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Evaluation Of Heavy Metals Concenteratioin In Fish From Alexandria Coast, Egypt

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Abstract

Cadmium Cu, Fe, Mn, Pb concentrations were determined in the muscles and organs (gills, liver, stomach and brain), of five fish species collected from Alexandria coast (El-Mex Bay) in December 2000. Four of them are carnivorous namely, *Diplodus sargus*, *Sparus auratus*, *Dicentrachus punctatus*, and *Mugil capito*, while the last one *Siganus rivulatus* is herbivorous. The results indicated high level of accumulation of these metals in the different organs of all studied fish, with respect to their correspondings in the muscle tissues. The accumulation factors for these metals were higher in the herbivorous fish. The essential metals (Fe, Cu, and Mn) were the more pronounced ones reflecting increase the trophic level of the fish. Lead concentration ranged from 1.2-3.5 mg/kg in the stomach and brain while it ranged from 0.4-0.9 mg/kg in fish muscles. Also, Cd level was generally lower than that of Pb in various organs while brain gained the highest values. Both of these toxic metals Pb and Cd were of higher values in the herbivorous fish than in carnivorous ones. Most of the fish generally showed levels of Cd in the organs which are close to that of the recommended standard (2.0 mg/kg) of the National Health and Medical Council in Australia, (NHMRC). However, none of them contained Cd concentrations above 0.5 mg/kg in their muscle tissues. Comparing the human metal intake due to consumption rate of fish muscles with the permissible level of a Provisional Tolerable Weekly Intake (PTWI) demonstrated that, the human consumption of these fish is still safe.

Introduction

Studies of heavy metals in fish are an important aspect of environmental pollution control, because human activities progressively increase the concentrations of heavy metals in aquatic system. (El-Nabawi *et al* 1987). Also, knowledge of levels of pollutants in edible marine organisms is important from a public health protection view - point. In addition, the distribution of trace elements, particularly within the tissues of marine animals, is of interest in understanding the role they play in the biochemical and physiological mechanisms of the organism (Emara *et al* 1993). Moreover, the amount of these elements reaching man by the food chain these trace contaminants may have effects on the ecosystem greater than those of the common pollutants.

Aquatic organisms require cert - ain trace metals to maintain normal metabolism. When present in excess, however, these essential metals such as Fe, Cu, and Mn may exert toxic effects. As to the metals, which are known to be harmful like Cd and Pb, their toxicity rises with their concentration in an accessible form. Many of them are known to be concentrated by marine

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organisms in food chain (Morales, 1980, Uysal, 1980, Emara, 1982, Shriadah and Emara, 1992 and El-Rayis *et al.,* 1997). In Alexandria Coast, El-Mex Bay (see figure 1), pollution by heavy metals may be derived from anthropogenic activities, due to industrial and agricultural drainage waters, and domestic effluents via different land based sources.

Two thirds of the Alexandria municipality wastewater is released after primary treatment into an inland lake called Lake Maryout prior to pumping into El-Mex Bay, (west of the city), together with agricultural runoff drained from the north-west part of the Nile delta. Part of the third of the Alexandria wastewater goes to the bay without treatment via neighbouring Western Harbour. The daily discharge rate from El-Mex Pumping Station to the bay is about 6 million cubic meters. Many investigations for the environ - mental conditions and levels of heavy metals in fish of the El-Mex bay have been carried out by several authors like (El-Rayis *et al.,* 1986, Abuldahab *et al,* 1990, and El-Rayis *et al.,* 1997). The present work is devoted to investigation of the level of Fe, Cu, Mn, Pb and Cd in muscle tissues and different organs for each of the edible and of commercial value fish *Diplodus sargus*, *Sparus auratus*, *Dicentrachus punctatus*, and *Mugil capito*, (as carnivorous fish) and *Siganus rivulatus* (as herbivorous fish) from El-Mex Bay area.

