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Trace Metals Content in Three Fish Species from Northern Part of the Suez Gulf, Red Sea, Egypt

MAHMOUD A. ABDELMONEIM*,
KHALID M. EL-MOSELHY** and SAMEH H. HASSAN***
*National Institute of Oceanography and Fisheries, Alexandria, Egypt,
**National Institute of Oceanography and Fisheries, Suez, Egypt,
***Zoology Dept., Faculty of Science, El-Mansoura Univ., Egypt

ABSTRACT. Samples of *Sardinella gibbosa*, *Saurida* sp. and *Epinephelus* sp. were collected from the Suez Gulf (Red Sea) and their organs were analyzed by flame atomic absorption spectrophotometer for some trace metals (cadmium, lead, copper and zinc). The results showed that the metals accumulate in the other organs to greater extent than in the muscle. The lowest accumulated metal is cadmium, while the highest is zinc. The elevated levels of zinc in *Sardinella gibbosa* and *Epinephelus* sp. were attributed to the intake of food from the polluted environment (area of oil fields). On the other hand, cadmium and lead recorded their highest values in *Epinephelus* sp. and *Saurida* sp. (carnivorous fishes), while zinc recorded in pelagic fish *Sardinella gibbosa* (herbivorous fish). The essential elements such as zinc and copper are accumulated in soft tissues as liver and gonads while the non-essential elements such as lead and cadmium are accumulated in hard tissues (bone and gills).

Introduction

The concentration of trace metals in marine fishes has received much attention, mainly concerned with the commercial ones. Since high levels of these metals in these species represent a potential human health hazard. The contamination level in fish reflected the water characteristics near industrialized locations compared to more distant water. Many countries have established guidelines regulation and procedure for application of trace metals.

Heavy metals such as cadmium (Cd), copper (Cu), lead (Pb) and zinc (Zn) introduced into the marine environment from effluents and river runoff, may concentrate in marine organisms by a factor ranging from 1000 to 10000 time (Virogradov, 1953). This means that marine organisms can store pollutants and then transfer them ultimately to human beings (El-Sokkary, 1980 and Uysal, 1980). As fishes are considered one of the most important groups on the top of aquatic food chain, they also clearly reflect the water quality (Roth and Hornung, 1977 and Abdelmoneim, 1994).

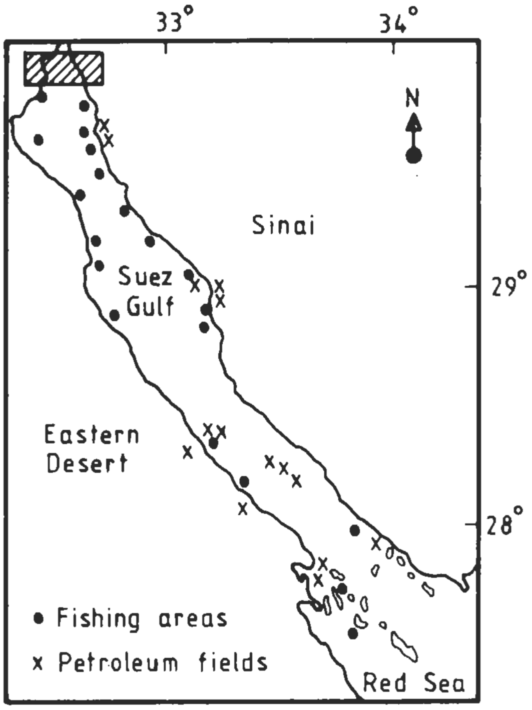
Within the Egyptian sector of Red Sea, the Suez Gulf is the most productive sector. Because the bottom of this area is suitable for trawling, thus fishing is concentrated in this gulf. The variety and abundance of different fish and crustaceans in the gulf may be attributed to its high primary productivity (Nassar, 1994).

Pollution in the Suez Gulf has increased in the recent years, through the ship's oil and refuse, several industrial drains and domestics drainage in the northern part and many oil fields in the southern part of the gulf (Fig. 1). Description of Suez Gulf and its neighbourhood area has been previously mentioned elsewhere (Awad *et al.*, 1983 and El-Sabh & Beltagy, 1983).

In the present investigation, concentration and bioaccumulation of Cd, Pb, Cu and Zn have been estimated in organs of three fish species namely, *Sardinella gibbosa, Saurida* sp. and *Epinephelus* sp. representing all fishing techniques (trawling, purse-seine and artisinal) in Suez Canal (Yousif, 1990).

Materials and Methods

Fish specimens (*Sardinella gibbosa, Saurida* sp. and *Epinephelus* sp.) were collected seasonally (spring 1991 – winter 1992) from the Suez Gulf by local fisherman.



