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Heavy Metal Contents in Coastal Water Fishes of West Malaysia

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The last decade has seen a period of rapid industrial development all over the world. Malaysia is no exception. With human advancement, industrial wastes and pollutants have become an increasingly important problem to consider in the control and maintenance of the environment. For Malaysia, dependent on fishes as a major source of protein, it is important to examine the levels of toxic metals in their flesh which could be a health hazard if industrial wastes are ultimately channeled to the sea.

WISSEMAN & COOK (1977) reported that many toxic elements from industrial wastes were ultimately deposited in ocean and lake sediments. Cadmium, lead, zinc, and mercury toxicity can seriously affect the health of man and other organisms, and these metals are heavily used without serious consideration as to how to dispose of them. Incidents of mercury toxicity in fishes in Japan and Sweden have led many investigators to examine mercury levels in their environment and locate possible sources of contamination (IRUKAYAMA 1967, BORG et al. 1966, UNDERDAL & HASTEIN 1971, WESTOO 1973, BLIGH 1971, JERVIS 1970).

In Malaysia, limited information on heavy metal contents in fishes and other marine organisms is available. NORAMLY & MAAROF (1973) reported the mercury levels in several species of marine fish, prawns, cuttlefish, crabs, and mollusca. They showed that the mercury levels in these species were less than 0.5 ppm and comparable to those reported by the Canadians, JERVIS (1970) and BLIGH (1971) and generally lower than the levels found in most fishes and shellfish normally eaten in Norway (UNDERDAL & HASTEIN 1971) and in Sweden (BORG et al. 1966).

This study was aimed at examining the contents of zinc, lead, cadmium, and mercury in fishes caught around the coastal waters of West Malaysia. The areas chosen differ in hinterland industrial development, consisting mainly of ports, shipping, oil refineries, and miscellaneous small manufacturing industries in the west and south and basically non-industrialized areas in the north and east of peninsular Malaysia. It was assumed that if there were any serious pollution resulting from industrial developments, the coastal water fishes and marine lives would also be affected. Since heavy metals like cadmium, lead, and mercury are cumulative in the fish's flesh, the levels of these metals would be good indicators of possible industrial pollution in the areas under study.

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EXPERIMENTAL

Sample Collection. Samples of six species locally found and consumed were collected at various locations; namely, Perlis and Penang in the northwest; Selangor, Melaka, and Johor in the southwest; and Trengganu in the northeast of peninsular Malaysia. The six species that could be found in all these areas were: Epinephelus chlostigma (Val), Plotosus anguillaris (Bloch), Sciaena russeli (Curvier), Sillago sihama (Forskal), Tachysurus maculatus (Thun), and Upeneus sulphureus (Curvier). Arrangements were made with the officers of a semigovernment body (Majuikan) responsible for small fishermen catches and marketing to have these fishes available when we went for collection. Three of each fish species were collected at each of the six locations, and duplicates of each sample were analyzed for the four metals.

The fish were weighed, tagged with identification number for species and location, dated, then placed in an ice box for storage until arrival at the laboratory. They were kept frozen in a -20°C freezer until ready for analyses. All samples were thawed to room temperature, deboned, and homogenized with a Waring blender before analyses. The digestion of sample was carried out using the procedures outlined in the manuals by COLEMAN INSTRUMENTS (1971a) for wet digestion of mercury and Varian II AAS_6 spectrophotometer for cadmium, lead, and zinc.

Mercury Analysis by Cold Atomic Absorption. Procedure for mercury analysis on digested samples were followed as outlined by HATCH & OTT (1968) and modified for use with a Perkin Elmer, Coleman MAS-50 mercury analyzer (COLEMAN INSTRUMENTS 1971b).

RESULTS

Table 1 summarizes the analytical results from six species of fish caught at six locations of peninsular Malaysia, viz., mean concentrations for cadmium, lead, zinc, and mercury digested tissues. The levels of the four metals were found to be below the maximum permissable limits (MPL) set by the United States Food and Drug Administration (USFDA 1974). The overall means for cadmium range from 0.03-0.05 ppm (MPL:2.0 ppm); lead, 0.21-0.32 ppm (MPL: 2.0 ppm); zinc, 2.3-6.5 ppm (MPL: 40 ppm); and mercury, 0.08-0.10 ppm (MPL: 0.5 ppm).

