical Analysis

The comparison among means ± SE (standard errors) was tested for significance using one-way ANOVA analysis and Duncan's multiple range tests. The statistical analyses were calculated, using the computer program of SPSS Inc. at 0.5 significance level, according to (Coakes and Steed, 2001).

Table 1. Details of surface water sampling location at Greater Cairo

Station	Features of station	Latitude	Longitude
1	Before El-Hawamdyia	31° 17′ 16.72″	29° 51′ 44.03″
2	In front of sugar factory, El-Hawamdyia	31° 16′ 49.44″	29° 53′ 52.8″
3	After El-Hawamdyia	31° 16′ 52.13″	29° 53′ 52.26″
4	In front of electric power station, Shoubra El-Khima	31° 14′ 06″	30° 07′ 30″
5	El-Warrak	31° 12′ 54″	30° 07′ 12″
6	El-Qanater El-Khyria, before bifurcation	31° 08′ 42″	30° 10′ 30″

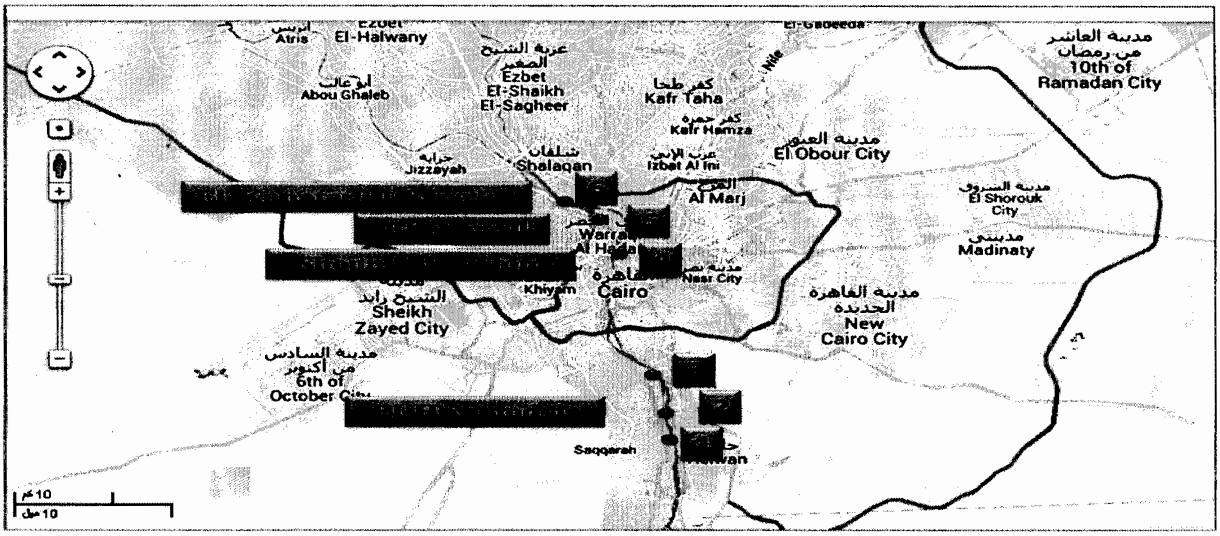

Fig. 1. Map showing the sampling sites along the area under investigation on the River Nile

RESULTS AND DISCUSSION

Heavy Metals in Water

The contamination of soils, sediments, water resources, and biota by heavy metals is of important concern especially in many industrialized countries because of their toxicity, persistence and bioaccumulative nature (Ikem *et al.,* 2003).

The primary source of heavy metals in irrigation and drainage canals is the discharge of domestic waste water which content high concentration of metals such as: Al, Cu, Fe, Pb and Zn (APHA, 1995).The present study deals with the concentration of such metals in water. Table 8 show recommended permissible limits of heavy metals in water (μg/l), according to WHO (1993).

