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Health risk assessment of heavy metals accumulation and Health status of *O. niloticus* from two Egyptian lakes

Dalia M. El-Gaar[1], Hala E. Ghannam[2], Sally M. Salaah[3,*]
Pollution Laboratory, Freshwater and Lakes Division, National Institute of Oceanography and Fisheries (NIOF), Cairo, Egypt
Corresponding author: sallysalaah84@gmail.com

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ABSTRACT

Water resources have become world social and economic concerns. Lake Nasser provides more than 95% of the Egyptian freshwater funds. Wadi Al-Rayan lakes are man-made with a vital role in irrigation water and fisheries. The present study was aimed to investigate and compare the effect of heavy metals (Fe, Zn, Mn, Cu, Pb and Cd) accumulation in muscles, liver and gills on the health status of *O. niloticus* collected from both lakes, and the potential human health hazard of consuming those fish. The results demonstrated that, the accumulation of different metals arranged in the following order; Fe> Zn> Mn >Cd> Cu> Pb in Nasser Lake, while the order was Fe> Zn> Mn >Cu> Pb>Cd in Wadi Al-Rayan Lake. The metal pollution index (MPI) in fish tissues followed the order: liver > gills > muscles. Moreover, the biochemical indices of *O. niloticus* from both Nasser and Wadi Al-Rayan Lakes showed a significant alteration due to metal pollution. Moreover, the human health hazard index recorded an adverse health effect for habitual fish consumers from Wadi Al-Rayan Lake during both seasons, while the same hazard recorded in spring for habitual fish consumers from Nasser Lake which yield an alarming concern for fish consumers' health.

INTRODUCTION

Lake Nasser formed by the conception of the Aswan High Dam**,** the Water quality of Lake Nasser is affected by several factors such as; water circulation, thermal stratification water levels, and pollutants **(El-Shabrawy, 2014)**. There are no direct sources for metal pollution affecting Nasser Lake. However, the anthropogenic activity of fishermen sewage, cruise ships, mining activities and fishing boats release their wastes effluents directly into the course of the Nile before it reaches Nasser Lake. Besides the natural geological settling out of sediment, atmospheric and soil erosion can induce heavy metals to the lake **(Darwish, 2013)**.Wadi El-Rayan Lake lies in El-Fayoum depression beside of the western desert; formed from two lakes with a connection channel between. The upper lake of Wadi El-Rayan receives frequent effluents of waste water from El-Wadi drain and the excess water from this lake streams to the lower one via the shallow connection channel **(El-Shabrawy, 2007)**. The lower lake receives pollutants from agricultural wastes such as; pesticides and fertilizers certainly will pass into the biotic elements of the ecosystem **(Mansour and Sidky, 2003)**. *O. niloticus* is popular species that has become worldwide for many reasons like, easy to grow and breed in a different of aquaculture systems**,** In Egypt, *O. niloticus* fish species are common species in the river Nile and several lakes. In addition, it is used as a bioindicator for detection of environmental pollution **(Ghannam, 2014; Khalil *et al.*, 2017)**. The anthropogenic activities pose a crucial environmental and human health problem, producing toxic materials as heavy metals (HM). Some of HM such as; Cu, Ni, Cr and Zn are essential trace metals to living organisms, however at high concentrations HM become a significant environmental pollutants with toxic effect **(Jaishankar *et al.*, 2014)**. Metals accumulate in fish tissues by direct contact via gills and dermal exposure or by absorption in the digestive tract of fish and also give a negative effect on the ecological balance of the environment and aquatic organisms**,** while the fish physiological activities during different seasons strongly affected by the bioavailability of heavy metals **(Tekin-Özan and Kir, 2008)**. Meanwhile, the bioaccumulation of different metals in fish has become a great concern, not only because of the dangerous to fish but also because their effect on human health **(Alhashemi *et al.*, 2012)**. Biological monitoring in lakes becomes more and more needed in studying ecosystem health status, because it is used to correlate between the pollutants and its effect on living organisms **(Reboa *et al.*, 2019)**. Human consumption of heavy metals from fish has been reported all the world **(Zhuang *et al.*, 2009)**. HM can diffuse into human metabolism *via* consumption of contaminated fish, which may cause severe deterioration of human's health **(Basiony, 2014)**. This work was designed to evaluate and compare the effect of heavy metals accumulation in *O. niloticus* from two lakes on the biochemical indices of *O. niloticus,* and the potetial human health risk of consuming fish.

