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COMPARATIVE STUDY ON HEAVY METALS CONTAMINATION OF THE THREE FISH SPECIES (*SOLEA AEGYPTIACA - TILAPIA ZILLII - MUGILL CEPHALUS*) ORGANS, WATER AND SEDIMENT FORM QARUN LAKE, EGYPT

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ABSTRACT

Comparisons of metal concentrations (Fe, Mn, Zn, Cu, Pb and Cd) in the livers, gills and muscle of three species (*Solea aegyptiaca , ilapia zillii* and *Mugill cephalus*) of fish species collected from Qarun Lake, Fayoum Governorate (Egypt) were collected during year 2005. Water from Lake Qarun, was found to contain lower levels of heavy metals. The highest concentration of metals was recorded in locations 2 and 4 near the mouth of main drains. The heavy metals showed differential bioaccumulation in fish organs (e.g. liver, gills and muscles), and the accumulation pattern (as total heavy metal residues) was varied seasonally as follows: summer > spring > winter > autumn. Moreover, the relative accumulation of total heavy metals in the studied fish showed the following pattern: *Solea aegyptiaca* < *Tilapia zillii* < *Mugill cephalus*. The metal levels found in muscle in the three species were below the permissible levels proposed by FAO (1983) for human consumption. Metals in the liver and gills were above the limit in the three species. All metals values in sediment sharply increase near the mouth of drains, while slightly increase in other locations.

Key words: Heavy metals, water, sediment, *Mugill cephalus, Tilapia zillii, Solea sp.*

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INTRODUCTION

Fish are a major part of the human diet and it is therefore not surprising that numerous studies have been carried out on metal pollution in different species of edible fish (Kucuksezgin *et al.*, 2001). Much has also been written about metal levels as a whole in fish, water and sediment in particular areas (Guhathakurta and Kaviraj, 2000; Topc_ uoglu *et al.*, 2002 & Karadede and U¨nlu¨, 2000).

The presence of metals in the environment is partially due to natural processes, such as volcanic activity and erosion, but is mostly the result of industrial wastes (PNUE, 1984). Contamination of aquatic ecosystems (e.g. lakes, rivers, streams, etc.) with metals has been receiving increased worldwide attention, (Bhattacharya & Sarkar, 1998 & Prat, *et. al.*, 1999). Fish are often at the top of the aquatic food chain and may concentrate large amounts of some metals from the water. Accumulation patterns of contaminants in fish depend both on uptake and elimination rates (Hakanson, 1984). The presence of heavy metals in different food items constitutes can cause serious health hazards, depending on their relative levels.

Studies in Egypt, conducted on fish samples collected from six Governorates, not including Fayoum, indicated the presence of some metals (e.g. lead, cadmium, chromium, zinc, copper, manganese and iron) in different fish organs (Gomaa, *et. al.*, 1995). Imported sardine and mackerel fish were found to contain levels of lead and chromium higher than the permissible limits proposed by FAO (1983), whereas concentrations of other metals, such as cadmium, copper, iron, manganese and zinc were found below the permissible limits (Abou-Arab, *et. al.*, 1996). Lake Qarun, is the main fishery resource in Fayoum Governorate (Egypt). The lake is used as a general reservoir for agricultural wastewater and drainage for fish farms. Taking into consideration that the lake is a closed basin, the accumulation of chemical pollutants is expected to increase annually in all its components (water, sediment and fish). Except for a limited study, which dealt with heavy metals in fish from the lake (Ibrahim, 1996), no further information is yet available. The present study was carried out undertaken to fill some existing gaps, such as: types and quantities of some heavy metals contaminating water, soil and fish in different locations of lake, distribution of heavy metals in different fish tissues organs (livers, gills and muscles) and seasonal variation of metals in the water, soil and fish.

This study aimed to analyze and compare different metal concentrations in water, sediment and three fish species from Qarun Lake. It is therefore safe to say that the fish have spent most of their lives in this environment and have not received food from outside or any other type of external influence. The metal content in the dorsal muscle was analyzed in each species because of its importance for human consumption, and the liver was also analyzed since this organ tends to accumulate metals (Marcovecchio, *et al.*, 1991). It is also a good indicator of chronic exposure to heavy metals because it is the site of metal metabolism (Miller *et al.*, 1992).

MATERIALS AND METHODS

Qarun Lake, located about 80 kilometers southwest of Cairo in Fayoum Government not far from the Nile Valley, is one of Egypt's most treasured natural landmarks and a resource that has helped support human culture for some 8,000 years. It is the only natural contemporary lake of any size in Middle Egypt. It is therefore rich in both natural and archaeological resources.

It receives its water budget from two sources, ground water and agriculture, sewage drainage water. The drainage water flows to the lake via ten drains (Fig. 1) namely; El-Batss, El-Wady, Bahr Yosuf, El-Bosser, Abo-Herawa, Abou-Tarfaya drains and other many small drains. The Qarun Lake today, 45 meters below sea level, has a surface area of 214 square kilometers.

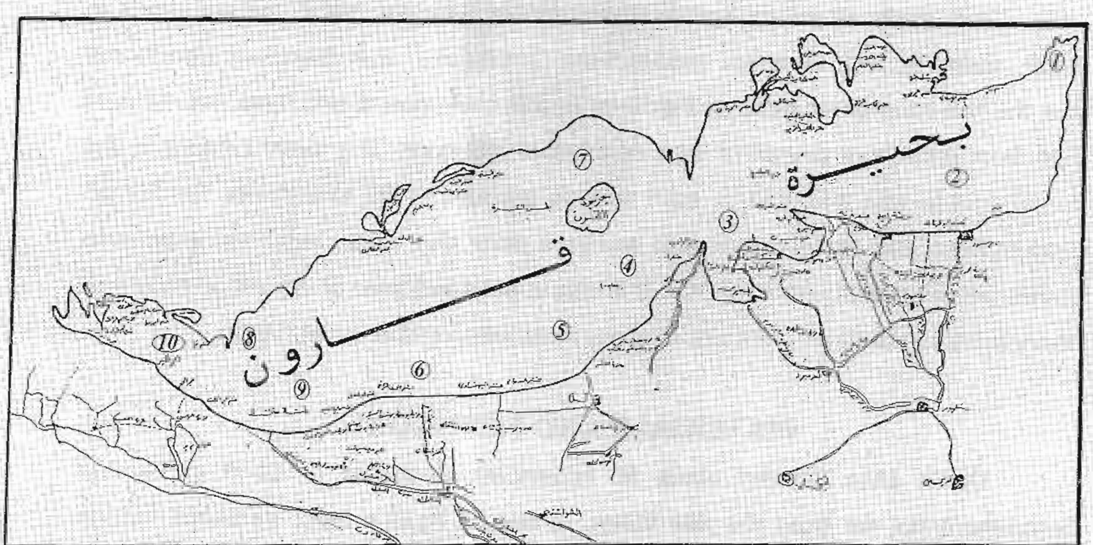

Fig. 1. Map of Qarun Lake

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The lake is differentiated into three different habitats or regions (Eastern, Middle and western). Each region has to some extent a distinctive character in terms of water quality and fish species distribution. The quality of water in the basins is affected by the location of the drains discharging into the lake and the direction of the prevailing wind. The different regions were subdivided into 10 selected stations, representing the different habitats of the lake (Fig. 1).

