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Heavy Metals in Three Commonly Available Coral Reef Fish Species From the Jordan Gulf of Aqaba, Red Sea

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Abstract

The concentrations of the heavy metals Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, and Zn were determined in the muscles, livers,, gills, gonads, and the stomachs of two detritus feeder *(Ctenochaetus striatus* and *Zebrasoma xanthurum)* and one herbivorous *(Scarus ferrugineus)* fish species collected from the Gulf of Aqaba. The mean concentrations of heavy metals among the organs of fish examined were generally significantly different (P<O.05). In general, muscles contained lower metal concentrations than other organs. Comparing species, there was no significant difference in the mean concentration of metals except Zn in the muscles of the examined fish species. By comparison, the mean concentrations of Zn, Cd and Cu were significantly different among the livers of these species. In gills, only Mn varied significantly. Only Cu and Pb varied among the stomachs of species examined. In gonads, there were significant differences between the mean concentrations of Cd, Cr, Cu, Mn, and Zn in one of the detritus feeder fishes and the herbivorous fish. The concentration of metals in the muscle tissues were generally low and within the ranges expected for metals in muscle of fish from relatively uncontaminated locations. The ranges are generally lower or within the ranges of the concentrations for these elements in fishes of the Red Sea (Hanna, 1989). Moreover, the values fall below the acceptable levels for human consumption recommended by FAO (1983) and WHO (1978, 1989, 1993) which means that they do not pose a significant threat to the health of human consumers. The results indicate that relatively high concentrations of heavy metals were found in liver and gill of the examined species, which suggest the possibility of using these two organs, particularly the liver, as bioindicators of metals present in the surrounding environment.

الملخص

تم تعيين تراكيز العناصر الثقيلة الكادميوم و الكوبالت والكروم والنحاس والحديد والمنجنيز والنيكل والرصاص والزنك في عضلات وكبد وخياشيم ومناسل ومعدة لنوعين من الأسماك الرمية (كتينوكيتاس ستراتس و زيبراسوما كزانثيورام) ونوع من الأسماك اكلة الأعشاب (سكارس فيروجينيوس) جمعت من خليج العقبة. كانت هنالك فروقات إحصائية في تراكيز العناصر الثقيلة بين اعضاء الأسماك التي تم فحصها. وبشكل عام إحتوت العضلات على أقل تراكيز للعناصر الثقيلة. بمقارنة أنواع الأسماك لم تكن هنالك فقروقات إحصائية في تراكيز العناصر بإستثناء الزنك في العضلات. بمقارنة تراكيز الزنك والكادميوم والنحاس في كبد السمك كان هنالك فروقات إحصائية. أما تراكيز المنجنيز فكانت هنالك فروقات إحصائية في الخياشيم. وأختلف كذلك إحصائيا تراكيزالنحاس والرصاص في معد الأسماك. أما في المناسل فكانت تراكيز الكادميوم والكروم والنحاس والمنجنيز والزنك تختلف إحصائيا. كانت تراكيزالعناصر في العضلات منخفضة وضمن التراكيزالمتوقعة للمناطق غير الملوثة. تقع هذة التراكيز ضمن مدى التراكيز لمنطقة البحر ألأحمر وضمن التراكيز المقبولة للأستهلاك البشري حسب منظمة الغذاء الدولية ومنظمة الصحة العالمية. وتشير التراكيز العالية للعناصر في الخياشيم و الكبد بإمكانية إستخدام هذة العناصر كمؤشر حيوي عن تراكيز العناصر في البيئة المحيطة.

Keywords: Heavy metals; Coral reef fishes; Herbivorous fish; Detritus feeder fish; Gulf of Aqaba; Red Sea;

