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Fe , Cu , Mn , Pb AND Cd IN SOME FISH SPECIES FROM WESTERN HARBOUR OF ALEXANDRIA , EGYPT

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ABSTRACT

Concentrations of Fe, Cu, Mn, Pb and Cd were determined in muscle and different organs of 7 different fish species from Western Harbour of Alexandria namely ***Diplodus sargus sargus*** *(Linnaeus 1758),* ***Sparus auratus*** *(linnaeus, 1758),* ***Dicentrachus punctatus*** *(Bloch, 1792),* ***Mugil capito*** *(Cuvier, 1829),* ***Morone labrax*** *(Linnaeus, 1758),* ***Lithognatus mormyrus*** *(Linnaeus, 1758)* and ***Siganus rivulatus*** *(Forsskal, 1775).* The results indicated a high level of accumulation for these elements in different organs of all fish studied, while their concentration in the muscle tissue showed the reverse. Toxic metals (Pb and Cd) have higher values in herbivorous fishes than in carnivorous one. Although most of the fish samples showed levels higher than National Health and Medical Council in Australia NHMRC recommendations (2.0 mg/kg in their organs), none of them contained cadmium concentrations in their muscle tissues above 0.5 mg/kg. Accumulation factor was found to be high in *Siganus rivulatus* for both Pb and Cd. By comparing the metal intake from consumption rate of fish with a Provisional Tolerable Weekly Intake (PTWI) demonstrated that, there is no risk from the human consumption of these fishes.

INTRODUCTION

Studies of heavy metals in fish are an important aspect of environmental pollution control because human activities progressively increase the concentrations of heavy metal in aquatic system. The study of fish muscle tissues is one of the means for investigating the amount of heavy metals reaching man by food chain and has therefore been investigated more than other organs. These trace contaminants may have the effects on the ecosystem greater than those of the more common pollutants. Many of trace metals are known to be concentrated by marine organisms in food chain (El-Sokkary, 1980; Morales, 1980; Uysal, 1980 ; Emara, 1982 and Shriadah and Emara, 1992).

In the Western Harbour of Alexandria (Fig.1) , pollutant metals may be derived from anthropogenic activities , especially from industrial, agricultural and domestic effluents via different sources:

1) El-Noubaria Canal, which passes across Lake Maryt discharges 9000 cubic meters daily of fresh waters, loaded with suspended substances.
2) Several outfalls at El-Mahmoudia Canal introduce remarkable amounts of untreaed domestic wastes.
3) El-Mex Pumping Station discharges 6 million cubic meters daily of polluted brackish waters.

Because of the scarcity of available data about the contamination levels of biota in Western Harbour by heavy metals, the present work introduces the results of studies on the levels of iron, copper, manganese, lead and cadmium in both muscle tissues and different organs for each of ***Diplodus sargus sargus*** *(Linnaeus, 1758),* ***Sparus auratus*** *(Linnaeus, 1758),* ***Dicentrachus punctatus*** *(Bloch, 1792),* ***Mugil capito*** *(Cuvier, 1829),* ***Morone labrax*** *(Linnaeus, 1758),* ***Lithognatus mormyrus*** (Linnaeus, 1758) and ***Siganus rivulatus*** *(Forsskal, 1775).*

MATERIALS AND METHODS

Fish samples (***Diplodus sargus sargus,Spatus auratus,Dicentrachus punctatus, Mugil capito, Morone labrax, Lithognatus mormyrus*** and ***Siganus rivulatus***) were collected from local fishermen at the Western Harbour of Alexandria and kept frozen (-20°C) perior to analysis, identified and prepared

for analysis according to Bernhard (1976). The different organs, i.e. muscle tissues, livers, gills, gonads, stomachs, intestinals and brains were collected separately for each species and homogenized to make composite sample. From each composite sample , 2 g were taken as analytic sample and digested with concentrated nitric acid inside closed teflon crucible in a steel block and a hotplate with thermostatic control. Wet digested samples were diluted with distilled water and analyzed using a Unicam SP 1900 atomic absorption spectrophotometer (AAS). Several water samples from different location of the studied area were colleccted and analyzed for determination of trace metals according the Standard methods, 1985.

