**Zagazig Veterinary Journal, ©Faculty of Veterinary Medicine,
Zagazig University, 44511, Egypt.
Volume 47, Number 4, p. 408-418, December 2019
DOI: 10.21608/zvjz.2019.14345.1058**

RESEARCH ARTICLE

Risk assessment of some toxic metals in fishes collected from Wadi El Rayan Lakes, Fayoum Governorate, Egypt

ShaimaaTaha[1], Mohamed A. Hussein[2] and Alaa Eldin M. Morshdy[2]
[1]Ministry of Environment, Egyptian Environmental Affairs Agency, Nature Conservation Sector, Egypt
[2]Food Control Department, Faculty of Veterinary Medicine, Zagazig University, 44511 Zagazig, Egypt

Article History: Received: 08/07/2019 Received in revised form: 06/08/2019 Accepted: 25/08/2019

Abstract

This study was conducted to evaluate the residual concentrations of Cadmium (Cd), Lead (Pb), Mercury (Hg) and Arsenic (As) in flesh of *Oreochromis niloticus* (*O. niloticus*) collected from lake I, lake II and farmed *O .niloticus*. *Bagrus bajad* (*B. bajad*) were obtained from lake I and Sea bass from lake II at Wadi El-Rayan, Fayoum Governorate, Egypt. The mean values of Cd were (0.023, 0.083, 0.023, 0.083 and 0.025); Pb (0.177, 0.373, 0.265, 0.446 and 0.168), Hg (0.034, 0.127, 0.02 ,0.297 and 0.03) and As (0.055, 0.069, 0.045, 0.072 and 0.072) ppm in examined *O. niloticus* lake I, lake II, Farmed *O. niloticus*, *B. bajad* lake I and Sea bass lake II, respectively. The Estimated Daily Intake (EDI) of Cd, Pb, Hg, and As was 0.033, 0.198, 0.07 and 0.043 µg/ kg body weight/day, respectively. Comparing of EDI of all examined toxic metals were below the Tolerable Daily Intake (TDI). The Target Hazard Quotient (THQ) of Cd (0.016 to 0.058) Pb (0.029 to 0.077), Hg (0.046 to 0.686), and As (0.104 to 0.167), respectively. All THQ of the examined metals in all fish species was below one. The Hazard index (HI) of all tested fish species was lower than one, indicating that there is no health risk for the consumer by ingesting multiple metals contained in fish from Wadi El Rayan Lakes.

Keywords: Toxic metals, *Oreochromis niloticus*, *Bagrus bajad*, Wadi El-Rayan, Risk assessment.

Introduction

Fish is considered one of the most foods consumed in Egypt as it provides high biological value of animal protein and solving the problem of red meat shortage [1].Wadi El-Rayan lakes are located in the Western Desert, 25 km south of Fayoum. The Wadi El-Rayan project was started as a reservoir for agricultural drainage water in Fayoum Governorate after the water level in Qaroun Lake was raised and the facilities constructed around it were threatened. Wadi El- Rayan lakes are supplying the community by fish which is a good source of protein, this type of services classified as provisioning services according to The Millennium Ecosystem Assessment [2].

Following the increase in human activities of various kinds, such as domestic, commercial, agricultural, industrial and navigation activities, different types of waste materials enter the aquatic ecosystems and affect its water quality [3]. Some aquatic organisms accumulate toxic metals to concentrations, which are higher than that present in water so they used as bio-indicators for water pollution with toxic metals and they represent public health hazard if consumed, as metals neither created nor destroyed by humans. Therefore, they tend to accumulate in the seawater, soils, freshwater, and sediments [4]. Contamination with heavy metals is a serious threat because of their toxicity, bioaccumulation, and biomagnifications in food chain [5].

The main source of heavy metals in fish tissues is the surrounding water. The entrance of heavy metals to the fish tissues occur through two major pathways, directly through

---

***Corresponding author e-mail: (shmhanya@gmail.com), Ministry of Environment, Egyptian Environmental Affairs Agency, Nature Conservation Sector, Egypt.**

the digestive tract by the consumption of contaminated algae or water and across permeable membranes such as gills [6].

Some heavy metals, such as cadmium and lead have no known essential role in living organisms, and are poisonous at even low concentrations. Moreover**,** the essential metals also become toxic at high concentrations [7].

The human is mainly exposed for such toxic metals through ingestion of contaminated food and water, which accounted for more than 90 % in comparing to inhalation route [8]. The prolonged exposure of human body to toxic metals at relatively low concentrations leads to many health problems [9]. Recently, the accumulation of toxic metals in the environment acquired an increasing concern due to the food safety issues and the associated potential public health hazards [10].

Thus, the purpose of this study was to determine the residual concentration of cadmium (Cd), lead (Pb), arsenic (As) and mercury (Hg) of three fish species *Oreochromis niloticus* (*O. niloticus*), *Bagrus bajad* (*B. bajad*) and *Sea bass* (*S. bass*) collected from Wadi El-Rayan lakes, Egypt. In addition, to estimate the dietary intake of such metals, as well as to assess the potential health risks associated with the consumption of farmed fish in comparison to wild fish by using: 1- the Target Hazard Quotient (THQ), which is the proportion of the exposure dose of the toxic metal to the oral reference dose of the same toxic metal (RFD). 2- the Hazzard Index (HI), which is to the sum of all THQ for various toxic metal exposures and has been performed to assess the probable human health hazard due to exposure to more than one toxic metal.