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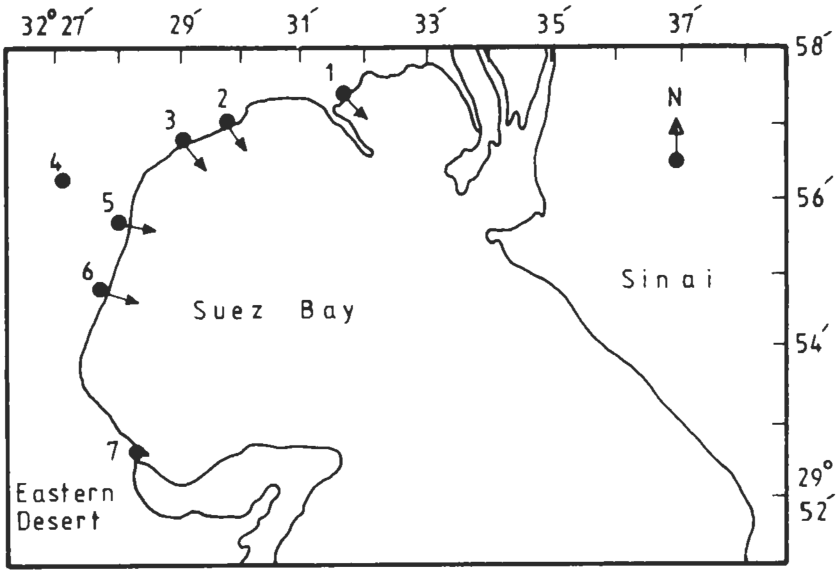

FIG. 1. Map of the northern part of Suez Gulf "Suez Bay"

1 – Nasr Petroleum Company. } Oil Refineries
2 – Suez Oil Producing Company. } Oil Refineries
3 – Municipal Sewage.
4 – Fertilizer Producing Company.
5 – Power Station.
6 – National Institute of Oceanography and Fisheries (NIOF).
7 – Ataka.

Weight and length of fish were estimated, then the organs (muscle, gills, liver, gonads, skin, bone and brain) were separated and stored in deep freezer (–20°C) according to FAO (1983) and UNEP/FAO/IAEA/IOC (1984) until time of analysis.

The soft tissues were digested in concentrated HNO_3 acid only, while the hard tissues were digested in concentrated HNO_3 and $HClO_4$ acids (FAO, 1976). Wet digested samples were diluted with deionized distilled water and analyzed using flame atomic absorption spectrophotometer (AAS) Buck Scientific, Model 200 A. The results were expressed in μg/g (ppm) wet weight.

Results and Discussion

Tables (1, 2 & 3) show the seasonal variation in the metals, Cd, Pb, Cu and Zn, in organs of fish species, *Sardinella gibbosa, Saurida* sp. and *Epinephelus* sp. Cadmium had its low value in muscle of *Sardinella gibbosa* (0.09 ppm) and high value in liver of *Saurida* sp. (2.15 ppm). Minimum and maximum values of lead

TABLE 1. Average and standard error of Cd, Pb, Cu and Zn in the organs of *Sardinella gibbosa* collected from Suez Gulf during 1991-1992 (ppm).

Metal	Season / Organ	Spring	Summer	Autumn	Winter
Cd	Muscle	0.14 ± 0.04	0.13 ± 0.04	0.09 ± 0.03	0.13 ± 0.04
	Gills	0.57 ± 0.07	0.72 ± 0.06	0.48 ± 0.08	0.36 ± 0.05
	Liver	0.67 ± 0.06	0.62 ± 0.12	0.37 ± 0.03	0.34 ± 0.03
	Gonads	0.18 ± 0.05	0.38 ± 0.09	0.22 ± 0.02	0.20 ± 0.02
	Skin	0.38 ± 0.07	0.68 ± 0.08	0.38 ± 0.02	0.40 ± 0.06
	Bone	0.83 ± 0.05	0.91 ± 0.08	0.85 ± 0.06	0.79 ± 0.07
	Brain	0.39 ± 0.04	0.19 ± 0.04	0.53 ± 0.12	0.15 ± 0.02
Pb	Muscle	0.78 ± 0.29	0.94 ± 0.21	0.69 ± 0.21	0.39 ± 0.10
	Gills	3.96 ± 0.65	3.36 ± 0.42	3.02 ± 1.03	2.17 ± 0.37
	Liver	3.67 ± 0.60	3.81 ± 1.40	2.04 ± 0.22	1.61 ± 0.37
	Gonads	0.82 ± 0.27	4.89 ± 0.04	1.42 ± 0.30	0.94 ± 0.15
	Skin	4.44 ± 0.68	4.58 ± 0.47	5.82 ± 1.13	3.30 ± 0.40
	Bone	3.49 ± 0.22	5.29 ± 0.39	3.68 ± 0.38	3.40 ± 0.49
	Brain	3.03 ± 0.02	1.75 ± 0.13	3.96 ± 0.64	0.42 ± 0.02
Cu	Muscle	1.30 ± 0.37	0.20 ± 0.06	0.20 ± 3.39	0.59 ± 0.10
	Gills	1.48 ± 0.34	0.51 ± 0.10	0.45 ± 0.09	0.95 ± 0.14
	Liver	4.27 ± 0.77	2.55 ± 0.89	2.32 ± 0.13	4.79 ± 0.16
	Gonads	1.45 ± 0.49	1.97 ± 0.58	0.73 ± 0.09	1.40 ± 0.19
	Skin	2.37 ± 0.48	1.34 ± 0.35	1.25 ± 0.04	2.20 ± 0.19
	Bone	1.43 ± 0.50	0.99 ± 0.21	0.33 ± 0.03	1.43 ± 0.18
	Brain	1.27 ± 0.35	0.76 ± 0.07	1.42 ± 0.20	0.38 ± 0.01
Zn	Muscle	7.29 ± 3.3	21.41 ± 2.5	20.91 ± 3.4	20.19 ± 3.4
	Gills	49.60 ± 7.4	63.92 ± 3.2	80.76 ± 6.8	66.02 ± 4.0
	Liver	25.23 ± 4.1	77.36 ± 12.2	50.22 ± 1.7	55.07 ± 1.2
	Gonads	29.97 ± 8.4	123.98 ± 9.2	140.77 ± 4.0	147.08 ± 0.1
	Skin	93.84 ± 5.2	91.23 ± 3.0	121.70 ± 2.6	156.19 ± 1.6
	Bone	30.49 ± 3.3	64.90 ± 2.9	76.82 ± 7.6	69.69 ± 3.1
	Brain	20.76 ± 6.5	57.68 ± 0.8	41.96 ± 1.9	24.33 ± 1.7

TABLE 2. Average and standard error of Cd, Pb, Cu and Zn in the organs of *Saurida* sp. collected from Suez Gulf during 1991-1992 (ppm).