Iron (Fe)

Iron concentration in the studied station are shown in Table 2. It was 0.592 mg/l at station (1) during spring, while the lowest value was 0.136 at station (4) during summer. The elevation of iron concentration at station (1) may be attributed to the release of iron from the factory of iron and steel which is not far from station (1). Also, the sediment during the dissolution of iron and its attributed to the discharge effluent from agricultural drain which was loaded by agriculture and domestic sewage in the River Nile (Tayel *et al.,* 2008; Mahmoud *et al.,* 2008). Again, increase may be due to the breakdown of organic matter and dead microorganism that releases the metal into the water (Price, 1976 ; Elewa *et al.,* 2009).

Table 2. Seasonal variations of iron concentration (mg/l) in the studied area during 2009

Sites	Seasons				
	Winter	Spring	Summer	Autumn	Mean ± SE
1	0.483	0.592	0.460	0.585	0.530 ± 0.03
2	0.290	0.371	0.309	0.303	0.318 ± 0.02
3	0.288	0.302	0.197	0.292	0.270 ± 0.02
4	0.251	0.219	0.136	0.287	0.223 ± 0.03
5	0.212	0.297	0.198	0.288	0.249 ± 0.03
6	0.269	0.371	0.184	0.274	0.275 ± 0.04
Mean ± SE	0.299±0.04	0.359±0.06	0.247±0.05	0.338±0.05	0.310±0.01

Permissible limit (≤1.0 mg/l) according to, WHO (1993).

Copper (Cu)

The toxicity of Cu can be affected by many factors in the water such as pH, hardness, temperature, alkalinity, chlorosity and presence of complexing agent, (Nather and Lim, 1991). WHO (1993) international standards for water sets maximum permissible level of copper for drinking water is 1.5 mg/l and the Egyptian Ministry of Health sets as a limit 1 mg/l. During spring, copper attained its maximum value 19.48 µg/l at station (2) during spring while, the lowest value was 4.70 µg/l at station (6) during winter. Table 3 show slightly increase of copper concentration during the hot seasons (spring and summer) than cold season (autumn and winter). These observation may be attributed to the high evaporation rate under raises temperature of water and air during hot seasons and to the release of Cu from sediment to overlying water (Abdo, 2002).

Lead (Pb)

Lead is a serious cumulative poison. Natural waters seldom contain more than 20 µg/l, although values as high as 400 µg/l have been reported. Lead in a water supply may come from industrial, mine and smelter discharges or from dissolution of old lead pumbing (APHA, 1992). WHO (1993) international standards for water, set 0.1mg/l as a maximum permissible level of lead; also the Egyptian Ministry of Health has set 0.05 mg/l for fresh water bodies. The values of lead obtained showed in Table 4. In the present study, lead concentrations maximum value was 73.66 µg/l during winter at site (1), while, the minimum value was 20.60 ±3.70 µg/l during autumn at station (3). The highest concentrations of lead during winter may be due to the precipitate of Pb salts at higher pH values in the form of carbonate (Ghallab, 2000). Also, the increase in Pb during winter season might be attributed to the decrease in water discharges during drought period, where the dilution and assimilative capacities of the Nile water are low as cited by (Abdel-Satar, 2005; Sitohy *et al.*, 2006; El-Sayed, 2011). While, the lowest Pb levels were recorded during autumn which can be attributed to formation of Fe $(OH)_3$ which act as absorbent for trace element (Badr *et al.*, 2006).

Manganese (Mn)

Manganese is considered to be essential element in the biochemical cycle of ecosystem and usually present in well waters as Mn $(HCO_3)_2$, $MnCl_2$ or $MnSO_4$. Mn (II) is unstable in oxygenated water and easily oxidized to higher form with the formation of solid MnO_2 which is very insoluble in water (Bewers *et al.*, 1976). The bacterial oxidation leads to the formation of Mn $(OH)_3$ depending on pH (Hutchinson, 1957). Concentrations of manganese rarely exceed 1 mg/l in undisturbed waters. The drinking-water standard for manganese is 0.05mg/l (Brooks *et al.*, 2003).