Materials and Methods

Samples collection

Fifty samples of fishes were collected from Wadi El-Rayan, Fayoum Governorate, Egypt. Samples represented by, *O. niloticus* (350 gm) *lake I*, *O. niloticus* (100-150 gm) lakeII, farmed *O. niloticus*, *B. bajad* (1.5 kg) lake I *and S. bass* (350 gm) lake II (10 samples of each). Samples were collected from September 2018 till April 2019. The collected samples were kept in an icebox and transferred directly to the Central Laboratory, Faculty of Veterinary Medicine, Zagazig University.

The location map for study areas (Figure 1) used in this work was downloaded fromUnited States Geological Survey (USGS) by using Earth Explorer and Global Visualization Viewer (GLOVIS) web applications. All image processing has been conducted using Environmental Systems Research Institute Architecture geographic information system (ESRI ArcGIS)10.5 Software. All data are in shapefile in decimal degrees unit, WGS 84 Ellipsoid and WGS84 datum.

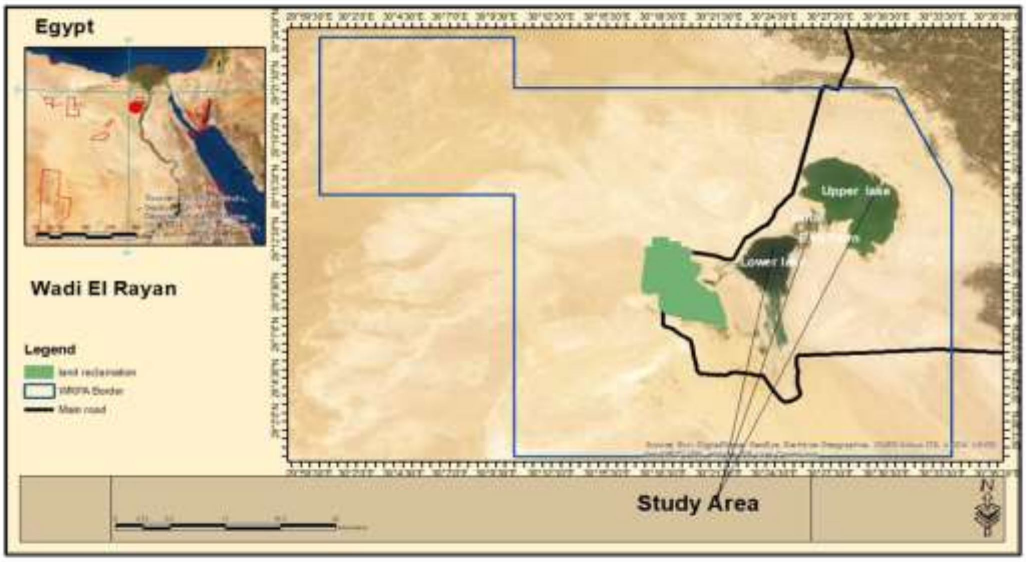

Figure 1: Location map for study areas for resik assessment of some toxic metals in fish of Wadi El Rayan lakes Fayoum Governorate

Digestion and analysis of samples

One gram of each fish muscle sample was placed in a clean screw capped tube contained 5 ml acid mixture (3 ml nitric acid (HNO3): 2 ml percholeric acid (HCLO4) (Merck, Germany) and digested according to Zantopoulos *et al.* [11]. The resultant solutions were then analyzed for determination of Cd, Pb, Hg and As.

Blank solution was prepared to check the possible trace of metals present in the deionized water or the acids used in dilution and digestion of the samples. Owing to mercury volatilization that occurred at temperature below 100ºC, this process was determined according to Diaz *et al.* [12] for determination of mercury at minimal temperature.

Sample Analysis

The samples were analyzed for heavy metals content by using Atomic Absorption Spectrophotometer (Perkin Elmer model specta-AA10, USA). Analysis of Cd, Pb, Hg and As was conducted by air/acetylene flow (5.5/1.11ml) flame A.A.S. whereas for Hg determination, cold vapor technique was applied using flame A.A.S set with M.H.S (mercury hydride system).

The obtained results were articulated as µg/g wet weight (ppm), and they were compared with Egyptian Organization for Standardization and Quality control (EOS) [13].

Estimated Daily Intake (EDI)

It is essential to evaluate the daily intake of metals from *O. niloticus, B. bajad* and *S. bass* consumption and to compare itwith Tolerable Daily Intake (TDI) values determined by international organizations for health and safety. The EDI was estimated using the equation described by the US Environmental Protection Agency, EDI= (Cm x FIR)/BW [14], where Cm is the heavy metals concentration in the examined sample (mg/kg wet weight); FIR is fish ingestion rate (48.57 g/day) [15]; BW is the body weight of Egyptian adults (70 kg). Then the EDI was compared to TDIs [16].

Target Hazard Quotient (THQ)

The health hazard of Egyptian people from *Oreochromis niloticus*, *Bagrus bajad* and *Sea bass* consumption was evaluated by assessment of Target Hazard Quotient. (THQ) is the proportion of the exposure dose of the toxic metal to the oral referencedose of the same toxic metal doses (RFD).The reference dose is the daily exposure of the estimation pollutant to which thepeople continuously exposed through a life without any hazard [17]. The reference oral dose value for Cd, Pb, Hg and As 0.001, 0.004, 0.0003 and 0.0003 (mg/kg BW/day), respectively [18]. The population might expose to health hazard if the THQ is higher than one. The Risk assessment was calculated by the following equation [19]:

$$THQ = \frac{EF \text{ x } ED \text{ x } FIR \text{ x } C}{RFD \text{ x } BW \text{ x } AT} x10$$

where, AT is the exposure time average (365 days/years of exposure, assumed as 70 years). BW is the body weight average (70 kg). RfD is the oral reference dose (mg/kg/day). C is the heavy metals concentration in fish (µg/g), FIR is the rate of food ingestion (g/person/day), ED is the averageduration of exposure (70 years). EF is the frequency of exposure (365 days/year).