RESULTS AND DISCUSSION

The results of water analysis indicated that the mean concentration of Cu, Pb, and Cd were 9,7, 62.2 and 26.8 µg/liter respectively. Mean concentrations of iron, manganese, lead and cadmium in the muscle and different organs of ***Diplodus sargus sargus, Sparus auratus, Dicentrachus punctatus , Mugil capito , Morone labrax , Lithognatus mormyrus*** and ***Siganus rivulatus*** are shown in Table (1). A perusal of this table shows that high levels of accumulation for these trace elements were observed in different organs of all fish studied, while their concentrations in the muscle tissues shows the reverse.

The ratio of trace metal concentrations (organs/muscle) was highest for copper in the gonads of *Sargus sargus* (360 times). The relative accumulation was more pronounced for the metals iron, copper and manganese in these studied fish.

In all fish studied, higher concentrations of the essential metals manganese, iron and copper reflect the increasing trophic level of the fish. These three metals are required metabolically by living organisms and the concentrations in the tissues may be actively regulated by these fishes. On the other hand, toxic metals such as lead and cadmium have higher values in herbivourus fish ***Siganus rivulatus*** than ***Carnivourus fishes*** (Tables 1 and 2).

Table (1): Concentrations of trace elements (mg kg^{-1}) in different fish species.

Fish species	*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	8.1	6.6	3.0	3.1	1.1
				Gi	10.0	6.3	4.8	2.3	0.4
				Go	16.2	14.4	7.1	4.0	2.2
				S	8.3	10.4	1.6	2.1	1.6
				I	17.7	3.2	5.6	2.8	0.7
				B	11.3	5.6	4.3	2.7	1.3
Sparus auratus	6	21.5-25.7	75.5-190.2	M	1.1	0.3	0.5	0.5	0.3
				L	11.0	8.7	1.1	1.0	0.2
				Gi	6.9	1.3	3.7	1.2	0.3
				Go	37.2	15.9	10.7	5.7	2.2
				S	9.7	7.5	5.4	3.1	0.6
				I	10.3	6.6	3.5	3.0	0.5
				B	10.9	8.6	2.9	2.1	0.8
Dicentrachus punctatus	7	20.5-24.5	25.5-195.8	M	2.4	0.7	1.3	0.8	0.1
				L	12.9	3.3	2.2	1.5	0.8
				Gi	5.5	1.8	2.4	1.4	0.3
				Go	14.4	8.9	4.0	4.4	1.4
				S	8.2	8.7	3.6	2.9	0.8
				I	12.7	3.3	1.4	2.5	0.3
				B	15.5	7.1	5.5	2.9	1.0
Mugil capito	8	1.7-24.4	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
				Gi	7.4	1.7	5.6	1.1	0.2
				Go	20.6	11.1	9.1	3.2	1.7
				S	11.3	2.9	2.1	1.2	0.4
				I	15.0	4.2	1.8	1.8	0.7
				B	16.4	6.6	4.5	3.0	1.4

Table (1): Continued.

Fish species	*N⁰*	*Length (cm)*	*Weight (g)*	*Organ*	*Fe*	*Cu*	*Mn*	*Pb*	*Cd*
Morone labrax	6	24-27.9	65.5-180.5	M	1.7	0.3	2.5	0.5	0.2
				L	10.9	7.2	3.5	1.1	1.5
				Gi	1.7	1.4	4.0	1.4	0.1
				Go	30.5	14.7	6.7	4.0	2.1
				S	8.4	2.7	5.1	1.6	2.0
				I	17.2	4.6	1.9	1.4	0.2
				B	13.4	11.4	2.8	2.5	1.0
Lithognatus mormyrus	7	16.6-18.5	00.2-120.3	M	3.3	0.5	3.0	0.7	0.1
				L	12.1	10.7	5.3	3.2	1.7
				Gi	4.4	3.0	2.4	2.1	0.4
				Go	35.8	11.8	6.6	5.7	2.0
				S	9.4	6.2	3.4	3.7	0.8
				I	13.1	2.5	4.6	4.0	0.8
				B	18.4	11.7	3.0	3.0	1.0
Siganus rivulatus	9	38.5-45.4	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
				Gi	10.1	5.9	5.8	3.2	0.6
				Go	31.0	10.0	6.8	3.8	1.9
				S	13.8	5.0	5.0	3.5	1.7
				I	19.2	1.6	4.3	2.2	0.7
				B	9.6	5.7	3.3	2.5	1.1

N⁰: Number of fish species in each composite samples.