MATERIALS AND METHODS

Sampling sites

A total of four sampling sites within twelve sampling point (three sampling points for each site), where S1, S2 represented Nasser Lake and S3, S4 represented Wadi Al-Rayan Lake (Table 1 and Figure 1). *O. niloticus* fish were collected from different sites of Nasser and Wadi Al-Rayan lakes in two batches 1^{st} during winter, 2019 and the 2^{nd} during spring, 2019. The average length of fish was 20.1 ± 7.3 cm and weighted 180.8 ± 51.3 g in Nasser Lake, while about 18.0± 5.3 cm in length and 142.8 ± 43.1 g weight in Wadi Rayan Lake.

Sample collection

Blood samples were withdrawn from arterial caudal vein **(Mazhar *et al.*, 1987)**, blood was left to coagulate then centrifuged at 3000 r.p.m. for 10 min. Then fish samples were quickly transported to pollution laboratory for dissection of muscles liver and gills for bioaccumulation of HM in fish tissues. The samples were digested for heavy metals analysis according to **Ghazaly (1988)**. HM (Fe, Zn, Mn, Cd, Cu, and Pb) concentrations in fish tissues were analyzed by atomic absorption mode GBC Savanta AA AA with GF 5000 graphite furnace.

Table 1: The latitude and longitude of Nasser and Wadi Al-Rayan Lakes sampling stations (GPS).

Location	Stations	Latitude	Longitude
		$23^{0}\ 01^{\backslash}\ 30^{\backslash\backslash}$	$32^{0}\ 67^{\backslash}\ 25^{\backslash\backslash}$
	S1	$22^{0}\ 62^{\backslash}\ 29^{\backslash\backslash}$	$32^{0}\ 37^{\backslash}\ 75^{\backslash\backslash}$
Nasser Lake		$22^{0}\ 46^{\backslash}\ 95^{\backslash\backslash}$	$31^{0}\ 74^{\backslash}\ 72^{\backslash\backslash}$
		$23^{0}\ 92^{\backslash}\ 48^{\backslash\backslash}$	$32^{0}\ 87^{\backslash}\ 02^{\backslash\backslash}$
	S2	$23^{0}\ 81^{\backslash}\ 59^{\backslash\backslash}$	$32^{0}\ 89^{\backslash}\ 92^{\backslash\backslash}$
		$23^{0}\ 33^{\backslash}\ 59^{\backslash\backslash}$	$32^{0}\ 90^{\backslash}\ 17^{\backslash\backslash}$
		$29^{0}\ 28^{\backslash}\ 12^{\backslash\backslash}$	$30^{0}\ 47^{\backslash}\ 25^{\backslash\backslash}$
Wadi Al-Rayan lake	S3	$29^{0}\ 25^{\backslash}\ 09^{\backslash\backslash}$	$30^{0}\ 47^{\backslash}\ 88^{\backslash\backslash}$
		$29^{0}\ 22^{\backslash}\ 12^{\backslash\backslash}$	$30^{0}\ 49^{\backslash}\ 34^{\backslash}$
		$29^{0}\ 20^{\backslash}\ 55^{\backslash\backslash}$	$30^{0}\ 40^{\backslash}\ 96^{\backslash\backslash}$
	S4	$29^{0}\ 17^{\backslash}\ 69^{\backslash\backslash}$	$30^{0}\ 39^{\backslash}\ 62^{\backslash\backslash}$
		$29^{0}\ 13^{\backslash}\ 88^{\backslash\backslash}$	$30^{0}\ 40^{\backslash}\ 77^{\backslash\backslash}$

