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Monitoring of some heavy metals and wellbeing status of some fish species from middle Alexandria and Sidi-Barany areas Mediterranean coast, Egypt

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Abstract

The present investigation deals with the levels of accumulation of Zn, Cu and Cd in various organs of some commercial fish in middle Alexandria, (Anfoushi-Montazah) and Sidi-Barany Mediterranean coastal areas. The average concentrations of metals ranged between 8.99-18.52 (Zn); 1.51-5.83 (Cu); 1.09-2.03 (Cd) mg/kg wet weight in muscles of fish from Anfoushi-Montazah coast and between 2.65-8.18 (Zn); 1.50-2.29 (Cu); 0.31-1.22(Cd) mg/kg wet weight in muscles of fish from Sidi-Barany coast. These figures indicate that the concentrations of these metals in the fish flesh are still below the maximum permissible limits for human consumption. The accumulation of these metals was found to follow the order muscles < gills < liver < gonads in organs of fish from Anfoushi-Montazah area, while, in organs of fish from Sidi-Barany coast, the metals accumulation in liver exceeds that in gonads. The abundance of these metals in fish organs was found to follow the order Zn > Cu > Cd in both areas. Statistically, accumulation of metals in fish was found insignificant, depending on species, in both studied areas, while, depending on organs, it was found significant for Zn, Cu and Cd in fish from Anfoushi-Montazah area and only for Cu in fish from Sidi-Barany coast. According to values of condition factors (K) and hepato-somatic index (H.S.I.), fish in both areas exhibit good wellbeing status, especially in Sidi-Barany coast.

Keywords: Mediterranean, Anfoushi-Montazah coast, Sidi-Barany coast, condition factor, hepato-somatic index.

1. Introduction

The Egyptian coastal water of the Mediterranean, annually, receives large inputs of industrial wastes, domestic and agricultural drainage water. The main sources of wastes effluents are the Nile River and northern lakes, in addition to, the marine transport and touristic activities.

Many studies were carried out to determine concentrations of heavy metals in fish tissues, water and sediments along Egyptian Mediterranean coastal area (El-Sammak and Abouel-Kassim, 1999; Shakweer, 1999; Aboul-Naga, *et al.*, 2002; El-Rayis and Abdallah, 2005; El-Moselhy and Hamed, 2006; Shakweer, *et al.*, 2006, 2008; El-Nemr *et al.*, 2007; El-Sikaily, 2008;).

Fulton’s condition factor (K) for fish is considered a popular metric that has been applied for comparing the condition, fatness and well-being of fish based on the assumption that heavier fish of a given length are in better conditions (Fulton, 1904; Tesch, 1968; Bolger and Connolly 1989). This index allows for more objective comparison between fish plump on either geographic, time or species basis and reflects the suitability of the environmental and feeding conditions for fish. It is computed as body mass divided by the cube of body length assuming isometric growth because length is raised to the third power. The assumption of isometric growth is a fair approximation for many species (Jones *et al.*, 1999; Kimmerer *et al.*, 2005).

Hepato-somatic index (H.S.I.) is another metric that has been used in fishery biology as a useful tool for assessing the fish condition. Facey *et al.* (2005) stated that H.S.I. as a biomarker is often correlated with exposure to various contaminants (e.g., polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and some heavy metals). Exposure to contaminants can lead to an increase in liver size as a result of increase in hepatocytes size (hypertrophy) or number (hyperplasia) (Hilmy *et al.*, 1983; Hinton and Lauren, 1990). Studies evaluating the relative liver size of fishes from contaminated and reference sites often utilize the H.S.I. (Heath, 1990; Facey *et al.*, 1999). Goede and Barton (1990) have used H.S.I. as a biomarker of contaminant exposure.

The present investigation covers two main objectives: 1. monitoring the accumulation levels of some heavy metals in muscles, gills, liver and gonads of some commercial fish species, at middle Alexandria (Anfoushi-Montazah) and Sidi-Barany Mediterranean coastal areas. 2. Studying the wellbeing status of these fish in relation to the accumulation levels of studied heavy metals in fish organs.

2. Materials and methods

Fish samples used in this work were collected through the project: "Fisheries and fishing tools at Alexandria coastal area between Agamy and Abu-Qir Bay" which was financed by NIOF and through the trip of NIOF ship (Salsabile) at the Egyptian Mediterranean north west coast during the period from 2003 – 2005

Fish samples (11 species) were regularly collected from Alexandria middle coastal area between Anfoushi and Montazah during the period from 2003 – 2005. At the same period fish samples (9 species) were regularly collected from Sidi-Barany coastal area (Figure 1). Fish were identified and their total length (T. L.), total weight (T. WT.) and gutted weight (Gut. WT.) were measured. Fulton's condition factor (K) for fish was calculated according to the equation:

K = [gutted weight (gm) / total length^3 (cm)] X 100. (Fulton, 1904; Bolger and Connolly, 1989).