Table 1 also gives the concentrations of cadmium, lead, zinc, and mercury in ppm for species averaged over all locations. The zinc and mercury contents for Tachysurus maculatus were highest (6.5 ppm and 0.01 ppm, respectively). This may be related to its peculiar habit of searching for food in muddy silt beds. These results demonstrate that for all the six species of fish studied, none have accumulated levels dangerous enough to pose a health problem or indicate serious industrial pollution in the areas studied.

TABLE 1 - Concentration of cadmium, lead, zinc, and mercury (ppm wet weight) of six species of fishes caught at six different locations[a].

Species		Locations						
		Perlis[c]	Penang[d]	Selangor[d]	Melaka[d]	Johor[d]	Trengganu[c]	X
Epinephelus chlorostigma (Val) (Kerapu)[b]	Cd	0.05±0.02	0.03±0.01	0.05±0.00	0.03±0.00	0.03±0.00	0.02±0.00	0.04
	Pb	0.35±0.17	0.17±0.1	0.53±0.13	0.2 ±0.02	0.19±0.02	0.32±0.06	0.29
	Zn	1.7 ±0.8	3.6 ±0.1	3.0 ±0.2	4.5 ±0.4	5.2 ±1.7	1.9 ±1.7	3.31
	Hg	0.08±0.02	0.14±0.03	0.04±0.01	0.11±0.01	0.08±0.02	.003±0.03	0.09
Plotus anguillaris (Bloch) (Semilang karang)[b]	Cd	0.04±0.01	0.03±0.00	0.04±0.00	0.07±0.03	0.02±0.00	0.03±0.00	0.04
	Pb	0.10±0.07	0.10±0.07	0.34±0.04	0.26±0.02	0.16±0.02	0.32±0.04	0.21
	Zn	1.5 ±0.9	1.5 ±0.1	3.6 ±0.5	4.0 ±0.1	5.4 ±1.0	3.7 ±0.5	3.28
	Hg	0.06±0.01	0.05±0.05	0.04±0.05	0.12±0.02	0.09±0.04	0.08±0.01	0.07
Sciaena russeli (Curvier) (Gelama)[b]	Cd	0.02±0.01	0.03±0.00	0.04±0.00	0.07±0.00	0.02±0.01	0.03±0.00	0.04
	Pb	0.03±0.00	0.17±0.08	0.5 ±0.08	0.08±0.01	0.32±0.2	0.34±0.1	0.24
	Zn	0.77±0.5	4.2 ±3.4	3.0 ±1.0	6.5 ±1.5	6.4 ±2.2	3.5 ±2.5	4.06
	Hg	0.07±0.00	0.08±0.01	0.06±0.01	0.12±0.02	0.05±0.00	0.1 ±0.02	0.08
Sillago sihama (Forskal) (Puntung damar)[b]	Cd	0.04±0.00	0.04±0.01	0.10±0.01	0.06±0.01	0.03±0.00	0.03±0.00	0.05
	Pb	0.36±0.1	0.23±0.06	0.46±0.04	0.35±0.01	0.24±0.04	0.18±0.06	0.30
	Zn	1.7 ±1.3	2.0 ±0.1	0.73±0.34	4.09±0.26	4.3 ±0.76	0.87±0.27	2.30
	Hg	0.07±0.02	0.08±0.04	0.07±0.02	0.11±0.00	0.05±0.01	0.12±0.01	0.08
Tachysurus maculatus (Thun) (duri)[b]	Cd	0.02±0.00	0.05±0.01	0.03±0.00	0.03±0.00	0.02±0.00	0.03±0.00	0.03
	Pb	0.11±0.04	0.28±0.04	0.31±0.04	0.13±0.06	0.12±0.03	0.31±0.07	0.21
	Zn	2.7 ±1.3	5.5 ±1.9	5.8 ±1.2	10.0 ±0.3	7.7 ±2.4	7.1 ±1.8	6.48
	Hg	0.09±0.05	0.02±0.00	0.15±0.03	0.1 ±0.02	0.12±0.01	0.1 ±0.01	0.10
Upeneus sulphureus (Curvier) (biji nangka)[b]	Cd	0.07±0.02	0.04±0.01	0.05±0.01	0.04±0.01	0.04±0.02	0.04±0.01	0.05
	Pb	0.42±0.23	0.07±0.00	0.43±0.21	0.29±0.04	0.51±0.15	0.19±0.04	0.32
	Zn	1.1 ±0.3	4.9 ±0.5	3.1 ±1.5	6.5 ±0.9	4.1 ±0.1	1.0 ±0.6	3.44
	Hg	0.05±0.02	0.08±0.01	0.1 ±0.01	0.09±0.01	0.12±0.04	0.12±0.02	0.09

a. Mean values of 3 fishes/location.
b. Local names used in Malaysia.
c. Areas with agriculture as major occupation.
d. Areas with industries as major occupation.
X. Overall mean value of 18 fishes/species.

