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Bioaccumulation profiles of heavy metals in fish collected from Rosetta branch of Nile River, Egypt: A case study for organ's responsibility

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Abstract

The accumulation patterns in organs of tilapia and catfish collected from 4 locations: Alqam, Shabour, Shobrakhite and Edfina from Rosetta branch of Nile River, Egypt during summer and winter 2018/2019 were assessed. Seven metals: Zinc (Zn), Cadmium (Cd), Lead (Pb), Ferrous (Fe), Nickel (Ni), Copper (Cu) and Manganese (Mn) were determined on Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) instrument. In water, Fe exhibited the greatest proportions, followed by Zn. But Cd and Ni exhibited the least values. Significant differences ($P<0.05$) were obtained in metal accumulation in organs, where liver and kidney exhibited the great concentrations, but muscles and gills exhibited the least uptake patterns. Bioconcentration factor (BCF) in tilapia were greater than catfish in the following order: Kidney> liver> gills> muscles. Cd exhibited the order in tilapia: kidney> liver> gills> muscles with BCF values: 11.72, 1.92, 1.87 and 0.85, respectively. Low BCF values were noticed for Mn, where it ranged from 0.04 to 0.54 in the above organs. Such these accumulations may induce adverse effects in fish along physiological status and their susceptibility to disease's infection. Also, may provide alarming signs for fish consumers in these regions.

Keywords: Heavy metals; Rosetta branch; Tilapia; Catfish; Bioconcentration factor; ICP-OES.

Introduction

In worldwide, industrial wastewater represents the main source of water pollution. Increase of modern industries, agricultural activities, tourism, and human activities are the main sources for chemical contaminants in ecosystem [1]. In Egypt, industries, agricultural runoff, and sewage are considered the primary sources of metals in fish and other aquatic organisms [2, 3]. Heavy metals (HMs) pollution in freshwater provides threat to public water supplies and consumers of fish [4]. They represent aquatic pollutants due to bio-accumulation and non-biodegradable properties in food [5]. In freshwater, fish are often at the top of the food chain and have tendency to accumulate HMs from water [6]. Studies on bioaccumulation of HMs in fish are important to determine the impact in aquatic system, and therefore obtains adverse effects in the organisms [7]. Prolonged exposure even in low concentrations have been stated to induce morphological, histological and biochemical alterations in fish [2, 6-8].

In general, environmental contaminants may increase responsibility of aquatic organisms to various diseases by interfering with normal functions of immune, reproductive and developmental processes of them [3]. This concept was documented by Wedemayer (1997) [9] who showed that, fish may also respond to a stressor by altering physiological processes to point that natural resistance and immunity to disease is reduced and they become more susceptible to infectious diseases. For HMs, several studies showed that, HMs may alter the physiological activities and biological parameters in organs and blood of fish. The alarming rate of disease associated with impacts of HMs and potential effects

f them on the aquatic biota have made it of concern and the need to assess accumulation of HMs [10]. On the other hand, seasonal changes in immune and physiological responses of fish are associated with changes of temperature and light density as environmental factors [11]. In fact, impact of metals on organisms in water bodies depends on the distribution of them between the dissolved form, molecular shape and other environmental conditions [12]. The study aims to assess HMs accumulation in water and fish (tilapia and catfish) collected from 4

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locations of Rosetta branch of Nile River in association with some organ's responsibility.

Materials and Methods

Description of the studied region

Four locations: Alqam, Shabour, Shoubrakhite and Edfina were chosen for sample collection (Figure 1). Water and fish (Tilapia and Catfish) were taken for analysis. Shabour and Shoubrakhite locate near brick making factories (used petroleum oils as a fuel) and Kafr El-Zayat region as a main industrial zone in The Delta Egypt. Alqam is near new lands cultivating with different kinds of fruits and vegetables and reservoir for drainage water coming from different governorates. On the other hand, Edfina represents the end point of Rosetta branch as a reservoir for drainage water coming from El-Behira and Kafr El-Sheikh governorates.

Samples collection

Fish: tilapia and catfish were caught from selected sites, packed in polyethylene pages, labelled and transferred in ice box. Water samples from different sites as marked in the geographic map were collected periodically every season from spring 2019 to winter 2020. One liter of water was collected in glass bottle from each site. The bottles were covered with aluminum foil and screwed carefully. All samples were preserved in an icebox during transfer.

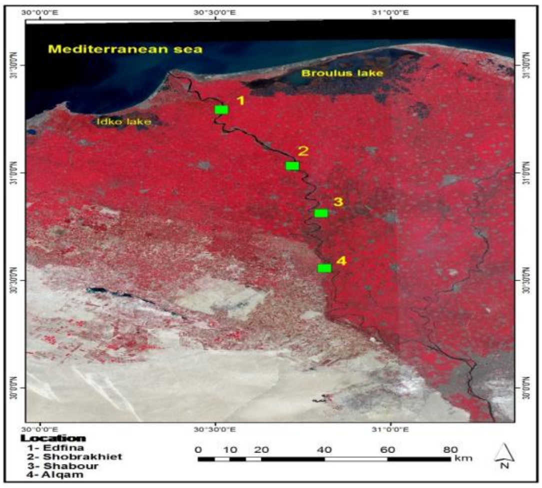


Figure 1: Locations of sample collection from Rosetta branch (google map).

Water characteristics

Water characters of the collected samples were analyzed at laboratory of soil fertility, Agriculture directorate, Damanhour, El-Behira governorate. The cations and anions were measured according to the method of Brunishalz et al. (1953) [13] and Reitemeier (1943) [14], respectively. Water samples pH values were determined according to Mc-Lean (1982) [15]. Electric conductivity also was measured.

Heavy metals (HMs) determination

Water

Heavy metals (HMs) in water samples were determined according to the method of APHA (1998) [16]. About 250 ml of the collected water were filtered through Whattman filter paper (No. 1) and 5 ml of concentrated nitric acid were added. The samples were boiled to constant volume (5 ml). After cooling, the remained mixture was dissolved in 3 ml of nitric acid, filtered and completed to 25 ml with deionized water. In blank sample, all procedures were done as described before without water source.

Tissues

The samples were dried in an oven at 70 °C until constant weight and then mineralised [17]. Ten ml of nitric acid/ sulphuric acid (4:1 v/v) mixture were added to 1 g of sample and heated about 1 h on a hot plate provided with a magnetic agitator and reflux condenser. After cooling, 10 ml of hydrochloric acid were added and the volume of the samples was reduced by heating mantles. Finally, the samples were reduced to 5 ml and diluted to 25 ml with deionized water for analysis by Inductive Coupled Plasma-Optical Emission spectrometry (ICP-OES).

ICP-OES.

All measurements were performed on Agilent microwave plasma model 4200 MP-AES at High Studies and Research Institute, Alexandria University, Alexandria, Egypt. An autosampler was used to deliver the samples into instrumental cyclonic spray chamber with mass flow controlled nebulizer gas flow 0.5 L/min. The instrument was operated in a fast sequential mode and featured a per litter cooled CCD detector. Background and spectral interferences could be corrected and accurately using Agilent's MP Expert Software.

The limits of detection (LODs) for measured metals were calculated as a double standard deviation of a series of measurements of a solution against the blank absorbance [18]. Working standards were used, quality assurance procedures and precautions were carried out to ensure the reliability of the results. Samples were carefully handled, and deionized water was used to avoid any contamination. A recovery experiment was carried out by spiked blank with 2 levels of multi-standards of desired metals, and the procedures were done as described above.

Bioaccumulation

Bioconcentration factor (BCF) is defined as the ratio between the chemical concentration in organism (C_{Org}) to the respective concentration in the surrounding media (C_w) [19].

$$BCF = \frac{Corg}{Cw}$$

Statistical analysis

Analysis of variance was used to compare means among treatments by using Student-Newman-Keals test [20].

Results

Water characteristics

The water characteristics of the studied locations were determined during the above period (Table 1). The data showed the values of E.C, pH, and the concentrations of some cations and anions. It seems that, pH values tend to be in a slight alkaline range. Anion (SO_4) exhibited the greatest mean concentration (0.70 mg/L) in Shobrakhite location, but no significant differences were obtained in values of Cl and HCO_3. Cations: Ca, Mg, and K showed no significant differences between the chosen locations. Cation, Na exhibited the greatest concentration (3.20 mg/L) in Alqam location, followed by Shabour (2.75 mg/L).

HMs

Seven HMs in water and tissue samples collected from 4 locations of Rosetta branch of Nile River were quantified. The examined metals were analyzed in the prepared samples as mentioned above. The instrument (ICP-OES) and used methods were calibrated and optimized for the work (Table 2).