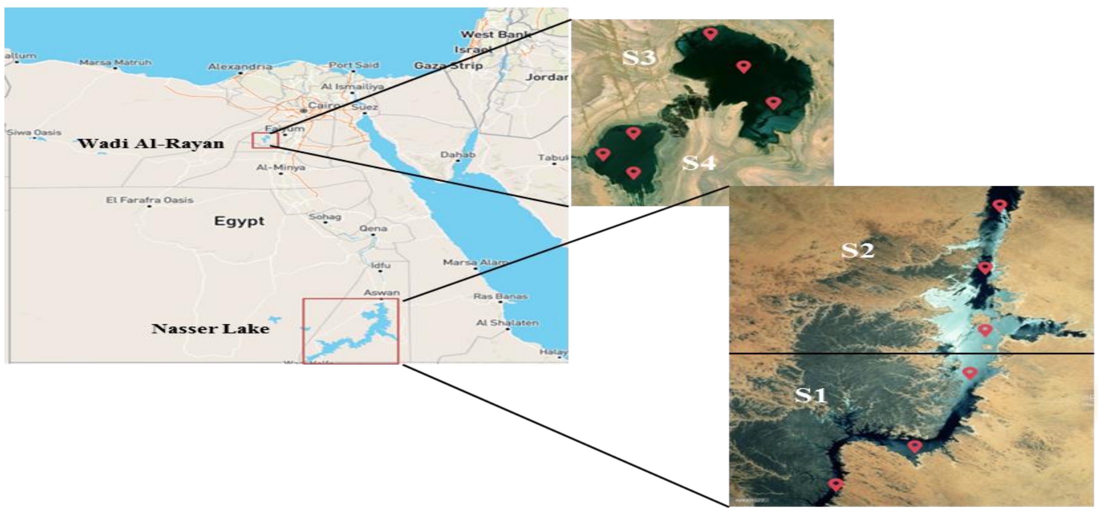

Figure (1): Sampling stations from Lake Nasser and Wadi Al-Rayan Lakes.

Metal Pollution Index (MPI)

The metal pollution index (MPI) is used to compare the total metals accumulation level in different tissues of the fish and (MPI) values were calculated by using the equation according to **Usero *et al*. (1997)**:

MPI = (Cf1 × Cf2 × Cf3 × · · · · Cfn) $1/n$ where, Cfn is the concentrations for the metal n (mg/kg dry weight) in the sample.

Human Risk Assessment

the metallic level of exposure after the consumption of edible (muscles) tissues of studied fish was calculated using the average daily intake of a certain chemical over a lifespan (ADD) was calculated by using the equation described by **USEPA (2000)**.

The hazard index HI (estimates the adverse health effects from intake of certain metal in food) was calculated from the following equation:

Hazard Index (HI) = ADD / Oral RfD proposed by **USEPA (2000)**. The values of oral RfD were based on the upper level of metal intake for adults suggested by the **FAO/WHO (2006)**. HI $\geq$ 1.0 when ADD of certain metal exceeds its oral RfD, this predict risk of adverse health effects, while HI<1 means non-hazardous health effects **(Lim *et al*., 2008)**.

Biochemical indices

Serum glucose levels were assessed using colorimetric method described by **Tietz (1995)**. Total protein in the serum of the tested fishes determined according to **Tietz (1994)**. Serum albumin was determined colorimetrically following the method of **Doumas *et al*. (1971)**. Aspartate aminotransferase (AST) and Alanine aminotransferase (ALT) activity was measured in the serum of the tested fishes using colorimetric determination according to **(IFCC, 1986)** Kinetic method. Serum creatinine was determined according to **Tietz (1986)**, while serum urea and uric acid were measured enzymatically using **Tietz (1990)** method. Total lipids were estimated using **Frings and Dunn (1970)**. Triglycerides were determined in the serum of the tested fishes using enzymatic-colorimetric test following the method of **Young and Pestaner (1975)**. Serum cholesterol was evaluated using enzymatic-colorimetric test as described by **Tinder (1969)**.

Statistical analysis

The results were calculated by using a Microsoft Excel sheet on Windows 2010. The statistical significance was set at $P < 0.05$ using SPSS for Windows version 23.0 (SPSS, Michigan Avenue, Chicago, IL, USA).The differences between treatments were analyzed using a one way Analysis of Variance (ANOVA) followed by Tukey Test..