Hazard index (HI)

The hazard index (HI) has been performed to assess the probable human health hazard between more than one toxic metal. The HI refers to the sum of all THQ for various metal exposures as described in the following equation:

HI = ΣTTHQs = THQ Cd + THQ Pb + THQ Hg +THQ As,where Σ TTHQs is the target hazard quotients of all metals and THQ Cd; THQ Pb; THQ As and THQ Hg are the target hazard quotients for Cd, Pb, As and Hg, respectively. When the hazard index become over 1, possible human health risk is expected [20].

Statistical data analysis

Statistical analysis of the data was performed using the SPSS program version 22. Results were tabulated as means ± standard error. Data were subjected to Microsoft Office Excel (2010) and One-Way analysis of variance (ANOVA) at 95% level of confidence to determine significant differences between the examined samples. Duncan’s multiple comparisons test considering the p-value ≤

0.05 statistically significant determined significant differences among the means

Results and Discussion

Cadmium residues (Cd)

The results in Table (1) showed that cadmium residues ranged from 0.01 to 0.03, 0.05 to 0.11, 0.01 to 0.03, 0.01 to 0.35 and 0.01 to 0.04 ppm with mean values of 0.023±0.003, 0.083±0.007, 0.023±0.003, 0.083±0.045 and 0.025±0.003 ppm for examined *O. niloticus* lake I, *O. niloticus* lake II, Farmed *O. niloticus*, *B. bajad* lake I and *Sea bass* lake II, respectively.

Table 1: Toxic metal residues estimated by using Atomic Absorption Spectrophotometer (Perkin Elmer model specta-AA10, USA). (ppm) in the examined fish species collected from different location (N= 10 for each)

Fish species	Location	Cadmium Mean ± SE	Lead Mean ± SE	Mercury Mean ± SE	Arsenic Mean ± SE
Oreochromis niloticus	Lake I	0.023 ± 0.003^{b}	0.177 ± 0.04^{c}	0.034 ± 0.003^{c}	0.055 ± 0.009^{ab}
	Lake II	0.083 ± 0.007^{a}	0.373 ± 0.053^{b}	0.127 ± 0.045^{b}	0.069 ± 0.003^{a}
	Farmed	0.023 ± 0.003^{b}	0.265 ± 0.056^{bc}	0.02 ± 0.005^{bc}	0.045 ± 0.002^{b}
Bagrus bajad	Lake I	0.083 ± 0.0.045^{a}	0.446 ± 0.106^{a}	0.297 ± 0.104^{a}	0.072 ± 0.006^{a}
Sea bass	Lake II	0.025 ± 0.003^{b}	0.168 ± 0.042^{c}	0.03 ± 0.004^{c}	0.072 ± 0.005^{a}

$^{(a,b.c)}$ Mean ± SE of the same column bearing different superscript letters indicate significant difference ($p < 0.05$). N= number of examined samples.

Nearly similar values (0.048±0.003 ppm) for *B. bajad* collected from various localities of River Nile at Lower Egypt obtained by Sallam *et al.* [21].

The analysis of variance (ANOVA) indicated significant increases ($P< 0.05$) in Cd level in *O. niloticus* samples collected from lake II and *B. bajad* from lake I that indicate the effect of water contamination on bioaccumulation in *O. niloticus* samples collected from lake II. Moreover, the effect bio-magnifications appear on *B. bajad* when compared with *O. niloticus* from lake I.

Considering the existing legal regulations on permissible limits of cadmium ESNo 7136/2010 [13], the maximum permissible limits (MPL) has been reported at 0.05wet weight for fish. The general acceptability was 34 (68%) (Table 2).

The high level of cadmium in samples exceeding the legal limits attributed to the wide using of cadmium in batteries manufacturing, galvanized pipes, solders and some metal fittings.

Table 2: Number of samples that revealed within or exceeding the maximum permissible limit of toxic metals in fish collected from different locations in Wadi El- Rayan lakes-Fayoum-Governorate, Egypt .

Fish species	Location	Cadmium(0.05)^{a}		Lead (0.1)^{a}		Mercury (0.2)^{a}		Arsenic (0.2)^{b}	
		Within	Exceeds	Within	Exceeds	Within	Exceeds	Within	Exceeds
Oreochromis niloticus	Lake I	10	0	4	6	10	0	10	0
	Lake II	0	10	0	10	6	4	10	0
	Farmed	10	0	3	7	10	0	10	0
Bagrus bajad	Lake I	4	6	2	8	3	7	10	0
Sea bass	Lake II	10	0	3	7	10	0	10	0
Total		34 (68%)	16 (32%)	12 (24%)	38 (76%)	39 (78%)	11 (22%)	50 (100%)	0

^{a}According to Egyptian standard (ES 7136) [13].

^{b} According to ISIRI No. 6952(Fish and fish products -Canned tuna fish in brine-Specifications and test methods). [45]

Risk assessment of exposure to cadmium due to fish consumption

Foods having toxic substances could present a noxious threat for the consumer which is depending on toxic metal concentration in diet and amount of food used [22]. Risk consists of detecting the toxicological appeals related to a specific substance [23]**.** The 'tolerable intake' is important to define 'safe' levels of intake; and can be stated on a daily basis (TDI or tolerable daily intake). TDI is the maximum amount of a pollutant to which individual can be exposed per day over a life span without an unacceptable risk of health problems.

Estimated daily intake of cadmium (EDI Cd)

In this study, dietary exposure assessment for Cd concluded from fish consumption was carried out by identifying the estimated daily intake in comparison to the tolerable daily intake. The average quantity of fish consumed per adult person (assuming a 70 kg person) every week was 12 ounces (approximately 340 grams weekly 48.57 g/ daily [24].