In water

The concentrations of HMs in water samples exhibited significant differences between the chosen locations (*P<0.05*). During winter, Fe exhibited the main contaminated metal in all locations as follows: Alqam> Shabour> Shobrakhite > Edfina with mean values: 951.99, 349.09, 337.02 and 149.43 mg/L, respectively, followed by Zn with the mean values: 380.76, 396.60, 336.78 and 263.54 mg/L. No significant differences were obtained in Cu concentrations. Lead (Pb) ranged from 4.44 to 9.36 mg/L. The least values were recorded for Cd. During summer, Fe exhibited the following order: Shabour> Shobrakhite> Alqam> Edfina with mean values: 351.84, 341.16, 246.85 and 130.32 mg/L, respectively. However, Zn exhibited the values: 17.28, 61.56, 15.84 and 19.55 mg/L for the above locations. The least values were recorded for Cd in the range (0.14-0.55 mg/L). Concentrations of Cu exhibited the range (38.28-79.68 mg/L), but concentrations of Mn exhibited the range (46.32-125.95 mg/L). Shobrakhite exhibited the greatest concentration of Pb (11.43 mg/L), followed by Edfina (2.60 mg/L). No significant differences were obtained between Shabour and Alqam. The same manner was observed in Ni concentrations, where Shobrakhite exhibited the greatest concentration (22.58 mg/L), followed by Shabour (5.03 mg/L), Edfina (4.93 mg/L) and Alqam (4.75 mg/L) (Figure 2).

Table 1

Water Characteristics (mean values) of Rosetta branch, Nile River during 2019-2020.

Location	EC (ds^{-1} m^{-1})	pH	Cations (mg/L)			Anions (mg/L)			
			HCO_3	SO_4	Cl	Ca	Mg	Na	K
Shobrakhite	0.46	7.14	0.30	0.70	2.90	1.15	0.75	2.65	0.25
Shabour	0.49	7.14	0.35	0.35	3.50	1.25	0.80	2.75	0.25
Edfina	0.51	7.17	0.30	0.30	3.10	1.00	0.65	2.40	0.30
Alqam	0.50	7.19	0.30	0.30	3.55	0.95	0.55	3.20	0.30

Table 2

Instrumental conditions of ICP-OES for HMs in water and tissues and recovery percentages.

Metal	Wavelength (nm)	LOD (ng/ml)	LOQ (ng/ml)	% Recovery	
				Tissues	Water
Zn	213.9	4.5	15.0	100.0	100.0
Cd	228.8	2.1	6000.0	84.45	80.25
Cu	324.8	0.7	2000.0	100.0	100.0
Ni	352.5	0.9	3000.0	100.0	88.20
Mn	403.0	0.2	666.0	100.0	75.00
Pb	405.8	3.2	11.5	100.0	99.90
Fe	371.9	25.0	75.0	100.0	100.0

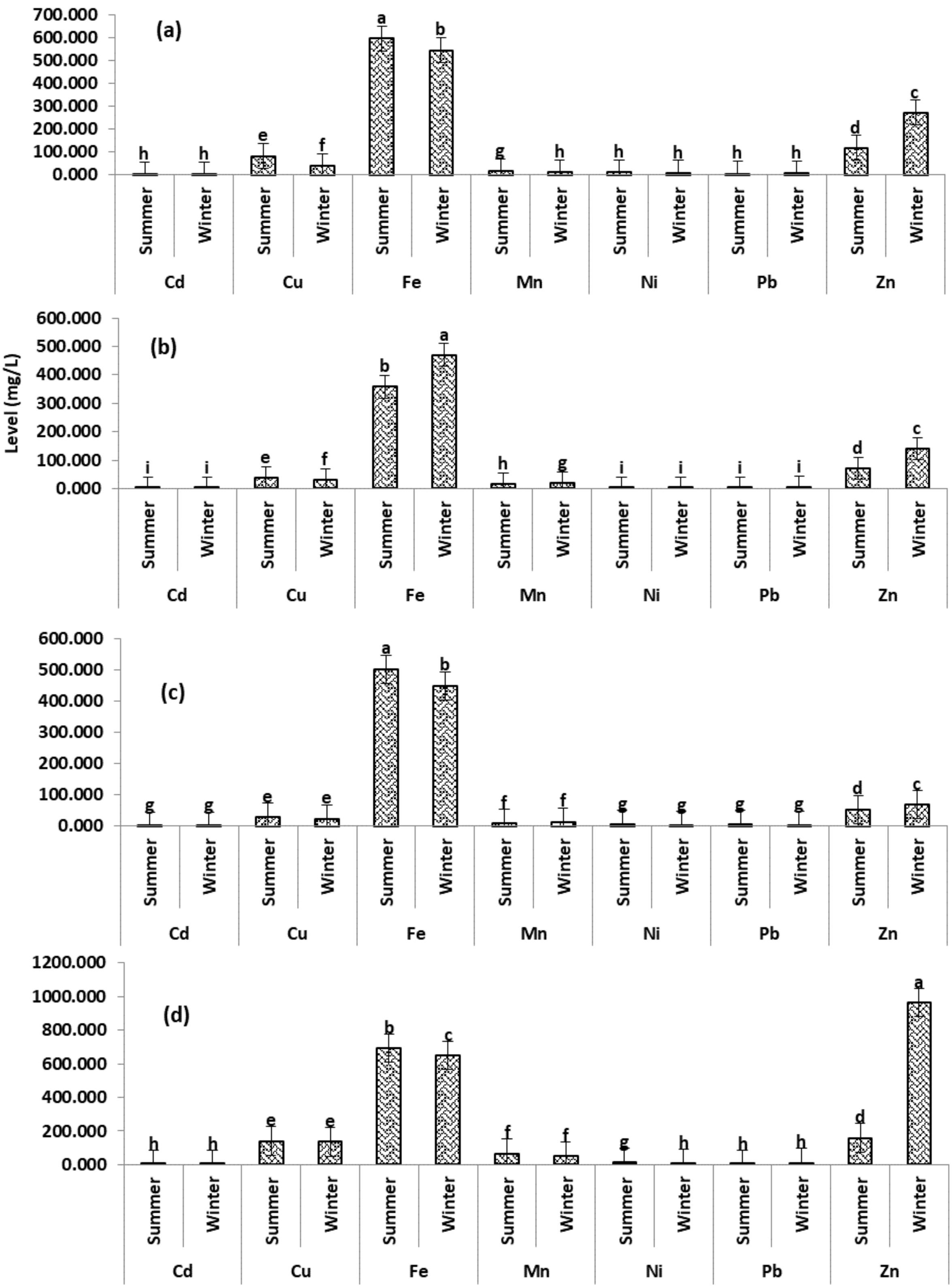
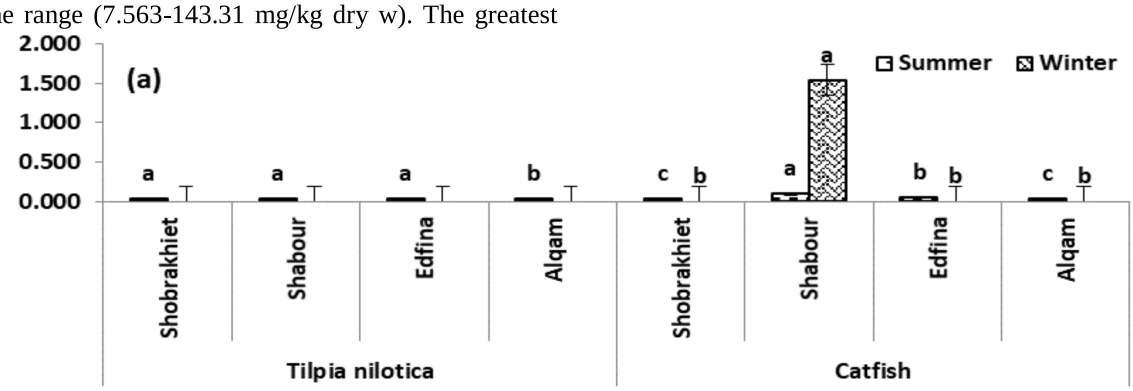
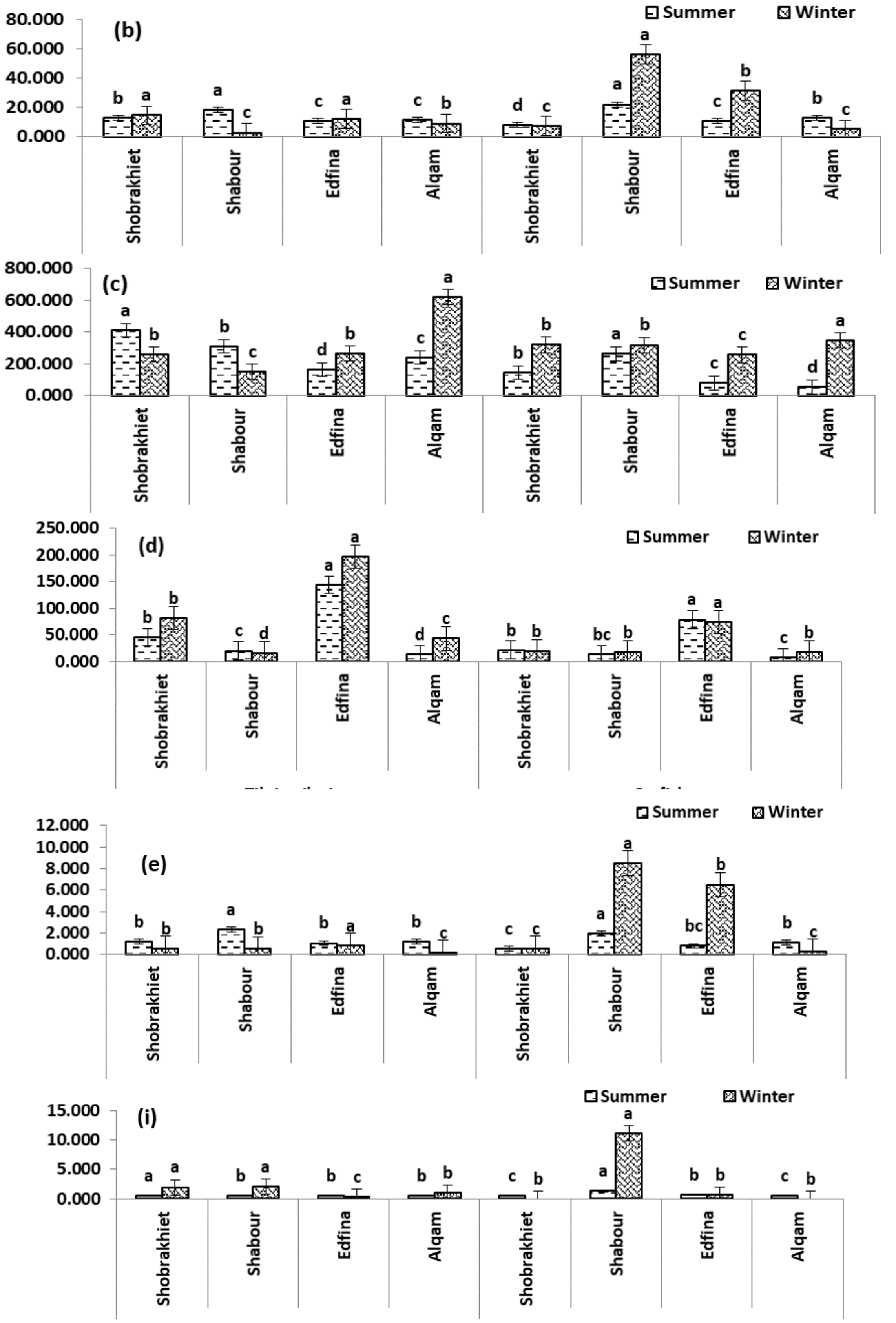