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1. Introduction

In recent years, the concentration of heavy metals in marine fishes has received great attention, particularly in developed and industrialized coastal areas (Denton and Burdon-Jones, 1986; Wahbeh and Mahasneh, 1987; Hanna, 1989; Rayment and Barry, 2000; Miao, 2001). Since 1975 the shipping and industrial activities at the Jordanian Aqaba town at the northern side of the Gulf of Aqaba have been increased tremendously (Abu Hilal, 1999). Parallel to this there has been a great demand for coastal development. The following categories of human activities are of particular environmental concern with regard to maintaining healthy coral reefs and pollution problems in the Gulf of Aqaba: tourism, sport and commercial fishing, boat anchoring, shipping of oil and hazardous material, dumping of debris and litter, wastewater disposal, and mariculture. Industrial and commerce activities in the Gulf have been increased with development of oil, marina, phosphate mineral and potash export and other industrial facilities. Shipping traffic in the northern Gulf of Aqaba is expected to increase during the next decade. Tourism and population growth is expected to continue during the next two to three decades, due in part to governmental policies encouraging growth in the area and facilitating increased tourism infrastructure. Consequently, unfavorable impact of these activities on the marine life is to be expected. A number of positive steps have been taken to address some of these concerns, however, many problems remain and expected to increase as both the permanent and tourist population growth. During the past two decades, several authors have studied the composition of heavy metals in the marine environment of the Gulf of Aqaba (Abu-Hilal, 1987; Abu-Hilal and Badran, 1990; Abu-Hilal *et al.*, 1993). Abu-Hilal (1987) has reported abnormally high concentrations (3-9 times) of heavy metals in near shore surface sediments at some stations in the northern portion of the Gulf of Aqaba. Moreover, the metal content of sea grasses (Wahbeh, 1984; Abu-Kharma, 2006), algae (Wahbeh *et al.*, 1985; Abu-Kharma, 2006), crustacea (Abu-Hilal *et al.*, 1988), zooplankton (Bani-Fawwaz, 2005), mussels (Ababneh, 2004; Al- Batainh, 2004), corals (Al-Shloul, 2006; Al-Tarabeen, 2006) and in several fish species (Wahbeh, 1985; Wahbeh and Mahasneh, 1987) have been reported. However, the amount of work on heavy metals in marine biota of the Gulf of Aqaba is still limited and there is a need for more studies. The lack of integrated data and scientific assessment of pollutants, their sources and effects on coral reef resources in the Gulf has impacted and hindered the management actions and efforts made by related authorities in this region (Abu Hilal, 1999; RSMPP, 2003). The present paper provides important information on the metal content in the muscles, livers, gills, gonads, and the stomachs of two detritus feeder fish species, *Ctenochaetus striatus* and *Zebrasorma xanthurum* and one herbivorous fish species *Scarus ferrugineus* that add to the limited scientific data and may be useful for environmental managers.

2. Materials and Methods

A total of 22 specimens of fish, 11 of the lined bristle tooth surgeonfish *C. striatus*, 4 of the yellow surgeonfish *Z. xanthurum*, and 7 of the parrot fish *S. ferrugineus*, were collected from three coastal areas along the northern portion of the Gulf of Aqaba (Fig. 1).

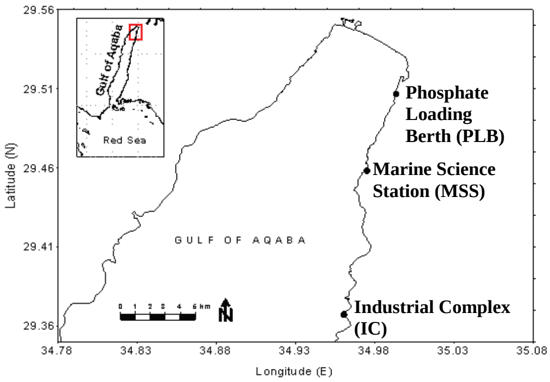

Figure 1: Locations of the sampling sites

The samples were collected using set-nets positioned at site, fish taps and spear gun. Spear shafts and heads were made of seawater resistant, stainless steel there by minimizing sample contamination. After capture the samples were weighed, measured, cleaned deionized-distilled water, stored in pre-cleaned plastic a, and kept frozen at -18^{0}C until further analysis. Pretreatment, preparation of sub samples and analysis were made according to FAO Technical Paper No. 212 *rrPC3* (1983). Frozen fish were partially thawed and dissected on a cleaned plastic sheet using scalpels with steel blades and plastic forceps. Flesh, liver, gill, gonads and stomach were taken out and dried in a pre-cleaned glass container at 80^{o}C to a constant weight.

A suitable volume of a mixture of hydrogen peroxide/nitric acid solution 1:1 v/v was used for the wet acid digestion of a pre-weighed tissue or organ. The analyses of all metals were performed by flame atomic spectrometry using a Perkin Elmer 3030 atomic absorption spectrophotometer with digital read-out, deuterium lamp background correction, and automatic zero to compensate the blank. Settings were those recommended by the manufacturer.