Table 3: Estimated daily intake (EDI) µg/ kg body weight/day of different metals in comparison to the Tolerable daily intake (TDIs) µg/ kg body weight in fish collected from different location s in Wadi El- Rayan lakes-Fayoum-Governorate, Egypt.

	Oreochromis niloticus			***Bagrus bajad***	***Sea bass***	**Average**	**TDIs**[a]
	Lake I	**Lake II**	**Farmed**	**Lake I**	**Lake II**		
EDI (Cd)	0.016	0.058	0.016	0.058	0.017	0.033	1
EDI (Pb)	0.123	0.259	0.184	0.309	0.117	0.198	3.57
EDI (Hg)	0.023	0.088	0.014	0.206	0.021	0.070	0.228
EDI (As)	0.038	0.048	0.031	0.050	0.050	0.043	2.1

EDI= (Cm x FIR)/BW.
Cm = Concentration of the heavy metal in the sample (mg/kg wet weight).
FIR = Fish ingestion rate 48.57 g/day**.**
BW is the body weight = 70 k.
[a] JECFA Joint FAO/WHO Expert Committee on Food Additives (JECFA)[25].

The presented data in Table (3) revealed that estimated daily intake (EDI) of cadmium from all examined fish samples ranged from 0.016 to 0.058 with an average 0.033 µg/ kg body weight/day. The EDI lower than the tolerable daily intake (1µg/ kg body weight/day) established by JECFA [25]. This clearly, shows that the Cd intake for the general population from tested fish samples were below the guidelines.

The EDI of cadmium over consumption of fish and seafood worldwide was 0.055, 0.13 and 0.007 µg/ kg body weight/day in Spain [26]**,** India[27] and Egypt[28], respectively.

Table 4: Target hazard quotient (THQ) and Hazard index (HI) of different metals from consumption of fish collected from different locations in Wadi El- Rayan lakes-Fayoum-Governorate, Egypt .

	Oreochromis niloticus			***Bagrus bajad***	***Sea bass***
	Lake I	**Lake II**	**Farmed**	**Lake I**	**Lake II**
THQ (Cd)	0.016	0.058	0.016	0.058	0.017
THQ (Pb)	0.031	0.065	0.046	0.077	0.029
THQ (Hg)	0.078	0.295	0.046	0.686	0.069
THQ (As)	0.127	0.159	0.104	0.167	0.166
HI	0.252	0.577	0.212	0.988	0.281

$$THQ = \frac{EF \times ED \times FIR \times C}{RFD \times BW \times AT} x10_{-3}$$

THQ is the target hazard quotient; EF is exposure frequency (365 days/year); ED is the exposure duration (70 years, average lifetime); FIR is the food ingestion rate (g/day); C is the heavy metal concentration in pigeon squabs (µg/g); RfD is the oral reference dose (mg/kg/ day); BW is the average adult body weight (70 kg); and AT is the averaging exposure time (365 days/ year × number of exposure years, assuming 70 years)

$$HI = THQ\ Cd + THQ\ Pb + THQ\ Hg + THQ\ As$$

Target hazard quotient of cadmium (THQ Cd)

The THQ exceeding 1 indicates that there is potential risk to human health, and THQ ≤ 1 indicated no adverse health effects. The showed data in Table (4) declared that THQ of cadmium were all lower than 1 and ranged from 0.016 to 0.058.

The THQ of cadmium was 0.002 to 0.19 from consumption of fish caught in Portuguese waters [29] and 0.02, 0.024 and 0.03 from consumption of Brush tooth Lizard fish, Mackerel and Horse Mackerel in Egypt [30] **.**

Lead residues (Pb)

The data in Table (1) showed that the lead residues ranged from 0.06 to 0.38, 0.23 to 0.68, 0.06 to 0.54, 0.035 to 0.850 and 0.04 to 0.32 ppm with mean values of 0.177±0.04, 0.373±0.053, 0.265±0.056, 0.446±0.106 and 0.168±0.042 ppm for examined *O. niloticus* lake I, *O. niloticus* lake II, Farmed *O. niloticus*, *B. bajad* lake I and *S. bass* lake II, respectively.

The results were in line with the finding of Saei-Dehkordi and Fallah [31] they detected (0.534 ppm) in fish samples collected from Iran. Lower lead values were obtained by Jorhem and Sundström [32] and Suppin *et al.* [33] who detected 0.008 and 0.018 ppm, respectively.

B. bajad samples significantly higher than other examined species ($P<0.05$) on contrary *o. niloticus* from the same site (lake I) significantly lower than other examined species Thus, illustrate the role of feed habits of fish on biomagnifications of lead.

According to ES*No*. 7136/2010 [13], the maximum permissible limit (MPL) has been reported at 0.1ppm wet weight for fish.

The data in Table (2) declared that the general acceptability was 12 (24%) the exceeded samples resemble 38 (76%) according to ES [13] permissible limits.

The higher percentage of fish samples exceeding the permissible limits may be due to the increased lead sources in the environment such as; lead paint, lead from combustion of fuel containing tetraethyl lead, plumbing leachates from pipes or solder and lead from leaded chips, and batteries[34].

Risk assessment of exposure to lead due to fish consumption

Estimated daily intake of lead (EDI Pb)

The presented data in Table (3) revealed that estimated daily intake (EDI) of lead from all examined fish samples ranged from 0.117 in *B. bajad* lake I to 0.309 in *S. bass* lake II with an average 0.198 µg/ kg body weight/day. The EDI of lead from consumption of fish lower than the tolerable daily intake (3.57-µg/ kg body weight/day) established by JECFA [25].Clearly, indicates the Pb intake for the general population from fish samples were below the guidelines.