Hepato-somatic index (H.S.I.) was calculated according to the equation:

H.S.I. = [liver weight (gm)/gutted weight (gm)]×100 (Goede and Barton, 1990; Facey *et al.,* 2005).

Tissue samples were taken from muscles, gills, liver and gonads (5 replicates) of 9 fish species from Anfoushi-Montazah and 3 species from Sidi-Barany coastal areas and were kept frozen in plastic bags for metals analyses. The sampled tissues were weighed (as wet weight) before treatment with 65% concentrated HNO_3 at 120^{o}C according to Bernhard (1976). The concentrations of Zn, Cu and Cd in fish tissues were determined, using Atomic Absorption Spectrophotometer (Perkin Elmer model 2380). For control quality, the standard reference material MA-A-2/TM (National Research Council, Canada) was used. The recovery percents were 96.08, 95.85 and 95.71 % for Zn, Cu and Cd, respectively.

Metal type, fish species and fish organs dependant variability of metals accumulation were examined using analysis of variance (ANOVA). Dependence of metals accumulation in fish organs on condition factor, total length and gutted weight values were examined using Pearson correlation test. All statistical analyses were carried out using SPSS-10 for windows.

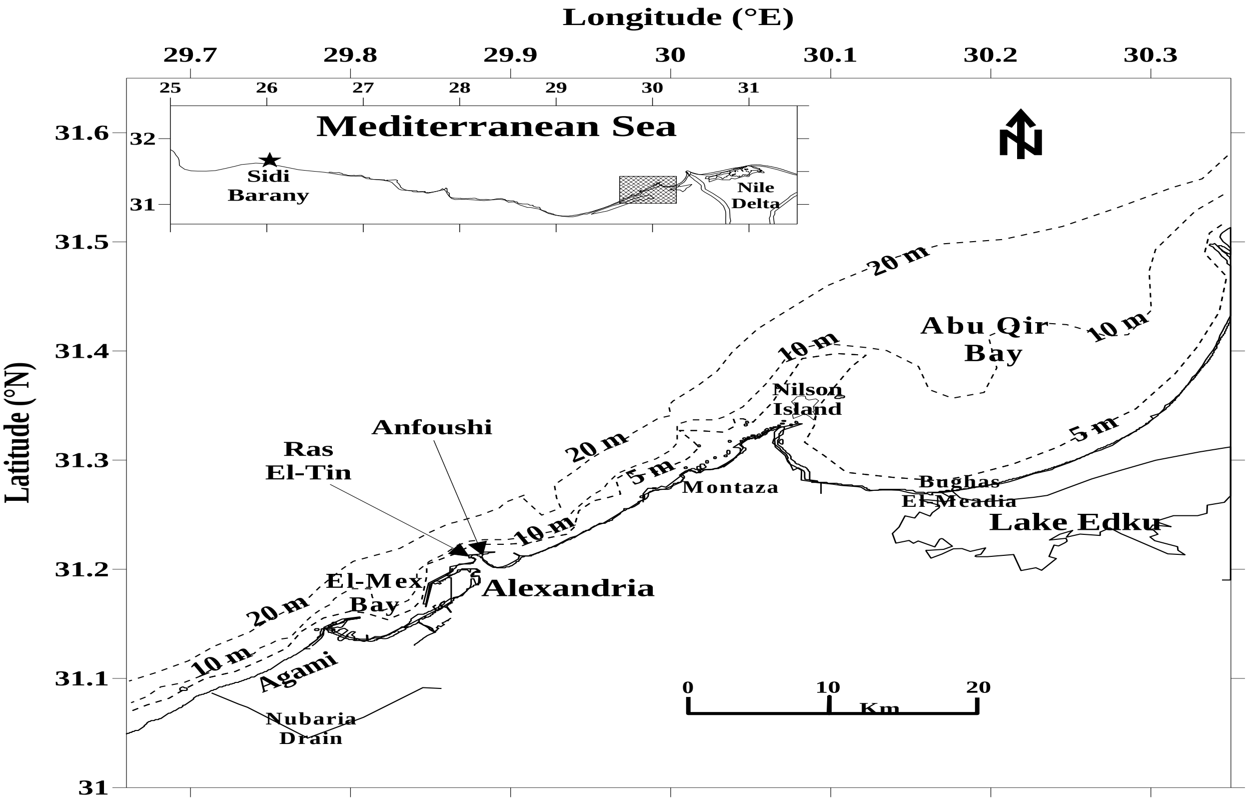

Figure 1. Sampling areas along middle Alexandria (Anfoushi-Montazah) and Sidi-Barany coast.