RESULTS

The values of heavy metals (Fe, Zn, Mn, Cd, Cu and Pb) were measured in muscles, liver and gills of *O. niloticus* fish during winter and spring 2019. The metals accumulation in *O. niloticus* from Lake Nasser followed the order Fe>Zn>Mn> Cd>Cu>Pb, while in Wadi Al-Rayan Lake followed the order Fe>Zn>Mn>Cu> Pb>Cd in muscles, liver and gills, respectively. According to Table (2 and 3), the accumulation of metals in fish tissues followed the manner: liver>gills>muscles. S1 recorded higher Fe, Mn and Cu in spring than winter, S2 also exhibited higher Fe, Mn, Cd and Cu in spring. S3 from Wadi Al-Rayan showed higher accumulation levels of Fe and Zn in winter than spring in tissues. S4 recorded higher HM accumulation in all examined fish tissues in winter. In winter (Table 2) Fe recorded highest accumulation at S4 (110.7) followed by S3 (95.71), S2 (50.72) and S1 (42.61) mg/kg dry weight, while Zn highest accumulation was at S3 (42.7) >S4 (31.51) >S2 (27.22) >S1 (24.90) mg/kg dry weight.

Mn exceed the MPL in all studied organs at S3 (3.9, 8.4, 6.8 mg/kg dry weight) and S4 (4.8, 8.7, 6.5 mg/kg dry weight) for muscle, liver and gills respectively. Although, Cd was not detected in tissues of fish from Wadi Al-Rayans S3 and S4, while S2 from Nasser Lake exhibited higher Cd (0.92 mg/kg dry weight) than S1 (0.65 mg/kg dry weight). Furthermore, Cu values did not exceed the MPL (30 mg/kg dry weight).

Pb was not recorded in fish tissues from Nasser Lake, while in Wadi Al-Rayan S4 (1.87 mg/kg dry weight) showed higher Pb than S3 (1.22 mg/kg dry weight) in fish tissues. However, in spring S3 recorded the highest accumulation of Fe (110.8) in sampled tissues followed by S4 and S2 (102.5 and 87.4 mg/kg dry weight), while S1 recorded the lowest value (70.16 mg/kg dry weight). S3 showed the highest Mn accumulation in fish tissues (6.9 mg/kg dry weight) followed by S4 and S2 (5.1 and 2.2 mg/kg dry weight). Whereas S1 from Nasser Lake recorded the lowest Mn value (0.29

mg/kg dry weight). While, Cd was not detected in fish tissues from Wadi Al-Rayan Lake, but in Nasser Lake recorded higher Cd at S2 than S1 (0.89 and 0.33 mg/kg dry weight).

Moreover, Pb was not detected in Nasser Lake while S3 exhibited more Pb than S4 from Wadi Al-Rayan Lakes.

Table 2: Heavy metals accumulation (mg/kg dry weight) and metal pollution index (MPI) in muscle, liver and gills of *O. niloticus* from Nasser and Wadi Al-Rayan Lakes during winter season 2019 (mean ± S.E; n=6 fish).