Results are expressed as the mean of duplicate determination for two composite samples.

M: Muscle tissues L: Livers Gi: Gills
Go: Gonads S: Stomachs I: Intestins
B: Brains

Table (2): Ratios of concentration of trace metals in different organs of the fish with that of muscle tissues.

Fish species	***Feeding***	***Organ / muscle***	***Fe***	***Cu***	***Mn***	***Pb***	***Cd***
D. sargus sargus	crustacea, molluscus, fishes	L / m	27.0	165.0	4.3	3.9	5.5
		Gi / m	33.3	157.5	6.9	2.9	2.0
		Go / m	54.0	360.0	10.1	5.0	11.0
		S / m	27.6	260.0	2.3	2.6	8.0
		I / m	59.0	80.0	8.0	3.5	3.5
		B / m	37.6	140.0	6.1	3.4	6.5
Sparus auratus	molluscus, crustacea, worms	L / m	10.0	29.0	2.2	2.0	0.7
		Gi / m	6.3	4.3	7.4	2.4	1.0
		Go / m	33.8	53.0	21.4	11.4	7.3
		S / m	8.8	25.0	10.8	6.2	2.0
		I / m	9.4	22.0	7.0	6.6	1.7
		B / m	9.9	28.7	5.8	4.2	2.7
Dicentrachus punctatus	small shoaling fish,wide range of invertebrate such as shrimps, brown crabs, squids	L / m	5.4	4.7	1.7	1.9	8.0
		Gi / m	2.3	2.6	1.8	1.8	3.0
		Go / m	6.0	12.7	3.0	5.5	14.0
		S / m	3.4	12.4	2.8	3.6	8.0
		I / m	5.3	4.7	1.0	3.1	3.0
		B / m	6.5	10.1	4.2	3.6	10.0
Mugil capito	minute bottom living, planktonic organism, also on suspended matter	L / m	9.3	12.2	2.4	2.3	2.0
		Gi / m	6.2	3.4	5.1	2.8	2.0
		Go / m	17.2	22.2	8.3	8.0	17.0
		S / m	9.4	5.8	1.9	3.0	4.0
		L / m	12.5	8.4	1.6	4.5	7.0
		I / m	13.7	13.2	4.1	7.5	14.0

Table (2): Continued.

Fish species	*Feeding*	*Organ / muscle*	*Fe*	*Cu*	*Mn*	*Pb*	*Cd*
Morone labrax	minute bottom	L / m	6.4	24.0	1.4	2.2	7.5
	living,	Gi / m	1.0	4.7	1.6	2.8	0.5
	planktonic	Go / m	17.9	49.0	2.7	8.0	10.5
	organism, also	S / m	4.9	9.0	2.0	3.2	10.0
	on suspended	I / m	10.1	15.3	0.8	2.8	1.0
	matter	B / m	7.9	38.0	1.1	5.0	5.0
Lithognatus mormyrus	Crustacea,	L / m	3.7	3.4	1.8	4.6	17.0
	fishes	Gi / m	1.3	6.0	0.8	3.0	4.0
		Go / m	10.8	23.6	2.2	8.1	20.0
		S / m	2.8	12.4	1.1	5.3	8.0
		I / m	4.0	5.0	1.5	5.7	8.0
		B / m	5.6	23.4	1.0	4.3	10.0
Siganus rivulatus	Sea weeds	L / m	4.2	49.0	4.3	1.1	0.5
		Gi / m	3.6	29.5	3.9	3.6	1.5
		Go / m	11.0	50.0	4.5	4.2	4.8
		S / m	4.9	25.0	3.3	3.9	4.3
		I / m	6.9	8.0	2.9	2.4	1.8
		B / m	3.4	28.5	2.2	2.2	2.8