Figure 2: Levels of HMs in water samples (Rosetta branch) collected from (a) Shabour, (b) Shoubrakhite, (c) Alqam and (d) Edfina, respectively, during winter and summer seasons 2019/2020.

In gills

Seven HMs in some organs of tilapia and catfish samples collected from different locations of Rosetta branch were quantified. The examined metals were analyzed in the prepared samples as mentioned above. Also, the instrument (ICP-OES) and used method were calibrated and adjusted for optimization. During winter, Cd was below detection limit (BDL) in gills of both tilapia and catfish, except in samples of catfish from Shobrakhite location with mean value 1.538 mg/kg dry w (Figure 3a). During summer, levels of Cd ranged from 0.035 to 0.092 mg/kg dry w. Copper (Cu) exhibited levels in range (7.98-22.23 mg/kg dry w) during summer. Catfish from Shobrakhite exhibited the least level (7.98 mg/kg dry w), while catfish samples from Shabour exhibited the greatest mean value (22.23 mg/kg dry w). During winter, Cu displayed the range 2.973-56.507 mg/kg dry w. The highest mean value (56.507 mg/kg dry w) was found in catfish of Shabour, followed by tilapia of Shobrakhite (14.156 mg/kg dry w), and tilapia of Edfina (12.243 mg/kg dry w). The least mean value (2.973 mg/kg dry w) was found in tilapia fish from Shabour (Figure 3b). During winter, Fe displayed mean levels in the range (151.803-620.35 mg/kg dry w). Tilapia fish from Alqam exhibited the greatest mean value (620.35 mg/kg dry w), followed by its catfish sample (349.61 mg/kg dry w), catfish of Shobrakhite (320.14 mg/kg dry w) and catfish of Shabour (318.19 mg/kg dry w). The least mean value (151.803 mg/kg dry w) was found in tilapia fish of Shabour. During summer, Fe displayed levels lower than winter in the range (54.36-240.30 mg/kg dry w). The least value (54.36 mg/kg dry w) was found in catfish of Alqam, while the greatest value (240.30 mg/kg dry w) was found in tilapia fish of Alqam (Figure 3c). During summer, Mn displayed the range (7.563-143.31 mg/kg dry w). The greatest mean value (143.31 mg/kg dry w) was found in tilapia fish of Edfina, followed by tilapia fish of Shobrakhite (45.87 mg/kg dry w), and catfish of Shobrakhite (21.81 mg/kg dry w). The least mean value (7.563 mg/kg dry w) was found in catfish of Alqam. During winter, Mn displayed the range 16.55-195.903 mg/kg dry w. The greatest mean value (195.903 mg/kg dry w) was found in tilapia fish of Edfina, followed by tilapia fish of Shobrakhite (80.913 mg/kg dry w) and tilapia fish of Alqam (43.087 mg/kg dry w). No significant differences were obtained in the mean values of other samples (Figure 3d). Nickel (Ni) displayed the least mean values in gills during winter, where it ranged from 0.15 to 8.49 mg/kg dry w. The greatest mean value (8.49 mg/kg dry w) was found in catfish of Shabour, followed by tilapia fish of Edfina (0.857 mg/kg dry w). During summer, it ranged from 0.54 to 2.34 mg/kg dry w. The greatest one (2.34 mg/kg dry w) was noticed in tilapia fish of Shabour, followed by (1.966 mg/kg dry w) in catfish of Shabour. The least mean value (1.308 mg/kg dry w) was found in catfish of Shabour. No significant differences were obtained in the other samples during summer. During winter, it ranged from ND to 11.09 mg/kg dry w. The greatest one (11.09 mg/kg dry w) was noticed in catfish of Shabour, followed by tilapia fish of Shabour (2.05 mg/kg dry w) (Figure 3i). Zinc (Zn) exhibited the range 52.843-730.133 mg/kg dry w, followed by tilapia fish of Shobrakhite (145.83 mg/kg dry w). The least one (52.843 mg/kg dry w) was noticed in catfish of Shobrakhite during winter. During summer, it ranged from 21.536 to 101.936 mg/kg dry w (Figure 3f).




(b)
Summer
Winter
80.000
60.000
40.000
20.000
0.000
Shobrakhiet
Shabour
Edfina
Alqam
Shobrakhiet
Shabour
Edfina
Alqam
(c)
Summer
Winter
800.000
600.000
400.000
200.000
0.000
Shobrakhiet
Shabour
Edfina
Alqam
Shobrakhiet
Shabour
Edfina
Alqam
(d)
Summer
Winter
250.000
200.000
150.000
100.000
50.000
0.000
Shobrakhiet
Shabour
Edfina
Alqam
Shobrakhiet
Shabour
Edfina
Alqam
(e)
Summer
Winter
12.000
10.000
8.000
6.000
4.000
2.000
0.000
Shobrakhiet
Shabour
Edfina
Alqam
Shobrakhiet
Shabour
Edfina
Alqam
(i)
Summer
Winter
15.000
10.000
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Shobrakhiet
Shabour
Edfina
Alqam
Shobrakhiet
Shabour
Edfina
Alqam

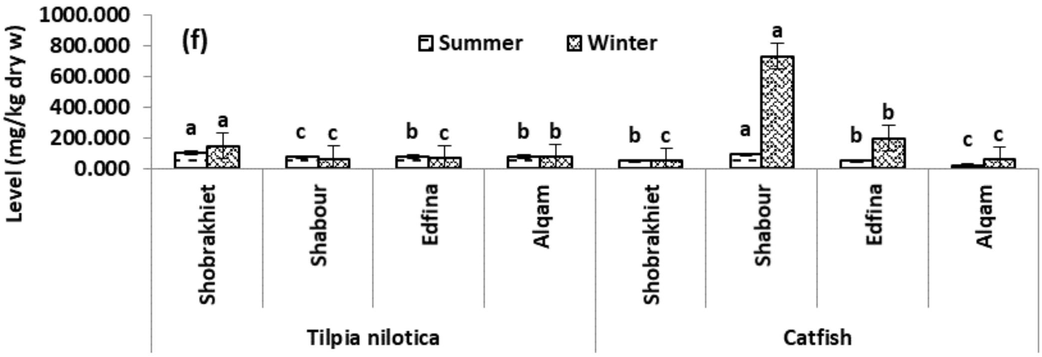


Figure 3: Levels of HMs (mg/kg dry w): (a) Cd, (b) Cu, (c) Fe, (d) Mn, (e) Ni, (i) Pb, and (f) Zn in gills samples of tilapia and catfish collected from Rosetta branch. Each value represents the mean of 3 replicates ± SE. The same letters indicate no significant difference at 0.05 levels.