The highest value of Mn was 148.4µg/l during winter at station (3), while the lowest value was 90.30µg/l during summer at station (6), the obtained values of manganese were represented in Table 5. The high concentration of manganese at stations (5) and (3) in the present

Table 3. Seasonal variations of copper concentration (µg/l) in the studied area during 2009

Sites	Seasons				
	Winter	Spring	Summer	Autumn	Mean ± SE
1	9.99	18.90	17.70	12.60	14.79 ±2.11
2	14.60	19.48	18.62	16.17	17.21 ± 1.12
3	11.20	18.26	16.5	13.85	14.95 ± 1.54
4	12.64	18.62	16.17	14.60	15.50 ± 1.26
5	13.10	15.90	15.39	13.81	14.55 ± 0.66
6	4.70	9.70	6.80	4.90	6.52 ± 1.16
Mean ± SE	11.03 ±1.56	16.81 ±1.65	15.19 ±1.91	12.65 ± 1.78	13.93 ± 1.92

Permissible limit (100 µg/l) according to WHO (1993).

Table 4. Seasonal variations of lead concentration (µg/l) in the studied area during 2009

Sites	Seasons				
	Winter	Spring	Summer	Autumn	Mean ± SE
1	73.66	63.65	34.62	28.35	50.07 ±11.00
2	53.01	50.10	25.20	21.20	37.37 ±8.25
3	51.17	48.00	24.62	20.60	36.09 ±7.86
4	49.10	47.06	39.43	25.07	40.16 ±5.44
5	57.68	59.10	43.65	38.10	49.63 ±5.19
6	66.10	51.60	38.20	33.60	47.37 ± 7.32
Mean ±SE	58.45±4.29	53.25±2.97	34.28±3.50	27.82±3.12	43.45 ± 7.36

Permissible limit 50 µg/l according to WHO (1993).

Table 5. Seasonal variations of manganese concentration (µg/l) in the studied area during 2009

Sites	Seasons				
	Winter	Spring	Summer	Autumn	Mean ± SE
1	134.80	133.40	104.50	124.40	124.27 ±6.98
2	131.20	122.40	120.12	110.60	121.08 ±4.23
3	148.40	124.50	116.65	120.40	127.38 ±7.15
4	148.00	125.20	119.80	120.40	128.45 ± 6.66
5	124.60	122.80	115.20	117.70	120.07±2.19
6	115.70	109.80	90.30	97.80	103.40 ± 5.74
Mean ± SE	133.78±5.78	123.10±3.41	111.09±5.22	115.21±4.33	120.78 ± 4.99

Permissible limit (5 - 50 µg/l) according to WHO (1993).

study may be due to high agricultural activities (pesticides and fertilizers) and factories wastes water in the River Nile and low water drought period. Also may be comes from the breakdown of organic matter and dead micro-organisms with subsequent release of the metal into water El-Sayed (2011).

Massoud *et al.* (1994) reported that the higher concentration of Mn was in presence of suspended organic matter, while the low concentration of manganese may be related to uptake of manganese by phytoplankton. The lowest values of Mn perhaps may be due to the precipitation or adsorption onto sediments due to the interaction with some other compounds (Canli and Kalay, 1998), or may be attributed to the oxidation of Mn^{+2} to solid MnO_2 which precipitate it to the sediment layer.

Zinc (Zn)

Levels of zinc in surface and ground water normally does not exceed 0.01 and 0.05 mg/l, respectively. Concentrations in tap water can be much higher as a result of dissolution of zinc from pipes (WHO, 1993). The highest value was 48.90 µg/l during winter at station (2), while lowest value was 11.60 µg/1 during summer at site (6), the obtained values of zinc were recorded in Table 6. Generally, the relatively increase of zinc concentrations during winter may be attributed to the low water level due to the drought period and the decrease of the absorption of zinc. On the other hand, highest value of zinc concentration may be attributed to industrial metals, cooling water at station power, domestic and agricultural sewage wastes water discharge affecting water of the River Nile. Ibrahim, (2007) recorded that; the high concentration of zinc may be attributed to adsorption of zinc hydroxide which binds to organic matter. Also, the decrease of zinc concentration in summer may be attributed to its adsorption on $Fe(OH)_3$ sediments. (Metawea, 2009; El-Sayed, 2011).