Metal	Season / Organ	Spring	Summer	Autumn	Winter
Cd	Muscle	0.14 ± 0.04	0.18 ± 0.05	0.16 ± 0.03	0.11 ± 0.04
	Gills	0.69 ± 0.08	0.76 ± 0.05	0.62 ± 0.06	0.60 ± 0.06
	Liver	0.42 ± 0.06	2.15 ± 0.24	0.19 ± 0.05	0.24 ± 0.05
	Gonads	0.23 ± 0.03	0.59 ± 0.09	0.14 ± 0.05	0.26 ± 0.04
	Skin	0.36 ± 0.05	0.43 ± 0.06	0.39 ± 0.05	0.48 ± 0.07
	Bone	0.82 ± 0.05	1.34 ± 0.03	1.03 ± 0.06	0.87 ± 0.07
	Brain	0.40 ± 0.03	0.64 ± 0.14	0.34 ± 0.10	0.27 ± 0.04
Pb	Muscle	0.69 ± 0.15	0.25 ± 0.05	1.78 ± 0.74	0.35 ± 0.05
	Gills	3.17 ± 0.32	1.95 ± 0.45	2.79 ± 0.35	2.17 ± 0.18
	Liver	1.71 ± 0.27	0.76 ± 0.15	1.79 ± 0.16	1.70 ± 0.19
	Gonads	1.14 ± 0.32	0.59 ± 0.25	2.23 ± 0.97	0.28 ± 0.02
	Skin	1.83 ± 0.21	0.80 ± 0.23	3.39 ± 0.41	2.13 ± 0.37
	Bone	3.79 ± 0.35	4.90 ± 0.45	5.19 ± 0.34	3.58 ± 0.55
	Brain	3.54 ± 0.33	0.61 ± 0.20	3.14 ± 1.50	0.63 ± 0.10
Cu	Muscle	0.41 ± 0.08	0.72 ± 0.29	0.27 ± 0.03	0.61 ± 0.15
	Gills	2.03 ± 0.67	1.26 ± 0.21	1.24 ± 0.56	1.32 ± 0.20
	Liver	8.78 ± 0.81	6.80 ± 0.31	9.13 ± 1.60	11.82 ± 1.1
	Gonads	0.60 ± 0.16	1.32 ± 0.27	3.31 ± 2.55	1.36 ± 0.08
	Skin	1.10 ± 0.31	3.26 ± 2.06	1.85 ± 0.55	2.44 ± 0.29
	Bone	1.04 ± 0.16	1.42 ± 0.27	1.67 ± 1.10	1.48 ± 0.16
	Brain	3.79 ± 0.45	2.27 ± 0.61	0.27 ± 0.04	1.06 ± 0.17
Zn	Muscle	6.64 ± 3.1	8.92 ± 1.2	8.08 ± 1.1	4.52 ± 1.5
	Gills	37.28 ± 3.1	44.91 ± 2.3	52.53 ± 2.8	53.92 ± 4.1
	Liver	44.32 ± 4.0	55.42 ± 3.4	66.71 ± 5.3	64.35 ± 5.1
	Gonads	22.54 ± 3.9	30.79 ± 5.7	64.05 ± 14.9	67.74 ± 3.3
	Skin	13.07 ± 3.5	26.57 ± 2.2	60.15 ± 4.4	42.77 ± 2.7
	Bone	33.00 ± 7.0	50.15 ± 2.6	55.14 ± 3.1	50.50 ± 3.0
	Brain	4.37 ± 1.0	21.83 ± 5.6	19.60 ± 4.9	12.61 ± 3.7

TABLE 3. Average and standard error of Cd, Pb, Cu and Zn in the organs of *Epinephelus* sp. collected from Suez Gulf during 1991-1992 (ppm).