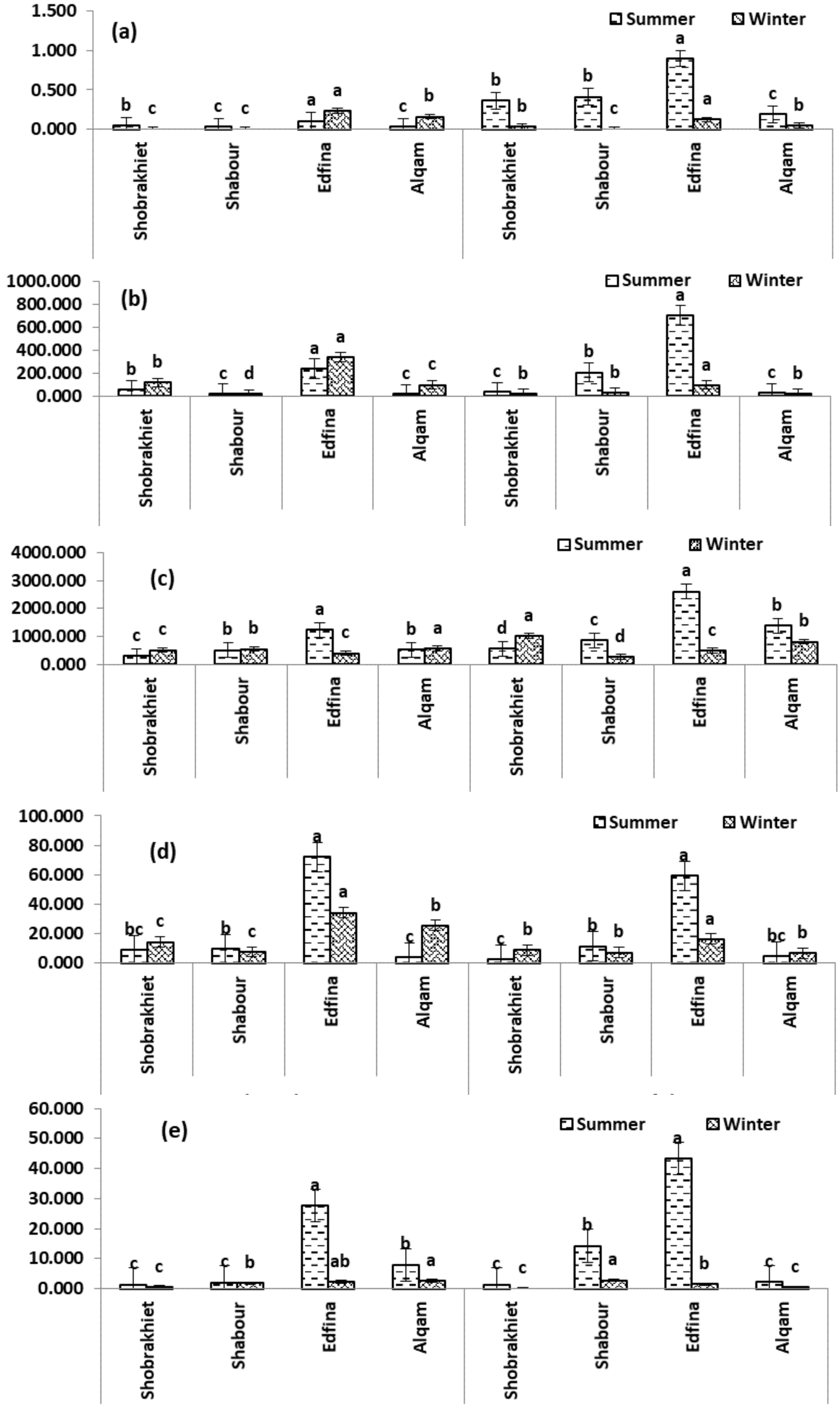
Liver

During summer, Cd displayed mean values in catfish greater than tilapia (Figure 4a). In catfish, it displayed the order: Shabour> Shobrakhite> Alqam> with mean values: 0.413, 0.360, and 0.189 mg/kg dry w, respectively. However, in tilapia it displayed the order: Edfina> Shobrakhite> Shabour> Alqam with mean values: 0.107, 0.043, 0.036 and 0.035 mg/kg dry w, respectively. During winter Cd did not exceed 1 mg/kg dry w in both type of samples. Edfina exhibited the greatest mean value (0.231 mg/kg dry w), followed by Alqam (0.159 mg/kg dry w) in tilapia. Copper (Cu) displayed the order: Edfina> Shobrakhite> Shabour> Alqam with mean values: 238.08, 52.89, 20.756 and 16.703 mg/kg dry w, respectively, in tilapia fish samples collected during summer (Figure 4b). In catfish, the order was: Shabour> Shobrakhite> Alqam with mean values: 205.117, 35.147, and 26.966 mg/kg dry w, respectively. On the other hand, it displayed the order: Edfina> Shobrakhite> Alqam> Shabour with mean values: 339.69, 115.94, 97.09 and 17.10 mg/kg dry w, respectively, in tilapia samples. No significant differences were observed in catfish arising values: 18.66, 18.33 and 27.46 mg/kg dry w in Shobrakhite, Alqam and Shabour, respectively, during winter. Essential metal (Fe) exhibited accumulation pattern in catfish samples greater than tilapia arising the order: Alqam> Shabour> Shobrakhite with mean values: 1388.477, 863.726, and 571.31 mg/kg dry w, respectively, during summer. The accumulation pattern in tilapia fish was as follows: Edfina> Alqam> Shabour> Shobrakhite with mean values: 1236.60, 528.557, 513.513 and 297.686 mg/kg dry w, respectively (Figure 4c). During winter, it displayed the order: Alqam> Shabour> Shobrakhite> Edfina with mean values: 584.54, 555.54, 518.96 and 402.20 mg/kg dry w, respectively. Shobrakhite location exhibited the greatest value (1018.59 mg/kg dry w), followed by Alqam (812.31 mg/kg dry w), and Shabour (273.64 mg/kg dry w). Manganese (Mn) showed accumulation pattern in tilapia fish as follows: Edfina> Shabour> Shobrakhite> Alqam with mean values: 71.94, 9.806, 8.996 and 3.93 mg/kg dry w, respectively, during summer. The accumulation pattern in catfish was as follows: Shabour> Alqam> Shobrakhite with mean values: 11.51, 4.626, and 2.548 mg/kg dry w (Figure 4d). During winter, the metal displayed the order: Edfina> Alqam> Shobrakhite> Shabour with mean values: 34.16, 25.53, 14.30 and 7.62 mg/kg dry w, respectively, in tilapia samples. In catfish, the metal displayed the pattern Shobrakhite> Shabour> Alqam with mean values: 8.80, 7.17 and 6.62 mg/kg dry w, respectively. Low accumulation pattern of Ni was obtained in most samples. It displayed the order: Edfina> Alqam> Shabour> Shobrakhite with mean values: 27.66, 7.96, 2.07 and 1.37 mg/kg dry w, respectively, in tilapia samples during summer (Figure 4e). The accumulation pattern in catfish recognized the order: Shabour> Alqam> Shobrakhite with mean values: 14.29, 2.23 and 1.39 mg/kg dry w, respectively. During winter, it displayed the order: Alqam> Edfina> Shabour> Shobrakhite with mean values: 2.62, 2.29, 1.79 and 0.60 mg/kg dry w, respectively, in tilapia samples. In catfish, the only detected values were 2.76 and 0.49 mg/kg dry w in Shabour and Alqam. Potential toxic metal (Pb) showed low pattern of accumulation in both type of fish (Figure 4i). In tilapia, it displayed the following order: Edfina> Shabour > Shobrakhite> Alqam with mean values: 1.74, 0.66, 0.62 and 0.51 mg/kg dry w, respectively, during summer. In catfish, it displayed the order: Shabour> Alqam> Shobrakhite with mean values: 5.93, 2.71 and 1.28 mg/kg dry w, respectively. During winter, accumulation pattern exhibited the mean values: 3.05, 2.76, 4.01 and 5.73 mg/kg dry w in tilapia samples of Shobrakhite, Shabour, Edfina and Alqam, respectively. Regarding catfish, the mean values were 3.12, 3.53 and 4.84 mg/kg dry w in Shobrakhite, Shabour and Alqam, respectively. Essential metal (Zn) displayed significant accumulation pattern in both type of fish (Figure 4f). It displayed the order: Edfina> Alqam>

Shabour> Shobrakhite with mean values: 104.22, 58.14, 57.06 and 55.51 mg/kg dry w, respectively, in tilapia fish samples during summer. In catfish, it displayed the order: Shabour> Shobrakhite> Alqam with mean values: 229.52, 106.23 and 75.16 mg/kg dry w, respectively. During winter, accumulation of Zn exhibited mean values: 79.96, 162.15, 93.09 and 114.55 mg/kg dry w in tilapia fish samples of Shobrakhite, Shabour, Edfina and Alqam, respectively. The accumulation pattern in catfish closed to mean values: 118.75, 87.79, and 97.25 mg/kg dry w in Shobrakhite, Shabour and Alqam, respectively.

