BIOACCUMULATION AND DISTRIBUTION OF SOME HEAVY METALS IN THE WATER AND THE NILE TILAPIA (*OREOCHROMIS NILOTICUS*) FROM LAKE MANZALA, EGYPT

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ABSTRACT

Lake Manzala is one of the economic lakes and one of the most important Delta wetlands in Egypt, due to its high productivity. The southern region of the Lake receives agriculture, industrial and sewage wastewaters without treatment from several drains; the most polluted one is Bahr El-Baqur drain. In the present study the distribution and accumulation of some heavy metals (Al, As, Cr, Co, Ni and Se) were studied in the water and the Nile Tilapia O. niloticus, during the period from winter 2012 to autumn 2013. Results showed that the concentrations of heavy metals in water followed the order Al>Ni>Cr. Heavy metals As, Co and Se were not detected in all water samples at the six selected sites. Al and Ni levels in water were higher than the international permissible limits of Australia and New Zealand. The levels of the heavy metals in gills and muscles of the Nile Tilapia followed the order Al>Ni>Co>As>Se and Cr. The concentrations of heavy metals exceeded the maximum permissible limits in all fish muscles. So, it can be conclude that the southern area of Lake Manzala is contaminated by high levels of heavy metals and the consumption of its fish is not safe and could cause health hazard to the local population as their diet depends mainly on fish.

Keywords: heavy metals, Lake Manzala, Bahr El-Baqur drain, Oreochromis niloticus.

INTRODUCTION

Lake Manzala is bounded by Mediterranean Sea to the north, the Suez Canal to the east, Damietta governorate to the west, Dakahlia and Sharkia governorates to the south. Now, the Lake is considered as a sink for disposing industrial and human wastes. A total amount of 7500 million cubic meters of untreated industrial, sewage and agricultural drainage water is discharged annually into the lake via numbers of drains (Abdel-Shafy and Aly, 2002). The main drains are Bahr El-Baqur, Hadous and Ramsis. Bahr El-Baqur is considered as one of the most polluted drains in Egypt. It receives and carries the greatest part of wastewater (3 billion m^3/years) into the lake through a very densely populated area of the Eastern Delta passing through Qalubyia, Sharkia, Ismaillia and Port Said Governorates (Zahran *et al*., 2015). Bahr El-Baqur drain has received considerable concern by Abdel-Azeem *et al*. (2007), Ali (2008) and Hamed *et al*., (2013)

Several investigations have been carried out concerning its ecosystem. These studies dealt with different environmental aspects of the Lake, including geological, aspects, hydrological regime, physico-chemical properties, bacterial indices, phytoplankton composition, benthic invertebrates and fishery status (Abbassy *et al*., 2003; Gad, 2005; Ali, 2008)

Additional recent information is needed to provide detailed database for water quality status that help in the proper management of the lake.

Therefore, the objectives of this study are:

1) To assess some heavy metals (Al, As, Cr, Co, Ni and Se) in the water and the Nile Tilapia *Oreochromis niloticus* collected from southern area of Lake Manzala and Bahr EL-Baqur drain.
2) To study the direct and indirect effect of sewage, industrial and agricultural wastewaters on the environmental condition of the Lake.

MATERIAL AND METHODS

1-Study area: Lake Manzala is located in the north-eastern corner of the Nile Delta. It is generally has a rectangular shape; about 60 km long and 40 km wide, and has an average depth of 1.3m. A total of 3.7 km^3 of draiage water flows annually into Lake Manzala from nine major drains and canals. The most important of these are Al Serw, Baghous, Abu Gurida and Bahr El-Baqur. Bahr El-Baqur drain is the most polluted one as it carries a mixture of treated and untreated wastewater originating from Greater Cairo area and contributes in deteriorating water quality of the Lake.

2-Water Samples:Water samples were collected from six selected stations (figure 1 and table 1) during the period from winter 2012 to autumn 2013 from a depth of 50 cm in clean plastic bottles and acidified with few drops of concentrated nitric acid to reduce the pH below 2 to prevent the microbial reactions. The samples were transferred to the laboratory and kept refrigerated for later analysis (APHA, 2012).