A standard curve was run with each analysis. A blank treated exactly as for the sample was also run with each batch of samples. Blanks were always of negligible values. The effect of interferences attributable to the matrix and the validity of the results were checked with the standard addition method. Recoveries were between 98 and 103% .The precision was confirmed by carrying out ten replicate analyses for three different samples. The coefficient of variation was less than 5% for all elements. Detection limits in µg g^{-1} (ppm) were 0.003 for Cd, 0.004 for Cr, 0.007 for Co, 0.003 for Cu, 0.005 for Fe, 0.003 for Mn, 0.008 for Ni, 0.005 for Pb and 0.002 for Zn. The AVOVA and Student's-t comparison tests have been used to compare the mean concentrations of heavy metals in different fishes and organs of these selected fish species.

3. Results

The mean concentrations of metals (µg g^{-1} dry weight) in the muscles, livers, gonads, gills, and the stomachs of fish examined are summarized in Tables 1, 2, 3, 4, and 5, respectively. The analysis of variance showed that the mean concentrations of heavy metals among the organs of each fish species were significantly different (P<0.05), except for Cr in the three species, Fe in *C. striatus*, and Mg in *Z. xanthurum* (Table 6). In general, the muscles of fish examined contained lower mean concentrations of metals. Among species, however, there were no significant differences (P>0.05) in the mean concentrations of metals in muscles, except for Zn where the mean ranged from 10.61 µg g^{-1} in *S. ferrugineus* to 21.38 µg g^{-1} in *C. striatus*. Similarly, there was a wide and significant difference in the mean concentrations of Zn among the livers of the three species, where it ranged from 82.78 µg g^{-1} in *S. ferrugineus* to 1512.57 µg g^{-1} in *C. striatus*. Moreover, there were significant differences in the means of Cd (1.86 µg g^{-1} in *S. ferrugineus* to 10.86 µg g^{-1} in *C. striatus*) and Cu (9.91 µg g^{-1} in *S. ferrugineus* to 67.28-µg g^{-1} in Z. *xanthurum*) among the livers of these fishes. Among the gills of the examined fish species, significant differences were found in the mean concentrations of Mg and Mn.

Table 1: Concentrations (Mean ± S.D µg g^{-1} dry weight) of metals in the muscles of three species of fish from the Gulf of Aqaba, Red Sea.

Metal	*Ctenochaetus striatus*	*Zebrasoma xanthurum*	*Scarus ferrugineus*	Difference among species
Cd	0.83±0.28	0.54±0.29	0.61±0.22	NS*
Co	2.23±0.94	2.88±1.24	2.29±0.64	NS
Cr	1.46±1.01	3.03±2.73	1.86±1.82	NS
Cu	0.87±0.47	1.03±0.62	1.26±1.35	NS
Fe	8.47±8.76	12.46±12.06	8.50±8.07	NS
Mg	892±389	960±306	951±354	NS
Mn	0.93±0.39	1.03±0.54	0.93±0.35	NS
Ni	1.90±0.71	2.53±1.03	2.17±1.90	NS
Pb	4.05±1.24	5.27±1.18	4.23±3.13	NS
Zn	21.38±9.68	18.58±17.05	10.61±2.45	S**

* NS: Not significant (P > 0.05); ** S: Significant (P < 0.05).

Table 2: Concentrations (Mean ± S.D µg g^{-1} dry weight) of metals in the livers of the examined fish species from the Gulf of Aqaba, Red Sea. Abbreviations are as in Table 1

Metal	*Ctenochaetus striatus*	*Zebrasoma xanthurum*	*Scarus ferrugineus*	Difference among species
Cd	10.86±9.12	5.68±5.06	1.86±1.52	S
Co	7.12±8.60	4.70±3.75	3.69±5.02	NS
Cr	2.16±1.76	2.18±0.88	2.74±2.04	NS
Cu	45.36±29.02	67.28±67.74	9.91±11.12	NS
Fe	2087±1832	1575±1344	723±522	NS
Mg	1163±1344	883±367	1059±1019	NS
Mn	5.55±4.84	3.85±0.49	3.41±1.74	NS
Ni	4.83±4.56	2.95±1.64	4.41±4.95	NS
Pb	14.54±13.46	6.95±2.70	8.02±12.33	NS
Zn	1512±897	222±227	82.78±66.72	S

Table 3: Concentrations (Mean ± S.D µg g^{-1} dry weight) of metals in the gonads of the examined fish species from the Gulf of Aqaba, Red Sea. Abbreviations are as in Table 1.