Metal	Season / Organ	Spring	Summer	Autumn	Winter
Cd	Muscle	0.17 ± 0.03	0.28 ± 0.09	0.17 ± 0.05	0.32 ± 0.04
	Gills	0.79 ± 0.06	1.05 ± 0.07	0.91 ± 0.06	1.01 ± 0.15
	Liver	0.50 ± 0.11	1.17 ± 0.21	0.34 ± 0.04	0.58 ± 0.10
	Gonads	0.30 ± 0.04	0.80 ± 0.19	0.27 ± 0.04	0.57 ± 0.06
	Skin	0.65 ± 0.04	0.44 ± 0.11	0.69 ± 0.04	1.05 ± 0.09
	Bone	0.92 ± 0.04	1.53 ± 0.09	1.13 ± 0.05	1.13 ± 0.04
	Brain	0.19 ± 0.03	0.70 ± 0.14	0.11 ± 0.03	0.38 ± 0.12
Pb	Muscle	0.63 ± 0.20	1.79 ± 0.63	1.01 ± 0.21	0.28 ± 0.05
	Gills	2.83 ± 0.52	5.19 ± 1.10	3.42 ± 0.27	3.87 ± 0.43
	Liver	0.70 ± 0.15	2.25 ± 0.47	1.11 ± 0.20	0.71 ± 0.19
	Gonads	1.44 ± 0.26	7.34 ± 2.85	0.93 ± 0.16	0.35 ± 0.14
	Skin	2.27 ± 0.33	2.55 ± 0.68	6.23 ± 1.17	2.74 ± 0.87
	Bone	3.97 ± 0.39	6.89 ± 0.73	4.53 ± 0.23	5.00 ± 0.49
	Brain	1.25 ± 0.41	4.87 ± 1.62	2.36 ± 0.22	0.26 ± 0.05
Cu	Muscle	0.49 ± 0.16	0.70 ± 0.21	0.20 ± 0.03	0.26 ± 0.04
	Gills	1.29 ± 0.29	1.20 ± 0.27	0.46 ± 0.06	1.60 ± 0.48

TABLE 3. Contd.

Metal	Season / Organ	Spring	Summer	Autumn	Winter
Cu	Liver	34.79 ± 3.82	9.57 ± 2.68	7.37 ± 1.74	12.78 ± 4.16
	Gonads	2.22 ± 0.36	3.63 ± 0.59	1.27 ± 0.19	4.13 ± 1.91
	Skin	3.51 ± 2.08	1.26 ± 0.43	0.48 ± 0.09	1.28 ± 0.26
	Bone	1.47 ± 0.32	2.21 ± 0.41	0.61 ± 0.09	1.28 ± 0.18
	Brain	4.96 ± 1.05	2.37 ± 1.06	1.00 ± 0.06	0.85 ± 0.19
Zn	Muscle	5.58 ± 2.8	24.48 ± 1.9	43.69 ± 15.7	14.67 ± 1.7
	Gills	10.09 ± 2.2	40.47 ± 2.7	47.01 ± 5.5	57.14 ± 3.7
	Liver	73.62 ± 2.5	76.20 ± 5.6	104.64 ± 8.4	81.99 ± 10.1
	Gonads	44.22 ± 8.0	122.9 ± 33.7	133.26 ± 4.9	115.2 ± 14.4
	Skin	12.56.65 ± 3.3	30.14 ± 4.3	63.59 ± 10.4	50.25 ± 1.9
	Bone	11.37 ± 3.6	44.21 ± 2.3	45.39 ± 4.3	69.46 ± 3.6
	Brain	3.00 ± 0.3	2.17 ± 0.9	7.09 ± 0.4	19.59 ± 2.8

were 0.25 and 7.34 ppm in muscle of *Saurida* sp. and gonads of *Epinephelus* sp., respectively. Also, copper showed its lowest value (0.20 ppm) in muscle of *Sardinella gibbosa* and *Epinephelus* sp., while the maximum value of copper (34.79 ppm) was recorded in liver of *Epinephelus* sp. Zinc showed a broad range varying from 2.17 ppm in brain of *Epinephelus* sp. to 156.19 ppm in skin of *Sardinella gibbosa*.

Annual mean concentration of metals in fish organs are shown in Table (4). Cadmium ranged from 0.12 ppm in muscle of *Sardinella gibbosa* to 1.18 ppm in bone of *Epinephelus* sp. Also, the lowest value of lead was recorded in muscle of *Sardinella gibbosa* (0.70 ppm) and highest value in bone of *Epinephelus* sp. (5.10 ppm). The minimum and maximum levels of copper were found in muscle and liver of *Epinephelus* sp. (0.41 and 16.13 ppm, respectively). In contrast, zinc concentration was high in skin of *Sardinella gibbosa* (115.74 ppm) and low in muscle of *Saurida* sp. (7.04 ppm).

Generally, cadmium, lead and copper recorded their highest values in *Epinephelus* sp. and *Saurida* sp. (carnivorous fishes) which present in the top of food chain. While zinc was recorded in pelagic fish, *Sardinella gibbosa* (herbivorous fish).

The metal concentration ratio in organs per muscle (organs/muscle) are shown in Table (5). It can be noticed that, hard tissues, as bone, showed the highest level of Cd and Pb (4.9-7.0) times and (5.5-5.7) time, respectively. On the other hand, the highest level of copper was presented in liver (6.1-39.3) time and zinc in gonads (4.7-6.6) time. Our results indicated that the essential elements, Cu and Zn, which play an important role in the physiological function of the organisms, were found with high level in soft tissues such as liver and gonads.

TABLE 4. The annual mean concentrations of cadmium, lead, copper and zinc in the organs of fish.