3. Results and Discussion

3.1. Concentrations of Zn in fish organs

Zinc is a constituent of many metalloenzymes, proteins and cellular structural components in the marine life, but it is listed also among the high potential pollutant metals. The essentiality of Zinc to marine organisms has been shown by Tucker and Salmon (1955) and Vallee (1978). They stated that this element is required for normal growth, development and function in all animal species. Characteristics of its deficiency include growth retardation, delayed sexual maturation, skin lesions, skeletal and fetal abnormalities.

In the present work, measurements of average Zn concentrations in organs of fish caught from Alexandria middle coast ranged between 8.99-18.52 in muscles, 28.54-93.32 in gills, 36.83-115.36 in liver and 54.09- 443.03 in gonads (Table 1), while, in organs of fish caught from Sidi-Barany coastal area, Zn average concentrations ranged between 2.65-8.18 in muscles, 15.74-28.22 in gills, 30.97-78.83 in liver and 29.35-67.25 mg/kg wet weight in gonads (Table 4). Accumulation of Zn in fish organs of Anfoushi-Montazah coast followed the order muscles < gills < liver < gonads, while, in fish organs of Sidi Barany coast the accumulation of Zn in liver exceeds that in gonads. These concentrations are comparable with the concentrations given by Shakweer (1999), who indicated that the concentrations of Zn in fish gills collected from the Egyptian Mediterranean coast ranged between 15.90 and 145.00 mg/kg.

However the increased concentrations of Zn in gills of fish may lead to some toxic effects. In this concern, Burton *et al.* (1972) indicated that the acute Zinc toxicity to rainbow trout supports the hypothesis that modifications of the gases exchange process at the gills creates hypoxia. Saleh *et al.* (1983), pointed out that the accumulation of zinc in the gills could be considered as the main reason of fish death in Lake Mariut at Alexandria, Egypt.

High concentrations of Zinc in the fish liver and spleen were reported by Hill *et al.* (2000). Papadopoulou *et al.* (1984) pointed out that the tendency for Zinc is to accumulate, mainly, in the liver of fish species caught from the Greece water. Nayak *et al.* (2005) pointed out that the order of accumulation of heavy metals in some marine fishes from Gopalpur coast (India) was liver > gill > muscles. The higher concentrations of heavy metals in fish liver have been attributed by Saleh *et al.* (1983) to the fatness of the liver, as well as due to the fact that the fish liver is the responsible organ for getting rid of toxicants.

It is obvious that gonads of fish, from the middle Alexandria coast, investigated in the present study accumulated Zn with highest concentrations in comparison with the other fish organs. This agrees with the data given by many authors. Windom *et al.* (1973) in their investigation on Zn concentrations in 35 fish species from the North Atlantic found that the gonads of these species accumulated elevated levels of Zn in comparison with the other body organs of fish.

Table 1. Concentrations of Zn (average ± s.d.) in different organs of fish (N = 5) caught from middle area (Anfoushi-Montazah) of Alexandria coast.

Species	Concentration mg/Kg wet weight			
	Flesh	Gills	Liver	Gonads
1. Lithognathus mormyrus	16.25 ± 7.34	56.03 ± 19.97	115.36 ± 114.72	417.59
2. Sparus auratus	16.46 ± 9.26	44.22 ± 1.97	45.18 ± 6.98	204.03 ± 48.72
3. Sphyraena chrysotaenia	13.52 ± 3.90	93.32 ± 92.86	54.85 ± 22.81	443.03
4. Siganus rivulatus	8.99 ± 1.94	28.54 ± 8.465	97.30 ± 55.14	427.7 ± 422.86
5. Sardinella maderensis	11.10 ± 2.922	40.78 ± 40.30	46.55 ± 20.13	203.28 ± 35.39
6. Sardinella aurita	18.52 ± 6.76	65.39 ± 14.90	--	255.8 ± 209.75
7. Belone belone	14.66 ± 4.26	55.31 ± 23.8	36.83 ± 19.79	54.09 ± 18.27
8. Trachynotus ovatus	14.59 ± 4.83	40.58 ± 2.15	--	--
9. Alpes djedaba	14.64 ± 1.89	30.12 ± 3.08	44.85 ± 6.78	273.06

3.2. Concentrations of Cu in fish organs

The study of copper salts toxicity to fish is interesting not only because of the occurrence of copper in trade wastes disposed to the marine environment but also because copper sulphate is used in some places on a large scale as an algaecide in drains and streams running and flowing into the sea. Eaton (1974) in a chronic toxicity test, using a Zn – Cu – Cd mixture, found that Zn in the mixture was no more toxic than alone, Cu toxicity is enhanced and Cd toxicity in the trimetal mixture was reduced.