Mean muscle concentrations of trace metals in ***Mugil*** spp. , ***Chrysophyrus auratus*** and ***Lithognatus mormyrus*** with the exception of iron were generally much higher than the limited data reported by Emara et al.(1993). Also, previous studies conducted by Shriadah and Emara (1992) , Emara ***et al.***(1993) showed a relatively low levels of Cu, Mn, Pb and Cd in the flesh of ***Siganus*** spp. than those reported in the present study. In contrast, these values were much lower than those reported by Uysal and Tuncer (1982) in ***Mugil*** spp. from Bay of Izmir (Table 3). These results indicated that, all fish studied did not reach the degree of dangerous compared with those found in the Bay of Izmir, also the results give a good declaration of the increase of metal pollution in the study area due to continuously discharging industrial, agricultural and domestic effluents.

The present study revealed higher levels of cadmium particularly in the different organs compared with 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 tolerance limits for such toxic metals as cadmium and lead in the edible parts of fish (Falandysz, 1985). The recommendations of National Health and Medical Research Council in Australia (NHMRC) specify that the concentrations of cadmium and lead in the edible parts of fish should not exceed 2.0 mg/kg. (Bebbington ***et al.***, 1977). In contrast to NHMRC levels, the Western Australian Food and Drug Regulations gave concentrations of 5.5 and 40 mg/kg for Cd and Zn, respectively as reported by Plaskett and Potter (1979). Although most of the fish samples showed levels higher than 2.0 mg/kg in their organs, none of them contained cadmium concentrations in their muscle tissues above 0.5 mg/kg.

The highest concentration factors for the investigated species for Pb and Cd were found in ***Siganus rivulatus*** where they were 14.5 and 14.9 respectively, that for the Cu was found for ***Dicentrachus punctatus***.

The risk to man from consumption 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 cadmium, copper and lead, PTWI values were calculated to be 300, 245000 and 2800 µg per 70 kg man , respectively. The percentage of the present concentrations to that of PTWI was estimated for these metals (Table (5). This table demonstrates that, the concentrations of race metals in fish reported in this study would be much lower than the PTWI values and accordingly there is no risk from the human consumption of these fish.

Table (3): Comparison between trace metals concentrations (mg kg^{-1}) in the fish muscles in the present study with those reported elsewhere in the Mediterranean Sea.

Fish species	*Fe*	*Cu*	*Mn*	*Pb*	*Cd*	*Reference*
Sparus auratus	1.1 5.03	0.3 N.D	0.5 0.05	0.5 0.71	0.3 0.1	Present study Shriadah and Emara(1992)
Mugil capito *Mugil* spp.	1.2 35.0-48.0 (39)	0.5 0.16-0.31 (0.23)	1.1 0.26-0.42 (0.35)	0.4 1.91-3.0 (2.67)	0.1 N.D	Present study Emara *et al.* (1993)
Mugil spp. (Bay of Izmir)	3.9-15.7	0.69-1.11	0.27-0.65	2.9-3.2	0.17-0.26	Uysal and Tuncer(1982) Uysal (1980)
Mugil auratus (Aegean coast)	-	5.1-9.0	5.2-8.1	12.5-18.0	-	
Lithognatus mormyrus	3.3 2.05	0.5 N.D	3.0 0.22	0.7 1.14	0.1 0.13	Present study Shriadah and Emara(1992)
Siganus rivulatus " "	2.8 0.05	0.2 N.D	1.5 0.05	0.9 0.44	0.4 0.02	Present study Shriadah and Emara(1992)
" "	-	8.0	-	0.60	0.023	El-Nabawi *et al.*(1987)
Siganus luridus	78.2±4.4	0.29±0.02	0.82±0.07	0.67±0.03	N.D	Emara *et al.* (1993)

Table (4): Concentration factors of Cu, Pb and Cd in different fish muscle studied.