Field trips to the studied area were carried out monthly during the year 2005 for measuring heavy metals concentration in water, sediment and fish organs (liver, gills and muscles).

Sediment analyses

Surface sediment samples from each station (10) of the lake were collected in each season using core sampler as described in (Boyd and Tucker, 1992) and kept in cleaned plastic bags. The samples were dried at 105 °C, grinded, sieved and the most fine grains were digested with a mixture of H_2O_2 and 2N HC1 till evaporation, then with concentrated HC1 and HNO_3. The samples were dissolved in 6 N HC1 and filtered then kept in 2 N HCI after filtration prior to elemental measurements according to the method of Nelson and Sommers (1982).

Fish Samples

Fish samples *(Solea aegyptiaca – Tilapia zillii - Mugill cephalus*) were collected from fishermen during the four seasons.

The different organs (Liver, gill and muscle) were collected separately from (about 20 fish in each season) of each species and dried in an oven at 105 °C for 24 hour to constant weight, then one piece of 5 gm (dry wt.) from each organ were ashed at 550 °C in a muffle furnace. After cooling, the samples were digested with concentrated HNO_3. Finally, the ash was dissolved by 1N HCl before analysis (AOAC, 1998). All metals were analyzed by an air-acetylene Atomic Absorption Spectrophotometer (Thrmo 2000) using graphite furnace.

Statistical analysis

One-way ANOVA was used to evaluate the significant difference of the concentration of different items studied with respect to sites and seasons. A probability at level of 0.05 or less was considered significant. Standard errors were also estimated. All statistics were run on the computer, using the SAS programme (SAS, 2000).

RESULTS AND DISCUSSIONS

The data presented in table (1) and Fig. (2 and 3) show the heavy metals concentrations in water at the different locations in Qarun Lake indicated that Locations 2 and 4 had the higher concentration level of all metals; but locations 6 and 9 had lower values than other locations. The highest concentration of metals in locations 2 and 4 may be due to the highest discharge of drainage and sewage wastewater from El- Bats and El-wady drain into these sits. The higher concentration of Fe than the others metals is related to the richness of drainage water with organic matter which chelates is metal. The same observation was recorded in Borulls Lake, which receive huge amounts of drainage water (Mousa, 2004).

Fish are often at the top of the aquatic food chain whish accumulate large amounts of some metals, such as lead, cadmium, chromium, copper, mercury, zinc and iron in their tissues. These metals accumulate differentially in fish organs and cause serious health hazards to humans. For this reason, the problem of fish contamination by toxic metals has received many investigations (e.g. Abou- Arab *et al.*, 1996; Barak & Mason, 1990; Gomaa *et al.*, 1995; Hernandez *et al.*, 1990 & Ibrahim, 1996).

The present study provides data about fish from Qarun Lake, Fayoum Governorate (Egypt) which is contaminated by a number of heavy metals. The concentrations of the metals analyzed in the livers and muscle of the three fish species are given in tables (2 to 7) and Fig. (5–7) from each of the four seasons. Among the four seasons, in liver of *Mugill cephalus* during four seasons (Summer, Autumn, Winter, Spring) Fe (1785.9, 266.3, 1022.9, 868.6 mg/kg), Cu (78.27, 33.71, 80.04, 65.11mg/kg), Zn (148.09, 55.71, 140.02, 128.1mg/kg), Mn (32.61, 14.73, 29.11, 27.07 mg/kg), Pb (3.16, 1.46, 3.21, 2.91 mg/kg), and Cd (3.36, 1.25, 3.42, 2.64 mg/kg). The metal concentrations in the liver of the three fish species caught in the Qarun Lake are comparable with those of other studies carried out in polluted areas. For example, the liver of the four species of fish from Manzala Lake, especially in area of the El-Kabouty Port polluted by effluents from many drains (Hadous, Ramsis and sewage wastewater from Baher El-Bakar drain) Mousa and Shaker, 2008. Also in fish caught off the coast of the United Arab Emirates (UAE) in the Arabian Gulf, an area polluted by hydrocarbons and heavy metals. The levels of Zn (34–70 mg/kg) and Cd (0.51–0.63 mg/kg) were similar to those in the present study and with those found (Al-Yousuf *et al.,* 2000). In a study carried out in fish from the Qarun Lake polluted by mining activities drains. Fe concentrations were similar to those of the Qarun Lake found in the livers of grey mullets from the Manzala Lake (Mousa and Shaker, 2008), an area polluted by industrial, sewage wastewater, and drainage water.

On the other hand, the metal levels in livers of the fish species from the Qarun Lake are lower than those in fish from Manzala Lake (Mousa and Shaker, 2008).

In this study the heavy metals concentration in muscle were considerably lower than those found in the livers, as shown in tables 2 to7 and Fig. (5-7), which shows the enrichment, factors in livers. These factors were calculated for each metal as the ratio of liver-to-muscle concentration. The accumulation of metals in the liver could be due to the greater tendency of the elements to react with the oxygen carboxylate, amino group, nitrogen and/or sulphur of the mercapto group in the metal-lothionein protein, whose concentration is highest in the liver (Al-Yousuf *et al.*, 2000). The accumulation of Cu can be explained by its relation to low-molecular weight proteins (metallothionein-like), which are concentrated in hepatic tissue (Hamza-Chaffai *et al.,* 1996; Ayas and Kolankaya, 1996). For most of the metals analyzed, maximum enrichment factors were found in fish species during summer.

Similarly to what we have said in relation to the livers, the mean metal concentrations in muscle from fish Manzala Lake were higher than those found in fish from the Qarun Lake. In order of significance, the Fe concentrations were followed by Zn, Cu, Mn, Pb and Cd.