Kidney

Cadmium (Cd) exhibited accumulation pattern closed to mean values: 0.29, 1.08, 0.39 and 2.09 mg/kg dry w in tilapia samples of Shobrakhite, Shabour, Edfina and Alqam, respectively, during summer (Figure 5a). Metal accumulation in catfish closed to mean values: 0.19, 0.96 and 0.04 mg/kg dry w in Shobrakhite, Shabour and Alqam, respectively. During winter, accumulation pattern in tilapia closed to mean values: 1.78, 6.34, and 0.38 mg/kg dry w in Shabour, Edfina and Alqam, respectively. Regarding catfish, Shabour exhibited the greatest mean value (1.27 mg/kg dry w), followed by Alqam (0.61 mg/kg dry w). the least one (0.10 mg/kg dry w) was found in Shobrakhite. Accumulation pattern of Cu in tilapia fish during summer closed to mean values: 119.00, 270.03, 103.85 and 118.24 mg/kg dry w in Shobrakhite, Shabour, Edfina and Alqam, respectively (Figure 5b). Regarding catfish, it closed to 51.74, 98.92 and 13.27 mg/kg dry w in Shobrakhite, Shabour, and Alqam, respectively. During winter, extensive accumulation was found in tilapia fish of Edfina (316.07 mg/kg dry w), followed by Shabour (87.00 mg/kg dry w), and Shobrakhite (51.93 mg/kg dry w). The least one was noticed in Alqam (11.99 mg/kg dry w). In catfish, it displayed the order: Shabour> Alqam> Shobrakhite with mean values: 86.52, 29.66, and 20.92 mg/kg dry w, respectively. Essential metal (Fe) recognized to accumulation profile in tilapia fish during summer inclosing to mean values: 672.93, 1260.67, 474.07 and 1488.31 mg/kg dry w in Shobrakhite, Shabour, Edfina and Alqam, respectively (Figure 5c). Regarding catfish, it closed to the values: 611.97, 1393.78, and 86.97 mg/kg dry w in Shobrakhite, Shabour, and Alqam, respectively. During winter, extensive accumulation was induced in tilapia arising values: 827.55, 1997.17, 1906.06 and 104.7 mg/kg dry w in Shobrakhite, Shabour, Edfina and Alqam, respectively. In catfish, it closed to values: 680.27, 972.86, and 1019.34 mg/kg dry w in Shobrakhite, Shabour, and Alqam, respectively. Manganese (Mn) exhibited accumulation pattern in tilapia fish during summer closing to mean values: 13.17, 25.45, 97.91 and 31.76 mg/kg dry w in Shobrakhite, Shabour, Edfina and Alqam, respectively (Figure 5d). During winter, it closed to values: 15.03, 34.05, and 0.84 mg/kg dry w in Shobrakhite, Shabour, and Alqam, respectively. In catfish, it closed to values: 15.03, 34.05, 0.84 mg/kg dry w and 7.54, 16.96, 8.26 mg/kg dry w during summer and winter in samples of Shobrakhite, Shabour and Alqam, respectively. Nickel (Ni) exhibited accumulation pattern in tilapia fish during summer greater than winter (Figure 5e). It closed to mean values: 7.55, 25.44, 12.20 and 26.47 mg/kg dry w in Shobrakhite, Shabour, Edfina and Alqam, respectively. Another finding was obtained in catfish closing to values: 4.45, 33.24, and 1.20 mg/kg dry w in Shobrakhite, Shabour, and Alqam, respectively. During winter, accumulation pattern in tilapia closed to 4.25, 39.74, 25.71 and 0.97 mg/kg dry w in Shobrakhite, Shabour, Edfina and Alqam, respectively. In catfish, it closed to 0.99, 6.44, and 1.26 mg/kg dry w in Shobrakhite, Shabour and Alqam, respectively. Potential toxic metal (Pb) closed to mean values: 4.15, 15.45, 5.39 and 30.00 mg/kg dry w in tilapia samples of Shobrakhite, Shabour, Edfina and Alqam, respectively, during summer (Figure 5i). In catfish, it closed to 2.87, 13.78, and 0.51 mg/kg dry w in Shobrakhite, Shabour and Alqam, respectively. During winter, tilapia fish samples exhibited the values: 6.94, 11.49, 35.35, and 1.60 mg/kg dry w in Shobrakhite, Shabour, Edfina and Alqam, respectively. While, catfish closed to 2.91, 10.09, and 7.33 mg/kg dry w in Shobrakhite, Shabour and Alqam, respectively. Essential one (Zn) closed to mean values: 104.63, 171.61, 1204.62 and 132.32 mg/kg dry w in tilapia samples of Shobrakhite, Shabour, Edfina and Alqam, respectively, during summer (Figure 5f). In catfish, it closed to 101.97, 261.98 and 10.05 mg/kg dry w in Shobrakhite, Shabour and Alqam, respectively. During winter, it closed to 491.75, 145.74, 2719.29 and 19.47 mg/kg dry w in tilapia samples of Shobrakhite, Shabour, Edfina and Alqam, respectively. However, it closed to 86.07, 833.57, and 104.25 mg/kg dry w in catfish samples of Shobrakhite, Shabour and Alqam, respectively.