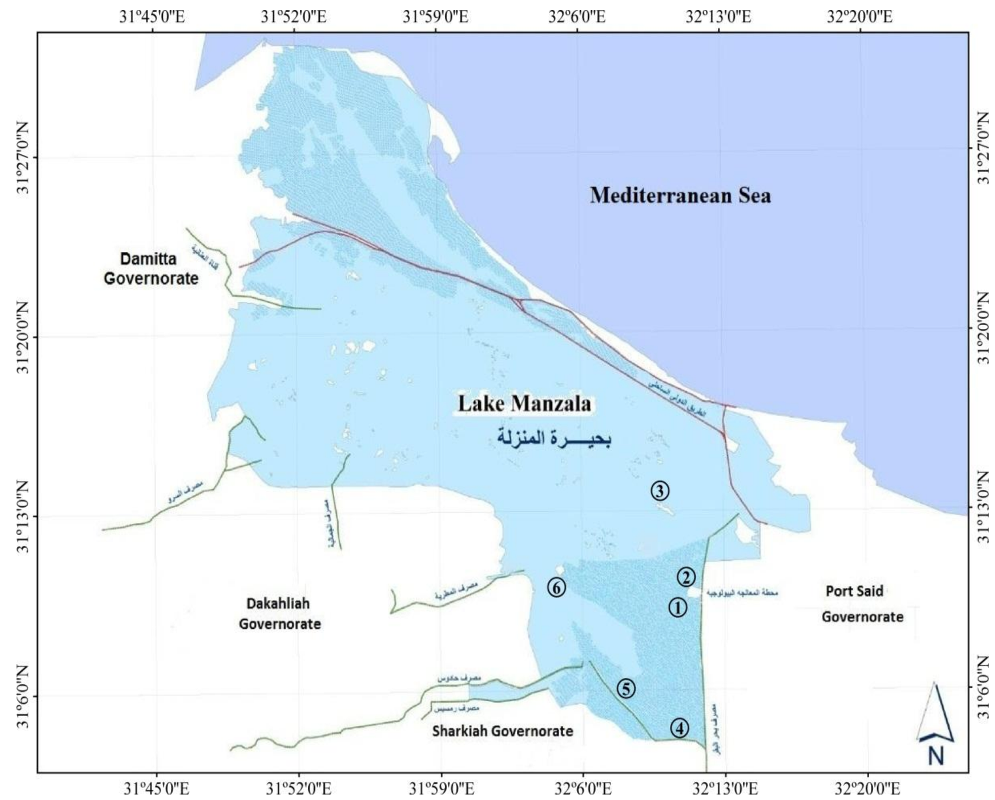

Figure (1): A map of Lake Manzala showing the sampling sites

Table (1): Locsites and coordinates.

sampling site	Location	Coordinates
1	End of Bahr El-Baqur drain before Engineered Wetland Station	31°09′56″ 32°04′54″
2	Effluent of Engineered wetland Station after treatment	31°10′23″ 32°12′33″
3	Inside the Lake North of Site No.2	31°10′08″ 32°15′21″
4	End of Bahr El-Baqur drain before discharge to the lake	31°04′07″ 32°10′37″
5	Inside the Lake downstream Bahr El-Baqur drain	31°07′31″ 32°06′02″
6	Inside the Lake North of Site No.5	31°10′11″ 32°03′36″

3-Fish Samples: *O. niloticus* fish samples were collected seasonally from the selected four sampling sites (1,3,4,6) (Table 1) during the same period from winter 2012 to autumn 2013; the collected fish has a length of 20 - 30 cm and a weight of 150-250 g . After fish dissection, muscles and gills of the fish were carefully separated out of body

4- Heavy Metals analysis:

4.1. in Water:

Heavy metal and trace element concentrations in water were determined as a total concentration using the Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES) with (Perkin Elmer optima model 5300). The samples were prepared and analyzed for (Al, As, Cr, Co, Ni, and Se) as to Standard Methods for (APHA, 2012). The concentrations were expressed in mg/L and the detection limit is 0.001 mg/l

4.2. in Fish tissues:

Tissue samples (muscles and gills) were dried in an oven at 105^{o}C for 24 hours ground to fine powder then digested according to the method described by Hamed *et al*., (2013). Heavy metals Al, As, Cr, Co, Ni, and Se in fish tissues were analyzed by using (ICP-OES), and expressed in µg/g dry wt.