Metal	Organ	*Sardinella gibbosa*	*Saurida* sp.	*Epinephelus* sp.
Cd	Muscle	0.12 (–)	0.15	0.24
	Gills	0.53	0.76	0.94
	Liver	0.50	0.75	0.65
	Gonads	0.25	0.31	0.48
	Skin	0.46	0.41	0.71
	Bone	0.84	1.01	1.18 (+)
	Brain	0.31	0.41	0.34
Pb	Muscle	0.70 (–)	0.76	0.93
	Gills	3.13	2.52	3.83
	Liver	2.78	1.49	1.19
	Gonads	2.02	1.06	2.51
	Skin	4.54	2.04	3.45
	Bone	3.96	4.36	5.10 (+)
	Brain	2.29	1.98	2.18
Cu	Muscle	0.57	0.50	0.41 (–)
	Gills	0.85	1.46	1.14
	Liver	3.48	9.13	16.13 (+)
	Gonads	1.39	1.64	2.81
	Skin	1.79	2.16	1.63
	Bone	1.04	1.40	1.39
	Brain	0.95	1.85	2.29
Zn	Muscle	17.45	7.04 (–)	22.10
	Gills	65.07	47.16	38.68
	Liver	51.97	57.70	84.11
	Gonads	110.45	46.28	103.88
	Skin	115.74 (+)	35.64	36.90
	Bone	60.47	47.20	42.61
	Brain	36.18	14.60	7.96

(–) : minimum (+) : maximum

TABLE 5. The ratio of organs/muscle for metals concentrations in fish samples.

Metal	Ratio	*Sardinella gibbosa*	*Saurida* sp.	*Epinephelus* sp.	
Cd	gills / muscle	4.4	5.1	3.9	
	liver / muscle	4.2	5.0	2.7	
	gonads/ muscle	2.1	2.1	2.0	(–)
	skin / muscle	3.8	2.7	3.0	
	bone / muscle	7.0	6.7	4.9	(+)
	brain / muscle	2.6	2.7	1.4	
Pb	gills / muscle	4.5	3.3	4.1	
	liver / muscle	4.0	2.0	1.3	
	gonads/ muscle	2.9	1.4	2.7	(–)
	skin / muscle	6.5	2.7	3.7	
	bone / muscle	5.7	5.7	5.5	(+)
	brain / muscle	3.3	2.6	2.3	
Cu	gills / muscle	1.5	2.9	2.9	(–)
	liver / muscle	6.1	18.3	39.3	(+)
	gonads/ muscle	2.4	3.3	6.9	
	skin / muscle	3.1	4.3	4.0	
	bone / muscle	1.8	2.8	3.4	
	brain / muscle	1.7	3.7	5.6	

TABLE 5. Contd.

Metal	Ratio	*Sardinella gibbosa*	*Saurida* sp.	*Epinephelus* sp.	
Zn	gills / muscle	3.7	6.7	1.8	
	liver / muscle	3.0	8.2	3.8	
	gonads/ muscle	6.3	6.6	4.7	(+)
	skin / muscle	6.6	5.1	1.7	
	bone / muscle	3.5	6.7	1.9	
	brain / muscle	2.1	2.1	0.4	(-)

(-) : minimum (+) : maximum

Table (6) shows metal relationships with other metals in muscle of fish by using T-test and probability of significant differences. Most of metals gave a highly significant differences (P < 0.01) for the tested fish, while cadmium with copper in *Epinephelus* sp. gave a less significant differences (P < 0.05) and lead with copper in both *Sardinella gibbosa* and *Saurida* sp. gave a non-significant differences (P < 0.5).

TABLE 6. Probability of the significant difference between metal levels in muscles of fish samples.

Fish	Metal	Cd	Pb	Cu	Zn
Sardinella gibbosa	Pb	0.001			
	Cu	0.001	0.5		
	Zn	0.001	0.001	0.001	
Saurida sp.	Pb	0.01			
	Cu	0.001	0.5		
	Zn	0.001	0.001	0.001	
Epinephelus sp.	Pb	0.001			
	Cu	0.05	0.01		
	Zn	0.001	0.001	0.001	

* P < 0.01 Highly significant
* P < 0.05 Significant
* P < 0.5 Nonsignificant

Table (7) shows the range and average of weight and length of the studied fish species. In each season, ten randomly selected fishes were weighed and lengthed. It is clear that, carnivorous fishes especially *Epinephelus* sp. were heavier than those of the herbivorous ones. Metals distribution in fish muscles related to weight and length of fish are shown in Fig. (2, 3 & 4). The concentration of copper apparently increases with weight and length for all fish studied. McFarlane and Franzin (1980) demonstrated a consistent positive correlation between copper accumulation in pike liver and fish age. The correlations for other metals tend to be inversely proportional with the weight and length. Hornung and Ramelow (1987) showed that there is no significant difference between accumulation of metals and length of fish species, *Mullus barbatus*.

TABLE 7. The annual range and average of weight and length for the fish collected from Suez Gulf during 1991-1992.

Parameter		Total weight g	Fork. length cm	Stand. length cm	Total length cm
Fish sp.	No.				
Sardinella gibbosa	40	17.1 – 39.9 29.8	11.1 – 15.0 13.4	10.2 – 13.8 12.3	12.6 – 17.1 15.2
Saurida sp.	41	23.5 – 208.0 100.3	14.9 – 29.0 22.3	13.6 – 26.5 20.7	16.1 – 31.6 24.6
Epinephelus sp.	40	98.2 – 809.8 416.1	23.1 – 37.9 28.9	16.5 – 33.5 24.5	20.2 – 40.7 30.6

Comparing our data (Table 4) with the recent literature in Table (8), it can be noticed that the concentrations of cadmium and copper in muscles of fish samples show a good agreement with the other data.

For lead, our data show a parallel pattern and at least, agreed with the recent data recorded by Emara *et al.* (1993).

Zinc shows a parallel pattern with respect to its minimum concentration (7.04 ppm) in relation to the data given in Table (8), whereas its maximum concentration (22.10 ppm) is higher than those of the other data. This may be attributed to the raise of oil activities in the Red Sea especially in the Suez gulf.