The present study indicates that copper accumulation ranged between 1.51-5.83, 1.69-9.95, 3.52-97.73 and 2.07-165.56 mg/kg wet weight in muscles, gills, liver and gonads of fish collected from Anfoushi-Montazah coast (Table 2), meanwhile, its accumulation ranged between 1.50-2.29, 1.02-5.26, 6.03-8.58 and 1.28-4.08 mg/kg wet weight in the same organs of fish collected from Sidi-Barany coast (Table 4). Accumulation of Cu follows the order muscles < gills < liver < gonads in fish organs of Anfoushi-Montazah coast, while in organs of fish caught from Sidi-Barany coast, its accumulation in gills and liver exceeds that in gonads.

The toxic process of copper in gills of fish was described by Ellis (1973) who pointed out that such process starts when this element attacks the respiratory system, where the gill filaments become filled with copper precipitate, and then, the spaces between gill lamellae become filled so that the circulation of blood is affected. Buckley *et al.* (1982) and Salanaki *et al.* (1982) pointed out that the liver of fish is the major storage organ for copper. Lauren and McDonalds (1987) stated that further copper uptake over a maximum concentration in the liver is distributed to other internal organs and may favour the existence of copper with high concentrations in gonads. It can be observed from the data given that fish caught from Anfoushi-Montazah coast accumulated, in most cases, high concentrations of copper in gonads.

3.3. Concentrations of Cd in fish organs

Cadmium enters the marine environment as a result of man's activities through both the atmosphere and hydrosphere. In the marine environment, some resistant organisms, such as crabs and molluscs may accumulate high levels of Cd in their soft tissues without apparent deterioration to their wellbeing. This accumulation may be derived from soluble Cd in the water or through food chain via Cd – contaminated algae and this can occur even from low concentrations in water.

In the present work, the concentration of Cd ranged between 1.09-2.03, 1.79-5.17, 2.1- 7.6 and 2.28-9.87 mg/kg wet weight in muscles, gills, liver and gonads of fish collected from Anfoushi-Montazah coast (Table 3). Meanwhile, Cd concentration ranged between 0.31-1.22, 0.74-2.12, 0.34-1.31and 0.84-5.96 mg/kg wet weight in muscles, gills, liver and gonads of fish collected from Sidi-Barany coast (Table 4). Cd accumulation in fish organs followed the order muscles < gills < liver < gonads in both studied areas.

It is worth pointing out to the fact that exceptionally higher concentrations were observed in some organs, especially liver and gonads of some species. However, it is obvious that the concentrations of such element in the fish flesh were mostly below the allowable concentrations. This means that fish collected from the studied areas were not subjected to severe Cd contamination.

Table 2. Concentrations of Cu (average ± s.d.) in different organs of fish (N = 5) caught from middle area (Anfoushi-Montazah) of Alexandria coast.

Species	Concentration mg/Kg wet weight			
	Flesh	Gills	Liver	Gonads
1. Lithognathus mormyrus	4.20 ± 3.24	9.95 ± 13.14	28.8 ± 32.07	104.44
2. Sparus auratus	1.51 ± 0.53	2.94 ± 1.23	3.52 ± 0.88	3.42 ± 0.47
3. Sphyraena chrysotaenia	4.47 ± 4.55	7.53 ± 7.77	6.05 ± 3.16	103.83
4. Siganus rivulatus	5.83 ± 4.21	6.83 ± 2.901	97.73 ± 80.83	165.56 ± 205.53
5. Sardinella maderensis	5.58 ± 4.67	3.38 ± 1.09	8.04 ± 3.95	2.07
6. Sardinella aurita	1.79 ± 0.50	4.87 ± 3.66	--	20.71 ± 14.0
7. Belone belone	2.42 ± 1.65	5.01 ± 3.98	3.71 ± 2.25	8.07 ± 6.41
8. Trachynotus ovatus	5.33 ± 1.58	4.70 ± 2.47	--	--
9. Alpes djedaba	5.08 ± 1.03	1.69	8.12 ± 7.89	10.28

Table 3. Concentrations of Cd (average ± s.d.) in different organs of fish (N = 5) caught from middle area (Anfoushi-Montazah) of Alexandria coast.