Materials and Methods

Samples of the selected commercial fish *Diplodus sargus*, *Sparus auratus*, *Dicentrachus punc - tatus*, *Mugil capito* and *Siganus rivulatus*, were collected once in December, 1999 from local fishermen of El-Mex Bay, Alexandria (figure1), and kept frozen (−20°C) prior to subjection to metal analysis. The analysis was commenced according to Bernhard (1976). The different organs, (liver, gills, stomach and brain) and muscle tissues were sampled by section from at least 6 individuals of each fish species (see table 1), then mixed to make a composite sample (UNEP, 1984, El-Nabawai *et al.,* 1987, EPA, 1991 and Tayel, 1995). From each composite sample, 2g

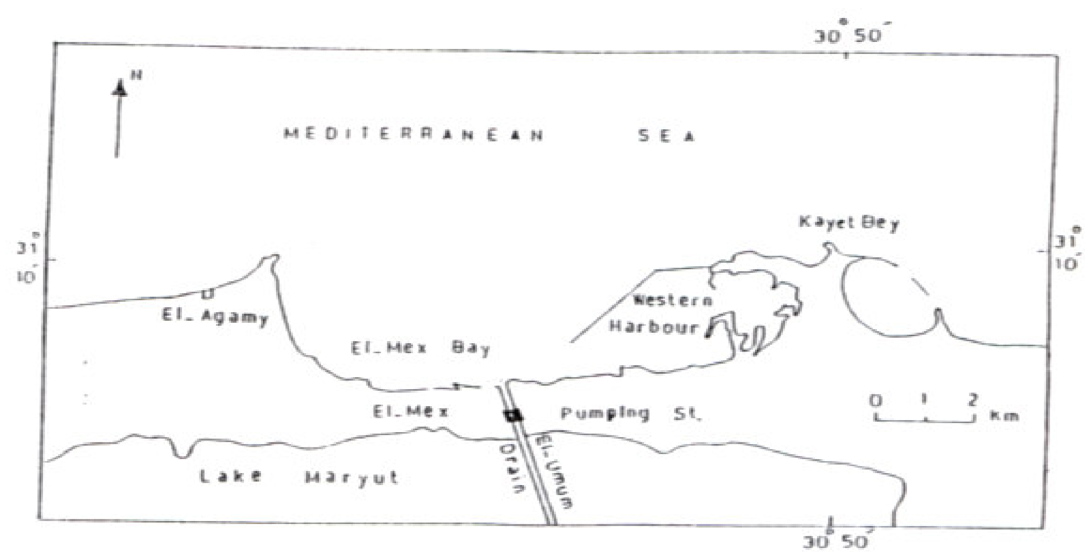

Figure 1 (Abuldahab, *et al* 1990)

were taken as analytic sample and digested with concentrated nitric acid inside closed teflon contained in a steel block (bomp). Digested samples were diluted with metals free water and analyzed using a Pye Unicam SP 1900 flame atomic absorption spectrophotometer (AAS). To control the analytical reliability and assure recovery efficiency and accuracy of the results, 7 analyses were conducted on (*Mytilus edulis*) Standard Reference Material 2974. The laboratory results showed recovery efficiency ranged from 88-101 % for the metals with coefficient of variation (CV) 10 – 14 % for all studied metals.

Table (1): Concentrations of trace metals (mg kg^{-1} D. Wt) in the tissue organs of five different fish species collected from El-Mex bay area in Dec. 2000