The EDI of lead through consumption of fish worldwide was 0.078, 0. 09 and 0.372 µg/ kg body weight/day in Spain [26], Portugal [29] and Egypt [28], respectively.

Target hazard quotient of lead (THQ Pb)

The calculated data in Table (4) declared that THQ of lead were lower than 1 and ranged from 0.029 to 0.077. The THQ of lead was 0.021 from consumption of fish caught in Portuguese waters [29]and 0.11, 0.06 and 0.12 from consumption of Brush tooth Lizard fish, Mackerel and Horse Mackerel in Egypt [30].

Mercury residues (Hg)

The results in Table (1) showed that the mercury residues ranged from 0.018 to 0.04, 0.02 to 0.31, 0.01 to 0.04, 0.01to 0.72 and 0.01 to 0.04 ppm with mean values of 0.034±0.003, 0.127±0.045, 0.02±0.005, 0.297±0.104 and 0.03±0.004 ppm for examined *O. niloticus* lake I, *O. niloticus* lake II, farmed *O. niloticus*, *B. bajad* lake I and *Sea bass* lake II, respectively.

The mercury concentration levels were in descending pattern in *B. bajad* lake I > *O. niloticus* lake II >*O. niloticus* lake I >*Sea bass* lake II > Farmed *O. niloticus*. It was cleared that the *O. niloticus from* lake II significantly higher contaminated with mercury ($P< 0.05$) than farmed and fish samples collected from lake I. Moreover, (*B. bajad* lake I) samples significantly higher than (*O. niloticus* lake I) which declared the effect of situation of fish species in food chain on the biomagnifications of mercury in fish muscle. Similar finding were obtained by Gad [35] who found that *B.*

bajad more contaminated with Hg residues than *O. niloticus.*

The results of farmed *O. niloticus* and fish from lake I in mercury residues were comparable to the finding of Sanzo *et al*. [36], Juresa and Blanusa, [37], Suppin *et al.* [33] and Essa and Rateb, [39] who detected 0.076, 0.34, 0.014 and 0.0045 ppm by, respectively.

The results of fish collected from lake II *O. niloticus* and *B. bajad* were nearly similar to Maghtouie *et al.*[40]they detected 0.526 ± 0.281 and 0.258 ± 0.10 ppm in summer and winter season, respectively.

Higher mercury value was obtained by Mukherjee and Bhupander [27], they detected 0.62±0.05 ppm from fish samples collected from India**.** A value of 0.54±0.03 and 0.56±0.01 ppm in Brush tooth Lizard fish and Mackerel fish were reported by Morshedy *et al.* [41]. According to ES *No.* 7136/2010 [13], the maximum permissible limits (MPL) has been reported at 0.2 ppm wet weight for fish. The results in Table (2) declared the general acceptability in all examined samples was 39 (78%) and the exceeded samples resemble 11 (22%) ES [13] permissible limits.

Risk assessment of exposure to mercury due to fish consumption

Estimated daily intake of mercury (EDI Hg)

The presented data in Table 3 revealed that estimated daily intake (EDI) of mercury from all examined fish samples ranged from 0.014 in farmed *O. niloticus* to 0.206 in *B. bajad* lake Iwith an average 0.07µg/ kg body weight/day. The EDI of mercury in tested samples was lower than the tolerable daily intake (0.228 µg/ kg body weight/day) which was established by JECFA [25] clearly, indicates the Hg intake for the general population from fish samples below the guidelines. The EDI of Hg in *B. bajad* lake I was the highest record in tested samples this contributed to the situation and feed habit of the fish which lead to bio magnification of mercury, while the most lower record was for farmed *O. niloticus* 0.014 µg/ kg body weight/day.

The EDI of mercury through consumption of fish and seafood worldwide was 0.14, (0.17 in summer and 0.086 in winter), 0.17 and 0.021µg/ kg body weight/day in Spain [26], Iran [40], India [27] and Egypt [28], respectively.

Target hazard quotient of mercury (THQ Hg)

The calculated data in Table (4) declared that THQ of mercury were lower than one and ranged from 0.046 to 0.686.

The THQ of mercury ranged from 0.025 to 1.30 from consumption of fish caught in Portuguese waters [29] and 0.025, 0.19 and 0.15 from consumption of Brush tooth Lizardfish, Mackerel and Horse Mackerel in Egypt [30]**.**

Arsenic residues (As)

The data in Table (1) showed that the tissue concentrations of arsenic ranged from 0.014 to 0.099, 0.058 to 0.079, 0.036 to 0.055, 0.051 to 0.091 and 0.058 to 0.094 ppm with mean values of 0.055±0.009, 0.069±0.003, 0.045±0.002, 0.072±0.006 and 0.072±0.005 ppm for examined *O. niloticus* lake I, *O. niloticus* lake II, farmed *O. niloticus*, *B. bajad* lake I and *Sea bass* lake II, respectively.

Nearly similar level of arsenic obtained 0.013±0.002 and 0.061±0.047 ppm in *B. bajad* and *O. niloticus* samples collected from fresh water fishes in Assiut Governorate [42]. Higher levels of arsenic were obtained by Rattanachongkiat *et al.* [43], Mukherjee and Bhupander [27] and Budiati [44], they detected 5.8 ppm in fish samples collected from Thailand; 0.66 ± 0.09 ppm from fish samples collected from India and2.14 ± 33, 1.7 ± 0.24 and 1.05± 0.88 ppm in three types of fish collected from Malaysia.

The level of arsenic residues equal in *B. bajad* lake I = *Sea bass* lake II, then decreased >*O. niloticus* lake II >*O. niloticus* lake I>farmed *O. niloticus*.