Cadmium (Cd)

Cadmium may enter water as a result of industrial discharge or due to the deterioration of galvanized pipe (APHA, 1995). Generally, Cd concentrations in the river and drains depend on the quantity of sewage discharge, agricultural discharges, domestic wastes and industrial discharges inflow to the river (Issa *et al.,* 1996). The obtained results in Table (7) showed that, the maximum value was 3.89 µg/1 during summer season at station (1), while the minimum value was 0.98 µg/1 during winter at station (3). The high concentration of cadmium in the present study may be due to direct industrial drains and of sewage and agriculture wastes. The high concentrations of Cd are attributed to Cd dissolution from sediment (Ghallab, 2000; Tayel, 2003; El-Sayed, 2011) or impact of sewage and industrial wastes, but the high value of Cd was recorded during summer which may be due to phytoplankton blooming during this seasons as mentioned by Abdo (2004). The decrease of Cd concentration during autumn may be attributed to its uptake by microorganisms and fish.

Table 8 reveal that, Pb and Cd in some stations showed rising in the range value of these metals, but the mean values of them were in the permissible limit, the mean values and range of Fe, Cu and Zn within the permissible limits. While, Mn were higher than the permissible limits according to WHO (1993).

Fish Analysis

Bioaccumulation of heavy metals in *Clarias gariepinus* muscles

The relationship between the concentration of heavy metals in water and their accumulation in *Clarias gariepinus* muscles was indicated in the present study. Bayomy and Tayel (2007) noticed that fish accumulates trace metals in muscles with lower quantities than those found in ambient water. The accumulation of heavy metals (iron, copper, zinc, manganese, lead and cadmium) in muscles of *clarias griepinus* fish were obtained from El-Hawamdyia and El-Kanater El-Khyria, Egypt during, 2009 are tabulated in Table 9, while the recommended permissible limits of heavy metals in fish tissues for human consumption according to FAO, 1992 are tabulated in Table 10.

Iron (Fe)

Iron toxicity causes hemorrhagic gastroenteritis, diarrhea, vomiting, convulsions, liver necrosis and death due to hepatic coma (Clarke *et al.,* 1981 ; Khallaf *et al.,* 1998). The lowest value was 104.6µg/g during winter at El-Kanater El-Kahyria, while the highest value was 258.0µg/g during autumn at El-Hawamdyia. In present study,

Table 6. Seasonal variations of zinc concentration (µg/l) in the studied area during 2009

Sites	Seasons				
	Winter	Spring	Summer	Autumn	Mean ± SE
1	26.40	23.60	16.90	22.40	22.32 ± 1.99
2	48.90	44.90	38.80	41.80	43.60 ± 2.16
3	40.20	34.12	23.60	33.60	32.88 ± 3.44
4	33.80	30.60	26.80	29.90	30.27 ± 1.44
5	26.40	20.60	14.80	19.20	20.25 ± 2.39
6	18.40	14.80	11.60	13.80	14.65 ± 1.42
Mean ± SE	32.35±4.91	28.10±4.81	22.08±4.44	26.78±4.59	27.33± 2.11

Permissible limit (100 µg/l) according to WHO (1993).

Table 7. Seasonal variations of cadmium concentration (µg/l) in the studied area during 2009

Sites	Seasons				
	Winter	Spring	Summer	Autumn	Mean ± SE
1	1.22	3.62	3.89	1.72	2.61 ± 0.67
2	1.08	1.72	2.04	1.38	1.55 ± 0.21
3	0.98	1.56	1.82	1.24	1.40 ± 0.18
4	1.56	1.86	2.14	1.66	1.80 ± 0.13
5	1.38	2.18	2.42	1.82	1.95 ± 0.23
6	1.52	1.74	2.31	1.72	1.82 ± 0.17
Mean ± SE	1.29±0.11	2.11±0.34	2.43±0.33	1.59±0.10	1.85 ± 0.26

Permissible limit (2 µg/l) according to WHO (1993).