(a)
(b)
(c)
(d)
(e)
Summer
Winter
Shobrakhiet
Shabour
Edfina
Alqam

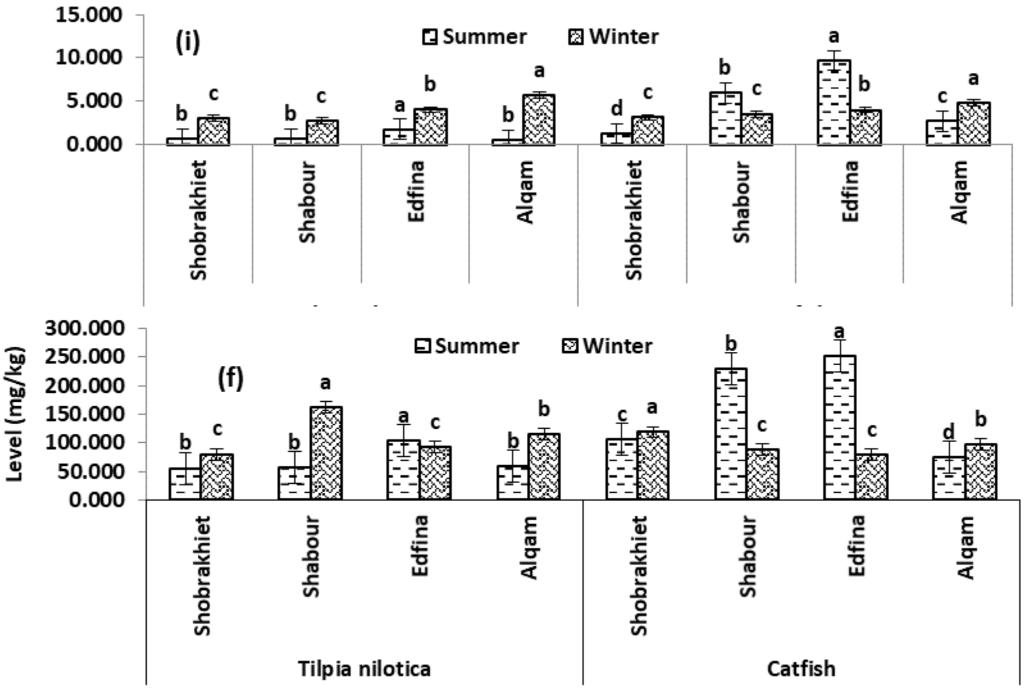
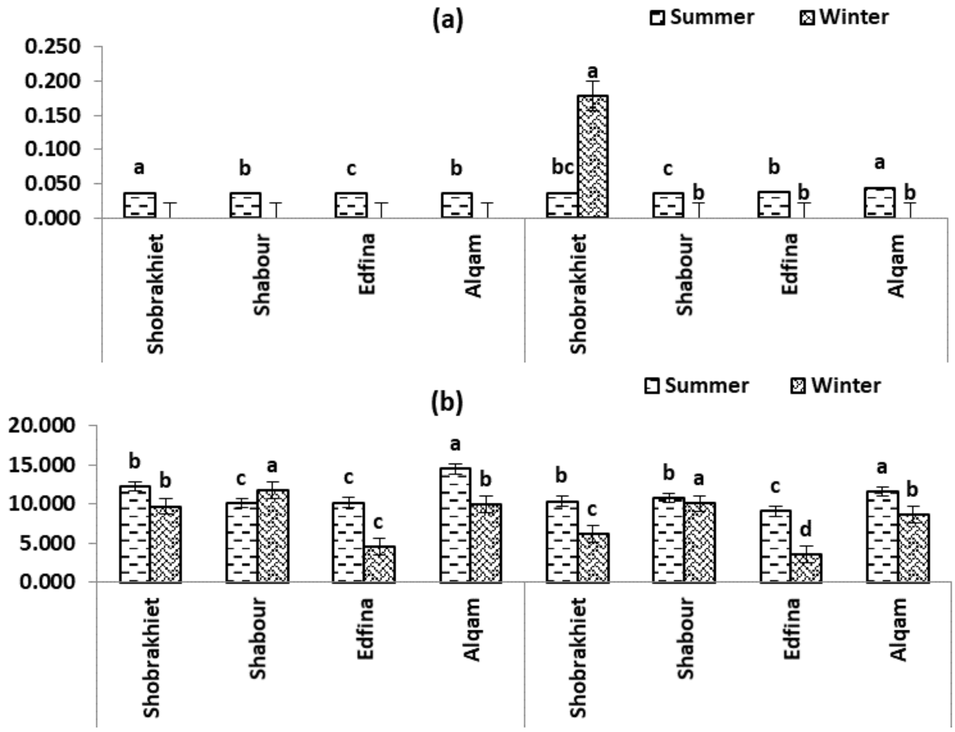
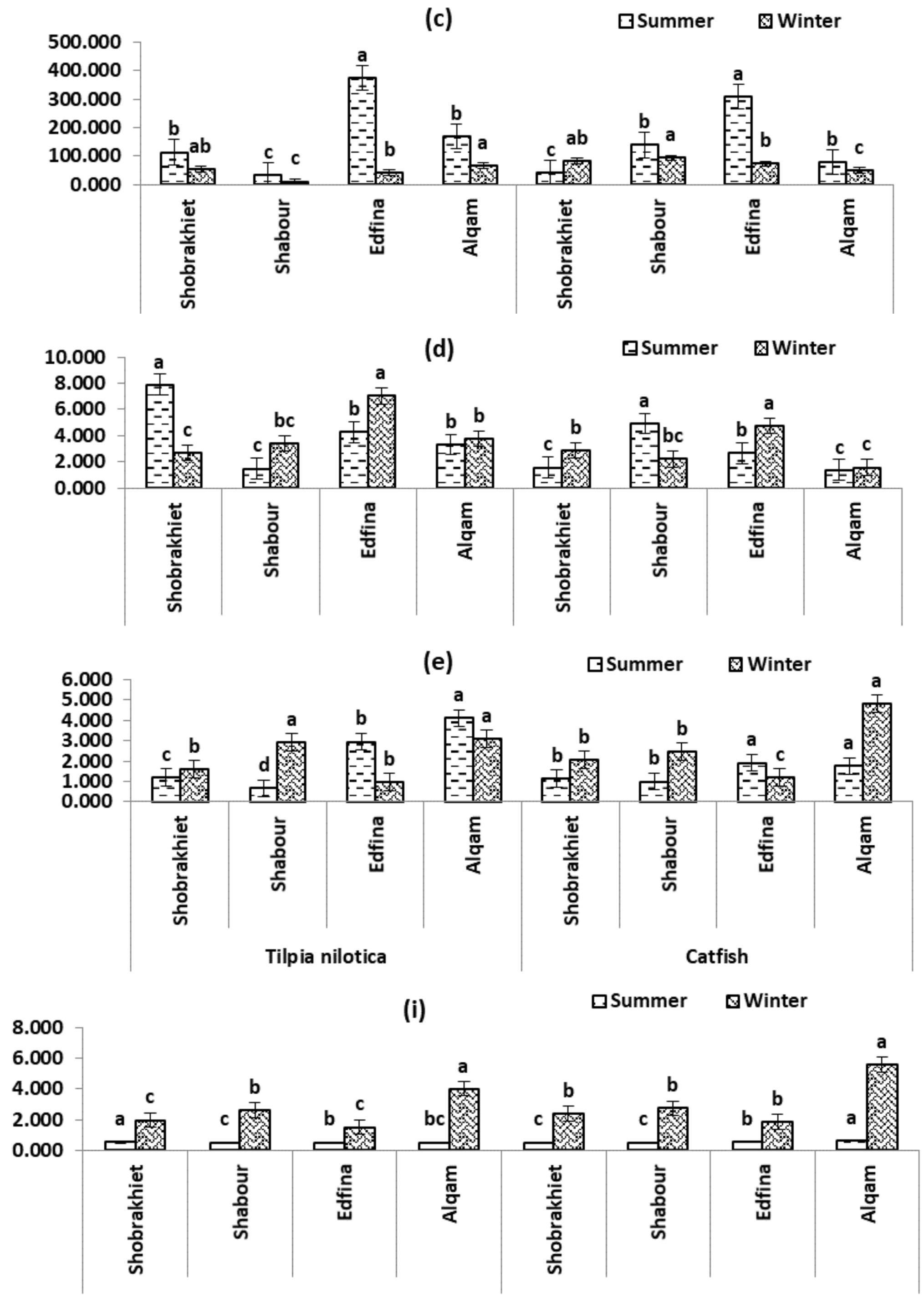


Figure 4: Levels of HMs (mg/kg dry w): (a) Cd, (b) Cu, (c) Fe, (d) Mn, (e) Ni, (i) Pb, and (f) Zn in liver samples of tilapia and catfish collected from Rosetta branch.




(c)
Summer
Winter
500.000
400.000
300.000
200.000
100.000
0.000
Shobrakhiet
Shabour
Edfina
Alqam
Shobrakhiet
Shabour
Edfina
Alqam
(d)
Summer
Winter
10.000
8.000
6.000
4.000
2.000
0.000
Shobrakhiet
Shabour
Edfina
Alqam
Shobrakhiet
Shabour
Edfina
Alqam
(e)
Summer
Winter
6.000
5.000
4.000
3.000
2.000
1.000
0.000
Shobrakhiet
Shabour
Edfina
Alqam
Shobrakhiet
Shabour
Edfina
Alqam
Tilpia nilotica
Catfish
(i)
Summer
Winter
8.000
6.000
4.000
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0.000
Shobrakhiet
Shabour
Edfina
Alqam
Shobrakhiet
Shabour
Edfina
Alqam

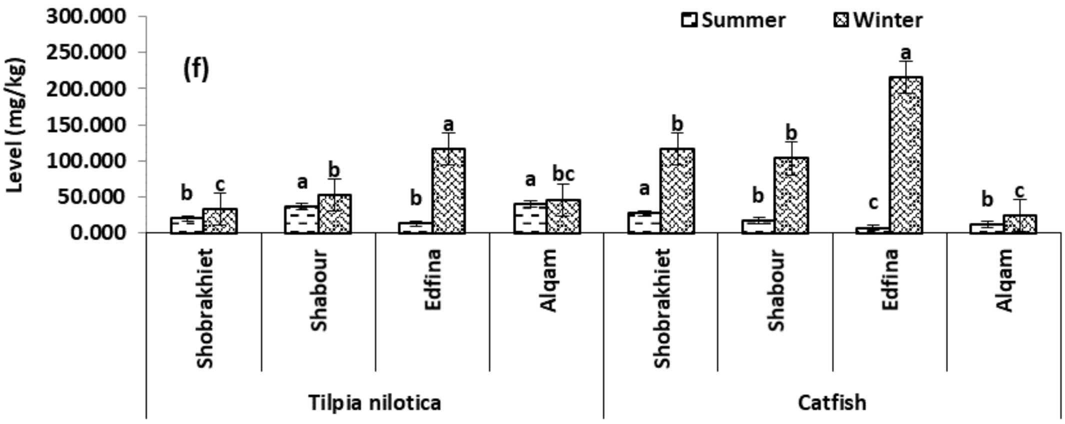


Figure 5: Levels of HMs (mg/kg dry w): (a) Cd, (b) Cu, (c) Fe, (d) Mn, (e) Ni, (i) Pb, and (f) Zn in muscle samples of tilapia and catfish collected from Rosetta branch.