Species	Concentration mg/Kg wet weight			
	Flesh	Gills	Liver	Gonads
1. Lithognathus mormyrus	2.03 ± 2.74	5.17 ± 5.23	4.58 ± 3.91	9.87
2. Sparus auratus	1.30 ± 0.21	4.25 ± 5.67	2.10 ± 0.53	3.07 ± 1.80
3. Sphyraena chrysotaenia	1.62 ± 1.12	3.01 ± 1.92	3.54 ± 1.85	--
4. Siganus rivulatus	1.54 ± 0.61	2.25 ± 1.66	3.36 ± 1.60	5.86
5. Sardinella maderensis	1.09 ± 0.68	2.73 ± 2.16	3.13 ± 1.28	2.28 ± 1.39
6. Sardinella aurita	1.91 ± 0.79	3.17 ± 1.18	--	6.73 ± 4.47
7. Belone belone	1.22 ± 0.67	3.5 ± 1.03	2.56 ± 1.44	--
8. Trachynotus ovatus	1.80 ± 0.65	1.83 ± 0.69	--	--
9. Alpes djedaba	1.16 ± 0.54	1.79	7.60 ± 8.34	3.59

Table 4. Concentrations of Zn, Cu and Cd (average ± s.d.) in different organs of fish (N = 5) collected from Sidi-Barany coastal area, north-west of Alexandria.

Metal	Species	Concentration mg/Kg wet weight			
		Flesh	Gills	Liver	Gonad
Zn	*Saurida undsquamis*	8.18 ± 4.16	22.80 ± 6.30	32.20 ± 28.84	32.27 ± 14.23
	Lepidotrigla cavillone	2.65 ± 3.39	28.22 ± 26.08	30.97 ± 17.00	29.35 ± 7.90
	Pagellus erythrinus	7.89 ± 9.23	15.74 ± 3.99	78.83 ± 85.81	67.25 ± 1.32
Cu	*Saurida undsquamis*	1.58 ± 1.78	5.26 ± 4.82	8.58 ± 6.83	1.28 ± 2.10
	Lepidotrigla cavillone	1.50 ± 2.31	3.01 ± 5.24	6.03 ± 9.76	4.08 ± 4.09
	Pagellus erythrinus	2.29 ± 1.71	1.02 ± 2.03	7.17 ± 5.80	--
Cd	*Saurida undsquamis*	0.49 ± 0.73	0.91 ± 1.47	0.34 ± 0.46	0.84 ± 0.93
	Lepidotrigla cavillone	0.31 ± 0.38	0.74 ± 1.29	0.81 ± 0.94	1.49 ± 1.86
	Pagellus erythrinus	1.22 ± 1.68	2.12 ± 1.61	1.31 ± 2.37	5.96 ± 10.90

3.4. Metals in fish muscles:

It is noteworthy that muscle tissues which account for most of the body weight of fishes and is of great importance as food, accumulated only lower concentrations of Zn, Cu and Cd in all sampled fish species in both studied areas if compared with their concentrations in the other organs of fish.

Comparing to the maximum acceptable concentrations of Zn in muscles: 40 mg/kg (FDA, 2001), Cu: 30 mg/kg (FAO, 1983), Cd: 2.0 mg/kg (NHMRC, 1974; FAO, 1992; FDA, 2001), it appears that the concentrations of these metals in the muscles tissues of fish collected from both areas of study were below the allowable limits.

These results agree with other reports indicating heavy metal concentrations in edible portions were lower than those in other portions (Gibbs and Miskiewicz, 1995; Hamza-Chaffai, *et al.*, 1996). Zheng Zhang, *et al.* (2007) found Cd, Cr, Cu, Hg and Pb levels in muscles lower than in intestines of 19 fish species in Banan section of Chongqing from Three Gorges Reservoir, China. Yi-Chun Chen and Meng-Hsien Chen (2001) reported Zn, Fe, Cu, Mn and Cd concentrations in muscles lower than in livers and gonads of 9 fish species collected from Ann-Ping coastal waters, Taiwan. Plaskette and Potter (1979) found Zn concentration in flesh lower than in other parts of the bodies of 12 fish species collected from Western Australia. Bryan (1964 and 1980) pointed out that the essential metals like zinc and copper are better regulated in fish muscles than the nonessential metals such as mercury and cadmium. Eisler and LaRoche (1972) showed that higher marine organisms can regulate zinc concentration in their tissues.