RESULTS AND DISCUSSION

1- Heavy Metals Concentration in Water Samples

Accumulation of toxic metals of hazards level in aquatic biota has become a problem of increasing concern and could lead to health hazards in man either through drinking of water and/or consumption of fish.

1.1. Aluminum (Al)**:** Table (2) shows the concentration of aluminum (Al) in water samples collected from different sites of Lake Manzala during the period from winter 2012 to autumn 2013. Al concentrations in the lake fluctuated between (0.59 ± 0.01) to (1.87 ± 0.02) mg/l. Highest concentration was recorded in site (1) in winter and the lowest was recorded in Site (2) in summer which facing effluent of engineered wetland status after treatment.

Table (2): Seasonal Variations of aluminum (Al) concentration (mg/l) in water samples from Lake Manzala

Seasons / sampling site	Winter	Spring	Summer	Autumn
1	1.87±0.02	1.54±0.08	0.87±0.03	1.08±0.05
2	0.84±0.06	1.20±0.10	0.59±0.01	1.04±0.02
3	1.20±0.10	1.40±0.02	1.79±0.04	1.20±0.01
4	1.8±0.04	1.84±0.06	1.59±0.03	1.3±0.02
5	1.45±0.13	1.84±0.02	1.70±0.02	1.35±0.06
6	1.42±0.00	1.71±0.01	1.77±0.03	1.23±0.20

The increased metal concentration in winter and decreased in summer is in agreement with the results obtained by Saeed and Shaker (2012) and Ali (2008) who reported that heavy metals concentrations showed seasonal variation being greater in winter and lowest in summer. This may be attributed to the phytoplankton growth which was higher in summer and autumn seasons that can absorb large quantities of heavy metals from water. Also, the decreased heavy metals in summer and spring are due to its adsorption into the clay particles and then sedimentation to the underlying sediment (Ali and Fishar, 2005).

This variation may be due to difference in the sources of Al pollution and physical-chemical conditions of water. It was noticed that Al concentrations in Lake Manzala water have exceeded the world permissible limits (1 µg/l at, pH 6.5 and 55 µg/l at pH 6.5) reported by Ontario Ministry of Environment (ANZECC and ARMCANZ, 2000).

1.2.Chromium (Cr) Table (3) shows the concentrations of chromium (Cr) in water samples collected from different sites of Lake Manzala during the period from winter 2012 to autumn 2013. The highest concentration (0.113±0.006) mg/l was recorded in site (1) in winter and the lowest (0.008±0.001) mg/l in site (4) in summer.

Table (3): Seasonal Variations of Chromium (Cr) concentration (mg/l) in water samples from Lake Manzala

Seasons / **Sampling site**	**Winter**	**Spring**	**Summer**	**Autumn**
1	0.113±0.006	0.083±0.006	0.009±0.01	0.090±0.01
2	0.063±0.006	0.087±0.006	0.009±0.01	0.070±0.006
3	0.073±0.006	0.063±0.006	0.033±0.01	0.013±0.001
4	0.080±0.001	0.069±0.001	0.008±0.001	0.030±0.001
5	0.078±0.001	0.073±0.005	0.031±0.01	0.014±0.002
6	0.014±0.001	0.065±0.004	0.033±0.01	0.017±0.001

Chromium does not occur freely in nature. The main chromium mineral is chromite. Chromium compounds can be found in waters only in trace amount (Authman, 2015). Cr concentration in all water samples collected from different sites of Lake Manzala still below the permissible limits (0.5 mg/l) recommended by ANZECC and ARMCANZ(2000).