Metal	*Ctenochaetus striatus*	*Zebrasoma* xanthurum*	*Scarus ferrugineus*	Difference among species
Cd	0.88±0.79	0.25	2.19±1.51	S
Co	3.05±2.14	2.50	12.70±17.84	NS
Cr	1.18±0.74	0.50	9.69±10.80	S
Cu	3.10±0.92	2.00	7.08±4.97	S
Fe	101.76±72.31	22.50	83.68±61.06	NS
Mg	910±616	185	1267±1177	NS
Mn	2.35±1.58	2.00	5.96±2.78	S
Ni	3.52±4.41	1.50	4.76±2.63	NS
Pb	3.63±1.68	2.50	11.53±14.64	NS
Zn	243.60±183.28	155.00	506.22±227.2	S

* only one specimen; ** difference between *C. Striatus* and *S. ferrugineus*

Table 4: Concentrations (Mean ± S.D µg g^{-1} dry weight) of metals in the gills of the examined fish species from the Gulf of Aqaba, Red Sea. Abbreviations are as in Table 1

Metal	*Ctenochaetus striatus*	*Zebrasoma xanthurum*	*Scarus ferrugineus*	Difference among species
Cd	2.19 ± 0.54	2.21 ± 0.82	1.63 ± 0.57	NS
Co	11.73 ± 3.30	10.76 ± 5.34	10.33 ± 4.42	NS
Cr	4.41 ± 2.27	8.03 ± 7.92	5.39 ± 4.01	NS
Cu	3.82 ± 1.47	3.65 ± 1.11	7.92 ± 0.52	NS
Fe	105.79 ± 34.52	128.07 ± 74.26	173.93 ± 97.53	NS
Mg	1050 ± 621	1037 ± 345	2115 ± 1335	S
Mn	6.49 ± 1.91	7.46 ± 2.69	22.33± 6.73	S
Ni	7.97 ± 2.78	6.99 ± 3.04	6.19 ± 2.59	NS
Pb	19.47 ± 7.52	22.24 ± 13.19	14.41 ± 6.12	NS
Zn	51.32± 21.11	46.63 ± 21.74	46.29 ± 15.33	NS

Table 5: Concentrations (Mean ± S.D µg g^{-1} dry weight) of metals in the stomachs of the examined fish species from the Gulf of Aqaba, Red Sea. Abbreviations are as in Table 1

Metal	*Ctenochaetus striatus*	*Zebrasoma xanthurum*	*Scarus ferrugineus*	Difference among species
Cd	4.13 ± 2.34	2.95 ± 1.61	4.92 ± 3.86	NS
Co	23.68 ± 13.32	16.00 ± 10.23	24.01 ± 19.68	NS
Cr	9.06 ± 13.49	17.98 ± 16.39	17.29 ± 27.37	NS
Cu	6.41± 2.51	11.43 ± 5.40	11.24 ± 6.13	S
Fe	5150 ± 1123	2080 ± 1291	1431 ± 1785	NS
Mg	5620 ± 2397	8409 ± 9584	5310 ± 1752	S
Mn	45.73 ± 34.41	48.75 ± 39.96	27.87 ± 23.95	NS
Ni	15.31 ± 9.34	13.75 ± 7.72	16.64 ± 14.58	NS
Pb	41.32 ± 24.08	22.35 ± 20.70	14.41 ± 6.12	S
Zn	91.76 ± 34.47	105.00 ±102.67	99.34 ± 22.73	NS

The highest Mg mean concentration found was 2115 µg g^{-1} in the gills of *S. ferrugineus* and the lowest (1037 µg g^{-1}) in *Z. xanthurum*. Similarly, Mn was highest in *S. ferrugineus* (22.33 µg g^{-1}) and the lowest in *C. striatus* (6.49 µg g^{-1}). Among the stomachs of various species, there were significant differences in the mean concentrations of Mg, Cu, and Pb. The mean concentration of Mg ranged from 5310 µg g^{-1} in *S. ferrugineus* to 8409 µg g^{-1} in *Z. xanthurum*. The mean concentration of Cu ranged from 6.41 µg g^{-1} in *C. striatus* to 11.43-µg g^{-1} in *Z. xanthurum*, while Pb ranged from 14.41 µg g^{-1} in *S. ferrugineus* to 41.32 µg g^{-1} striatus. In gonads, there were significant differences (P< (0.05) student t-test) between the means of Cd (0.88 and 2.19 µg g^{-1}), Cr (1.18 and 9.69 µg g^{-1}), Cu (3.10-7.08 µg g^{-1}), Mn (2.35 and 5.96 µg g^{-1}), and Zn (243.60 and 506.22 µg g^{-1}) in *C. striatus* and *S. ferrugineus*, respectively. No comparison was made with the means of metals in the gonad of *Z. xanthurum* since only one specimen was analyzed.