Fish species	*Cu*	*Pb*	*Cd*
D. *sargus sargus*	0.4	12.9	7.5
Sparus auratus	3.2	8.0	11.2
Dicentrachus punctatus	7.5	12.9	3.7
Mugil capito	5.3	6.4	3.7
Morone labrax	1.0	8.0	7.5
Lithognatus mormyrus	5.3	11.3	3.7
Siganus rivulatus	2.1	14.5	14.9

Table (5): Mean concentrations of trace metals Cu , Cd and Pb in fish samples and their percentage of Provisional Tolerable Weekly Intake (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
Morone labrax	0.30	0.5	0.2	0.014	2.05	7.67
Lithognatus mormyrus	0.50	0.7	0.1	0.023	2.87	3.83
Siganus rivulatus	0.20	0.9	0.4	0.009	3.70	15.34

REFERENCES

American Public Health Association, 1985. Standard methds for examination of water and waste water. Washington, 16th Ed. D.C. 1268 pp.

Bebbington, G.N.; Mackay, N.J.; Chvoika, R.; William, R.J.; Dunn, A. and Auty, E.H. (1977). Heavy metals selenium and arsenic in nine species of Australian commercial fish. Aust. J. Mar. Freshwater Res., 28: 277-286.

Bernhard, M. (1976). Manual of methods in aquatic environment research: Sampling and analysis of biological materials. FAO Fisheries Tech. Paper No.158 FIRI/TI58, Part 3, 1-23, Rome.

Bernhard, M. (1982). Levels of trace metals in the Mediterranean (Review Paper). VIes Journees Etud. Pollutions, Cannes, CIESM, pp.237-243.

El-Nabawi, A.; Heinzow, B. and Kruse, H. (1987). As, Cd, Cu, Pb, Hg ancwd Zn in fish from the Alexandria region. Bull. Environ. Contam. Toxicol., 39: 889-897.

El-Sokkary, I.H. (1980). Mercury accumulation in fish from the Mediterranean coastal area of Alexandria, Egypt. Ves Journees Etud. Poll., Caliari, C.I.E.S.M., 493-496.

Emara, H.I. (1982). Study of some heavy metals in Abu-Qir Bay and Lake Edku. Ves Journees Etud. Poll. Cannes, C.I.E.S.M., 395-399.

Emara, H.I.; El-Deek, M.S. and Ahmed, N.S. (1993). Comparative study on the levels of trace metals in some Mediterranean and Red Sea fishes. Chem. and Ecology, 8: 119-127.

Falandysz, J. (1985). Trace metals in flat fish from the southern Baltic, Z. Lebensm Unters Forsch, 181: 117-120.

Morales MIN, B. (1980). Determination of trace elements in otoliths of sea fish reared in tanks. Ves Journees Etud. Poll., Cagliari, C.I.E.S.M., 369-372.

National Academy of Sciences, National Academy of Engineering (1972). Section III - Freshwater aquatic life and wildlife, and Section IV - Marine aquatic life and wildlife. Pages 106-296 in Water Quality Criteria. Ecological Research Series, EPA-R3- 73-033, March 1973, NAS, Washington, DC.

1979). Heavy metal concentrations in the muscle tissue of 12 species of teleost from Cockburn Sound, Western Australia. Aust. J. Mar. Freshwater Res., 30: 609-616.

Shriadah, M.M.A. and H.I. Emara (1992). Iron, Manganese, nickel, lead, and cadmium in fish and crustacea from the Eastern Harbour and El-Mex Bay of Alexandria. Bull. High Inst. Public Health, Vol. XXII, No 3, 515-525.

Uysal, H. (1980). Levels of trace elements in some food chain organisms from the Aegean coasts. Ves Journees Etud. Poll., Cagliari, C.I.E.S.M., 503-512.

Uysal, H. and S. Tuncer (1982). Levels of heavy metals in some commercial food species in the Bay of Izmir (Turkey). VIes Journees Etud. Poll., Cannes., C.I.E.S.M., 323-327.