1.3. Nickel (Ni)

Nickel released from the process of nickel mining and by industries that convert scrap or new nickel into alloys or nickel compounds or by industries that use nickel and its compounds. These industries may also discharge nickel into wastewaters. Once Nickel released to the environment it forms complexes with many ligands, making it more mobile than most heavy metals (Palaniappan and Karthikeyan, 2009). While Nickel is an essential element at low concentrations for many organisms, it is toxic at higher concentrations; exposure to Nickel may lead to various adverse health effects such as nickel allergy, contact dermatitis and organ system toxicity. The effect of Nickel on freshwater fishes was studied by Al-Attar (2007) who reported that sublethol concentrations of Nickel causes a decreased in serum Na+ and osmolarity and increase in serum glucose, cholesterol, Triglycerids, AIT, AST and total protein of *O. niloticus*.

Table (4) shows the concentrations of nickel (Ni) in water samples collected from different sites of Lake Manzala during the period from winter 2012 to autumn 2013. nickel (Ni) concentration ranged from (0.15 ± 0.01) to (0.63 ± 0.06) mg/l. Highest concentration (0.63 ± 0.06) mg/l was recorded at site (1) in winter and the lowest (0.15 ± 0.01) mg/l was recorded at sites (2&5) in summer.

Table (4): Seasonal Variation of nickel (Ni) concentration (mg/l) in water samples from Lake Manzala

Seasons / Sampling sites	**Winter**	**Spring**	**Summer**	**Autumn**
1	0.63±0.06	0.52±0.02	0.22±0.01	0.34±0.01
2	0.42±0.02	0.38±0.01	0.15±0.01	0.27±0.01
3	0.21±0.01	0.16±0.01	0.18±0.01	0.18±0.01
4	0.56±0.01	0.28±0.01	0.19±0.01	0.23±0.01
5	0.29±0.01	0.23±0.01	0.15±0.01	0.19±0.01
6	0.24±0.01	0.21±0.02	0.19±0.01	0.22±0.01

Ni concentrations in water of Lake Manzala are higher than the permissible level (0.02 mg/l) recommend by ANZECC and ARMCANZ (2000).The abundance of heavy metals in water samples collected from different sites of Lake Manzala followed the order Al>Ni> Cr. Co and trace elements (As, and Se) were less than the detection limits (0.001 mg/l) of the instrument (ICP-OES) in all water samples collected from different sites of Lake Manzala during all seasons.

2- heavy metals in fish tissues

Heavy metals are considered the most important element of pollution in the aquatic environment because of their toxicity and accumulation in organisms like fish and then go to man. Fish accumulated heavy metals to concentration higher than that present in water (Boran and Altinok , 2010).

Heavy metals accumulated in fish tissues through two mechanisms namely bio-concentration (uptake form the surrounding environment and bio-magnification (uptake through the food chain). Bioaccumulation occurs when an organism absorbs a toxic substance at a rate greater than that at which the substance is lost. Bioaccumulation results from a dynamic equilibrium between exposure from the external environment and uptake, storage and excretion with an organism (Zhou *et al*., 2008).

2.1. Aluminum (Al)

Aluminum is not considered to be an essential element in humans. Exposure to aluminum has been implicated in a number of human pathologies including encephalopathy, dialysis dementia and Alzheimers disease (Narin *et al*., 2004). The results of Table 5 revealed that the concentration of accumulated Al in the gills of studied fish ranged from (66.67 ± 0.02) to (175.00 ± 0.05) µg/g dry weight. The highest concentration of Al was recorded in fish collected from site (4) in summer and the lowest (66.67 ± 0.02) µg/g dry weight was recorded in fish collected from site (3) in winter.

Table (5): Seasonal variations of aluminum (Al) concentrations (µg/g dry wt.) in tissues of *O. niloticus* fish from different sites of Lake Manzala.

