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Heavy Metal Concentrations in Shrimp, Crab, and Sediment Obtained from AD-Dammam Sewage Outfall Area

Muhammad Sadiq, Tahir H. Zaidi, Amir-ul-Hoda, and Atique A. Mian

Water and Environment Division, Research Institute, University of Petroleum and Minerals, Dhahran, Saudi Arabia

Pollution of marine ecosystem by toxic metals like cadmium, chromium, lead, mercury, nickel, etc. is a widespread problem (BROOKS and RUMSEY 1974; FORSTNER and WITTMAN 1979; ROTH and HORNUNG 1977; SCHAULE and PATTERSON 1978; STEEMAN and WIUM-ANDERSON 1970; PARR 1979). Oil Spills, sewage effluents, industrial discharges, auto emissions, dredging activities, and garbage dumps are some of the major sources of metal pollution of marine ecosystem.

Metals, after entering the water, may precipitate or adsorb on solid surfaces, remain soluble or suspended in water or may be taken up by fauna and flora (LANDE 1977; LELAND 1977; OEHME 1978; REAY 1972; REIMER et al. 1975). These metals may accumulate in marine organisms that are consumed by human (GUTHERIE et al.1979; OEHME 1978; REAY 1972).

The city of AD-Dammam, Saudi Arabia, has been discharging its sewage effluents in the Arabian Gulf for the last several years. Sewage effluents may contain high concentration of metals and may become one of the major source of metal pollution (BOYDEN and ROMERIL 1974; CHEN et al. 1974; HELZ et al. 1975; MACKAY et al. 1972). The AD-Dammam sewage outfall area, though not commercially important, is a local fishing and shrimping ground. The sewage outfall area was, therefore, selected to study the concentrations of cadmium, cobalt, chromium, copper, manganese, iron, nickel, lead and zinc in sediment. Uptake of these metals by shrimp and crabs from the same area were also investigated.

MATERIALS AND METHODS

Juvenile shrimps, Penaeus semisulcatus species, were caught from AD-Dammam sewage outfall area on June 20, 1981. The collected animals were thoroughly rinsed in the seawater to remove debris, if any. Twenty shrimp specimens, approximately 10 grams of body tissue, were prepared by dissecting the organism(s) and removing the exoskeleton(shell). In cases where the body tissue from a single shrimp weighed less than 7 grams, two or more organisms of approximately the same weight were homogenized together.

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The body tissue, about 10 grams, was taken into 150 ml capacity, air tight, wide mouth nalgene bottles. Five ml of concentrated nitric acid and three ml of 72% perchloric acid were added to each bottle. The bottles were closed tightly and left overnight. The acid-muscle mixture was digested in a temperature controlled water bath at 85°C for three hours. The bottle caps were loosened to release acid vapour pressure from the digestion bottles.

On the completion of the digestion, the bottles were cooled, the contents were filtered through ashless Whatman filter paper # 42, and volume was made to 100 ml with 0.5% HNO_3. The solution was stored in polyethelene bottles for subsequent metal analyses. Ten crab specimens were prepared similarly.

Ten sampling positions covering 1000m x 200m area, about one kilometer from the AD-Dammam sewage outfall were selected. The distances between sampling sites, along the shore and off the shore directions were 200 m and 100 m, respectively. Three sediment cores, diameter 6 cm and depth 30 cm, were collected from each site. The excess water was drained and the sediment core was divided into two parts, 0-15 and 15-30 cm. Sediment samples were dried at 60°C, crushed in a porcelain mortar and pestle to pass through 40 mesh sieve. Broken shells and organic matter were removed and the samples were stored in plastic containers.

Two grams of well homogenized sediment sample was taken into a 150 ml teflon beaker. Ten ml of concentrated HNO_3, three ml of 72% perchloric acid (to oxidize and decompose the organic matter and minerals) and five ml of hydroflouric acid (to solublize silica) were added to each beaker and the beakers were left overnight. The acid-sediment mixture was slowly digested to near dryness on a controlled temperature hot plate (temperature was kept below 120°C). The residue was dissolved in five ml concentrated HNO_3 and the volume was made to 100 ml. The acid digest was stored in polyethelene bottles for subsequent metal analyses.

The concentrations of cadmium (Cd), Chromium (Cr), cobalt (Co), copper (Cu), manganese (Mn), lead (Pb), nickel (Ni), and zinc (Zn) were determined in the acid digest of sediment, shrimp and crab using Perkin-Elmer Atomic Absorption Spectrophotometer Model 560 and Graphite Furnace Model HGA 500.

RESULTS AND DISCUSSION

Concentrations of Cd, Cr, Co, Cu, Ni, Pb and Zn in shrimps, crabs and sediments are given in Tables 1, 2 and 3, respectively.