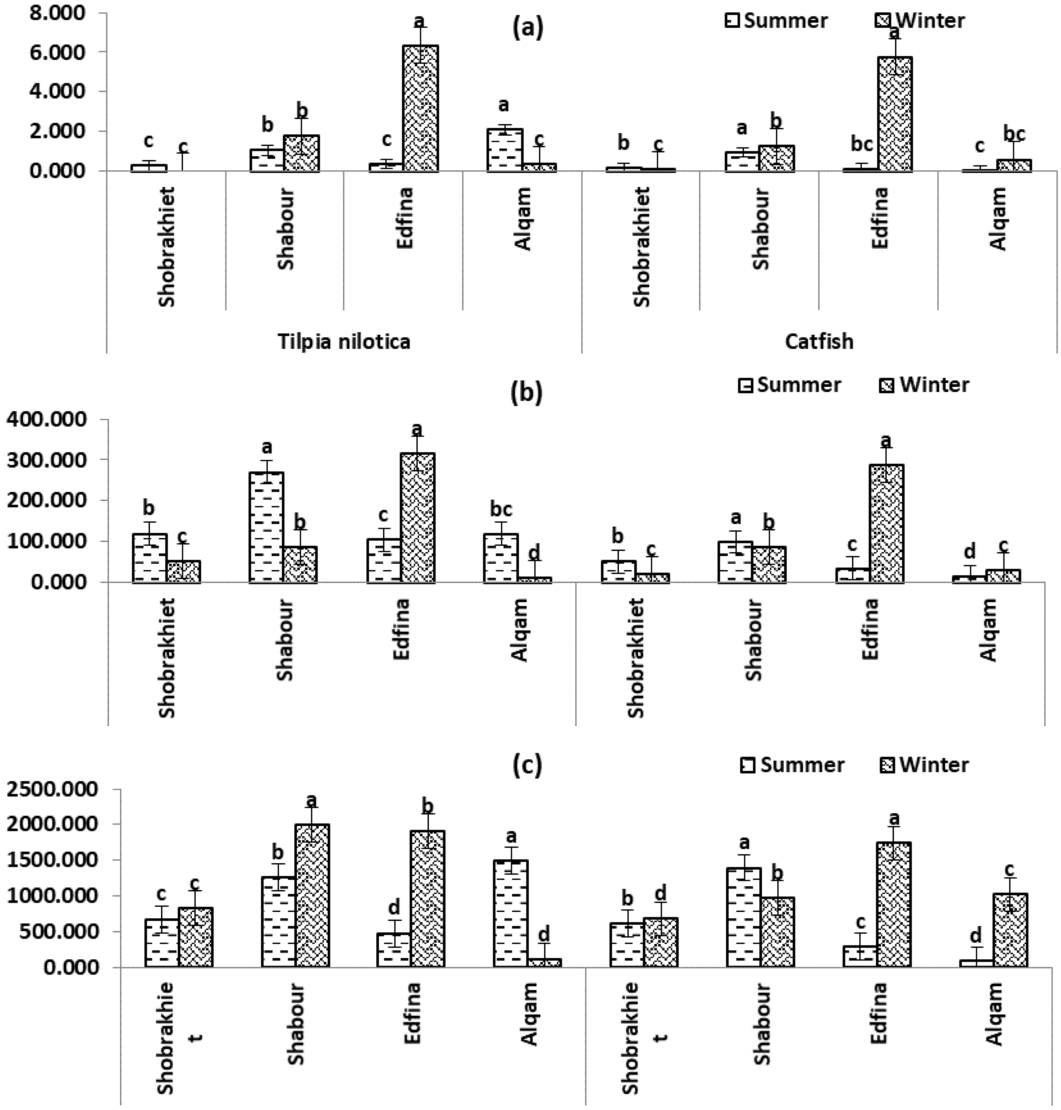
Muscles

During winter, no significant differences were obtained in mean values of Cd in tilapia samples (0.035-0.037 mg/kg dry w) (Figure 6a). During winter, all values were BDL, except samples of Alqam exhibited mean value (0.16 mg/kg dry w). In catfish, the detected levels ranged from 0.037 to 0.044 mg/kg dry w during summer, but the levels were BDL during winter, except samples of Shobrakhite which did not exceed 0.18 mg/kg dry w. In tilapia, Cu exhibited mean values: 12.18, 10.11, 10.18 and 14.45 mg/kg dry w in samples of Shobrakhite, Shabour, Edfina and Alqam, respectively, during summer (Figure 6b). During winter, it closed to the values: 9.66, 11.71, 4.49 and 9.89 mg/kg dry w for locations at the same manner. Regarding catfish, it closed to levels in ranges: 10.34-11.51 mg/kg dry w and 6.20-10.02 mg/kg dry w during summer and winter, respectively. Significant accumulation was obtained of Fe in tilapia samples (Figure 6c). It closed to values: 112.87, 32.73, 375.39, 168.36 mg/kg dry w and 53.67, 10.17, 41.82, 65.95 mg/kg dry w during summer and winter, respectively. In catfish, it closed to values ranged from 41.55 to 138.78 mg/kg dry w during summer and ranged from 49.67 to 92.98 mg/kg dry w during winter. Trace element (Mn) recognized to mean values: 7.86, 1.47, 4.26 and 3.30 mg/kg dry w in tilapia samples of Shobrakhite, Shabour, Edfina and Alqam, respectively, during summer (Figure 6d). During winter, it closed to mean values: 2.70, 3.39, 7.02 and 3.75 mg/kg dry w in the above locations at the same manner. Regarding catfish, it closed to values that ranged from 1.56 to 4.92 mg/kg dry w during summer and ranged from 1.56 to 2.85 mg/kg dry w during winter. In case of Ni, accumulation pattern recognized to low values in both fish (Figure 6e). In tilapia, it closed to 1.20, 0.66, 2.94 and 4.11 mg/kg dry w in Shobrakhite, Shabour, Edfina and Alqam, respectively, during summer. However, it closed to 1.59, 2.92, 0.96 and 3.09 mg/kg dry w during winter in locations at the same manner. Regarding catfish, it closed to values in ranges: 0.99-1.79 mg/kg dry w and 2.07-4.80 mg/kg dry w during summer and winter. Potential toxic metal (Pb) did not exceed 0.53 mg/kg dry w in tilapia samples collected during summer, but received to the highest value (3.99 mg/kg dry w) during winter in samples of Alqam (Figure 6i). In catfish, accumulation pattern during winter was greater than summer. During summer, it did not exceed 0.64 mg/kg dry w, while ranged from 2.37 to 5.58 mg/kg dry w during winter. Essential metal (Zn) in tilapia fish exhibited the mean values: 20.32, 37.05, 13.19, 40.29 mg/kg dry w and 33.39, 52.92, 117.09, 46.30 mg/kg dry w during summer and winter in Shobrakhite, Shabour, Edfina and Alqam, respectively (Figure 6f). Low accumulation pattern was obtained in catfish during summer (range; 12.41-27.33 mg/kg dry w) and increased to range (24.03-116.75 mg/kg dry w) during winter.

BCF

The output data of BCF associated with metals transfer from water to organs of both fish were recognized with significant differences during the study periods. In tilapia fish, regional mean values of Cd exhibited the order: kidney> liver> gills> muscles with values: 11.72, 1.92, 1.87 and 0.85, respectively (Table 3). The greatest BCF of Cu was noticed in kidney (4.40), followed by liver (0.403), and muscles (0.222). The least one (0.181) was noticed in gills. Accumulation factor of Fe exhibited the order: kidney> liver> gills> muscles with values: 2.49, 1.81, 1.20 and 0.21, respectively. Low BCF values were noticed for Mn, where it ranged from 0.04 to 0.54 in the above organs. Increased BCF values were noticed for Ni, where the greatest value (4.53) was noticed in kidney, followed by liver (2.89) and gills (0.96). The least one (0.57) was noticed in muscles. The same pattern was noticed for Pb with the greatest value (3.54) in kidney, followed by liver (2.99), but the least one (0.23) was noticed in muscles. Values of BCF for Zn were noticed for the greatest one (2.89) in kidney, followed by gills (0.81). The least one (0.079) was noticed in muscles.

Regarding catfish, BCF values were lower than tilapia in most metals (Table 4). The greatest BCF value of Cd (3.53) was noticed in liver, followed by (3.35) in kidney and gills (1.59). The least one was recorded in muscles (0.58). The greatest value of Cu was noticed in kidney (1.62), followed by liver (0.89) and gills (0.39), but the least one (0.26) was noticed in muscles. In contrast, the greatest value of Fe (2.16) was noticed in gills. Values of Mn did not exceed 0.196 in kidney, but the least one (0.086) was noticed in liver. The greatest value (3.26) of Ni was noticed in liver, followed by kidney (1.99), and gills (0.61). The least one (0.303) was noticed in muscles. No significant differences were obtained in BCF values of liver and kidney, where they exhibited 1.31 and 1.25. The least one (0.22) was noticed in muscles. Slight increase of BCF was noticed in kidney (1.24) for Zn. The least one (0.101) was noticed in muscles.