3.5. Metal type, fish species and fish organs dependent variations of metals levels

Statistically, ANOVA analysis revealed that fish at both Anfoushi-Montazah and Sidi-Barany coastal areas, dependent on fish species, exhibit insignificant accumulation ($F = 0.03$, $F = 0.44$) at 0.05 level, while, dependent on metals type, they exhibit significant accumulation ($F = 111.12$, $F = 7.72$) in muscles, respectively, at 0.01 level (Table 5).

On the other hand, ANOVA analyses revealed, dependent on fish species, insignificant accumulation of Zn, Cu and Cd in fish organs at both studied areas. Meanwhile, dependent on organs, fish at Anfoushi-Montazah coastal area exhibit significant accumulation of Zn ($F = 14.54$, $p < 0.01$), Cu ($F = 3.49$, $p < 0.05$) and Cd ($F = 3.54$, $P < 0.05$), while, fish at Sidi-Barany coastal area exhibit, only, significant Cu accumulation ($F = 7.33$, $P < 0.01$) in fish organs.

Table 5. One-tailed ANOVA results for accumulation of metals in fish muscles from Anfoushi-Montazah (I) and Sidi-Barany (II) coastal areas.

One-tailed ANOVA		Source	F
I	Accumulation of metals in muscles	Species	0.03
		Metals	111.12**
	Accumulation of Zn in organs	Species	0.37
		Organs	14.54**
	Accumulation of Cu in organs	Species	1.48
		Organs	3.49*
	Accumulation of Cd in organs	Species	1.03
		Organs	3.54*
II	Accumulation of metals in muscles	Species	0.44
		Metals	7.72**
	Accumulation of Zn in organs	Species	0.92
		Organs	3.53
	Accumulation of Cu in organs	Species	0.06
		Organs	7.33**
	Accumulation of Cd in organs	Species	2.76
		Organs	1.25

** Significant correlation coefficient at $P < 0.01$.
* Significant correlation coefficient at $P < 0.05$.
N = 5 in all tests.

3.6. Fish condition

It is a matter of fact that the condition of fish is an important factor which may be affected by the uptake of heavy metals from the ambient water. It was emphasized by many authors that the condition of fish is related to the concentration of these metals. Fulton's condition factor (K) allows for comparing fish condition of different populations and species on either geographic or time basis and reflects the suitability of the environmental and feeding conditions for fish (Fulton, 1904; Bolger and Connolly, 1989).

In present work, biometric characters, condition factor (K) values of fish from both studied areas were shown in Tables 6 and 7. Values of K ranged between 0.1-1.55 for fish of Anfoushi-Montazah coast (Table 6), meanwhile, for fish from Sidi-Barany coast, K values ranged between 0.58- 1.48 (Table 7). The results of Pearson correlation analyses revealed insignificant correlation between concentration of Zn, Cu and Cd in muscles of fish at both studied coastal areas and T.L., Gut. Wt. and K. Meanwhile, Cd concentration exhibit negative significant correlation, only, with T.L. ($r = -0.690$, $P = 0.02$) and Gut. wt. ($r = -0.624$, $P = 0.036$) of fish at Anfoushi-Montazah coastal area (Table 8). These results mean that accumulation of Zn, Cu and Cd in the edible parts of fish at both studied areas still not attained harmful levels.

The liver is of a key importance when studying the action of pollutants on fish. It is the primary organ for transformation of organic xenobiotics and also for the getting rid of harmful trace metals. Since many of these metals tend to accumulate to high concentrations in the liver, its cells are exposed to high levels of harmful alterations. Heath (1990) pointed out that the ratio of liver to body weight greatly differs between and within various species. This ratio (liver–somatic index) is useful in assessing the general condition of fish. According to Hilmy *et al.* (1983), DDT poisoning rapidly produces enlargement of liver.

In the present study, the calculated values of hepato-somatic index (H.S.I.) are given in Tables 6 and 7. Values of H.S.I. ranged between 0.62 - 2.6 for fish of Anfoushi-Montazah coast (Table 6), meanwhile, for fish from Sidi-Barany coast, they ranged between 0.53 - 2.61 (Table 7). These results may be evidence for different response of fish to metals in both studied areas. The results of ANOVA analyses and Pearson correlation test may prove that the fish condition in both studied areas is not bad, especially, in Sidi-Barany coastal area.

Table 6: Biometric characters, condition factor (K) and hepato-somatic index (H.S.I.) of fish caught from Anfoushi-Montazah area, middle Alexandria coastal area.