Fish species	Fish No	Length (cm)	Weight (g)	Organ	Fe	Cu	Mn	Pb	Cd
D. Sargus sargus	9	18.3-21.2	50.3-60.7	M	0.3	0.04	0.7	0.8	0.2
				L	80.1	6.6	3.0	3.1	1.1
				G	10.0	6.3	4.8	2.3	0.4
				S	8.3	10.4	1.6	2.1	1.6
				B	11.3	5.6	4.3	2.7	1.3
Sparus auratus	6	21.5-25.7	175.5-190.2	M	1.1	0.3	0.5	0.5	0.3
				L	11.0	8.7	1.1	1.0	0.2
				G	6.9	1.3	3.7	1.2	0.3
				S	9.7	7.5	5.4	3.1	0.6
				B	10.9	8.6	2.9	2.1	0.8
Dicrentrachus punctatus	7	20.5-24.5	125.5-195.8	M	2.4	0.7	1.3	0.8	0.1
				L	12.9	3.3	2.2	1.5	0.8
				G	5.5	1.8	2.4	1.4	0.3
				S	8.2	8.7	3.6	2.9	0.8
				B	15.5	7.1	5.5	2.9	1.5
Mugil capito	8	21.7-24.4	80.2-98.5	M	1.2	0.5	1.1	0.4	0.1
				L	11.1	6.1	2.6	0.9	0.2
				G	7.4	1.7	5.6	1.1	0.2
				S	11.3	2.9	2.1	1.2	0.4
				B	16.4	6.6	4.5	3.0	1.4
Siganus rivulatus	9	385-45.4	45.5-60.0	M	2.8	0.2	1.5	0.9	0.4
				L	11.7	9.8	6.5	1.0	0.2
				G	10.1	5.9	5.8	3.2	0.6
				S	13.8	5.0	5.0	3.5	1.7
				B	9.6	5.7	3.3	2.5	1.1

M: Muscle, L: Liver G: Gills, S: Stomach B: Brain

Table (2): Ratios of metal concentration in different organs to that in muscle tissues of the fish.

Fish species	Feeding	Organ/ muscle	Fe	Cu	Mn	Pb	Cd
D. sargus[(a)]	Crustacea, molluscus & fishes	L/ M	267.0	165.0	4.3	3.9	5.5
		G/ M	33.3	157.5	6.9	2.9	2.0
		S/ M	27.6	260.0	2.3	2.6	8.0
		B/ M	37.6	140.0	6.1	3.4	6.5
S. auratus[(a)]	Molluscus, crustacea, worms	L/ M	10.0	29.0	2.2	2.0	0.7
		G/ M	6.3	4.3	7.3	2.4	1.0
		S/ M	8.8	25.0	10.8	6.2	2.0
		B/ M	9.9	28.7	5.8	4.2	2.7
D. punctatus[(a)]	Small shoaling fish, & wide range of invertebrate as shrimps, brown crabs, & squids	L/ M	5.4	4.7	1.7	1.9	8.0
		G/ M	2.3	2.6	1.8	1.8	3.0
		S/ M	3.4	12.4	2.8	3.6	8.0
		B/ M	6.5	10.1	4.2	3.6	10.0
M. capito[(a)]	Minute bottom living planktonic organism, and on suspended matter	L/ M	9.3	12.2	2.4	2.3	2.0
		G/ M	6.2	3.4	5.1	2.8	2.0
		S/ M	9.4	5.8	1.9	3.0	4.0
		B/ M	13.7	13.2	4.1	7.5	14.0
S. rivulatus[(b)]	Algae, diatoms	L/ M	4.2	49.0	4.3	1.1	0.5
		G/ M	3.6	29.5	3.9	3.6	1.5
		S/ M	4.9	25.0	3.3	3.9	4.3
		B/ M	3.4	28.5	2.2	2.2	2.8

(a): Carnivorous fish *(b):* Herbivorous fish

Table (3): Comparison between trace metals concentrations (mg kg^{-1}) in muscles of the fish from El-Mex Bay and from elsewhere in the Mediterranean Sea.

Fish	**Fe**	Cu	**Mn**	**Pb**	**Cd**	**Reference**
Sparus auratus	11	0.3	0.5	0.5	0.3	Present study
	5.03	N.D	0.05	0.71	0.1	(1)
	19.0	9.5	2.0	-	0.14	(2)
	62.0	7.1	3.0	-	0.54	
	24.0	4.0	4.0	-	0.23	
Mugil capito	1.2	0.5	1.1	0.4	0.1	Present study
Mugil spp.	35.0-48.0 (41.5)	0.16-.0.31 (0.23)	0.26-0.42 (0.34)	1.91 -3.0 (2.46)	N.D	(3)
(Bay of Izmir)	3.9-15.7 (9.8)	0.69-1.11 (0.9)	0.27-0.65 (0.46)	2.9-3.2 (3.05)	0.17-0.26 (0.215)	(4)
M. auratus (Aegean coast)	-	5.1-90	5.2-8.1	12.5-18.0	-	(5)
Siganus rivlatus	2.8	0.2	1.5	0.9	0.4	Present study
	0.05	N.D	0.05	0.44	0.02	(1)
	-	8.0	-	0.60	0.023	(6)
S. luridus	78.2± 4.4	0.29± 0.02	0.82± 0.07	0.67± 0.03	N.D	(3)

ND: not detected.