The heavy metals concentrations obtained in this study ranged with the permissible limit according to Thompson (1990). A comparison of the metal concentrations in the three species analyzed (see Fig. 5-7) revealed that the highest mean concentrations of Fe, Mn, Zn, Cu, Pb and Cd, in *Mugil sp.*, muscle, while presented the lowest **mean** levels of these metals in *Solia vulgaris*. On the contrary, *Mugil sp.*, showed the largest number of maximum values heavy metals followed by the *Tilapia zillii* and then *Solia vulgaris*. *Mugil sp.* had higher concentrations of the measured metals compared to the other species.

Generally, the results of heavy metal analyses in fish indicate that *Mugil sp.*, from the lake had the tendency to accumulate higher levels of metals than *Tilapia zillii*. Studies indicate that fish accumulate metals from the water, and the accumulation pattern depends on both uptake and elimination rates (Hakanson, 1984). Moreover, tables (2 to 7) demonstrate the seasonal variation of heavy metals in the three organs of the three fish species from Qarun Lake. The maximum concentrations of metals, Fe, Mn, Zn and Cu were obtained from summer in the three fish species. The lowest concentrations of metals were observed in samples of the autumn. The seasonal variation of heavy metals (as total values), based on the present data revealed the following sequence: summer > spring > winter > autumn.

Tables (2–7) provide information about the distribution of heavy metals among different parts of the fish body (e.g. liver, gills and muscles). The present findings agree with previous investigation of Barak & Mason, (1990); Gomaa *et al.*, (1995); Hernandez *et al.,* (1990); Ibrahim, (1996), who concluded that heavy metals accumulate differentially in fish organs.

In Egypt, as in other parts of the world, fish are liable to be contaminated by pollutants such as pesticides and heavy metals. Contamination levels can be compared to the permissible limits recommended by Food and Agriculture Organization (FAO, 1983). Accordingly, the mean concentrations of heavy metals in muscles for the different studied fish species were within the permissible limits of FAO (1983).

Our results agree with Ibrahim (1996) who found that "Mousa" (*Solea sp.*) from Lake Qarun had heavy metals levels were below the permissible limits. The author mentioned that lead in this fish, as well as, cadmium and lead in (*Tilapia zillii*) and (*Mugil sp.*) from the lake, were detected at concentrations below the permissible limits. Ibrahim (1996) and Mansour and Sidky, 2002 based their results on samples of winter and summer only, from Lake Qarun whereas the present results were based on samples, representing different seasons, over the year.

In their studies on heavy metals in fish imported to Egypt, Abou-Arab *et al.* (1996) found that sardine and mackerel had higher levels of lead and chromium than the permissible limits proposed by FAO. However, other metals (e.g. cadmium, copper, iron, manganese and zinc) were found at levels lower than the proposed permissible limits.

The fish farms in Fayoum Governorate are draining into the lake, which is a closed ecosystem. This in turn may be considered as one of the factors contributing in contamination of Lake Qarun, besides contamination from agricultural drainage water.

Spanish legislation establishes maximum levels for four of the metals studied, above which human consumption is not permitted: 1 mg/kg for Cd, 20 mg/kg for Cu, 1 mg/kg for Hg and 2 mg/kg for Pb (all expressed in wet body mass) (BOE, 1991). The present study results showed that the concentrations of these metals in muscle in the three studied species were in all cases considerably lower than the maximum levels set by law and, therefore, the muscle of all the fish analyzed was fit for human consumption in Egypt.

The metal with the concentration closest to the legal limit was Fe which only reached levels more than the guideline, and the furthest was Cd with concentrations over 10 times below the guideline.

There is also legislation in other countries regulating the maximum concentrations of other metals. For example, the Western Australian Food and Drug Regulations limitation levels for Zn at 40 mg/kg (Tayel, 1995). According to the UK Food Standards Committee Report, Zn levels in food should not exceed 50 mg/kg (Cronin *et al.,* 1998). These limits were not exceeded in the muscle of any of the fish analyzed in this study. The highest concentrations found for these elements in muscle were two times lower than the legislated level for Zn, Cu and Mn and many more times for Pb and Cd. We can therefore conclude that these metals present no problem for the consumption of muscle of these fish.

In the liver and gills, all metals levels were above the Spanish legal limits. In relation to the other legislation mentioned above, the Fe, Mn, Zn and Cu limit were exceeded, where the concentration was much above the maximum UK limit. However, fish livers are very seldom consumed except in restricted areas where the daily intake is fortunately low (Hamza-Chaffai *et al.*, 1996).

Sediment quality is a good indicator of pollution in water column, where it tends to concentrate the heavy metals and other organic pollutant. The highest levels of heavy metals concentrations were detected at stations 2 and 4 (Fig. 2). This is in coincidence with Zyadah (1997) and Mousa, (2004) who attributed the increasing levels of all residual elements in Manzala Lake and Borulls lake sediment in the southern basin of the lake, in area highly affected by drain water discharge. They added that, for most metals, values tend to decrease gradually further away from the drains. Carbonell *et al.* (1998) conclude that metal concentrations in sediments depend primarily upon the nature of the input sources and the distance from anthropogenic influences.

CONCLUSIONS

The heavy metals concentration in water increased near the mouth of the drains especially El-Bats and El-Wady. The sediment from Qarun Lake showed greater concentrations of all metals studied than those from water and fish; undoubtedly because the soil is a big store for heavy metals affected by contamination from agriculture drains. The metal content in fish livers and gills were considerably higher than in muscle.

A comparison of the species analyzed showed that the *Mugil sp.* is the fish that accumulates the most metal in the liver and gills, on the contrary, the least in muscle. It had the highest levels of metals in muscle, with average maximum concentrations of Fe, Mn, Zn, Cu, Pb and Cd. From the legal standpoint, the muscle of all the fish caught was suitable for human consumption. Among the species studied, the *Solia sp.* is the most suitable for use as a bioindicator for pollution, particularly its liver. We found the largest significant correlations was given between the metal content in the liver of common sole and the water content, and between the contents in liver and sediment.