Table 8. Recommended permissible limits of heavy metals in water (µg/l), according to WHO, (1993)

Heavy metals	Present study	Mean	Permissible limit
	Range		
Fe mg/l	0.136 – 0.592	0.310	0.1 – 1.0
Cu µg/l	4.70 – 19.48	13.93	100
Pb µg/l	20.60 – 73.66	43.45	50
Mn µg/l	90.30 – 148.4	120.78	5 - 50
Zn µg/l	11.60 – 48.90	27.33	100
Cd µg/l	0.98 – 3.89	1.85	2

Table 9. Seasonal variations of Fe, Cu, Pb, Mn, Zn and Cd accumulation in muscles (µg/g dry wt.) of *Clarias garipinus* inhibiting at El-Hawamdyia and El-Katanter El-Khyria during, 2009

Metals	Winter		Spring		Summer		Autumn		Mean ± SE	Mean ± SE
	1	2	1	2	1	2	1	2	1	2
Fe	185.0	104.6	217.5	145.7	181.6	109.5	258.0	120.5	210.53±17.77	120.08±9.17
Cu	18.9	11.3	11.6	8.8	4.0	1.9	21.0	9.0	13.88±3.86	7.75±2.03
Pb	36.9	20.5	18.5	15.5	19.7	13.5	31.5	13.9	26.65±4.50	15.85±1.61
Mn	57.0	22.5	27.9	25.2	25.0	13.9	28.0	16.0	34.48±7.54	19.40±2.66
Zn	42.2	31.6	51.5	50.0	43.6	37.9	67.9	26.8	51.30±5.90	36.58±5.02
Cd	5.2	2.8	15.3	6.1	15.6	10.0	10.9	3.6	11.75±2.43	5.63±1.62

1: El-Hawamdyia 2: El-Kanater El-Kahyria

Table 10. Recommended permissible limits of heavy metals in fish tissues (µg/g dry wt.) for human consumption, according to FAO, 1992

Heavy metals	Present study Rang	Mean	Permissible limit
Fe µg/g	104.6 – 258.0	165.30	30.0
Cu µg/g	1.9 – 21.0	10.81	20.0 – 30.0
Pb µg/g	13.5 – 36.9	21.25	2.0
Mn µg/g	13.9 – 57.0	26.94	30.0
Zn µg/g	26.8 – 67.9	43.94	50.0
Cd µg/g	3.6 – 15.6	8.69	2.0

the iron accumulation in *Clarias gariepinus* muscles were higher than the permissible limit. The increase of iron concentration in muscles of selected fish might be attributed to increase of total dissolved iron in investigated areas causing increase the free metal ion concentration and accordingly increased iron uptake by different fish organs, as explained by Ibrahim and Mahmoud (2005). These accumulations were higher in fish living in El-Hawamdyia water than that living in El-Kanater water; this may be due to large amounts of wastes from sugar factory and iron and steel factory. The same observation was reported by Haggag *et al.* (1993).

Copper (Cu)

Copper is commonly occurring element in natural water and sediment (Yacoub, 2007). Copper is relatively low in toxicity if compared to the other metals like mercury, lead and cadmium (Bayomy and Tayel, 2007). The lowest values were 1.9 µg/g during summer at El-Kanater El-Khyria station, while the highest value was 21.0µg/g which recorded at El-Hawamdyia station during autumn. In present study, the values of copper accumulation within the range obtained by El-Serafy *et al.* (2005). Also these values were higher at El-Hawamdyia than those of El-Kanater and all values still in the permissible limit recorded by National Health and Medical Research Council (2005), in Australia as standard concentration for human consumption which is 30 µg Cu/g as cited by Yacoub *et al.* (2008). The obtained results revealed that slightly increase in copper accumulation in fish samples of El-Hawamdyia. Also the increased copper during winter and autumn (cold seasons) at two studied stations may be due to the decrease in water discharging during these seasons as recorded by Sitohy *et al.* (2006) and Ahmed (2007).

Lead (Pb)

Lead is non-essential element and higher concentration can occur in aquatic organisms close to anthropogenic sources (Yacoub, 2007). It is toxic even at low concentrations and has no known function in biochemical processes (Burden *et al.,* 1998). The major source of lead is the use of leaded gasoline (Yacoub and Abdel-Sater, 2003). The highest lead accumulation value in skin and muscles of *Clarias gariepinus* was 36.9µg/g during winter season at El-Hawamdyia. However the lowest value was 13.5µg/g at El-Kanater El-Khyria during summer. The obtained data for lead accumulation in water of the area under study may be due to huge amount of waste water from sugar factory, agricultural activity and sewage waste inflow in studied area. Also these values were higher than that recorded by FAO (1992) as permissible limit (2.0µg/g). On the other hand, the values during winter were higher than other season's.