Tissues	Sampling site	Winter	Spring	Summer	Autumn
Gills	Lake 3	66.67±0.02	68.53±0.01	92.33±0.03	106.00±0.04
	Lake 6	70.00±0.03	80.00±0.05	100.00±0.06	115.00±0.05
	Drain1	109.00±0.06	92.00±0.01	163.53±0.03	141.00±0.02
	Drain 4	115.00±0.04	100.00±0.06	175.00±0.05	155.00±0.02
Muscles	Lake 3	63.33±0.03	45.85±0.05	74.33±0.06	76.60±0.05
	Lake 6	70.00±0.04	50.00±0.03	80.00±0.06	85.00±0.02
	Drain 1	78.00±0.02	58.00±0.02	112.00±0.02	110.00±0.02
	Drain 4	66.67±0.02	68.53±0.01	120.00±0.05	106.00±0.04

Data are represented as mean ± S.E of 8 fishes (µg/g dry wt.)

Also, the concentration of Al in muscles of *O. niloticus* fish ranged from (45.85 ± 0.05) to (120.00 ± 0.05) µg/g dry weight.

The highest concentration was recorded in fish collected from site (4) in summer and the lowest was recorded in muscles of fish collected from site (3) in spring.Results indicated that the highest concentrations of Al was recorded in fish gills in summer at site (4); Bahr El-Baqur drain, which is contaminated by large quantity of sewage, agricultural and domestic effluent that contains large concentrations of Al. Also, the highest concentration of Al in gills of *O. niloticus* collected from different sites of Lake Manzala can be related to direct touch of polluted waters to gills, and accumulation of such metals from water primarily through fish gills. Lowest concentration of Al was recorded in *O. niloticus* fish muscles in spring season at site (3); Lake Manzala, which receives organic and inorganic pollutants. This variation in Al concentration maybe due to the nature of water source. In general, Al concentration in gills and muscles exceeded the permissible international level (0.1 µg/g) recommended by ANZECC and ARMCANZ (2000).

2.2. Arsenic (As)

Arsenic is actively metabolized in the tissue of fish especially in organs, such as liver and has the tendency to accumulate as reported in different fish. The results of Table 6 revealed that concentration of (As) in gills and muscles ranged from (9.00 ± 0.3) to (15.50 ± 0.6) µg/g dry weight in gills and (6.72±0.6) to (13.00±0.67) µg/g dry weights in muscles. Highest concentration was recorded in the gills of *O. niloticus* collected from site (4) in summer and the lowest was recorded in muscles of *O. niloticus* collected from site (3) in winter.

Authman *et al.* (2015) reported that total arsenic in marine fish, shellfish and freshwater fish tissues ranged from 0.19 to 65, 0.2 to 125.9 and 0.007 to 1.46 µg/g dry wt respectively. Arsenic also is known to induce a number of major stress protein families including heat shock proteins (Bamen *et al*., 2002).

Table (6): Seasonal variations of arsenic (As) concentrations (µg/gdry wt.) in tissues of *O. niloticus* fish from different sites of Lake Manzala.

Tissues	sampling site	Winter	Spring	Summer	Autumn
Gills	Lake 3	10.17±.0.67	11.27±0.58	13.43±0.60	11.17±0.40
	Lake 6	11.00±0.58	11.60±0.06	14.00±0.67	11.50±0.30
	Drain1	13.00±0.60	11.70±0.58	14.87±0.67	9.00±0.30
	Drain 4	13.50±0. 67	12.00±0.58	15.50±0.60	10.00±0.30
Muscles	Lake 3	6.72±0.60	7.44±0.06	10.63±0.30	7.80±0.03
	Lake 6	7.00±0.13	8.00±0.06	13.00±0.67	8.50±0.03
	Drain 1	10.33±0.60	8.73±0.06	11.17±0.30	9.23±0.30
	Drain 4	11.00±0.60	9.50±0.30	12.00±0.60	10.00±0.30

Data are *represented* as mean ± S.E of 8 fishes (µg/g dry wt.)

The highest concentrations of the accumulated As was found in the summer and the lowest was recorded in winter. The concentrations of As in muscles and gills of *O. niloticus* collected from different sites of Lake Manzala are higher than the permissible limits (0.5 µg/g) that recommended by ANZECC and ARMCANZ (2000). The concentrations of As in fish tissues in the present study was higher than that recorded previously by Authman *et al*. (2015), who reported that the total arsenic of freshwater fish tiusses ranged from 0.07 to 1.46 µg/g.