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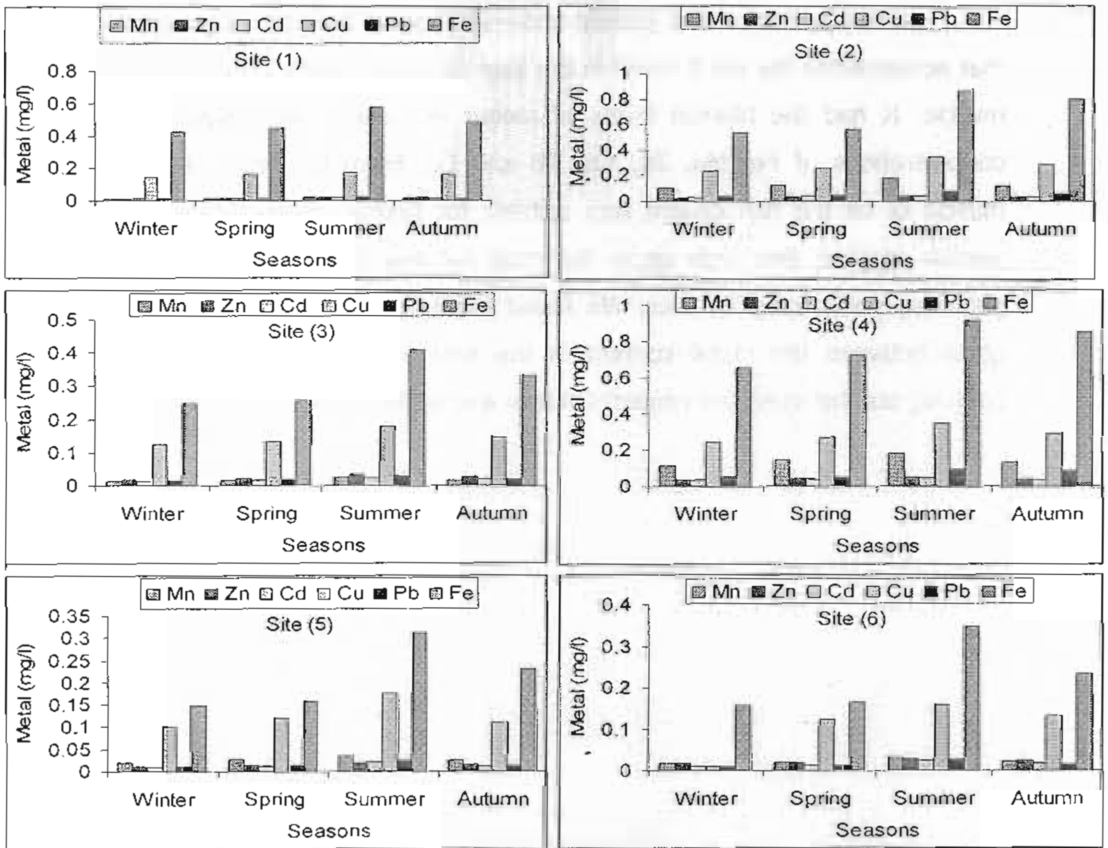

Fig. 2. Seasonal average of heavy metals concentration (mg/l) in water samples Collected from stations "1 to 6" for Qarun Lake during the experimental period.

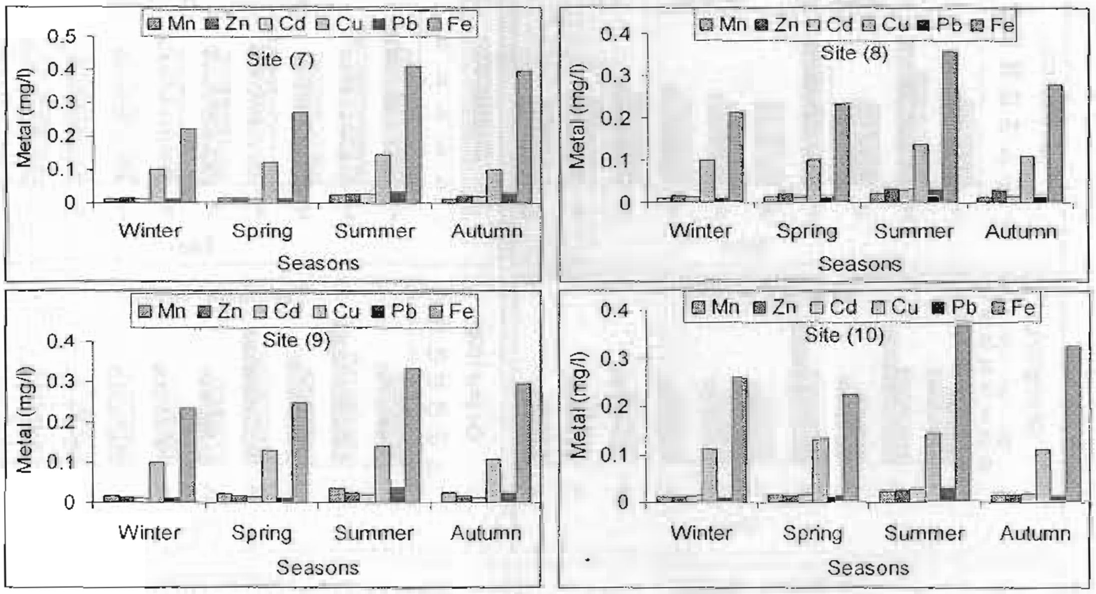

Fig.3. Seasonal average of heavy metals concentration (mg/l) in water samples Collected from stations "7 to 10" for Qarun Lake during the experimental period.