4. Discussion

The concentration of heavy metals in teleost fishes may be affected by many variables most important of which are: species, body size, organ, and feeding habits (Cross et *al.*, 1973; Eustace, 1974). The present work reveals significant differences of metal concentration among different organs of the same species, particularly the presence of lesser concentrations of metals in muscles than those in other organs examined. Similar conclusions were reported by other workers. Wahbeh and Mahasneh (1987) found lesser concentrations of metals in the muscles than those in the livers, gills, and gonads of six species of fish from the Gulf of Aqaba. Similarly, the muscles of 21 fish species from the Red Sea proper contained lesser metal concentrations than the livers (Hanna, 1989). Comparable lower metal concentrations were also found in the muscles than the livers of Chondrichthys fishes from North Atlantic (Windom *et al.*, 1973). In experimentally contaminated perch, the muscles contained lesser concentration of Cd than other organs (Edgren and Notter, 1980). In general, the concentrations of the metals investigated in the three species were found to be comparable with those reported from other fishes (Wright, 1976; Denton & Burdon-Jones, 1986; Miao *et al.*, 2000; Rayment & Barry, 2000). Furthermore, the ranges of concentrations are either lower or within the ranges of the concentrations for these elements in fishes of the Red Sea (Hanna, 1989). Even the highest individual values of metal obtained for the muscle tissue in the present study are close to or within the range of those reported for many species in different environments (Table 7).

By comparison, the concentrations of metals in the present study are generally lower than those reported by Wahbeh and Mahasneh (1987) for other species from the same study area in the Gulf of Aqaba. According to Zdanowicz *et al.* (1992), it is uncommon to find differences in metal levels between fish species.

Table 6: Results of the analysis of variance comparing the mean concentrations of metals among the organs examined. DF, degrees of freedom; P, significance probability.

Metal	*Ctenocheatus straitus*		*Zebrasoma xanthurum*		*Scarus ferrugineus*		Total	
	DF	P	DF	P	DF	P	DF	P
Cd	4,41	< 0.01	4, 20	0.02	4, 25	< 0.01	4,96	< 0.01
Co	4,41	< 0.01	4,17	0.01	4,22	0.02	4,90	< 0.01
Cr	4,41	0.07	4,19	0.06	4,24	0.24	4,94	< 0.01
Cu	4,41	< 0.01	4,20	< 0.01	4,25	0.04	4,96	< 0.01
Fe	4,41	0.16	4,20	0.03	4,26	0.02	4,97	0.01
Mg	4,41	< 0.01	4,20	0.06	4,26	< 0.01	4,97	< 0.01
Mn	4,41	< 0.01	4,19	< 0.01	4,26	< 0.01	4,94	< 0.01
Ni	4,41	< 0.01	4,19	< 0.01	4,24	0.01	4,94	< 0.01
Pb	4,41	< 0.01	4,19	< 0.01	4,25	0.02	4, 95	< 0.01
Zn	4,41	< 0.01	4,20	< 0.01	4,26	< 0.01	4, 97	< 0.01

Table 7: Heavy metal levels (µg g^{-1} dry weight unless otherwise mentioned) in the muscles of fish examined from the Gulf of Aqaba, Jordan and other selected areas.

Location/Reference	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
Present study (mean)	0.66	2.47	2.12	1.05	9.81	0.96	2.20	4.52	16.86
Gulf of Aqaba (1)	2.60	2.72	0.83	NM*	56.33	12.18	0.30	1.43	20.9
Red Sea (2)	0.16-3.5	0.02-0.12	0.06-4.3	1.7-39.6	NM	NM	0.20-7.0	0.05-1.3	8.4-195
Mediterranean (3)	0.33	NM	2.1	3.8	NM	NM	1.8	1.8	27.2
North Atlantic (4)	<0.1-2.1	NM	NM	1.5-3.2	NM	NM	NM	0.5-1.0	8-20
New S. Wales (5)	0.04	NM	NM	0.04-0.87	NM	NM	NM	0.45-0.67	4.24-9.56
North Carolina (6)	NM	NM	NM	0.61	NM	0.22	NM	NM	6.4
South Pacific Ocean (7)	0.01-0.46	NM	NM	0.11-2.65	NM	NM	NM	0.1-0.8	1.9-7.6
North Pacific Ocean (8)	1.2-6.3	NM	7.5-24	14-125	NM	NM	NM	9.3-31.5	84-273
Great Barrier Reef (9)	<0.1	NM	NM	0.47-2.40	NM	NM	NM	NM	4.3-41.8