2.3. Chromium (Cr)

Chromium is an essential nutrient metal, necessary for metabolism of carbohydrates that potentiates insulin action **(Farag *et al*., 2006).** The results of table (7) revealed that the concentration of Chromium (Cr) in *O. niloticus* tissues (gills and muscles), collected from different sites of Lake Manzala during winter 2012 to autumn 2013 seasonally. The results revealed that the concentration of Cr in fish *O. niloticus* ranged from (0.63 ± 0.06) to (1.60 ±0.01) µg/g dry wt. in gills and between (0.53 ± 0.01) to (1.09±0.03) µg/g dry weights in muscles. The highest concentration was recorded in gills of fish collected from site (4) in summer and the lowest concentration was recorded in fish collected from site (3) in winter.

Table (7): Seasonal variations of chromium (Cr) concentrations (µg/g dry wt.) in tissues of *O. niloticus* fish from different sites of Lake Manzala.

Tissues	Stations	Winter	Spring	Summer	Autumn
Gills	Lake 3	0.63±0.06	0.63±0.06	1.43±0.01	0.98±0.02
	Lake 6	0.75±0.06	0.78±0.03	1.38±0.03	0.93±0.02
	Drain1	0.64±0.06	1.30±0.03	1.54±0.03	1.03±0.02
	Drain 4	0.85±0.03	1.39±0.06	1.60±0.01	1.10±0.02
Muscles	Lake 3	0.53±0.01	0.68±0.05	0.90±0.05	0.73±0.05
	Lake 6	0.56±0.01	0.63±0.01	0.96±0.01	0.76±0.06
	Drain 1	0.66±0.01	0.69±0.03	1.06±0.03	0.65±0.05
	Drain 4	0.69±0.05	0.67±0.01	1.09±0.03	0.63±0.05

Data are represented as mean ± S.E of 8 fishes (µg/g dry wt.)

The highest values of Cr concentrations were recorded in gills of *O. nilotius* in summer at site (4) and the lowest values were recorded in muscles at site (3) in winter. The concentrations of Cr in *O. niloticus* tissues at all seasons in all sites were higher than the permissible levels (0.15 µg/g dry wt.) recommended by ANZECC and ARMCANZ (2000).

2.4. Cobalt (Co)

The result of Table 8 revealed that the concentration of Cobalt (Co) in fish tissues ranged between (51.33 ± 0.58) to (100.00 ± 0.60) µg/g dry wt. in gills and (11.00±0.30) to (50.00±0.58) in muscles. The highest concentrations was recorded in gills fish collected from site (4) in summer and lowest was recorded in gills fish collected from site (3) in winter.

Table (8): Seasonal variations of *cobalt (Co)* concentration (µg/gdry wt.) in tissues of *O. niloticus* fish from different sitesof Lake Manzala.

Tissues	sampling site	Winter	Spring	Summer	Autumn
Gills	Lake 3	51.33±0.58	61.67±0.60	80.33±0.60	73.00±0.58
	Lake 6	55.00±0.58	65.00±0.60	85.00±0.60	75.00±0.58
	Drain1	59.00±0.58	77.00±0.60	95.83±0.60	68.00±0.58
	Drain 4	62.00±0.60	80.00±0.58	100.00±0.60	75.00±0.52
Muscles	Lake 3	11.00±0.30	37.00±0.30	43.00±0.58	36.50±0.48
	Lake 6	15.00±0.30	42.00±0.60	48.00±0.48	42.00±0.60
	Drain 1	26.00±0.60	12.00±0.30	43.80±0.6	13.00±0.30
	Drain 4	30.00±0.58	16.00±0.30	50.00±0.58	15.00±0.30

Data are represented as mean ± S.E of 8 fishes (µg/g dry wt.)

Cobalt concentration in fish tissues (gills and muscles) were higher than the permissible levels (1.2 µg/g) that recommended by ANZECC and ARMCANZ (2000). The present results of Co agreed with that of El- Moselhy (1999) and Ali (2008) on *O. niloticus* from lake Manzala which was from 0.32 to 0.89 µg/g.