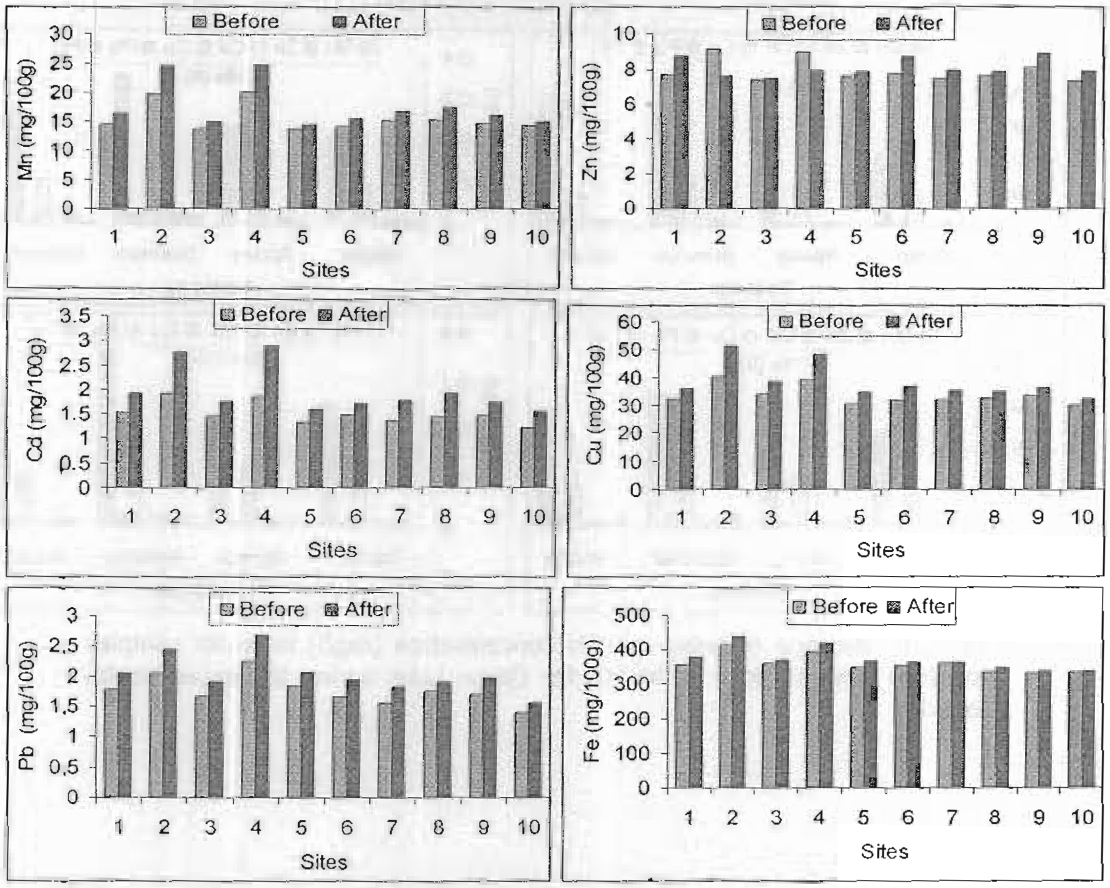

Fig. 4. Some heavy metals concentrations (mg/100 g) in soil surface layer before and after the period study in different stations.

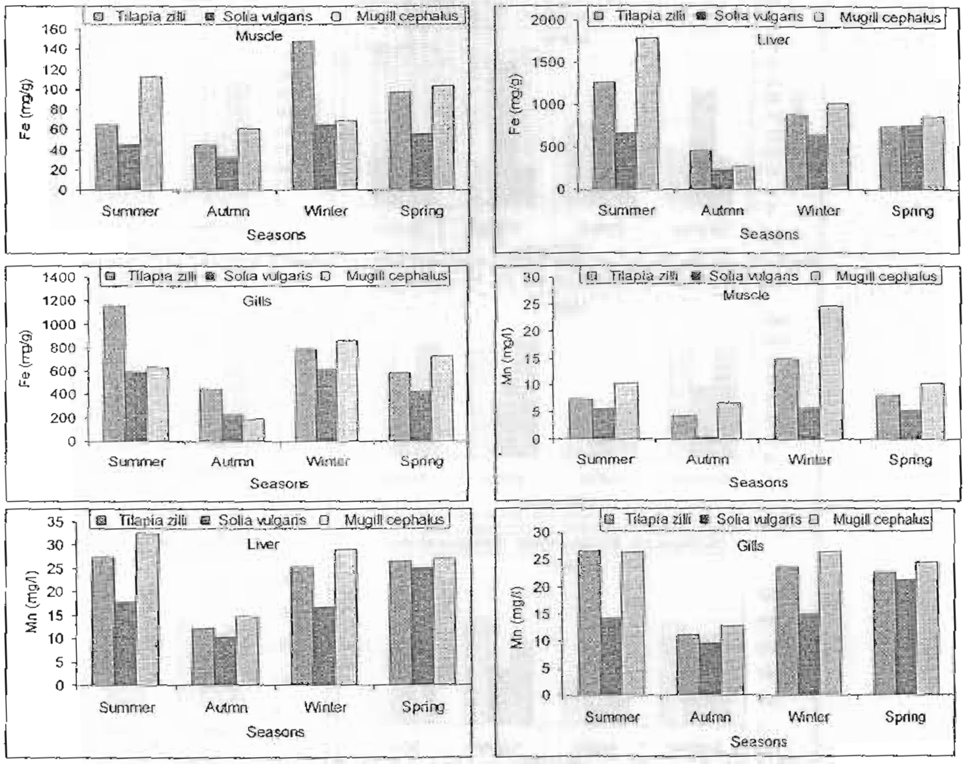

Fig. 5. Seasonality fluctuation of Fe and Mn values (µg/g dry wt) in different tissues of different fish species inhabiting Qarun Lake.

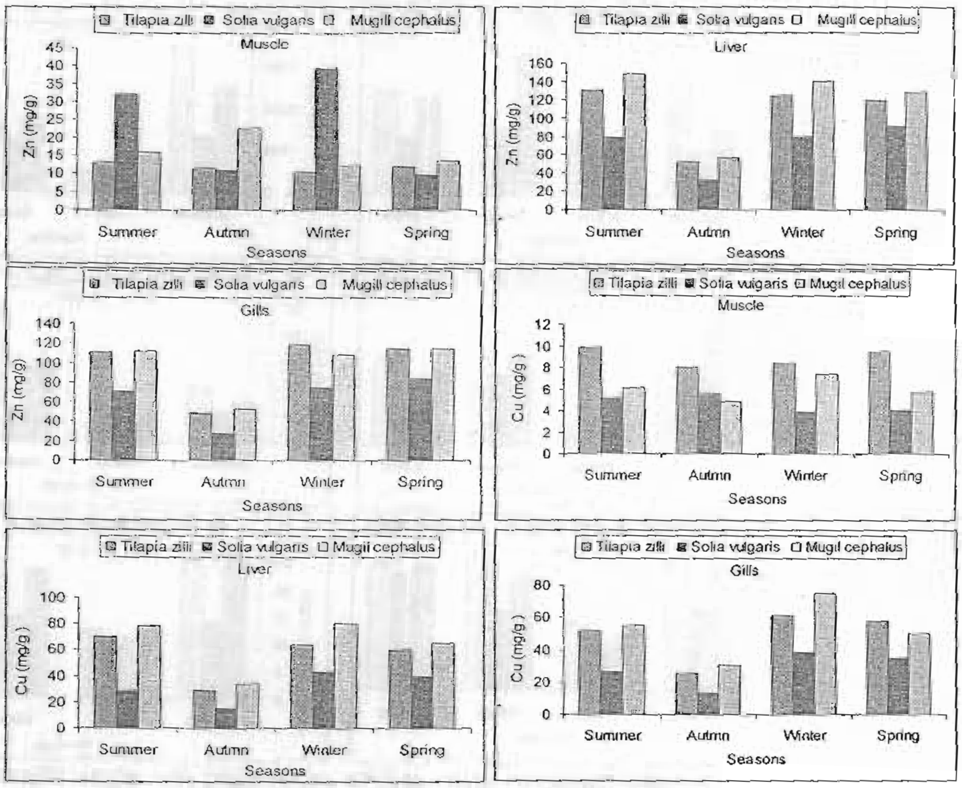

Fig. 6. Seasonality fluctuation of Zn and Cu values (μg/g dry wt) in different tissues of different fish species inhabiting Qarun Lake.