The concentrations of Cd in the shrimps ranged from 0.067 to 0.100 µg, with an average of 0.087 µg/g wet tissues. The weight of

shrimp specimens varied from 2.6 to 18.1 grams. Regression analysis of the data did not show a significant correlation between Cd concentrations and the shrimp specimens' weight. Concentrations of Cd in the crabs varied from 0.029 to 0.088 µg/g wet tissue.

TABLE 1: Metal Concentrations in the Shrimps from AD-Dammam sewage Outfall Shrimping Area.

Sample #	Average Wt. (g)	Metal Concentration (µg/g of wet tissue)						
		Cd	Cr	Co	Cu	Ni	Pb	Zn
1(5)**	3.4	0.083	0.794*	0.88	6.04	0.52	0.41	27.50
2(2)	9.6	0.090	0.044	0.90	6.72	0.54	0.51	28.90
3(4)	4.3	0.081	0.113	1.08	6.63	0.61	1.22	29.18
4(3)	5.1	0.085	0.079	1.20	7.07	0.60	0.97	32.18
5(5)	3.6	0.084	0.046	1.00	6.32	0.56	0.66	26.98
6(2)	8.8	0.080	0.081	0.84	5.80	0.50	1.33	28.60
7(2)	10.0	0.100	0.054	0.71	5.79	0.42	0.42	31.42
8(3)	5.7	0.086	0.029	0.92	4.60	0.52	0.47	29.65
9(3)	5.7	0.097	0.095	0.99	5.43	0.43	0.65	27.50
10(2)	8.5	0.094	0.061	0.86	7.83	0.37	0.28	40.47
11(2)	8.3	0.085	0.046	1.11	5.90	0.57	0.38	32.47
12(1)	15.2	0.091	0.056	0.97	12.52	0.45	0.45	48.04
13(3)	7.0	0.078	0.057	0.93	4.03	0.52	9.64*	26.05
14(1)	18.1	0.067	0.041	1.02	14.66	0.59	0.25	46.69
15(3)	5.8	0.090	0.049	0.84	6.70	0.50	0.71	29.70
16(7)	2.6	0.084	0.045	1.47	4.95	0.84	3.08*	25.70
17(3)	6.2	0.093	0.074	0.99	8.03	0.56	0.74	33.92
18(3)	7.4	0.094	0.041	0.96	5.55	0.51	0.51	30.08
19(5)	3.5	0.096	0.062	1.09	9.13	0.62	0.28	38.07
20(4)	4.5	0.084	0.046	0.86	5.00	0.47	0.37	26.98
Average		0.087	0.059	0.98	6.93	0.54	0.73	32.02

*Not included in computing average or statistical analysis.

**Number in brackets indicate the number of organisms of similar weight which were homogenized together.

Like shrimp, there was no significant correlation between the concentrations of Cd and the crab body weight. A comparison of Cd concentrations in the shrimps and crabs indicated that the shrimps were accumulating more Cd as compared with the crabs, (Tables 1 and 2). The storage of Cd in the fish tissue has been reported in the literature (BRYAN 1973, GUTHERIE et al. 1979, PEDEN et al. 1975) but nothing is known regarding the accumulation of Cd in shrimp or crab. The concentrations of Cd in the

sediments from AD-Dammam sewage outfall area ranged between 2.0 to 3.7 µg/g sediment.

Chromium concentrations in the shrimps and crabs ranged between 0.029 - 0.113 and 0.09 - 0.20 µg/g wet tissue, respectively. It may be pointed out that contrary to Cd, Cr was accumulating more in crabs than in shrimps. The reason for this antagonistic behavior between Cd and Cr is unknown. The concentration for Cr in AD-Damman sewage outfall sediments varied from 11.0 to 23.6 µg with an average content of 18.1 µg/g sediment.

TABLE 2: Metal Concentrations in the Crabs caught from AD-Dammam Sewage Outfall Area.

Sample #	Average Wt(g)	Metal Concentrations (µg/g of Wet Tissue)						
		Cd	Cr	Co	Cu	Ni	Pb	Zn
1(2)*	36.7	0.030	-	1.51	5.94	0.65	1.01	37.70
2(1)	83.0	0.029	0.17	1.91	5.72	0.64	1.08	35.94
3(1)	64.5	0.030	0.09	1.01	16.63	0.57	1.04	46.09
4(1)	125.2	0.047	0.04	0.89	9.24	0.56	0.66	40.47
5(1)	56.5	0.031	0.13	1.11	20.73	0.52	0.94	45.15
6(1)	163.9	0.045	0.13	0.77	10.91	0.45	2.01	40.36
7(1)	50.5	0.056	0.16	1.20	18.11	0.61	0.75	42.54
8(2)	43.9	0.046	0.10	0.85	16.63	0.46	0.84	37.00
9(1)	108.3	0.088	0.09	1.00	10.83	0.61	3.89	42.83
10(1)	160.5	0.030	0.20	1.22	8.48	0.60	1.01	41.11
Average		0.043	0.12	1.15	12.32	0.57	1.32	40.92

*Number in brackets indicate the number of organisms of similar weight which were homogenized together.