2.5. Nickel (Ni):

Nickel released from the process of nickel mining and by industries that convert scrap or new nickel into alloys or nickel compounds or by industries that use nickel and its compounds. These industries may also discharge nickel into wastewater. Once Nickel released to the environment it forms complexes with many ligands, making it more mobile than most heavy metals, (Palaniappan and Karthikeyan, 2009). Table (9) shows the concentrations of Nickel (Ni) in gills and muscles of *O. niloticus* fish collected from different sites of Lake Manzala during the period winter 2012 to autumn 2013. The concentration of (Ni) ranged between (65.00 ± 0.03) to (100.00 ± 0.03) µg/g dry wt. in the gills, while from (40.0 ± 0.03) to (90.00 ± 0.03) µg/g dry wt. in the muscles. The highest concentration was recorded in gills of *O. niloticus* collected from site (6) in winter and the lowest recorded in muscles of fish collected site (6) in spring.

Table (9): Seasonal variations of *nickel (Ni)* concentrations (µg/gdry wt.) in tissues of *O. niloticus* fish during the study from different sites of Lake Manzala.

Tissues	sampling site	Winter	Spring	Summer	Autumn
Gills	Lake 3	95.50±0.04	66.67±0.05	65.00±0.03	69.00±0.30
	Lake 6	100.00±0.03	70.00±0.04	68.00±0.05	75.00±0.05
	Drain1	81.60±0.6	75.40±0.06	70.00±0.30	86.00±0.03
	Drain 4	85.00±0.04	85.00±0.05	75.00±0.03	90.00±0.05
Muscles	Lake 3	55.50±0.06	40.00±0.03	45.00±0.06	43.00±0.05
	Lake 6	60.00±0.05	50.00±0.03	50.00±0.50	50.00±0.03
	Drain 1	55.00±0.50	60.00±0.60	65.00±0.04	85.00±0.05
	Drain 4	50.00±0.20	65.00±0.05	70.00±0.06	90.00±0.30

Data are represented as mean ± S.E of 8 fishes (µg/g dry wt.)

The concentrations of Ni in gills and muscles of O. *niloticus* collected from different sites of Lake Manzala are higher than the permissible limit (0.4 µg/g dry wt.) recommended by ANZECC and ARMCANZ (2000).

2.6.Selenium (Se):

Selenium is widely distributed throughout the environment and is found in most ground and surface waters at concentrations between 0.1 and 0.4 µg/L of Se (Muscatellos and Janz, 2009). The results of Table (10) revealed that the concentration of (Se) ranged between (0.60 ± 0.05) to (2.67 ± 0.002) µg/g dry weight. The highest concentration of (Se) was recorded in muscles of fish collected from site (1) in summer and in gills of fish from site (3) in winter. These concentrations are higher than the permissible levels (1.0 µg/g dry wt.) recommended by

ANZECC and ARMCANZ (2000). For all sites the Se concentrations in muscles were lower than the permissible levels in winter.

Table (10): Seasonal variations of selenium (Se) concentration (µg/g dry wt.) in tissues of O. niloticus fish from different sites of Lake Manzala.

Tissues	sampling site	Winter	Spring	Summer	Autumn
Gills	Lake 3	0.64±0.05	0.96±0.05	1.38±0.05	0.7±0.05
	Lake 6	0.78±0.02	0.80±0.05	1.50±0.02	0.82±0.01
	Drain1	0.94±.05	0.85±0.02	1.54±0.01	0.74±0.01
	Drain 4	0.90±0.05	0.92±0.06	1.68±0.03	0.85±0.02
Muscles	Lake 3	1.83±0.01	1.88±0.01	2.10±0.06	1.96±0.06
	Lake 6	1.95±0.05	1.70±0.02	1.85±0.05	2.00±0.05
	Drain 1	2.23±0.01	1.98±0.01	2.67±0.06	1.96±.06
	Drain 4	2.50±0.05	2.20±0.01	2.40±0.06	1.80±0.05

Data are represented as mean ± S.E of 8 fishes (µg/g dry wt.)