TABLE 8. Mean concentrations of cadmium, lead, copper and zinc in muscles of Red Sea fishes.

Fish	Cadmium (ppm)	Lead (ppm)	Copper (ppm)	Zinc (ppm)	References
Lethrinus mahsenodes	0.51	1.14	0.34	4.81	Abdelmoneim & El-Deek, 1992
Lethrinus nebulosus	0.39	0.64	0.45	6.87	
Siganus spp.	N.M.	0.62	0.34	N.M.	Emara *et al.*, 1993
Cephalopholus spp.	N.M.	0.84	0.71	N.M.	
Liza ramada	N.M.	0.26	0.68	N.M.	
Mugil cephalus	N.M.	0.75	0.64	N.M.	
Epinephelus spp.	0.17	0.53	0.66	3.37	
Mugil seheli	0.13	0.54	0.59	15.28	Abdelmoneim *et al.*, 1994a
Acanthopagurus areolatus	0.26	3.36	0.51	4.34	Abdelmoneim *et al.*, 1994b
Hemiramphus spp.	0.55	3.51	0.51	10.22	
Shyraena obtusata	0.27	3.96	1.01	6.46	
Epinephelus spp.	N.M.	4.54	0.68	4.56	El-Deek *et al.*, 1994
Sardinella gibbosa	0.12	0.70	0.57	17.45	Present study
Saurida sp.	0.15	0.76	0.50	7.04	
Epinephelus spp.	0.24	0.93	0.41	22.10	

N.M. : Not measured.

Conclusion

Our results indicated that, although the sampling site (Suez Bay) is known to be influenced by industrial

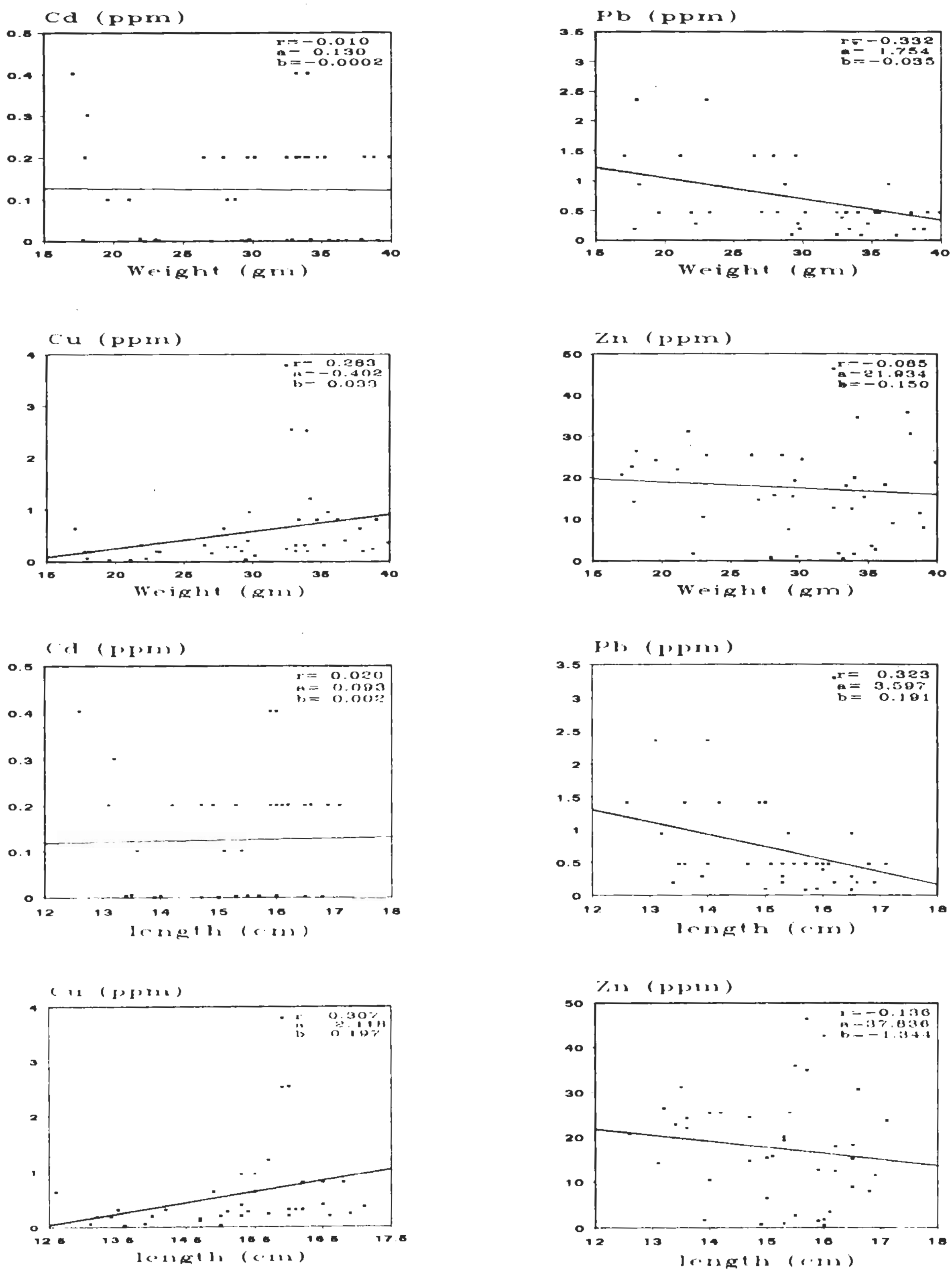

FIG. 2. Relations between weight and length and heavy metals in muscle of *Sardinella gibossa*.