(1) Shriadah and Emara (1992)
(2) Ezzat *et al*., (1985)
(3) Emara *et al*. (1993)
(4)Uysal and Tuncer (1982)
5)Uysal (1980)
(6)El-Nabawi *et al* (1987)

Table (4): Mean concentrations of the studied trace metals in the fish muscles and their percentage to the provisional tolerable (PTWI).

Fish species	**Mean concentration (mg/kg)**			**% of the present concentrations to that of PTWI**		
	Cu	**Pb**	**Cd**	**Cu**	**Pb**	**Cd**
D. Sargus sargus	0.04	0.8	0.2	0.002	3.29	7.67
Sparus auratus	0.30	0.5	0.3	0.014	2.05	11.50
Dicentrachus punctatus	0.70	0.8	0.1	0.033	3.29	3.83
Mugil capito	0.50	0.4	0.1	0.023	1.64	3.83
Siganus rivulatus	0.20	0.9	0.4	0.009	3.70	15.34

Calculated PTWI values Cu, Pb and Cd are 2121, 24.3 and 2.6 mg/ 70 kg man, respectively.

Results and Discussion

The analytical results (mg/kg on the dry weight basis), of the trace metals (Fe, Mn, Cu, Pb and Cd) in the muscle tissues and in different organs (liver, brain, stomach and gills) of the studied five Mediterranean fish species are shown in Table 1. A perusal of this table shows in all the tested fish species, high accumulation of these metals in different organs, with respect to those in the muscle tissues. Iron was the more dominant one among in the studied metals. Same results were also noticed by Vigh *et al* (1996) where trace metals were concentrated in kidney and liver than in muscle and gut of the fish. Also, Fe was of higher concentration compared to the toxic metals (Pb and Cd) in muscle tissue in all studied fish with the exception of *D. sargus* fish. Also, from Table 1, Fe, Cu and Mn concentrations were higher than those of the toxic metals Pb and Cd in all fish studied. These results are in accordance with the findings of Matta *et al* (1999) where, Fe was the most abundant one followed by Cu and Cd but in fish barracuda (*Sphyraena argentea*) liver.

Brain and gills of the tested fish (Table 1) gained a high level (10.9-88.1 mg/kg) of Fe than other metals in all studied fish except of *Sigarus rivulatus* where stomach had the highest Fe content (13.8 mg/kg). The increased concentration of the essential metals (Fe, Cu and Mn) reflects the increasing trophic level of the fish, as these metals are required metabolically by living organisms and the concentrations in the tissues may be actively regulated by these fish. The average concentrations of Cu in fish muscle and organs are shown in Table 1, that the lower concentration was found in muscle tissue where it was in the range 0.04-0.7 mg/kg dry weight. In addition, brain, stomach and liver showed high Cu level in all fish studied. It was also noted that *D. sargus* contained the highest level of Cu (10.4 mg/kg) in their stomach. These results are in line with that recorded by Moore and Ramamoorthy (1984), they reported that residues of copper in muscle tissue are low, and frequently decline with age and size of fish.

The concentrations of the toxic metal Pb and Cd were generally higher in fish organs than that detected in their muscles (Table 1). Lead concentration ranged between 1.2 and 3.5 mg/kg in the stomach while it ranged from 0.4-0.9 mg/kg in fish muscles. Also, brain had a high Pb concentration (2.1-3.0 mg/kg). These results agreed well with a study carried out by Zauke *et al* (1999) who stated that, concentration of Pb and Ni are below limits of detection in liver and muscles tissues of 15 marine species collected from Barents Sea.