Comparison of species and location with ANOVA showed significant decrease ($p< 0.05$) in *O. niloticus* from lake I. Moreover, species variation was detected in lake II between *Sea bass* and *O. niloticus*.

Therefore, to our knowledge, no existing legal regulations on permissible limits for the total arsenic in seafood in Egypt but according to ISIRI No. 6952[45] all examined fish samples not exceed the established limit 0.2 ppm for fish and fish products.

Risk assessment of exposure to arsenic due to fish consumption

Estimated daily intake of arsenic (EDI As)

The presented data in Table (3) revealed that estimated daily intake (EDI) of arsenic from all examined fish samples ranged from 0.031 to 0.050with an average 0.043µg/ kg body weight/day and not exceeded the tolerable daily intake (2.1µg/ kg body weight/day) established byJECFA [25]**.** The EDI of arsenic through consumption of fish and seafood worldwide was 2.9, 0.18, 1.37 and 0.550 µg/ kg body weight/day in Spain [26], India [27], Malaysia [44] and Egypt [28], respectively.

Target hazard quotient of arsenic (THQAs)

The THQ exceeding one indicates that there is potential risk to human safety, and THQ ≤ 1 indicated no adverse health effects. The showed data in Table (4) declared that As THQ values were lower than 1 and ranged from 0.104 to 0.167. The THQ was 1.21 to 8.69 from consumption of fish caught in Portuguese waters [29].There are no THQ values over 1 through consumption of fish in all examined species. This indicates that health risks associated with As exposure for adults are insignificant Hazard index (HI) of toxic metals which defined as Summations of Target Hazardous Quotient Σ THQ, which can estimate the risk of exposure to a mix of pollutants [46] included in flesh of fish. The presented data in Table (4) revealed that (HI) values of toxic metals for all examined fish species were lower than 1, although *B. bajad* (0.988), was border line, still there is no health risk for the consumer by ingesting contaminated fish by multiple metals contained in fish

Conclusion

Generally, fish samples obtained from Lake II of Wadi El-Rayan more contaminated than Lake I and farmed fish of Wadi El-Rayan. Samples collected from fish farm were lower in concentration in toxic metals than Lake I and Lake II and this indicate lower health hazard from fish obtained from aquaculture of Wadi El-Rayan. On contrary, *B. bajad* from Lake I more contaminated than other examined species, which attributed to the feeding behavior (higher trophic situation in food chain leads to bio-magnification).

The study recommended to use the HI of toxic metals in flesh of fish as an assessment tool to assess the quality and safety of fish produced from different Egyptian lakes .Continuous monitoring of HI can be used as an indicator about the continuation of supply for ecosystem services (provisioning services).

Conflict of interest

The authors have no conflict of interest to declare

Acknowledgement

Sincere thanks to Dr. Mohamed Talaat El-Hennawy, PhD of Ecololgy, Egyptian Ministry of Environment for his help in the ecological side of the research. Dr. Mohamed Sameh Mohamed, the Director General of Central parks and the National Focal Point for Natural Heritage and Dr. Khaled Allam Harhash, the former director of Biodiversity Central Department, Egyptian Ministry of Environment for their willing assistance, continuous advice and encouragement.

References

[1] Hussein, M. A.; Merwad, A. M.; Elabbasy, M. T.; Suelam, I. I.; Abdelwahab, A. M. and Taha, M. A. (2019): Prevalence of Enterotoxigenic Staphylococcus aureus and Shiga Toxin Producing Escherichia coli in Fish in Egypt: Quality Parameters and Public Health Hazard. Vector-Borne Zoonot, 19(4): 255-264.

[2] La Notte, A.; D'Amato, D.;Mäkinen, H.;Paracchini, M. L.;Liquete, C.;Egoh, B. and Crossman, N. D. (2017): Ecosystem services classification: A systems ecology perspective of the cascade framework. Ecol Indic, *74*, 392-402.

[3] Authman, M. M. (2011): Environmental and experimental studies of aluminium toxicity on the liver of *Oreochromis niloticus* (Linnaeus, 1758) fish. Life Sci, *8*(4), 764-776.

[4] Mitra, A.; Barua, P.; Zaman, S., and Banerjee, K. (2012): Analysis of trace metals in commercially important crustaceans collected from UNESCO

protected world heritage site of Indian Sundarbans. Turk J Fish Aquat Sc, *12*(1), 53-66.

[5] Demirezen, O. and Uruc, K. (2006): Comparative study of trace elements in certain fish, meat and meat productsMeat Sci., 74(2), 255-260.

[6] Förstner, U. and Wittmann, G. T. (2012): Metal pollution in the aquatic environment. Springer Science & Business Media.

[7] Panayotidis, P., and Florou, H. (1994): Copper, cadmium and iron in marine organisms in a eutrophic estuarine area (Amvrakikos Gulf, Ionian Sea, Greece). Toxicol. Environ. Chem., *45*(3-4), 211-219.

[8] Jaishankar, M.;Tseten, T.;Anbalagan, N.; Mathew, B. B., and Beeregowda, K. N. (2014): Toxicity, mechanism and health effects of some heavy metals. Interdiscip. Toxicol, 7(2), 60-72.

[9] Castro-González, M. I.and Méndez-Armenta, M. (2008): Heavy metals: implications associated to fish consumption. Environ Toxicol Pharmacol 26:263–271.

[10] Raknuzzaman, M.; Ahmed, M.K.; Islam, M.S.; Habibullah-Al-Mamun, M.; Tokumura, M.; Sekine, M.; Masunaga, S. (2016): Trace metal contamination in commercial fish and crustaceans collected from coastal area of Bangladesh and health risk assessment. Environ SciPollut R23, 17298-17310.