Species	Length range (cm)	Average total length. (cm)	Average total weight (g)	Average gutted weight (g)	Condition factor (K)	Hepato-somatic index (H.S.I.)
1. Lithognathus mormyrus	9.7 – 12.9	10.5± 1.04	14.8± 5.4	13.9± 5.29	1.18± 0.05	1.87± 0.44
2. Sparus auratus	20.8 –22.3	21.6 ± 0.75	130.0± 30.53	122.0 ± 25.59	1.20 ± 0.17	1.87 ± 0.99
3. Sphyraena chrysotaenia	16.5 –17.2	16.7± 0.28	24.5± 0.86	22.8± 0.85	0.49± 0.02	1.75± 0.26
4. Siganus rivulatus	14.5 –15.1	14.7 ± 0.35	41.8± 3.63	32.5 ± 3.29	1.02 ± 0.07	1.97± 0.47
5. Sardinella maderensis	17.4 –19.1	18.1 ± 0.89	48.5± 9.31	44.6 ± 8.50	0.75 ± 0.05	0.62 ± 0.08
6. Sardinella aurita	10.7 –14.5	13.5 ± 1.32	21.1± 5.80	14.8 ± 4.91	0.73 ± 0.04	--
7. Belone belone	33.2– 46.6	36.7 ± 3.90	62.8± 24.85	52.0 ± 18.06	0.10 ± 0.01	2.60 ± 1.40
8. Trachynotus ovatus	11.7 –20.9	17.1 ± 4.82	49.8± 34.05	44.5 ± 30.66	0.75 ± 0.03	--
9. Alpes djedaba	15.1 –36.1	24.4 ± 6.58	212.0±171.71	189.0 ± 155.19	1.10 ± 0.04	1.79 ± 0.50
10. Diplodus surgus	17.0 –19.5	18.2 ± 1.00	104± 21.21	94.1 ± 19.58	1.55 ± 0.10	1.21 ± 0.23
11. Liza ramada	18.2 –25.5	22.2± 3.88	10.3± 49.47	89.6± 43.96	0.77 ± 0.01	2.51 ± 0.80

Table 7. Biometric characters, condition factor (K) and hepato-somatic index (H.S.I.) of fish caught from Sidi-Barany coastal area, north-west of Alexandria.

Species	Length range (cm)	Average total length. (cm)	Average total weight (g)	Average gutted weight (g)	Condition factor (K)	Hepato-somatic index (H.S.I.)
1. Saurida undsquamis	11.3 – 33.0	21.1 ± 5.96	90.0± 74.63	77.0 ± 61.60	0.58 ± 0.08	2.61 ± 1.18
2. Lepidotrigla cavillone	16.2 – 20.9	18.5 ± 1.94	64.0± 15.57	57.4 ± 13.91	1.19 ± 0.04	1.92 ± 0.33
3. Pagellus erythrinus	13.4 – 16.4	14.6 ± 1.20	41.2 ± 10.83	37.8±10.13	1.19± 0.04	1.09±0.23
4. Trachinus draco	20.4 – 27.3	24.2± 2.84	95.0± 37.11	85.1± 35.91	0.58± 0.08	--
5. Platycephalus indicus	16.0 – 21.0	18.7 ± 11.80	86.5± 22.36	77.0 ± 19.85	1.15 ± 0.03	2.05±1.16
6. Uranoscopus scaber	11.9 – 19.5	15.9 ± 2.70	69.8± 32.38	63.9 ± 29.61	1.48 ± 0.08	1.63 ± 0.73
7. Spicara flexusa	11.8 – 16.4	14.7 ± 1.48	28.3± 9.91	26.5 ± 9.84	0.79 ± 0.12	1.14 ± 0.48
8. Spicara smaris	11.4 – 13.0	12.1 ± 0.71	14.1± 1.78	13.0 ± 1.9	0.73 ± 0.03	1.24 ± 0.35
9. Serranus hepatus	12.5 – 19.6	16.4 ± 2.23	56.2± 24.10	51.1 ± 21.30	1.10 ± 0.06	0.53 ± 0.51

Table 8. Pearson correlation between concentration of metals in muscles and TL, Gut. Wt. and K of fish from Anfoushi-Montazah (I) and Sidi-Barany (II) coastal areas.