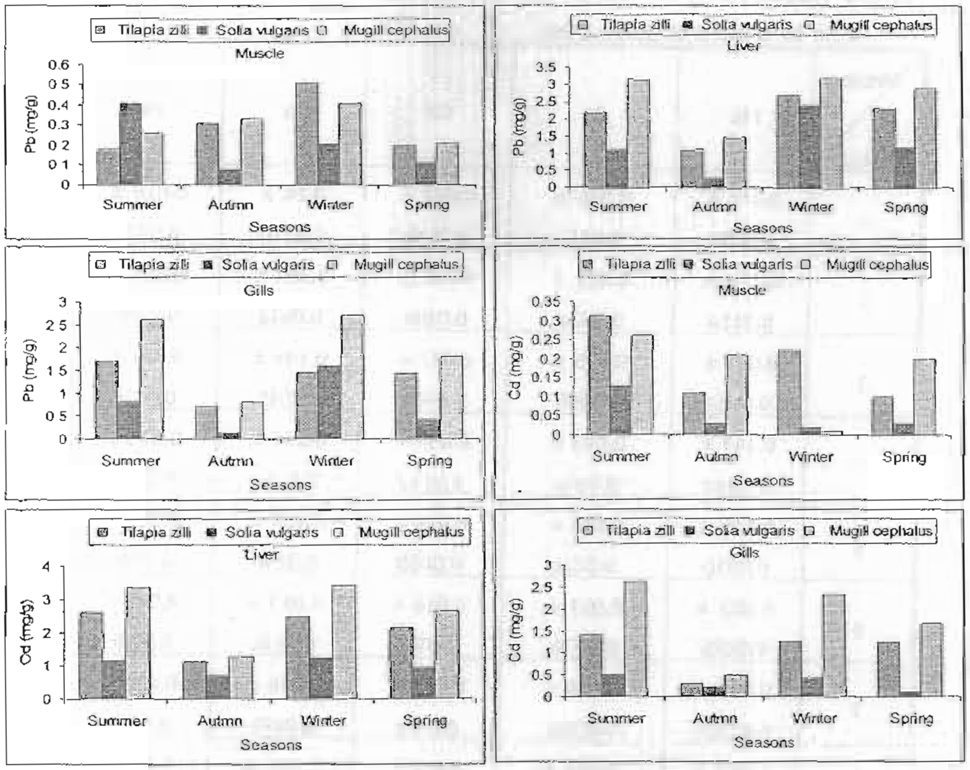

Fig. 7. Seasonality fluctuation of Pb and Cd values (μg/g dry wt) in different tissues of different fish species inhabiting Qarun Lake.

Table 1. Annual average of heavy metals concentration (mg/l) in water samples collected from 10 stations of Qarun Lake

Metals / Locations	Mn	Zn	Cd	Cu	Pb	Fe
1	0.014 ± 0.004c	0.016 ± 0.001c	0.012 ± 0.011b	0.16 ± 0.011b	0.014 ± 0.002c	0.481 ± 0.031b
2	0.132 ± 0.011a	0.031 ± 0.042a	0.036 ± 0.020a	0.282 ± 0.051a	0.055 ± 0.034b	0.694 ± 0.004a
3	0.017 ± 0.005c	0.025 ± 0.004b	0.017 ± 0.040b	0.145 ± 0.001b	0.021 ± 0.011c	0.312 ± 0.002b
4	0.143 ± 0.003a	0.043 ± 0.002a	0.038 ± 0.021a	0.290 ± 0.011a	0.074 ± 0.004a	0.788 ± 0.021a
5	0.026 ± 0.001b	0.016 ± 0.022c	0.014 ± 0.003b	0.102 ± 0.024b	0.015 ± 0.004c	0.211 ± 0.015c
6	0.022 ± 0.003b	0.021 ± 0.042b	0.016 ± 0.002b	0.013 ± 0.011c	0.015 ± 0.002c	0.225 ± 0.002c
7	0.016 ± 0.011bc	0.019 ± 0.014bc	0.018 ± 0.001b	0.116 ± 0.002b	0.021 ± 0.004c	0.325 ± 0.014b
8	0.014 ± 0.012c	0.025 ± 0.001b	0.017 ± 0.011b	0.122 ± 0.001b	0.017 ± 0.021c	0.271 ± 0.014c
9	0.025 ± 0.015b	0.017 ± 0.026c	0.014 ± 0.005b	0.012 ± 0.034c	0.021 ± 0.014c	0.277 ± 0.012c
10	0.016 ± 0.002bc	0.016 ± 0.005c	0.018 ± 0.001b	0.123 ± 0.011b	0.015 ± 0.004c	0.294 ± 0.021c

Letters a, b and c show differences among locations. Data shown with different letters are statistically significant at the $p < 0.05$ level.

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Table 2, Seasonal mean ± SE and annual average of iron (Fe) concentrations (mg/g dry wt) in different tissues of different fish species inhabiting Qarun Lake.

Fish sp.	Tissue	Summer	Autumn	Winter	Spring
Mugill cephalus	Liver	1785.9 ± 142.6 aw	266.3± 6.1 dx	1022.9± 8.4 bw	868.6 ± 16.4 cw
	Gill	932.5 ± 52.6 ax	188.05 ± 11.4 bx	856.5 ± 13.7 ax	724.22 ± 88.12 aw
	Muscle	112.2 ± 3.88 az	61.1 ± 20.6 by	68.8 ± 2.2bz	103.3± 3.2ay
	Average	**943.51**	**171.82**	**646.40**	**565.36**
Tilapia zillii	Liver	1266.6 ± 112.4 ax	456.3 ± 6.7 cw	886.9 ± 11.7 bx	742.3 ± 78.8 bw
	Gill	1156.3 ± 114.2 ax	444.5 ± 19.9 sw	786.3 ± 22.2 bx	588.4 ± 65.2 cw
	Muscle	64.7 ± 2.6 cz	45.2± 1.1 cy	148.6 ± 16.2 az	96.7± 9.1 by
	Average	**829.21**	**315.30**	**607.29**	**475.80**
Solla vulgaris	Liver	668.3 ± 13.2 a	236. 5.1 bx	646.3 ± 7.2 ax	762.2 ± 8.4 aw
	Gill	596.9 ± 7.7 ay	224.3 ± 6.3 cx	612.3 ± 8.5 ax	423.2 ± 7.9 bx
	Muscle	45.6± 1.3 bz	32.4 ± 1.6 cy	65.2 ± 4.7 az	56.6 ± 4.0 az
	Average	**436.95**	**164.31**	**441.26**	**384.01**

Means with the same litter are not significantly a, b, c litter's present difference among season in the same fish, w, x, z litters present difference among different fish in the same season. Data shown with different letters are statistically significant at the $p < 0.05$ level

Table 3. Seasonal mean ± SE and annual average of manganese (Mn) concentrations (mg/g dry wt) in different tissues of different fish species inhabiting Qarun Lake.