Manganese (Mn)

Manganese is toxic only when present in high amount, but at low levels is considered as micronutrient (Ibrahim and Tayel, 2005). The highest manganese accumulation value was 57.0µg/g during winter season at El-Hawamdyia station; however, the lowest value was 13.9µg/g at El-Kanater El-Khyria, during summer season. In the present study values of manganese accumulation muscles of selected fish were higher than the permissible limit (30.0 µg/g) at El-Hawamdyia, as recorded by FAO (1992).

Zinc (Zn)

Zinc is an essential element and is a common pollutant as well (Tayel, 2007). Mining, smelting and sewage disposal are major sources of zinc pollution. It is taken up by fish directly from water especially by mucous and gills (Mahmoud *et al.,* 2008). Yacoub (2007) reported that zinc concentrations in muscle tissue of fish species from non-polluted areas, were less than 1 ppm. The highest zinc accumulation value in muscles of *Clarias gariepinus* was 67.9µg/g. However the lowest value was 26.8µg/g at El-Hawamdyia and El-Kanater El-Khyria respectively, during autumn season. In the present study the average of zinc accumulation in muscles of polluted area was higher than that of non-polluted areas, and also higher than the permissible limit (50.0µg/g) recorded by FAO (1992). This increasing in zinc accumulation may be due to high amount of sewage wastes discharged into investigated area as cited by Ibrahim (2007). Also the change of zinc accumulation in muscles during the four seasons related to its fluctuation in water during the same season as recorded by Tayel (2007).

Cadmium (Cd)

Cadmium is highly toxic non-essential heavy metals and it does not has a role in biological processes in living organisms. Thus even in low concentrations, cadmium could be harmful to living organisms (Burden *et al.,* 1998; Yacoub, 2007). The lowest value of cadmium accumulation in *Clarias gariepinus* muscles was 2.8µg/g, during winter season at El-Kanater El-Khyria. While the highest value was 15.6µg/g during summer season at El-Hawamdyia station. In the present study cadmium level was higher than the permissible limit (2.0 µg/g), as recorded by FAO (1992). The obtained high level of cadmium accumulation in *Clarias gariepinus* muscles at the present study may be due to its strong binding with cystein residue of metallothionein this explanation agree with that mentioned by Abu El-Ella (1996) and Tayel *et al.* (2008).

Table 10 showing that, the copper values are within the permissible limits while Fe, Mn, Zn, Pb and Cd were higher than permissible limits according to FAO (1992).

Biochemical studies

Serum parameters including, glucose,- total protein, albumin, globulin, alanine aminotransferase level, asprtate aminotransferase level, uric acid and blood urea have been used as an indicator of fish healthy status. In addition these measurements can be considered as an important indicator to know the effect of pollutants on fish health (Ibrahim *et al.,* 2009). In the present study the previous biochemical parameters which lead us to evaluate *Clarias garipinus* health and growth inhabiting in El-Hawamdyia and El-Kanater El-Khyria were determined and the results are illustrated in Table 11.

Table 11. Glucose, serum total protein, S. Albumin, S. Globulin, S. ALT, S. AST, S. Uric acid and blood urea values of *Clarias gariepinus* at El-Hawamdyia station and El-Kanater El-Khyria station during, 2009

Parameters	Winter		Spring		Summer		Autumn		Mean ± SE	
	1	2	1	2	1	2	1	2	1	2
Glucose (mg/100ml)	240.3	84.2	135.5	92.5	195.1	115.2	221.0	75.5	197.98±22.79	91.85±8.52
T. protein (g/dl)	2.5	2.0	3.0	2.3	4.7	3.8	3.6	2.5	3.45±0.47	2.65±0.40
Albumin (g/dl)	1.2	1.0	0.6	0.4	1.4	1.1	1.6	0.7	1.20±0.22	0.80±0.16
Globulin (g/dl)	1.3	1.0	2.4	1.9	3.3	2.7	2.0	1.8	2.25±0.42	1.85±0.35
ALT (IU/ml)	40.3	22.2	39.5	23.0	60.8	34.5	35.7	23.6	44.08±5.66	25.83±2.91
AST (IU/ml)	163.2	77.1	148.3	95.7	172.9	129.6	165.8	81.7	162.55±5.17	96.03±11.87
Uric acid (mg/dl)	5.3	3.1	1.3	1.2	3.9	1.4	2.8	1.4	3.33±0.85	1.78±0.44
Blood urea (mg/dl)	77.9	30.8	62.9	52.6	72.8	42.1	35.1	23.4	62.18±9.55	37.23±6.41