Lead residues were detected in all fish samples collected (Table 1). The levels of Pb in muscle tissue are usually lower than those in organs. This may be explained by the relatively low rate of binding to SH groups (Moore and Ramamoorthy, 1984).

Cadmium concentration was generally lower than Pb concentration in various organs and its range is between 0.1-1.7 mg/kg also gills showed the lowest concentration as compared to other organs (Table 1). These results are not in line with that recorded by Sangalang and Freeman (1979) who found that, gills and the posterior kidney revealed a high metal content than other tissue. Also, stomach, brain and liver showed nearly the same concentration in various fish species (Table 1). These results agree with Romeo *et al* (1999) who declared that, Cd and Cu were present in low level in the muscle and gills and higher levels are encountered in the livers. On the other hand, toxic metals such as Pb and Cd have higher values in the stomach of the herbivorous fish *Siganus rivulatus* than carnivorous fishes (Table 1 and 2).

The obtained results in Table 2 indicate that the concentrations of trace metals are usually higher in organs than muscle tissue. For example, the liver: muscle ratio of cadmium for *D. sargus* and *Dicentrachus punctatus* were 5.5:1 and 8.0:1 respectively. A study by Mackay *et al* (1975) showed that the ratio of mercury in the liver:muscle in block marlin collected from Australia was 1.4:1. Also, a high organ:muscle ratio was observed in Cu concentration in *D. sargus sargus* where it were 165:1, 157.5:1, 260:1 and 140:1 in liver, gills, stomach and brain respectively (Table 2). These results are in same line with El Nabawi *et al.,* (1987) who detected that total residue are slightly higher in organs than in muscle tissue, for Hg, and Cd. In addition: the stomach : muscle ratio of Pb was high in *Sparus auratus*, *Dicentrachus punctatus* and *Siganau rivulatus* where these were 6.2 : 1, 3.6 : 1 and 3.9 : 1 respectively. Table (2) indicated also that the ratio of concentration of Pb of organs with that of muscle tissues was lower, while Cu ratios showed the highest values. Also Cu concentration ratios of *D. sargus* was higher than other elements where stomach ratio : muscle ratio was 260 : 1.

Results in Table (3) shows a comparison between trace metals concentration (mg/kg) in fish muscle in the present study with their correspondings reported elsewhere in the Mediterranean Sea. This table shows that, the level of concentration of Fe in the muscles of *Mugil* species was 1.2 mg/kg. This was lower than that found by Emara *et al* (1993) and Uysal and Tuncer (1982) (41.5 and 9.8 mg/kg, respectively, Table 3). On the other hand, the level of Cu and Mn (0.5 and 1.1 mg/kg respectively) in Mugil muscle were higher than what has been found by Emara *et al* (1993), (0.23 and 0.34 mg/kg respectively). Lead concentration in muscle of *Mugil capito* was 0.4 mg/kg, which is lower than what is reported by Emara *at al* (1993) and Uysal (1980), (Pb concentrations were 2.46 and 3.05 mg/kg respectively). The table also shows that Cd concentration of *Mugil* muscle was 0.1 mg/kg that agrees well with that of Uysal and Tuncer (1982). Concentration of Fe in muscles of *Siganus rivulatus* was 2.8 mg/kg, it is higher than the value recorded by Shriadah and Emara (1992), (Fe concentration was 0.05 mg/kg). Emara *et al* (1993) detected a high level of Fe concentration in muscles of *Siganus luridus* (78.2

mg/kg). Also Mn concentration (1.5 mg/kg) was higher than that reported by Shriadah and Emara (1992) and Emara *et* al (1993) where Mn concentrations were 0.05 and 0.82 mg/kg respectively. Copper concentration in *Siganus* muscles was 0.2 mg/kg. This concentr - ation is lower than the value (8 mg/kg) reported by El Nabawi *et al* (1987). The concentration of the toxic metals Pb and Cd in muscles of *Siganus* species were 0.9 and 0.4 mg/kg respectively. These results are higher than what has been found by Shriadah and Emara (1992) and El Nabawi *et al* (1987).