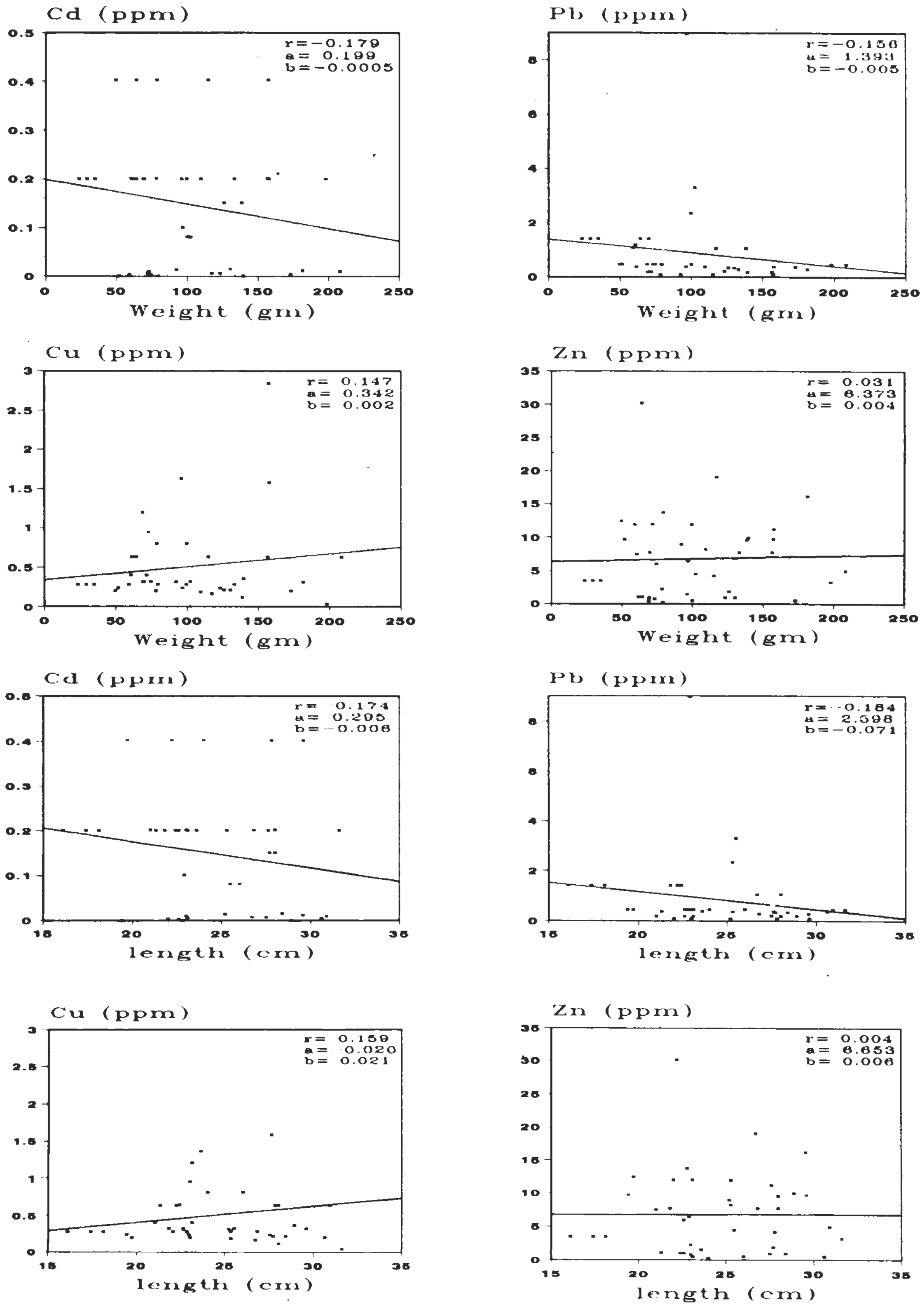

FIG. 3. Relations between weight and length and heavy metals in muscle of *Saurida* sp.