			Nasser Lake			
		S1			S2	
	Muscles	Liver	Gills	Muscles	Liver	Gills
Fe	31.35±3.9	42.61±1.9	38.19±8.8	38.95±0.56	50.725*±5.9	42.71±4.9
Zn	6.14±0.2	24.90±0.33	11.10±1.59	6.05±0.24	27.22±1.76	11.71±1.04
Mn	0.27±0.004	1.32*±0.07	0.614±0.16	0.367±0.05	1.439*±0.09	0.675±0.08
Cd	0.35±0.07	0.65*±0.19	0.53*±0.04	0.4±0.03	0.92*±0.27	0.84*±0.06
Cu	0.04±0.004	0.08±0.024	0.06±0.014	0.04±0.002	0.09±0.029	0.06±0.002
Pb	Nd	Nd	Nd	Nd	Nd	Nd
MPI	2.07	2.33	2.19	2.18	2.40	2.20
			Wadi Al-Rayan Lake			
		S3			S4	
	Muscles	Liver	Gills	Muscles	Liver	Gills
Fe	35.7±0.31	95.71*±0.05	77.3*±0.02	33.6±0.05	110.7*±0.07	82.3*±0.13
Zn	22.3±0.57	42.7*±0.04	37.6±0.031	23.17±0.042	31.51±0.09	26.25±0.6
Mn	3.9*±0.05	8.4*±0.13	6.8*±0.25	4.8*±0.22	8.7*±0.51	6.5*±0.18
Cd	Nd	Nd	Nd	Nd	Nd	Nd
Cu	2.7±0.52	8.5±0.21	5.3±0.17	3.9±0.52	7.1±0.52	4.7±0.41
Pb	0.62*±0.34	1.22*±0.22	0.95*±0.27	1.02*±0.021	1.87*±0.031	1.17*±0.081
MPI	2.31	2.74	2.63	2.32	2.75	2.60

*surpassed the (MPI) maximum permissible limit of FAO (1983) and WHO (1989); 50, 40, 1, 0.5 , 30, and 0.5 for Fe, Zn, , Mn, Cd, Cu and, Pb respectively. Nd; Not detected

The accumulation of HM showed alterations in fish tissues from Nasser Lake and Al-Rayan Lakes (Tables 2 and 3). Mn and Pb accumulation in winter exceeded the permissible limits within all sampled tissues. Liver and gills from Nasser Lake in winter also showed higher levels than the permissible. Spring as well, recorded higher Fe than FAO permissible limits, in both liver and gills from all sites, while Pb exceeded the permissible limits in all sampled tissues from Wadi Al-Rayan Lake.

The hazard index (HI) in Table (4) recorded no health effect for normal fish consumers because all results were below 1. But, an adverse health effect for habitual fish consumers were recorded in Wadi Al-Rayan Lake during both seasons, while the same hazard recorded in spring for habitual fish consumers from Nasser Lake.

Biochemical indices of *O. niloticus* from Nasser and Wadi Al-Rayan Lakes during winter and spring 2019 were recorded in Table (5).The biochemical indices showed seasonally alterations, in winter S4 recorded the highest significant increase ($P<0.05$) as 230.4 (mg/dL), 6.06 (mg/dL), 29.6 (IU/mL), 333.8 (mg/dL), 213.4 (mg/dL), 213.8 (mg/dL), 7.61 (mg/dL) and 6.03 (mg/dL) in glucose, total protein, ALT, triglycerides, cholesterol, total lipid, urea and uric acid levels among sites, respectively. However, S1 showed the lowest levels 154.3 (mg/dL), 2.96 (mg/dL), 0.99 (mg/dL), 49.11

(IU/mL) and 3.3 (mg/dL) for glucose, total protein, albumin, AST and uric acid among sites, respectively. While, highest levels of glucose, total lipids, ALT, AST, total protein, creatinine, urea, and uric acid were displayed in S4 from Wadi Al-Rayan Lake (Table 5).

Table 3: Heavy metals accumulation (mg/kg dry weight) and metal pollution index (MPI) in muscle, liver and gills and of *O. niloticus* from Nasser and Wadi Al-Rayan Lakes during spring season 2019 (mean ± S.E; n=6 fish).