Fish sp.	Tissue	Summer	Autumn	Winter	Spring
Mugill cephalus	Liver	32.61 ± 0.22 aw	14.73 ± 0.32 bw	29.11 ± 0.22 aw	27.07 ± 0.11 aw
	Gill	26.40 ± 1.56 aw	12.85 ± 0.74 w	26.41 ± 0.41 aw	24.51 ± 0.42 aw
	Muscle	10.32 ± 0.74 bx	6.72 ± 0.92 cx	24.64 ± 0.99 aw	10.41 ± 0.21 bx
	Average	**23.11**	**11.43**	**26.72**	**20.70**
Tilapia zillii	Liver	27.41 ± 0.23 aw	12.35 ± 0.14 bw	25.46 ± 1.65 aw	26.71 ± 1.01 aw
	Gill	26.71 ± 0.61 aw	11.12 ± 0.13 bw	23.71 ± 1.71 aw	22.71 ± 0.81 aw
	Muscle	7.52 ± 0.54 by	4.39 ± 0.24 bx	14.95 ± 0.52 ax	8.19 ± 0.71 bx
	Average	**20.55**	**9.29**	**21.37**	**19.20**
Solia vulgaris	Liver	17.82 ± 1.32 bx	10.42 ± 0.24 bw	16.85 ± 1.04 bx	25.12 ± 1.12 bx
	Gill	14.24 ± 2.50 bx	9.65 ± 0.36 bw	15.08 ± 1.06 bx	21.41 ± 0.71 bx
	Muscle	5.71 ± 1.40 ay	0.375 ± 0.65 by	5.91 ± 0.09 ay	5.42 ± 0.41 ax
	Average	**12.59**	**7.94**	**12.61**	**17.32**

Means with the same litter are not significantly a, b, c litters present difference among season in the same fish, w, x, z litters present difference among different fish in the same season. Data shown with different letters are statistically significant at the $p < 0.05$ level

Table 4. Seasonal mean ± SE and annual average of zinc (Zn) concentrations (mg/g dry wt) in different tissues of different fish species inhabiting Qarun Lake.

Fish sp.	Tissue	Summer	Autumn	Winter	Spring
Mugill cephalus	Liver	148.09 ± 1.56 aw	55.71 ± 0.14 bw	140.02 ± 1.12 aw	128.12 ± 0.42 aw
	Gill	112.20 ± 5.32 ax	52.93 ± 0.26 bw	108.22 ± 0.91 ax	115.09 ± 0.14 aw
	Muscle	15.84 ± 1.6 bz	22.41 ± 0.44 ay	12.14 ± 0.75 bz	13.52 ± 0.46 by
	Average	**92.04**	**43.68**	**86.79**	**85.58**
Tilapia zillii	Liver	130.51 ± 1.42 aw	51.35 ± 0.22 bw	124.61 ± 0.41 aw	119.14 ± 0.61 aw
	Gill	110.45 ± 1.31 ax	49.21 ± 0.46 bw	118.71 ± 0.24 ax	115.07 ± 1.42 a
	Muscle	12.95 ± 0.56 a	11.35 ± 0.35 a	10.35 ± 0.14 a	11.81 ± 0.61 ay
	Average	**84.64**	**37.30**	**85.56**	**82.01**
Solia vulgaris	Liver	78.01 ± 1.04 ay	31.14 ± 0.12 bx	79.52 ± 0.19 ay	91.11 ± 0.04 ax
	Gill	71.12 ± 1.07 ay	28.42 ± 0.71 bx	75.61 ± 0.61 ay	83.16 ± 0.16 ax
	Muscle	32.11 ± 1.14 ayz	10.81 ± 1.64 bz	39.42 ± 1.42 ayz	9.56 ± 0.13 by
	Average	**60.41**	**23.46**	**64.79**	**61.28**

Means with the same litter are not significantly a, b, c litter's present difference among season in the same fish, w, x, z litters present difference among different fish in the same season. Data shown with different letters are statistically significant at the $p < 0.05$ level

Table 5. Seasonal mean ± SE and annual average of cupper (Cu) concentrations (mg/g dry wt) in different tissues of different fish species inhabiting Qarun Lake.

Fish sp.	Tissue	Summer	Autumn	Winter	Spring
Mugill cephalus	Liver	78.27 ± 0.22 aw	33.71 ± 0.81 cw	80.04 ± 1.04 aw	65.11 ± 0.43 aw
	Gill	54.90 ± 0.11 bx	30.91 ± 0.95 cw	75.09 ± 1.01 aw	50.21 ± 0.31 aw
	Muscle	11.06 ± 4.32 bz	14.71 ± 0.17 ax	12.55 ± 2.40 by	10.04 ± 1.50 by
	Average	**46.43**	**23.14**	**54.18**	**40.38**
Tilapia zillii	Liver	70.32 ± 1.51 aw	29.11 ± 2.14 bw	64.14 ± 1.61 aw	60.04 ± 1.07 aw
	Gill	51.49 ± 1.63 ax	25.42 ± 1.81 bw	61.19 ± 2.14 aw	58.12 ± 2.41 aw
	Muscle	9.90 ± 1.82 az	8.11 ± 0.44 ay	8.41 ± 2.52 ay	9.51 ± 0.41 ay
	Average	**43.90**	**20.88**	**44.58**	**42.56**
Solia vulgaris	Liver	29.21 ± 0.41 by	15.51 ± 0.12 cx	42.91 ± 1.40 ax	39.41 ± 1.21 ax
	Gill	26.425 ± 0.52 by	13.61 ± 0.22 cx	38.71 ± 1.21 ax	35.11 ± 0.04 ax
	Muscle	6.11 ± 0.41 bz	4.81 ± 0.14 by	7.40 ± 0.45 ay	5.81 ± 0.91 by
	Average	**20.28**	**11.57**	**28.51**	**26.21**

Means with the same litter are not significantly a, b, c litter's present difference among season in the same fish, w, x, z litters present difference among different fish in the same season. Data shown with different letters are statistically significant at the $p < 0.05$ level

Table 6. Seasonal mean ± SE and annual average of lead (Pb) concentrations (mg/g dry wt) in different tissues of different fish species inhabiting Qarun Lake.