Cobalt concentrations in the shrimps specimens caught from AD-Dammam sewage outfall area ranged from 0.71 to 1.47 µg, with an average content of 0.98 µg/g wet tissue. Regression analysis of Co concentrations and the shrimp body weight showed no significant correlation. Cobalt concentrations in the crabs varied from 0.77 to 1.51 µg/g wet tissue. It may be pointed out that the absorption of Co by the shrimp and the crab was quantitative almost similar. Cobalt contents in the sediment varied from 14.5 to 31.5 µg/g sediment.

TABLE 3. Metal Concentrations in the Sediments from AD-Dammam Sewage Outfall Area

Sample #	Depth (cm)	Metal Concentrations (μg/g of Sediment)						
		Cd	Cr	Co	Cu	Ni	Pb	Zn
1 - S	0-15	2.0	22.0	28.0	9.5	23.0	16.5	14.0
	15-30	3.0	16.5	26.0	13.5	28.0	11.0	19.5
2 - D	0-15	3.5	22.0	14.5	9.5	38.0	4.5	18.5
	15-30	3.0	16.5	26.0	10.0	19.5	16.5	16.5
3 - S	0-15	2.5	22.0	23.0	10.0	24.5	22.0*	14.5
	15-30	3.0	16.9	28.0	12.5	25.5	7.5	26.5
4 - D	0-15	2.5	23.0	22.1	12.5	31.0	6.0	18.6
	15-30	2.5	15.9	26.0	12.0	33.0	4.5	38.5
5 - S	0-15	2.5	16.5	21.0	8.5	23.0	5.0	18.0
	15-30	3.0	22.0	31.5	14.5	28.0	33.0*	-
6 - D	0-15	2.5	22.0	31.5	16.0	32.0	6.5	22.5
	15-30	3.0	22.0	18.0	9.5	35.0	5.5	19.0
7 - S	0-15	2.5	11.6	23.0	8.5	21.4	7.5	14.5
	15-30	3.0	16.5	31.5	9.8	27.0	5.5	18.0
8 - D	0-15	3.0	23.6	21.6	11.0	29.5	7.0	38.0
	15-30	3.7	16.5	25.0	17.5	27.9	16.5	38.0
9 - S	0-15	3.0	16.5	14.5	8.5	23.5	6.0	20.5
	15-30	2.7	16.5	26.0	9.8	53.0	5.0	26.0
10 - D	0-15	3.5	11.5	19.5	11.0	24.5	5.5	50.5
	15-30	3.5	11.0	21.0	9.5	25.5	8.4	20.5
Average		2.9	18.1	23.9	11.2	28.6	10.0	22.2

S = Shallow i.e. near the shore and 1 meter deep water at low tide
D = Deep i.e. far from the shore and 1.5 meter deep water at low tide.

*Not included in averaging.

The average concentration of Cu in the shrimp, crab and sediment from AD-Dammam sewage outfall area were 6.93, 12.32 and 11.20 µg/g wet tissue or sediment, respectively. The body weight and Cu content in the shrimps were not significantly correlated. Like the shrimps, the body weight of the crabs and Cu contents were not significantly correlated. Comparing average content of the concentrations of Cu in the shrimps and crabs, it was noticed that Cu in the crabs was almost double than that in the shrimps. It may be postulated that crab accumulates more Cu in their edible tissues.

Nickel concentrations in the shrimps ranged from 0.37 to 0.84 µg, with an average of 0.54 µg/g wet tissue. Like other elements discussed so far, no significant correlation was observed between Ni content and the shrimp body weight. No correlation between the concentrations of Ni and the crab body weight was observed. The concentrations of Ni in the sediment ranged between 19.5 to 53.0 µg, with an average of 28.6 µg/g sediment.

The average contents of Pb in the shrimps and crabs were 0.73 and 1.32 µg/g wet tissues, respectively. The variation in Pb concentrations in the shrimp was more pronounced than in the crab. Like Cr and Cu there was more Pb in the crabs than in the shrimps. It may be hypothesized tha the crabs have more absorption tendency for Cu, Cr, and Pb as compared with the shrimps. The average content of Pb in the sediments was 10 µg/g sediment.

Concentrations of Zn in the shrimps ranged from 25.7 to 48.04 µg/g wet tissue. Crabs analyzed in this study contained Zn from 35.94 to 46.09 µg/g wet tissue. On the average, crabs have accumulated more Zn than shrimps. No significant correlation was observed between Zn and the body weight of crab or shrimp. The concentrations of Zn in the sediments from AD-Dammam Sewage Outfall area varied from 14.5 to 38.5 µg/g sediment, with an average of 22.2 µg/g sediment. Further studies are needed to correlate metal concentrations in the sediment, shrimp, and crab to anthropogenic sources or activities in the area.

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