	Nasser Lake					
	S1			S2		
	Muscles	Liver	Gills	Muscles	Liver	Gills
Fe	56.67*±1.09	70.16*±4.38	57.15*±0.28	76.87*±1.06	87.48*±5.97	77.30*±7.9
Zn	2.937±0.04	37.186±0.81	22.214±0.46	4.122±0.45	34.57±1.55	28.91±1.36
Mn	0.293±0.001	1.67±0.11	0.83±0.23	1.50±0.43	2.20±0.025	1.54±0.019
Cd	0.33±0.005	0.37±0.003	0.37±0.002	0.73*±0.007	0.89*±0.04	0.77*±0.09
Cu	0.06±0.002	0.13±0.004	0.09±0.019	0.06±0.011	0.14±0.013	0.12±0.002
Pb	Nd	Nd	Nd	Nd	Nd	Nd
MPI	2.27	2.55	2.40	2.42	2.62	2.55
	Wadi Al-Rayan Lake					
	S3			S4		
	Muscles	Liver	Gills	Muscles	Liver	Gills
Fe	28.3±0.52	110.8*±1.32	52.9*±0.34	30.5±2.03	102.58*±3.3	71.8*±0.27
Zn	18.2±0.63	19.6±0.21	17.3±0.11	13.6±0.52	18.7±0.53	16.2±0.31
Mn	4.5±0.21	6.9±0.52	6.3±1.21	3.5±0.31	5.1±0.33	4.2±1.1
Cd	Nd	Nd	Nd	Nd	Nd	Nd
Cu	3.3±0.71	4.9±1.3	4.2±0.21	3.6±0.71	6.1±0.22	4.7±0.41
Pb	0.9*±0.05	1.2*±0.3	1.02*±0.02	0.51*±0.07	1.1*±0.08	0.9*±0.02
MPI	2.21	2.64	2.41	2.20	2.66	2.49

*surpassed the (MPI) maximum permissible limit of FAO (1983) and WHO (1989); 50, 40, 1, 0.5 , 30, and 0.5 for Fe, Zn, , Mn, Cd, Cu and, Pb respectively. Nd; Not detected

Table 4: Hazard index (HI) for muscle consumption of *O. niloticus* from Nasser and Wadi Al-Rayan Lakes during winter and spring 2019.

Season	Stations	HI	Fe	Zn	Mn	Cd	Cu	Pb	Cumulative Risk Effect
Winter	S1	N	0.02	0.009	0.003	0.16	0.0001	Nd	0.19
		H	0.09	0.04	0.013	0.72	0.0006	Nd	0.86
	S2	N	0.03	0.009	0.004	0.18	0.0001	Nd	0.22
		H	0.09	0.04	0.02	0.81	0.001	Nd	0.96
	S3	N	0.02	0.03	0.05	Nd	0.011	0.40	0.52
		H	0.10	0.15	0.23	Nd	0.05	1.83	2.36[C]
	S4	N	0.02	0.03	0.05	Nd	0.01	0.81	0.93
		H	0.10	0.16	0.24	Nd	0.06	3.70	4.25[C]
Spring	S1	N	0.04	0.004	0.003	0.17	0.0002	Nd	0.21
		H	0.17	0.02	0.02	0.77	0.0009	Nd	0.97
	S2	N	0.05	0.006	0.02	0.33	0.0002	Nd	0.40
		H	0.22	0.03	0.08	1.50	0.001	Nd	1.83[C]
	S3	N	0.2	0.03	0.04	Nd	0.008	1.26	0.37
		H	0.08	0.12	0.20	Nd	0.04	0.28	1.70[C]
	S4	N	0.02	0.02	0.04	Nd	0.012	1.02	0.31
		H	0.09	0.09	0.18	Nd	0.06	0.22	1.43[C]

N: normal consumption, H: habitual consumption; c: HI ≥ 1, at which adverse health effects may occur. Nd: not detected.

Table 5: Biochemical indices of *O. niloticus* from Nasser and Wadi Al-Rayan Lakes during winter and spring 2019 (Mean ± S.D).