1: El- El-Hawamdyia 2: Kanater El-Kahyria * Data are presented as means ± standard error

Serum Glucose (SG)

Serum glucose level recorded highest value during winter and it was 240.3mg/100ml at El-Hawamdyia, while, the lowest value was 75.5mg/100ml during autumn at El-Kanater El-Khyria. The obtained values at El-Hawamdyia were higher than those obtained at El-Kanater El-Khyria region during all season. The increase of serum glucose may be due to the withdrawal of water from blood to muscles to overcome the depletion of oxygen content in the polluted area, or due to the breakdown of glycogen in liver (Ibrahim *et al.,* 2009). Also, this hyperglycemia may be due to enhanced glycogen breakdown in liver, probably because of anaerobic stress and the high concentration of heavy metals in water (Tayel, 2003). The reported hyperglycemia may be also due to the increase in plasma concentration of catecholamines and corticosteroid as stress response of fish subjected to environmental alteration (Tayel *et al.,* 2008).

Serum Total Protein (STP)

The important function of serum total protein is to maintenance of osmotic balance between the circulating blood and tissue spaces (Tayel, 2003). The obtained values of serum total protein ranged from 2.0g/100 ml during winter at El-Kanater El-Khyria to 4.7g/100ml at El-Hawamdyia during summer. The obtained data from El-Hawamdyia station were higher than those recorded at El-Kanater El-Khyria station during four seasons. The present results showed that the fish caughted during winter recorded values less than those obtained during summer season at the studied stations. Also the obtained values from El-Hawamdyia station were higher than those from El-Kanater El-Khyria station.

Increasing the total serum protein may be due to the changes taking place in serum globulin metabolism or to several types of pollutants, or may be from sewage wastes, temperature increasing, biological oxygen demand, nutrient salts and heavy metals as reported by Tayel *et al.,* (2008).

Serum Albumin (SA) and Serum Globulin (SGl)

Determination of albumin and globulin were taken into consideration, as variation in total serum protein is more or less due to the changes taking place in the serum globulin metabolism and also may be due to several types of pollution (Tayel, 2003). The serum albumin in the present study ranged from 0.4 g/dl to 1.6 g/dl during spring and autumn at El-Kanater El-Khyria and El-Hawamdyia stations, respectively. The obtained data from El-Hawamdyia station showed relatively higher values than those obtained from the same fish species living in El-Kanater El-Khyria region. The globulin values varied between 1.0 g/dl to 3.30 g/dl during winter and summer at El-Kanater El-Khyria and El-Hawamdyia, respectively. The values of albumin and globulin for the selected fish living in the two areas were within the range obtained by Tayel (2003) and Mahmoud and El-Nagger (2007). The increase in albumin and globulin for fish living in El-Hawamdyia station (industrial waste water) may be explained as a result of the increase in metabolic rate of albumin and globulin due to the decrease or depletion in dissolved oxygen. This explanation agreed with that reported by Tayel *et al.* (2007).

Alanine Aminotransferase Level (ALT) and Asprtate Aminotransferase Level (AST)

The aminotransferase alanine and aminotransferase aspartate are two important key enzymes considered as sensitive markers to evaluate hepatocellular damage and some hepatic diseases (Aly *et al.,* 2003). The increase of serum aminotransferase might reflect myocardial and hepatic intoxication, leading to extensive liberation of the enzymes into the blood (Ibrahim and Mahmoud, 2005). The obtained data of ALT from *Clarias gariepinus* at the selected stations were ranged between 22.2 IU/ml and 60.8 IU/ml during winter and summer at El-Kanater El-Khyria and El-Hawamdyia stations, respectively While, The obtained data of AST level in serum varied from 77.1 IU/ml to 172.9 IU/ml during winter and summer at El- Kanater El-Khyria and El-Hawamdyia stations, respectively.