The results in Table (3) indicated that, all fish studied did not enrich the metals to dangerous levels compared with that found e.g. in Bay Izmir (Uysal and Tuncer, 1982). At the same time the present results revealed the presence of a high level of Cd particularly in the fish organs with respect to those of Health Standards levels (0.5 mg/kg) established by US National Academy of Science (1972). So far in many countries there are no maximum allowable limits for such toxic metals Cd and Pb in the edible parts of fish (Falandysz, 1985). However, the recommendations of National Health and Medical Research Council of Australia (NHMRC) specify that, the concentrations of Cd and Pb in the edible parts of fish should not exceed 2.0 mg/kg (Bebbington *et al*, 1977). In contrast to NHMRC level, the Western Australian Food and Drug Regulations gave concentrations of 5.5 and 40 mg/kg for Cd and Zn respec - tively as reported by Plaskett and Potter (1979). Although most of the fish samples in the present study showed Cd levels closed to that of the NHMRC (2.0 mg/kg) in their organs, non-of them contained Cd concentrations in their muscle tissues exceeding 0.5 mg/kg.

The risk to man from consum - ption of metals in fish has been discussed by Bernhard (1982). This can be estimated by comparing the metal intake from an observed consumption rate of fish with a Provisional Tolerable Weekly Intake (PTWI), for the metals Pb, Cu and Cd. The respective PTWI values for these three metals were calculated to be 24.5, 2121 and 2.6 mg per 70 kg man. An estimation for the percentage of the concentrations obtained in the present study to that of these metals was made and listed in (Table 4). This table demonstrates that, the concentration of these metals in fish would be extremely lower than PTWI values and accordingly, the human consumption of fish caught from the Alexandria region is safe. Therefore, it does not pose a health hazard, but protection of the aquatic environment is warranted to preserve this important part of the traditional diet. Moreover, regular monitoring of pollutants in fish and other biota are essential from the point of view environmental toxicology and set database for these researches.

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تقييم تركيز المعادن الثقيلة فى بعض اسماك شواطى الإسكندرية

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أستاذ مساعد ببرنامج حماية البيئة – الأكاديمية العربية للعلوم والتكنولوجيا والنقل البحري

في هذه الورقة البحثية تم تعيين تركيز عناصر النحاس والحديد والمنجنيز فى الاعضاء والأحشاء الداخلية (الخياشيم –الكبد-الأمعاء والمخ) لخمسة أنواع من الأسماك تم تجميعها من خليج المكس بالإسكندرية أربعة أنواع من هذه الأسماك صنفت كآكلة لحوم وهى الشرغوش والدنيس والقاروص والبوري الحر أما النوع الخامس(البطاطا) فهو من آكل الأعشاب.

أظهرت نتائج البحث ارتفاع نسبة تركيز هذه المعادن فى كل أعضاء الأسماك موضع الدراسة بالنسبة لتركيزها فى أنسجة لحومها .

وأوضحت الدراسة أن معامل التركيز لهذه المعادن عالي فى الأسماك نباتية التغذية فتراوح تركيز الرصاص من 1,2 إلى 3,5 ملليجرام لكل كيلو جرام من المخ والأمعاء فى حين تراوح بين 0,4 إلى 0,9 ملليجرام لكل كيلوجرام من الأنسجة اللحمية لهذه الأسماك. أما بالنسبة لتركيز الكادميوم فكان أقل من تركيز الرصاص فى معظم الاعضاء الداخلية فى حين ظهر أكبر تركيز فى المخ.

وأظهرت النتائج أيضا أن مستوى تركيز عنصري الرصاص والكادميوم فى الأسماك النباتية التغذية كانت أعلى من مستواها فى الأسماك حيوانية التغذية. وكان مستوى تركيز عنصر الكادميوم فى معظم أعضاء الأسماك موضع الدراسة فى حدود المستوى المسموح به عالميا وهو 2 ملليجرام لكل كيلوجرام. وبحساب متوسط استهلاك الفرد من الأسماك موضع الدراسة نجد أن نسبة مايدخل جسم الإنسان من هذه المعادن الثقيلة مازال أمناً