	Winter				Spring			
	S1	S2	S3	S4	S1	S2	S3	S4
Glucose (mg/dL)	154.3 ±11.4^{c}	113.02 ±6.88^{d}	162.2 ±3.5^{bc}	230.4 ±4.1^{a}	125.35 ±4.11^{c}	106.92 ±3.07^{d}	150.3 ±3.7^{b}	212.4 ±2.9 ^{a}
Total protein (mg/dL)	2.96 ±0.20^{c}	3.3 ±0.15^{c}	4.28 ±0.52^{b}	6.06 ±0.19^{a}	3.85 ±0.17^{c}	4.30 ±0.26^{c}	5.47 ±0.35^{b}	6.96 ±0.36^{a}
Albumin (mg/dL)	0.95 ±0.05^{c}	1.01 ±0.04^{c}	3.12 ±0.20^{a}	2.41 ±0.26^{b}	1.75 ±0.07^{c}	1.59 ±0.08^{c}	3.96 ±0.29^{a}	3.06 ±0.21^{b}
ALT (IU/mL)	19.53 ±2.8^{b}	14.4 ±3.53^{c}	19.4 ±1.60^{b}	29.6 ±2.51^{a}	11.6 ±1.83^{c}	7.45 ±1.62^{d}	15.1 ±1.11^{b}	20.35 ±1.53^{a}
AST (IU/mL)	49.11 ±7.3^{c}	26.37 ±5.4^{d}	68.7 ±3.43^{b}	76.1 ±2.43^{ab}	46.4 ±6.92c^{d}	43.9 ±5.46^{c}	54.1 ±3.23^{bd}	63.65 ±3.64^{a}
Triglycerides (mg/dL)	131.88 ±7.1^{d}	221.86 ±7.6^{c}	308.6 ±4.42^{b}	333.8 ±3.61^{a}	300 ±6.21 ^{b}	392.5 ±7.15^{a}	121.0 ±2.92^{d}	247.2 ±2.14^{c}
Cholesterol (mg/dL)	113.61 ±5.8^{d}	146.27 ±6.4^{c}	181.6 ±2.11^{b}	213.4 ±2.80^{a}	195.3 ±6.78^{b}	241.62 ±7.28^{a}	150.81 ±2.87^{d}	171.6 ±2.31^{c}
Total lipids (mg/dL)	1039.83 ±6.5^{d}	1118.61 ±5.7^{c}	1837 ±3.90^{b}	2138 ±4.41^{a}	530 ±4.42 ^{c}	520 ±4.14^{d}	1766.6 ±4.88^{b}	2012.5 ±3.52^{a}
Creatinine (mg/dL)	1.14 ±0.22^{a}	1.13 ±0.25^{a}	1.16 ±0.22^{a}	1.38 ±0.25^{a}	0.32 ±0.02^{c}	0.35 ±0.04^{c}	0.68 ±0.21^{b}	0.75 ±0.13a^{b}
Urea (mg/dL)	6.31 ±0.4^{b}	5.13 ±0.26^{c}	6.05 ±0.35^{b}	7.61 ±0.28^{a}	4.05 ±0.17^{c}	3.875 ±0.30^{c}	4.95 ±0.35^{b}	5.52 ±0.28^{a}
Uric acid (mg/dL)	3.3 ±0.23^{c}	2.89 ±0.21^{c}	4.14 ±0.35^{b}	6.03 ±0.24^{a}	2.95 ±0.21^{c}	2.04 ±0.28^{d}	3.30 ±0.31^{bc}	5.17 ±0.27^{a}

Data were presented as mean ± SD (n=6 fish). Values within a row with different superscripts differ significantly (Tukey Test, $P<0.05$).

DISCUSSION

Ecologically HM considered as one of the crucial challenges in the aquatic ecosystem owing to their persistence, toxicity, and bioaccumulation that can adversely impact the aquatic ecosystem and living organisms as well **(Ghannam, 2015 a, b; Xu *et al.*, 2018)**. Generally, rivers and lakes receive HM from natural and anthropogenic sources, commonly natural sources are less hazardous than the human's abusive practices, besides being toxic to aquatic environment, HM also negatively affect the aquatic organisms' health through their accumulation **(Paul, 2017)**. Since humans are the final consumer in the food chain, fish loaded with HM can pose a potential health hazard to humans. HMs may cause many biological, biochemical malfunction, and various diseases **(Ali and Khan, 2019)**. The bioaccumulation of HM in the edible parts of fish has gained a lot of attention **(Talab, 2016; Azab *et al.*, 2019; Ghannam, 2021)**. The present work recorded seasonally fluctuation in HM accumulation in fish. In Nasser Lake, high accumulation level of HM in fish tissues was recorded especially in spring. Even though, the lake has no direct sources of HM pollution, however the lake receives HM via the anthropogenic activity such as; fishing boats and fishermen sewage as well as cruise ships that directly dispose their wastes effluents in the lake. Moreover, the Nile receives pollution including the domestic, agricultural, industrial wastes, and mining activities even before it reaches the Egyptian territory **(Darwish, 2013)**.