The present data shows that the values of ALT and AST obtained from fish caughted from El-Hawamdyia station were higher than those obtained from the same fish species obtained from El-Kanater El-Khyria station. On the other hand, these values recorded the highest level during the summer season at the two stations. The values of ALT and AST were within the same range obtained by Aly *et al.* (2003) and Bayomy and Mahmoud (2007). These results showed a general trend of increase in ALT and AST activities, also, indicated that the pollutants in the Nile water has an effect on the liver cells as evidenced by the alterations occurred in both AST and ALT activities. Also the increments in the ALT and AST activities could considered as indicators for liver damage (Ibrahim and Mahmoud, 2005) and may be attributed to industrial wastes at El-Hawamdyia station and the increasing of biological oxygen demand, ammonia, nitrate, nitrite and heavy metals in the River Nile.

Serum uric acid

The values of serum uric acid ranged from 1.2 mg/dl to 5.3 mg/dl during spring and winter at El-Kanater El-Khyria and El-Hawamdyia stations, respectively. These values were within the same range obtained by Haggag *et al.* (1993). The increase of serum uric acid may be due to disturbances and damage in the kidney (Maxine and Benjamine, 1985), or may be due to the action of copper accumulation on the glomerular filtration rate which causes pathological changes of the kidney (Oikari and Soivio, 1977).

Blood Urea

The obtained results of blood urea from El-Hawamdyia showed relatively higher values than those obtained from El-Kanater El-Khyria station. The values of blood urea varied from 23.4 mg/dl to 77.9 mg/dl during autumn and winter, at El-Kanater El-Khyria station and El-Hawamdyia station, respectively. The obtained results showed a decrease in blood urea during autumn season at the two selected stations. While the increase of these values recorded during winter at El-Hawamdyia station and spring at El-Kanater El-Khyria. The obtained values were within the same range obtained by Haggag *et al.* (1993). The Increasing of blood urea may be due to industrial and agriculture wastes at El-Hawamdyia station and from increasing of ammonia, nitrate, nitrite and heavy metals in River Nile water as mentioned by Hassaan, (2011).

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التلــوث بالعناصـــر الثقيلــة فــي ميــاه نهــر النيل وعضلات أسماك القراميط بمنطقة القاهرة الكبري

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يهدف هذا البحث الي كشف مستوي تلوث ماء نهر النيل بالعناصر الثقيلة في منطقة القاهرة الكبري خلال عام كامل (٢٠٠٩) حيث تم تقسيمه الي اربعة مواسم هي الشتاء والربيع والصيف والخريف في المنطقة الممتدة بين الحوامدية الي القناطر الخيرية قبل التفريع، اضافة الي دراسة تلوث عضلات اسماك القراميط في منطقتي الحوامدية والقناطر الخيرية بالعناصر الثقيلة، تم سحب عينات الماء واسماك القراميط من المحطات المحددة، كما تم تقدير عناصر الحديد والنحاس والرصاص والمنجنيز والزنك والكادميوم الثقيلة في الماء وفي عضلات اسماك القراميط خلال المواسم الاربعة، اضافة الي ذلك تم إجراء بعض اختبارات الوظائف الحيوية بالدم مثل الجلوكوز ووظائف الكبد ووظائف الكلي، أشارت نتائج الدراسة إلى ارتفاع نسبة التلوث بعناصر الرصاص والمنجنيز والكادميوم الثقيلة في محطات الحوامدية الثلاثة بنسب أعلى من المسموح بها من قبل منظمة الصحة العالمية بينما كانت نسبتهم في الحدود المسموح بها في باقي المحطات، كما اظهرت الدراسة ان التلوث الحادث في منطقة الحوامدية له تاثير مرضي علي اسماك القراميط وقد ظهر ذلك واضحا في القياسات الحيوية بالدم للجلوكوز ووظائف الكبد والكلي والتي ربما يرجع سببها إلى وجود مصانع الحديد والصلب والسكر بالحوامدية والتي تؤثر علي المياة والاسماك وبالتالي صحة الانسان.

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