[11] Zantopoulos, N.; Antoniou, V.; Pestaga, V. and Zdragas, A., (1996): Copper Concentrationin sheep liver and kidney in Greece, Vet. Hum. Toxicol, 38 (3), 184-185.

[12] Diaz, C.; Gonzalez-padron, A.; Fr-ias.L; Hardissor, A. and Lozano, M. (1994): Concentrations of mercury in fish and salted marine fish from the Canary Islands. J. Food Prot., 57 (3): 246- 249.

[13] Egyptian Organization for Standardization and Quality control (2010): Maximum level contaminants in foodstuffs. ESNO. 7136/2010. Cairo, Egypt (http://www.eos.org.eg/en/standard/12561).

[14] US Environmental Protection Agency, EPA (2010): Integrated Risk Information System (IRIS). Cadmium (CASRN-7440-43-9) Integrated Risk Information System (IRIS). Cadmium (CASRN-7440-43-9.http://www.epa.gov/iris/subst/0141.htm (Accessed 18.08.2018).

[15] Food and Agricultural Organization (FAO) (2010): The State of World Fisheries andAquaculture. Rome, Italy (http://www.fao.org/3/a-i1820e.pdf).

[16] Food and Agriculture Organization / World Health Organization (FAO/WHO) (2011): Joint FAO/WHO Food Standards Program Codex Committee on Contaminants in Foods, FifthSession, The Hague, the Netherlands, 21-25 March 2011 (http://www.fao.org/input/download/report/758/REP11_CFe.pdf).

[17] Okoro, C.C.;Aboaba, O.O.;Babajide, O.J. (2010): Quality Assessment of a commonNigerian Marine Fish, Croaker (*Pseudotolithus elongatus*) under different Storage Conditions.NY Sci J., 29-36.

[18] USEPA (2000): Risk-based concentration table. United States Environmental ProtectionAgency, Philadelphia; Washington DC.

[19] Yi, Y.; Yang, Z. and Zhang, S., (2011): Ecological risk assessment of heavy metals insediment and human health risk assessment of heavy metals in fishes in the middle and lowerreaches of the Yangtze River basin. *Environ Pollut*. 159: 2575‑2585.

[20] Huang, M.; Zhou, S.; Sun, B. and Zhao, Q. (2008): Heavy metals in wheat grain: assessment ofpotential health risk for inhabitants in Kunshan, China. Sci. Total Environ405, 54-61.

[21] Sallam, K. A.; El-Sebaey, H. E.S.and Morshdy, A.M. (1999): Mercury, cadmium and lead levels in Bagrus bayad fish from the river Nile, Delta Region, Egypt. J Egypt Public Health Assoc.; 74(1-2):17-26.

[22] Hajeb, P., Jinap, S., Ismail, A., Fatimah, A. B., Jamilah, B. and Rahim, M. A. (2009): Assessment of mercury level in commonly consumed marine fishes in Malaysia. Food Control 20(1): 79-84.

[23] Kuhnlein, H. V. and Chan, H. M. (2000): Environment and contaminants in traditional food systems of northern indigenous peoples. Annu Rev Nutr. 20(1): 595-626.

[24] USEPA (United States Environment Protection Agency) (2004): National listing of fish advisories. EPA-823-F-04-016.Office of water, Washington, DC, USA.

[25] JECFA Joint FAO/WHO Expert Committee on Food Additives (JECFA), (2004): Safety evaluation of certain food additives and contaminants. WHO Food Additives Series No. 52. World Health Organization, Geneva.

[26] Llobet, J. M.; Falco, G.; Casas, C.; Teixido, A. and Domingo, J. L. (2003): Concentrations of arsenic, cadmium, mercury, and lead in common foods and estimated daily intake by children, adolescents, adults, and seniors of Catalonia, Spain. J. Agric. Food Chem. 51(3): 838-842.

[27] Mukherjee, D. P. and Bhupander, K. (2011): Assessment of Arsenic, Cadmium, and Mercury Level In Commonly Consumed Coastal Fishes from Bay of Bengal, India. Food Sci. Qual. Manag, 2

[28] Morshey, A. E. D. A., Darwaish, W. S., Hussein, M. A., & El Ebidy, O. M. Heavy Metals Residues in Marketed Fish at Manzala, Dakahlyiaa. 2nd Conference of Food Safety, Suez Canal University, Faculty of Veterinary Medicine. Volume I August: 111-118

[29] Vieira, C., Morais, S., Ramos, S., Delerue-Matos, C., & Oliveira, M. B. P. P. (2011): Mercury, cadmium, lead and arsenic levels in three pelagic fish species from the Atlantic Ocean: intra-and inter-specific variability and human health risks for consumption. Food Chem. Toxicol., 49(4), 923-932.

[30] Ali, E.T. (2018): Chemical safety of imported frozen fish. M.V.Sci. Thesis. (Meat Hygiene). Fac. Vet. Med. Zag. Univ. Egypt.

[31] Saei-Dehkordi, S. S. and Fallah, A. A. (2011): Determination of copper, lead, cadmium and zinc content in commercially valuable fish species from the Persian Gulf using derivative potentiometric stripping analysis. Microchem J. 98(1): 156-162.

[32] Jorhem, L. and Sundström, B. (1993): Levels of lead, cadmium, zinc, copper, nickel, chromium, manganese, and cobalt in foods on the Swedish market, 1983–1990. J Food Compos Anal. 6(3): 223-241.

[33] Suppin, D.; Zahlbruckner, R.; Krapfenbauer,C.C.; Hassan, H.C. and Smulders, F.G.M. (2005): Mercury, lead and cadmium content of fresh and canned fish collected from Austrianretail operations. Ernährung/Nutrition, 29/NR. 11: 456-460.