Pearson correlation			Zn-muscles	Cu-muscles	Cd-muscles
I	TL	Correlation coefficient	0.006	- 0.299	- 0.690*
		P	0.494	0.217	0.020
	Gut.wt.	Correlation coefficient	0.085	- 0.031	- 0.624*
		P	0.414	0.468	0.036
	K	Correlation coefficient	0.046	0.160	0.162
		P	0.453	0.341	0.338
II	TL	Correlation coefficient	- 0.068	- 0.877	- 0.827
		P	0.478	0.159	0.190
	Gut.Wt.	Correlation coefficient	0.047	- 0.816	- 0.757
		P	0.485	0.196	0.226
	K	Correlation coefficient	- 0.540	0.418	0.329
		P	0.318	0.363	0.393

* Significant correlation coefficient at $P < 0.05$.

4. Conclusions

The accumulation of Zn, Cu and Cd in muscles of studied fish still below the recommended maximum permissible limits, although they attained higher values in gills, liver and gonads of fish from both studied areas. The values of k and H.S.I. of fish may indicate the suitability of environmental conditions, food availability and normal growth in both investigated areas. The correlation consequences between concentrations of studied metals and T.L., Gut. Wt. and K of fish in both areas may indicate that the concentrations of these metals in the ambient water still below the minimal risk concentration, especially in Sidi-Barany area.

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رصد تركيزات بعض المعادن الثقيلة و حالة بعض الأسماك فى المنطقة الشاطئية بين الأنفوشى و المنتزه ـ الإسكندرية ، و شاطئ سيدى برانى ـ غرب الإسكندرية ـ مصر

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يهدف هذا البحث إلى رصد تركيزات معادن الزنك و النحاس و الكادميوم فى أنسجة بعض الأسماك الاقتصادية من المنطقة الشاطئية بين الأنفوشى و المنتزه بالإسكندرية و المنطقة الشاطئية بسيدى برانى- غرب الإسكندرية . و قد وجد أن متوسطات تركيزات هذه المعادن تتراوح بين 8.99- 18.52 ؛ 1.51- 5.83 ؛ 1.09- 2.03 فى عضلات الأسماك من المنطقة الشاطئية بين الأنفوشى و المنتزه ، بينما متوسطات التركيزات فى عضلات الأسماك من منطقة سيدى برانى فقد تراوحت بين 2.65 – 8.18 ؛ 1.50 – 2.29 ؛ 0.31 – 1.22 مللى جرام / كيلو جرام (أنسجة رطبة) من الزنك و النحاس و الكادميوم .

بمقارنة هذه التركيزات بمعدلات التركيزات المسموح بها عالميا لهذه المعادن ، وجد أن هذه التركيزات هى فى الحدود المقبولة عالميا . كما وجد أن تركيزات هذه المعادن فى كل من العضلات ، الخياشيم ، الكبد ، المناسل تتبع الترتيب : الزنك > النحاس > الكادميوم . كما وجد أن تركيزاتها فى الأعضاء المختلفة يتبع الترتيب : العضلات < الخياشيم < الكبد < المناسل فى أسماك المنطقة الشاطئية بين الأنفوشى و المنتزه ، أما فى أسماك المنطقة الشاطئية بسيدى برانى فقد وجد أن تركيزات هذه المعادن فى الكبد أعلى منها فى المناسل ، و قد وجد أيضا ، أن قيم معامل الحالة (K) تتراوح بين 0.1 - 1.55 و معامل الكبد (H.S.I.) تتراوح بين 0.62- 2.51 لأسماك المنطقة الشاطئية بين الأنفوشى و المنتزه و قيم معامل الحالة تتراوح بين 0.58- 1.48 و معامل الكبد بين 0.53- 2.61 لأسماك المنطقة الشاطئية بسيدى برانى .

إحصائيا وجد أن تركيزات هذه المعادن فى العضلات معنويا ($F = 111.12, P < 0.01$) بالنسبة لأنواع المعادن ، غير معنويا ($F = 0.03, P > 0.05$) بالنسبة لأنواع الأسماك ، كما وجد أن تركيزات الزنك ($F = 14.54, P < 0.01$) و النحاس ($F = 3.49 , P < 0.05$) و الكادميوم ($F = 3.54, P < 0.05$) معنويا فى الخياشيم و الكبد و المناسل فى أسماك المنطقة الشاطئية بين الأنفوشى و المنتزه ، أما فى أعضاء أسماك المنطقة الشاطئية بسيدى برانى فقد وجد تركيز النحاس فقط معنويا ($F = 7.33, P< 0.01$).

من نتائج معاملى الحالة و الكبد و التحليل الاحصائى يتضح أن حالة الأسماك فى كل من المنطقتين جيدة من حيث النمو و إن كانت الحالة الصحية لها ليست كذلك.