* NM = Not Measured; (1) Wahbeh & Mahasneh, 1987; (2) Hanna, 1989; (3) Roth & Hornung, 1977; (4) Windom et al., 1973; (5) Bebbington et al., 1977; (6) Cross et al., 1973 (µg g^{-1} wet weight); (7) Powell et al., 1981 (mg kg^{-1} wet weight); (8) Miao et al. 2001; (9) Denton & Burdon- Jones, 1986.

The concentration of metals in the muscle tissues were generally low and within the ranges expected for metals in muscle of fish from relatively uncontaminated locations. Moreover, the values of these metals found in the examined fish species from the Gulf of Aqaba fall below the acceptable levels for human consumption recommended by FAO (1983) and WHO (1978, 1989, 1993) which means that they do not pose a significant threat to the health of human consumers.

Site-specific differences in metal concentrations contained in specific organ may be attributed to differences in the diet of the various fish species. Wahbeh and Mahasneh (1987) reported significant differences ($P<0.05$) in metal levels contained in the gills, muscles, livers, and gonads among six fish species from the Gulf of Aqaba. In the present work, two of the three species examined were detritus feeders and the third was an herbivorous fish feeding on algae growing on corals. There were no significant differences in metal concentrations among these species, except for Zn in the muscles, Zn, Cu, and Cd in the livers, Mg and Mn in the gills, and Cu, Mg, and Pb in the stomachs. These differences may also be partially related to feeding habits of the fish examined since the Zn, Cu, and Cd concentrations were lowest in the herbivorous fish. On the other hand, the concentrations of Mg and Mn were highest in the gills of herbivorous fish which indicates that other variables may affect the accumulation of metals, such as the rate of uptake and excretion (Cross *et al.,* 1973; Stagg et *al.,* 1982), chemical form of the metal (Bowen, 1966), and species (Murphy *et al.,* 1978). Worth mentioning that the examination of the results of the present work showed no clear trends of increasing or decreasing of metal concentrations in the fish tissue with age and size.

5. Results

The results indicate that relatively high concentrations of heavy metals were found in liver and gill of the examined species. This is in agreement with previous reports (Mears and Eisler, 1977; Eisler, 1981; Hanna, 1989; Al-Yousuf *et al.*, 2000; Calni and Atli, 2003; Karadede *et al.*, 2004). Thus, the liver and gill in fish are more often recommended as environmental indicator organs of environmental pollution than other fish organs. The results of the present study suggest the possibility of using these two organs, particularly the liver, as bioindicators of metals present in the surrounding environment. However, it is believed that monitoring of these species should be repeated on similar-sized populations on more occasions and over a longer period in order to establish if the results and associated correlations were sufficiently consistent and robust for monitoring purposes.

6. Discussion

The muscles, livers, gills, gonads, and stomachs of two detritus feeder and one herbivorous fish species collected from the Gulf of Aqaba were analyzed for nine heavy metals. The mean concentrations of heavy metals among the organs of fish examined were generally significantly different ($P<0.05$). Muscles contained lower metal concentrations than other organs. Comparing species, there was no significant difference in the mean concentration of metals in muscles, except Zn, which varied also among the livers of these species. Moreover, Cd and Cu means were significantly different among the livers. In gills, Mg and Mn means varied significantly. Similarly, Mg in addition to Cu and Pb varied among the stomachs of species examined. In gonads, there were significant differences between the means of Cd, Cr, Cu, Mn, and Zn in one of the detritus feeder fishes and the herbivorous fish. The concentration of metals in the muscle tissues were generally low and within the ranges expected for metals in muscle of fish from relatively uncontaminated locations. The ranges are generally lower or within the ranges of the concentrations for these elements in fishes of the Red Sea (Hanna, 1989). The values fall below the acceptable levels for human consumption recommended by FAO (1983) and WHO (1978, 1989, 1993) which means that they do not pose a significant threat to the health of human consumers. Relatively high concentrations of heavy metals were found in liver and gill of the examined species, which suggest the possibility of using these two organs, particularly the liver, as bioindicators of metals present in the surrounding environment.

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