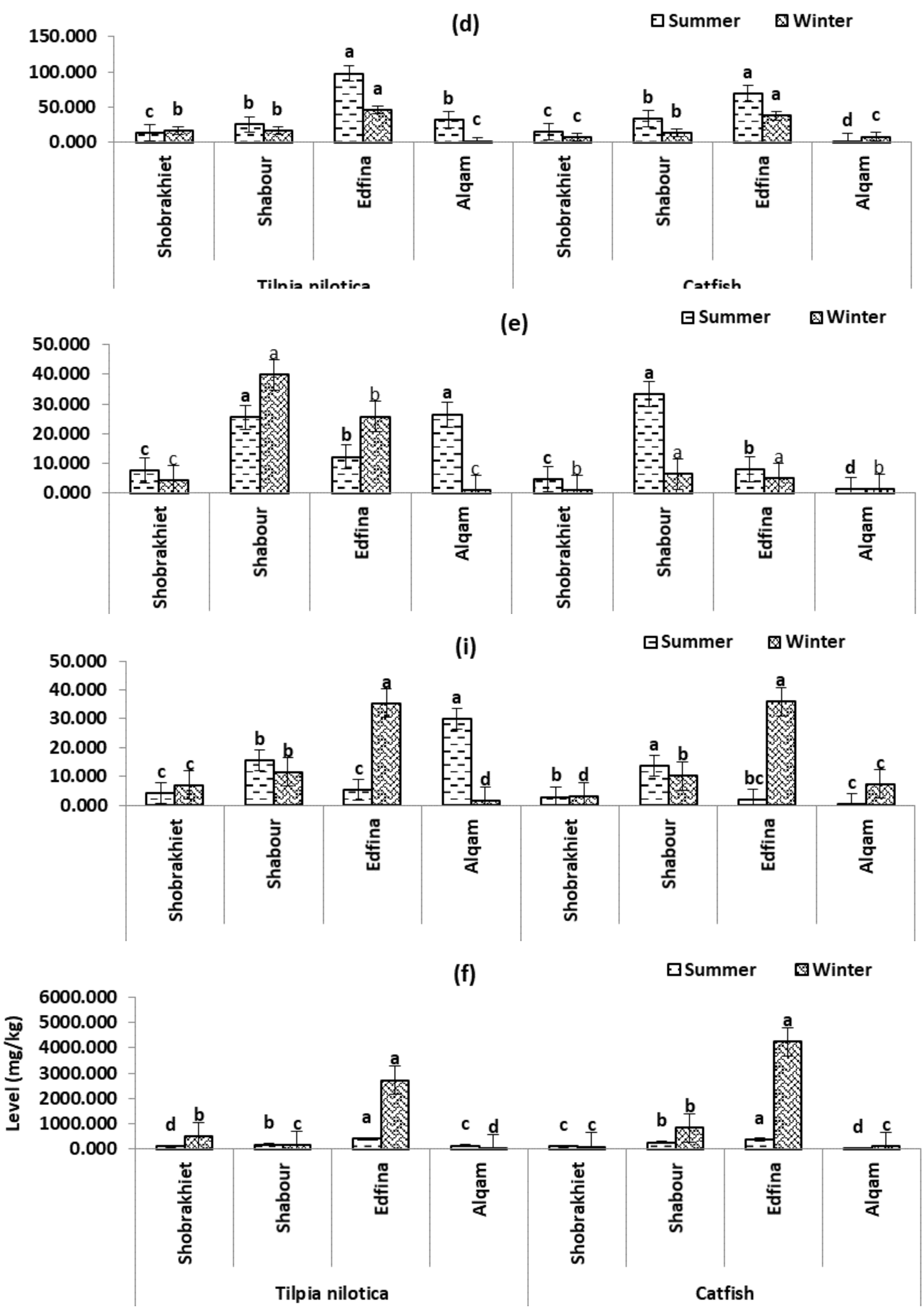


Figure 6: Levels of HMs (mg/kg dry w): (a) Cd, (b) Cu, (c) Fe, (d) Mn, (e) Ni, (i) Pb, and (f) Zn in kidney samples of tilapia and catfish collected from Rosetta branch.

Table 3
BCF mean values of HMs accumulated in tilapia fish tissues in association with water media of Rosetta branch, Nile river, Egypt.

Region/Organ	BCF						
	Cd	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Zn**
Gills							
Shoubrakhite	0.67	0.15	0.08	0.52	0.82	0.54	0.04
Shabour	2.19	0.26	0.28	0.28	0.66	0.28	0.12
Edfina	2.08	0.14	0.17	1.08	1.53	0.33	0.04
Alqam	2.52	0.18	0.31	0.27	0.81	0.27	0.12
Regional mean	**1.87**	**0.18**	**0.21**	**0.54**	**0.96**	**0.36**	**0.81**
Liver							
Shoubrakhite	0.57	0.22	0.08	0.13	1.21	1.75	0.04
Shabour	2.28	0.17	0.21	0.14	2.88	0.33	0.12
Edfina	2.84	0.79	2.96	0.38	6.09	8.41	0.12
Alqam	1.99	0.43	4.05	0.14	1.38	1.51	0.18
Regional mean	**1.92**	**0.41**	**1.81**	**0.19**	**2.89**	**2.99**	**0.12**
Muscles							
Shoubrakhite	0.22	0.15	0.13	0.059	0.25	0.21	0.03
Shabour	1.29	0.14	0.08	0.029	0.09	0.18	0.12
Edfina	0.56	0.27	0.36	0.036	1.58	0.21	0.04
Alqam	1.333	0.34	4.22	0.037	0.38	0.321	0.12
Regional mean	**0.85**	**0.22**	**1.19**	**0.041**	**0.57**	**0.23**	**0.08**
Kidney							
Shoubrakhite	1.58	0.62	0.52	0.17	2.22	1.47	0.27
Shabour	5.153	4.53	6.46	0.34	4.65	4.75	3.67
Edfina	35.96	5.02	2.98	0.51	8.19	6.29	0.45
Alqam	4.20	7.43	3.97	0.17	3.07	1.68	7.18
Regional mean	**11.72**	**4.41**	**2.49**	**0.29**	**4.53**	**3.54**	**2.89**

Table 4
BCF mean values of HMs accumulated in Catfish tissues in association with water media of Rosetta branch, Nile river, Egypt.

Region/Organ	BCF						
	Cd	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Zn**
Gills							
Shoubrakhite	0.47	0.02	0.06	0.23	0.69	0.15	0.03
Shabour	3.54	1.02	1.04	0.22	0.83	1.13	0.31
Alqam	0.76	0.13	0.45	0.12	0.29	0.24	0.12
Regional mean	**1.59**	**0.39**	**0.52**	**0.19**	**0.61**	**0.51**	**0.15**
Liver							
Shoubrakhite	1.34	0.07	0.03	0.05	4.91	0.31	0.33
Shabour	6.75	1.68	1.69	0.15	1.62	3.03	1.39
Alqam	2.49	0.92	0.84	0.06	3.24	0.59	0.66
Regional mean	**3.53**	**0.89**	**0.86**	**0.09**	**3.26**	**1.31**	**0.79**
Muscles							
Shoubrakhite	0.69	0.03	0.03	0.02	0.39	0.09	0.03
Shabour	0.62	0.31	0.37	0.06	0.33	0.31	0.12
Alqam	0.42	0.45	6.07	0.02	0.19	0.27	0.15
Regional mean	**0.58**	**0.26**	**2.16**	**0.03**	**0.31**	**0.22**	**0.10**
Kidney							
Shoubrakhite	0.96	0.31	0.18	0.13	1.91	0.62	0.18
Shabour	8.63	4.03	3.94	0.42	3.37	2.56	3.21
Alqam	0.45	0.52	1.67	0.04	0.71	0.58	0.34
Regional mean	**3.35**	**1.62**	**1.93**	**0.19**	**1.99**	**1.25**	**1.24**

Discussion

In the present study, concentrations of the measured HMs showed significant variations in locations of Rosetta branch of Nile River. The accumulated proportions in organs of tilapia and catfish recognized gradually BCF during summer and winter seasons. Fe exhibited the greatest proportions, followed by Zn and Mn. This concept may be associated with the industrial plans of these regions, especially brick making factories surrounding water resources in Shabour, Kafr El-Zayat and Shobrakhite. They considered main sources of HMs emitted into the environment. Also, the start materials used in this process is highly containing of Fe, Mn, as well as the fuel used is main source of Cd and Pb. As documented in the literature, industrial activities can introduce Cd and Pb to Nile River. Also, discharge of various treated and untreated liquid waste to the water can introduce large quantities of HMs in the Nile River [21]. In fact, accumulation patterns of HMs in fish depend on both uptake and elimination rates [22]. In the present study, uptake of liver and kidney was greater than muscles and gills. This finding is in accordance with that obtained by Eissa et al. (2013) [3] who described that tilapia and catfish have survived a colossal environmental crisis of Mariotteya a water body in 2009. Also, gills may be developed to defense mechanism such as excessive mucous secretion and clogging gills. Accumulation of HMs in samples of contaminated areas was in compatible with liver of tilapia obtained from industrial area of Shoubra El-Khema [23].

Cd and Pb are toxic at low concentrations, non-biodegradable and have no role in biological processes in living organisms. Thus, these concentrations could be harmful to fish. The present findings are in accordance with that obtained by Rashid (2001) [24] who stated that, greatest proportions of Pb in fish were in kidney and liver, followed by bone and muscles of tilapia from Nile River at Assiut region.

Fe is an abundant and important element. The increase of Fe accumulation in fish was greater than other metals, it may be attributed to total dissolved Fe in Nile water and by different organs [25]. Furthermore, the presence of the regional brick making and others such fertilizers and pesticides industries in Kafr El-Zayat district may be cause of elevation of Fe levels in water and fish tissues.

Zn was detected in all fish samples. Fish can accumulate Zn from both surrounding water and from their diet [26]. Although Zn is an essential element, at high concentration it can be toxic to fish, cause mortality, growth retardation, and reproductive impairment [27]. It is capable of interacting with other elements producing antagonistic, additive, or synergistic effect [26].

The presents findings deal variations in HMs accumulation in both fish. This concept depends on feeding habits [28], ecological needs, metabolism [29], age, size and length of the fish [30] and their habitats [31].

Conclusion

The present data show the positive accumulation pattern of HMs in organs of tilapia and catfish in collected samples from Rosetta branch of Nile River. Such these profiles may induce adverse effects in fish along physiological status and their susceptibility to disease's infection. Also, may provide alarming signs for fish consumers in these regions.

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Compliance with ethical standards
The experiments have been carried out in accordance with the European Ethical Guidelines (Directive 2010/63/EU, 2010).

Declaration of Conflicting of Interest
The authors declare that no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Supplementary data
No supplementary data are provided.

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