Fish sp.	Tissue	Summer	Autumn	Winter	Spring
Mugill cephalus	Liver	3.16 ± 0.001 aw	1.46 ± 0.11 bw	3.21 ± 0.12 aw	2.91 ± 0.02 aw
	Gill	2.62 ± 0.07 ax	0.81 ± 0.001 cx	2.71 ± 0.22 ax	1.80 ± 0.001 bx
	Muscle	0.26 ± 0.09 bz	0.33 ± 0.01 abx	0.41 ± 0.01 az	0.21 ± 0.41 bz
	Average	**2.01**	**0.87**	**2.11**	**1.64**
Tilapia zillii	Liver	2.19 ± 0.002 ax	1.11 ± 0.002 bw	2.70 ± 0.001 ax	2.31 ± 0.04 aw
	Gill	1.71 ± 0.11 ay	0.71 ± 0.24 bx	1.46 ± 0.21 ay	1.43 ± 0.002 ax
	Muscle	0.18 ± 0.001 cz	0.31 ± 0.002 by	0.51 ± 0.02 a	0.20 ± 0.05 cz
	Average	**1.36**	**0.71**	**1.56**	**1.31**
Solia vulgaris	Liver	1.12 ± 0.001 by	0.30 ± 0.001 Cy	2.40 ± 0.04 ax	1.20 ± 0.04 bx
	Gill	0.82 ± 0.002 byz	0.12 ± 0.12 cz	1.61 ± 0.02 ay	0.41 ± 0.01 cyz
	Muscle	0.41 ± 0.14 az	0.08 ± 0.14 cz	0.21 ± 0.001 bz	0.11 ± 0.001 bz
	Average	**0.78**	**0.17**	**1.40**	**0.57**

Means with the same litter are not significantly a, b, c litter's present difference among season in the same fish, w, x, z litters present difference among different fish in the same season. Data shown with different letters are statistically significant at the $p < 0,05$ level

Table 7. Seasonal mean ± SE and annual average of cadmium (Cd) concentrations (mg/g dry wt) in different tissues of different fish species inhabiting Qarun Lake.

Fish sp.	Tissue	Summer	Autumn	Winter	Spring
Mugill cephalus	Liver	3.36 ± 0.01 Aw	1.25 ± 0.26 cw	3.42 ± 0.04 aw	2.64 ± 0.16 bw
	Gill	2.62 ± 0.07 ax	0.49 ± 0.01 cz	2.32 ± 0.09 ax	1.65 ± 0.001 bx
	Muscle	0.26 ± 0.09 az	0.21 ± 0.04 az	0.01 ± 0.001 bz	0.20 ± 0.02 az
	Average	**2.08**	**0.74**	**1.92**	**1.50**
Tilapia zillii	Liver	2.61 ± 0.41 ax	1.11 ± 0.001 bw	2.50 ± 0.61 ax	2.12 ± 0.001 aw
	Gill	1.41 ± 0.022 ay	0.30 ± 0.02 b	1.25 ± 0.11 ay	1.24 ± 0.06 ax
	Muscle	0.31 ± 0.001 az	0.11 ± 0.001 c	0.22 ± 0.14 bz	0.10 ± 0.40 cz
	Average	**1.44**	**0.51**	**1.32**	**1.15**
Solia vulgaris	Liver	1.14 ± 0.24 ay	0.71 ± 0.44 bx	1.22 ± 0.12 ay	0.91 ± 0.04 abz
	Gill	0.51 ± 0.10 ayz	0.21 ± 0.11 byz	0.42 ± 0.11 ayz	0.10 ± 0.002 bz
	Muscle	0.13 ± 0.001 az	0.03 ± 0.01 bz	0.02 ± 0.01 bz	0.03 ± 0.001 bz
	Average	**0.59**	**0.32**	**0.55**	**0.35**

Means with the same litter are not significantly a, b, c litter's present difference among season in the same fish, w, x, z litters present difference among different fish in the same season. Data shown with different letters are statistically significant at the $p < 0.05$ level

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دراسة مقارنة على التلوث بالعناصر الثقيلة فى أنسجة ثلاث أنواع من الأسماك (البلطى الزيلى – البورى – الموسى) والمياة والتربة ببحيرة قارون– الفيوم – مصر

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٢. المعمل المركزى لبحوث الثروة السمكية بالعباسة – شرقية

فى دراسة لتقدير عناصر الحديد – المنجيز – النحاس – الزنك – الرصاص – الكادميوم فى مياة وتربة وأنسجة (الكبد – الخياشيم – اللحم) فى أسماك البورى – البلطى – الموسى المصادة من بحيرة قارون بمحافظة الفيوم خلال عام كامل ٢٠٠٥ . تم تقسيم البحيرة الى عشرة مواقع لتجميع عينات المياة والتربة وتم تجميع عينات الاسماك من الصيادين داخل البحيرة.

وكانت أهم النتائج كما يلى:–

إرتفاع تركيز جميع المعادن الثقيلة فى المياة والتربة كلما إقتربنا من مصبات المصارف الزراعية داخل البحيرة خصوصا المصارف الكبرى مثل البطس والوادى وغيرهما

أعلى تركيز للمعادن الثقيلة كان لعنصر الحديد فى المياة والتربة ثم المنجنيز والنحاس والزنك ، وأقل تركيز للمعادن الثقيلة فى المياة والتربة كان عنصرى الرصاص والكادميوم.

التربة هى الأكبر فى محتوى المعادن الثقيلة عن المياة والأسماك حيث تعتبر المخزن الكبير لكل العناصر وكان محتوى المعادن فى كبد الاسماك أكبر عنة فى الخياشيم، وإنخفاض محتوى المعادن فى اللحم عن الكبد والخياشيم.

تعتبر أسماك العائلة البورية ذات قدرة كبيرة على تجميع الملوثات داخل أنسجتها عن أسماك البلطى الزيللى، وتمتاز أسماك الموسى بإنخفاض محتواها من المعادن الثقيلة عن باقى الأنواع الأخرى من الأسماك.

عموما وجد أن تركيز العناصر فى الكبد والخياشيم أعلى من الحدود المسموح بها وهى أجزاء غير مأكولة بينما التركيز فى اللحم كان أقل من الحدود المسموح بها .

تنصح الدراسة بضرورة العمل على معالجة مياة المصارف قبل أن تصب داخل البحيرة خصوصا أن هذة الكميات فى زيادة مستمرة وإستخدام المبيدات والأسمدة الغنية بالعناصر الصغرى فى تزايد وأن البحيرة من البحيرات المغلقة مما يهدد بزيادة تراكم الملوثات بها.