It is clear from the present study that gills of *O. niloticus* has a higher tendency to accumulate heavy metals more than muscles, and the order of metals in accumulation follows the concentrations pattern Al>Ni>Co>As>Se and Cr . The basic reason for this, is the external position and its proximately to ambient toxicant in addition, the highly branched structural of organization gill and resultant highly increased surface area along the large volume of water passing of the gill surface as well as the relatively small biomass when compared to their surface area(Jayakumar and Paul, 2006). The present results agree with that of Gad and yacoub (2009). Lower accumulation of Al, Ni, Co, As, Se and Cr in fish muscles may be attributed to various reasons; firstly the muscles do not come into direct contact with the toxicant, secondly the muscles is not an active site for detoxification and therefore transport of heavy metals from other tissues to muscles does not seen to be occurred (Jayakumar and Paul, 2006). Moreover, metal accumulation in fish is not only depends on the types of metals and its concentrations in water, but also on the structure of the tissues and organs and the interaction of heavy metals in the environment (Karayakos and Aya, 2004). The present results agree with the results of Gad (2007) and Gad and Yacob (2009).

CONCLUSION AND RECOMMENDATION

The pollution of the southern region of Lake Manzala by agricultural, industrial and sewage wastes causes accumulation of large quantity of heavy metals in water and fish muscles (edible parts), that exceeded the maximum permissible limits recommended by **ANZECC and ARMCANZ (2000)**, and this causes harmful impact on human. So, the following recommendations should be taken into consideration to protect and maintain the quality of aquatic environment in the Lake Manzala and reduce the risk of pollution:

[1] Carrying out an intensive plan for monitoring water quality of aquatic environment especially in northern lakes; seasonally and regionally.

[2] The Egyptian Environmental Affairs Agency (EEAA) should attend in all international conventions to prohibit the excessive usage of the environmental pollutants and to restrict discharging of wastewater

(sewage, industrial, domestic and agriculturally) into the River, canals and lakes without being treated according to the international standards including the Egyptian laws No. 48 (1982) and No. 4 (1994) for protection of the aquatic environment.

[3] Continuous evaluation of the water quality and other aquatic environment components especially the biota should be carried out to ensure ecological system integrity.

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تراكم وتوزيع بعض العناصر الثقيلة في المياه والبلطي النيلي في بحيرة المنزلة، مصر

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المستخلص

تعتبر بحيرة المنزلة احدى البحيرات الشمالية الهامة في مصر من الناحية الاقتصادية وذلك لانتاجيتها السمكية. يستقبل الجزء الجنوبي للبحيرة العديد من المصارف المحملة بالمخلفات الصناعية والزراعية والصرف الصحي غير المعالج، وابرز تلك المصارف هو مصرف بحر البقر الذي ينقل الصرف الصحي من القاهرة الكبرى الي بحيرة المنزلة.

لذلك كان من الاهمية دراسة بعض العناصر الثقيلة والنادرة مثل (الالومنيوم Al – الزرنيخ As – الكروم Cr – الكوبلت Co – النيكل Ni – السيلينيوم Se) في عينات المياه وأسماك البلطي النيلي في البحيرة ومصرف بحر البقر وذلك خلال شتاء ٢٠١٢ وحتي خريف ٢٠١٣ لمعرفة مدى تراكم هذه العناصر خاصة الاجزاء المأكولة من الاسماك. وقد خلصت الدراسة الي ان تركيزات العناصر الثقيلة للمياه تزداد علي النحو التالي Al>Ni>Cr بينما اظهرت النتائج ان تركيزات العناصر As Co, ,Se,تحت حد الكشف . في حين اظهرت النتائج تراكم العناصر الثقيلة في أنسجة الاسماك (الخياشيم – العضلات) على النحو التالي Al>Ni>Co>As>Se>Cr. وقد زادت هذه التركيزات عن الحدود المسموح بها عالميا مما يمثل خطرا مباشرا على صحة الافراد الذين يعتمدوا علي الاسماك كوجبات أساسية في هذه المنطقة.