[34] Committee on Environmental Health. (2005): Lead exposure in children: prevention, detection, and management. Pediatrics. 116(4): 1036-104**6.**

[35] Gad, N. S. (2010): Organochlorine pesticides and trace metals contamination in some marketable fish in Egypt. Egyptian Journal of Aquatic Research, 2010, 36(4), 633-642.

[36] Sanzo, J. M., Dorronsoro, M., Amiano, P., Amurrio, A., Aguinagalde, F. X. and Azpiri, M. A. (2001): Estimation and validation of mercury intake associated with fish consumption in an EPIC cohort of Spain. Public Health Nutr. 4(5): 981-988.

[37] Jureša, D. and Blanuša, M. (2003): Mercury, arsenic, lead and cadmium in fish and shellfish from the Adriatic Sea. Food AdditContam. 20(3): 241-246.

[38] Suppin, D.;Zahlbruckner, R.; Krapfenbauer- Cermak, C. H.; Hassan-Hauser, C. H. and Smulders, F. J. M. (2005): Mercury, lead and cadmium content of fresh and canned fish collected from Austrian retail operations.

Arbeitstagung Des Arbeitsgebietes Lebensmittel hygiene. 46: 633.38

[39] Essa, H. H.; Rateb, H. Z. (2011): Residues of some heavy metals in fresh water fish (*Oreochromis niloticus and Labeo niloticus*) in Assiut city markets. Assiut University Bulletin Environmental Research, 14(1):31-39

[40] Maghtouie, A. H., Neissi, G., Nasseri, S., Gholaminezhad, E., Shalamzari, N. and Nikpour, Y. (2011): Determination of mercury in mullet fish (Liza abu) from Arvand River, Iran. World Journal of Fish and Marine Sciences (WJFMS). 3(6): 514-517.

[41] Morshedy, A.; Eldosky, K.E. and El-Sebaie, S. (2007): Some heavy metal residues in mackerel and saurus fish. Zag. Vet. J. 35(4):114-120.

[42] Salem, D.A. (2003): Survey of some environmental pollutants in freshwater fishes in Assiut governorate, Egypt. Ass. Univ. Bull. Environ. Res. 6 (2).15-38.

[43] Rattanachongkiat, S., Millward, G. E. and Foulkes, M. E. (2004): Determination of arsenic species in fish, crustacean and sediment samples from Thailand using high performance liquid chromatography (HPLC) coupled with inductively coupled plasma mass spectrometry (ICP-MS). J Environ Monitor. 6 (4): 254-261.

[44] Budiati, T. (2010): The presence of arsenic as heavy metal contaminant on salmon: a risk assessment. International Journal of Basic and Applied Sciences.10(5): 6-12.

[45] ISIRI No. 6952 (Fish and fish products - Canned tuna fish in brine-Specifications and test methods).

[46] USEPA, (United States Environment Protection Agency) (1989): Risk Assessment Guidance for Superfund, Vol 1. EPA/540/1-89/002.Office of Emergency and Remedial Response, USEPA, Washington, DC.

الملخص العربي

تحليل المخاطر لبعض المعادن السامة في الأسماك من بحيرات وادى الريان ، محافظة الفيوم , مصر.

شيماء طه[١]، محمد عبد الله محمد حسين[٢]وعلاء الدين محمد مرشدى[٢]
[١]وزارة البيئة/ جهاز شئون البيئة / قطاع حماية الطبيعة
[٢]قسم مراقبة الأغذية -كلية الطب البيطري -جامعة الزقازيق – جمهورية مصر العربية

اجريت هذه الدراسة لتقييم التركيزات المتبقية من الكادميوم والرصاص والزئبق والزرنيخ في لحوم بعض الأسماك وتتمثل فى بلطي بحيرة واحد، بلطي بحيرة أثنين، أسماك البلطى المستزرعة، بياض بحيرة واحد وقاروص بحيرة أثنين وتم جمعها من وادي الريان، محافظة الفيوم، مصر. وكانت متوسطات الكادميوم كالتالي ٠.٠٢٣، ٠,٠٨٣، ٠.٠٢٣، ٠.٠٨٣ و ٠.٠٢٥ والرصاص0 (,١٧٧، ٠.٣٧٣، ٠.٢٦٥، ٠.٤٤٦ و ٠.١٦٨)والزئبق (٠.٠٣٤، ٠.١٢٧، ٠.٠٢، ٠.٢٩٧ و ٠.٠٣) والزرنيخ (٠.٠٥٥، ٠.٠٦٩، ٠.٠٤٥، ٠.٠٧٢ و ٠.٠٧٢) جزء في المليون فى بلطى بحيرة واحد، بلطى بحيرة أثنين، أسماك البلطى المستزرعة ، بياض بحيرة واحد و قاروص بحيرة أثنين . ووجد أن والرصاص والزئبق والزرنيخ الذي يدخل جسم الإنسان بالميكروجرام /كجم من وزن الإنسان فى اليوم من جميع عينات الأسماك التي تم فحصها كان ٠.٠٣٣، ٠.١٩٨، ٠.٠٧ و٠.٠٤٣ ميكروجرام / كيلوجرام من وزن الجسم / يوم، على التوالي. ووجد أن كمية المعادن السامة التى تدخل جسم الإنسان بسبب أستهلاك الأسماك من بحيرات وادي الريان أقل من الحدود المسموح بها عالميا وعلى وجه الخصوص في الأسماك المستزرعة والتي تعتبر أقل من مثيلتها البرية.ووجدان مؤشر المخاطر لجميع أنواع الأسماك أقل من واحد، مما يشير إلى أنه لا يوجد خطر صحي على المستهلك من خلال تناول لحوم الأسماك بما تحتويه من معادن سامة من بحيرات وادي الريان