The MPI of the studied organs followed the order: liver > gills > muscles for accumulation in *O. niloticus* fish. Muscles recorded the lowest MPI among tissues, due to their low affinity for metal accumulation. Moreover, **Barath Kumar *et al*. (2019)** recoded a indirect relation between fat content and metal accumulation, which leads to low metabolic activity of the muscle. HM have an important effect on activities of enzyme that have association in specific substrate convenience for metabolism **(Carvalho and Fernandes, 2019)**. HM Traces in fish organs were used as an indicator to early identification of local pollution type **(Weber *et al.*, 2013)**. Many food safety researchers concern consumption of metal that accumulated in food, as it may cause negative effect on human health **(Shaheen *et al.*, 2015)**.

Liver and kidney functions such as; Total protein, Albumin, AST, ALT, , Urea, Uric acid, Creatinine levels in blood serum are key bioindicators for pollution **(Kayode and Shamusideen, 2010)**. The biochemical indeces in the present study recorded a HM dependent relation. The present hyperalbuminemia could be related to general nutritional status or the liver malfunction induced by HM accumulation in liver (**Gopal *et al.*, 1997; Salaah and El-Gaar, 2020**). Also, serum total protein is used as another indicator of liver malfunction **(Mutlu *et al.*, 2005; Sobha *et al.*, 2007)**.

Blood glucose level is highly influenced by carbohydrate metabolism rate under stress and hypoxic conditions, which usually causes a rapid glucocorticoids secretion from the adrenal tissue **(Abbas *et al.*, 2006)**. The present work recorded a remarkable elevation in the levels of serum total lipid (cholesterol and triglyceride), this may occur during lipids mobilization, oxidation or through lipids utilization **(Zutshi *et al.*, 2010)**. Previous studies reported hyper LDL-cholesterolemia in fish exposed to metal stress **(Mutlu *et al.*, 2015).** Levels of cholesterol, lipoproteins and triglyceride values are directly linked to lipid metabolism, and the liver and kidney functions. The increase of cholesterol content and glucose levels anticipate the involvement of amino acids and acetyl Co-A into the biosynthesis of cholesterol **(Jain, 1999; Aride *et al.*, 2007).** Furthermore, metal pollution was connect to cell injury *via* oxidation and lipid peroxidation, which may alter the pre-mentioned indices **(Aly *et al.*, 2020; Salaah and El-Gaar, 2020)**. Plasma uric acid and creatinine are indicators of renal impairment and higher levels refers to kidney injuries when fish exposed to metals **(Ismail and Mahboub, 2016)**.

Concerning the present findings, both ALT and AST levels as well as urea, creatinine, and uric acid levels in blood serum of *O. niloticus* were significantly increased, **(Salaah *et al.*, 2018; Amani *et al.*, 2020; Khan *et al.*, 2020)**. The present elevation in enzymes activities may be related to liver and kidney malfunction due to the damage caused by HM exposure **(Barisic *et al.*, 2019; Salaah and El-Gaar, 2020)**, this in agree with the data findings in **Table 3**, as liver recorded the highest HM bioaccumulation among all tissues.

CONCLUSION

In Nasser and Wadi Al-Rayan Lakes, Fe was recorded the highest concentration. The accumulation of heavy metals in tissues of the studied fish were in the following order: liver>gills>muscles. In addition, MPI for fish from Wadi Al-Rayan Lake were found to be higher than those of Lake Nasser. The higher levels of HI were recorded at S3 and S4 in muscles from fish samples during winter but HI ≥ 1 were recorded in S2, S3 and S4 during spring. Biochemical indicese recorded an elevation depend on HM accumulation levels in fish tissues, especially in fish from Wadi Al-Rayan Lake, as compared to Lake Nasser. Generally, Metals can accumulate in the edible parts of fish leading to irreversible changes in fish and potential risk to fish consumers.

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