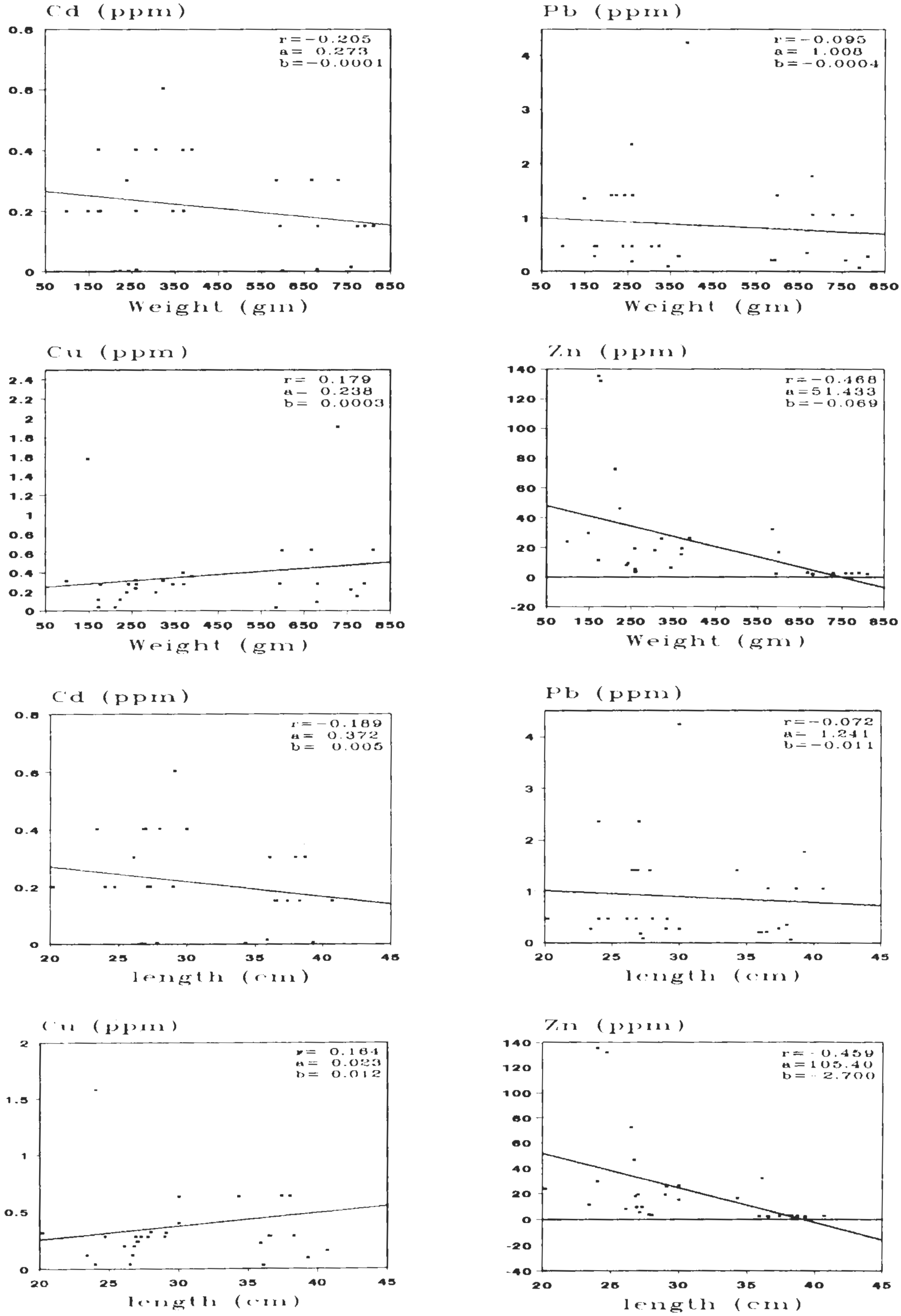

FIG. 4. Relations between weight and length and heavy metals in muscle of *Epinephelus* sp.

oil and domestic wastes, but no significant effects were recorded especially in muscles (edible parts) of the investigated fish collected in that time.

Internationally, the maximum limits of trace metals in the edible parts (muscles) of fish should not exceed concentrations of 2, 2, 30 and 1000 ppm wet weight for Cd, Pb, Cu and Zn, respectively (WHO, 1973; Bebbington *et al.*, 1977; Kakulu *et al.*, 1987 and FAO, 1992).

The obtained results in this study indicated that the concentrations of the trace metals in muscles of the studied fishes were under the acceptable limits. Thus, these species of fishes can be considered safe for human consumption.

Regarding the other fish organs, the concentrations of trace elements were under the acceptable limits except lead.

In conclusion, muscles of the studied fish species is considered safe from the public health point of view. Internal organs should not be used as fish meals and other nutrition purposes.

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دراسة المحتوى من العناصر الثقيلة النادرة فى ثلاثة أنواع من الأسماك المصادة من شمال خليج السويس (البحر الأحمر)، مصر

محمود أحمد عبد المنعم* ، خالد محمد المصيلحي* ، سامح حافظ حسن**

*المعهد القومى لعلوم البحار والمصايد - جمهورية مصر العربية

**كلية العلوم - جامعة المنصورة - جمهورية مصر العربية

المستخلص: أجريت هذه الدراسة على عينات من أسماك السردين والمكرونة والكشر، جمعت من مياه خليج السويس (البحر الاحمر)، حيث تم قياس تركيزات بقايا عناصر الكادميوم والرصاص والنحاس والزنك في لحوم عضلات تلك الاسماك، وأيضا في أعضائها المختلفة، وذلك باستخدام جهاز الامتصاص الطيفي الذري.

وقد أوضحت نتائج الدراسة مايلي:

احتوت عضلات الاسماك على تركيزات من هذه العناصر أقل من تلك التى وجدت فى بقية أعضاء السمكة، وقد تميز عنصر الكادميوم بأقل تركيز، بينما كان أعلى التركيزات لعنصر الزنك، فى عضلات الاسماك وأعضائها على السواء.

كان لبقايا العنصرين غير الاساسيين (الكادميوم والرصاص) أعلى التركيزات فى الاعضاء السمكية الصلبة كالعظام والخياشيم، بينما سجلت بقايا العنصرين الاساسيين (النحاس والزنك) أعلى التركيزات فى الاعضاء السمكية الرخوة، مثل الكبد والمناسل.

تميزت الاسماك آكلة اللحوم (الكشر والمكرونة) بارتفاع تركيزات بقايا عنصرى الكادميوم والرصاص فى كل من عضلاتها وأعضائها، فى حين كان الزنك هو العنصر الاعلى تركيزا فى السردين، وهى سمكة عائمة آكلة العشب.