Analysis of variance (Table 2) showed significant differences ($P<0.01$) due to species, locations, and also species by location interaction. Only for mercury were there no species differences. Differences due to species could be expected as species such as Sillago sihama and Upeneus sulphureus search for food on sandy seabeds; Epinephelus chlorostigma and Plotus anguillaris habitate around rocks and corals; Sciaena russeli pick up food suspended in water, and Tachysurus maculatus usually seek food particles in the silt and muddy environment. The locations may also be a contributing factor to the amount of heavy metals picked up by these different species. For the areas under study, Penang, Selangor, Melaka, and Johor can be classified as industrialized while Perlis and Trengganu are mainly agricultural. Fishes caught in Melaka showed a mean mercury value of 0.107 ppm, the highest reported. Zinc level reported in this study was slightly lower than those reported by other workers (see Table 3). The concentrations of these metals in the fish's tissue were generally lower than the safety levels recommended by international regulating agencies such as the USFDA (1974), WHO (1972), and the Environmental Protection Agency (EPA) (1972).

Although many researchers have shown that levels of heavy metals increased with age and weight, this study did not reveal such relationship (Table 4). This may be due to the smaller types of fish studied. The weights ranged from 20 to 720 g but almost 90% of the samples had weights below 160 g. Thus differences were not big enough to show a significant body weight relationship with heavy metal contents. The large standard deviations reflect the variations due to fish species and the locations.

DISCUSSION

Researches on mercury and other heavy toxic metals were prompted by incidences such as the tragedy in Minamata Bay (IRUKAYAMA 1964), pollution to environment and biological systems by mercury in Sweden (PEAKALL & LOVETT 1972), and mercurial poisoning in Iraq, Pakistan, and Guatamala (BAKIR et al. 1973). Cadmium toxicity in fishes were reported by KOPP & KRONER (1969), LOVETT et al. (1972), and many others. NEHRING & GOETTL (1974) reported zinc toxicity in rainbow trout, and RAY (1978) reported the bioaccumulation of lead in Atlantic salmon. Environmental influences of trace metals in fish has been reported by ABDULLAH et al. (1976), UNDERDAL & HASTEIN (1971), BENSON et al. (1976), and PEGENKOPF & NEUMAN (1974). Many of these investigators related the metals to the high background level under study.

While extensive studies of this nature have been conducted in developed nations, very limited information on heavy metal contents in the environment and biological systems is available in less developed and developing countries.

This study provides baseline data and information on the heavy

TABLE 2 - Analysis of variance for cadmium, zinc, lead, and mercury for species, location, and species x location values.

Source of Variation	df	F - values			
		Cadmium	Zinc	Lead	Mercury
Treatment totals	35				
Species	5	6.29**	14.24**	3.36**	2.06^{ns}
Location	5	8.59**	18.89**	11.53**	5.02**
Species x Location	25	4.04**	1.41^{ns}	3.15**	4.13**
Residual	72				
Total	107				

** $P < 0.01$
ns not significant

TABLE 3 - Mean values of cadmium, lead, zinc, and mercury concentration at six locations averaged over all species[a].

Locations	Metals			
	Cadmium	Lead	Zinc	Mercury
Perlis	0.04±0.02	0.23±0.15	1.56±0.60	0.07±0.01
Penang	0.04±0.01	0.17±0.07	3.64±1.45	0.08±0.04
Selangor	0.05±0.02	0.43±0.08	3.20±1.47	0.08±0.04
Melaka	0.04±0.02	0.22±0.09	5.93±2.13	0.11±0.01
Johor	0.03±0.01	0.26±0.13	5.51±1.25	0.08±0.03
Trengganu	0.03±0.01	0.28±0.07	3.01±2.12	0.10±0.02

[a] Mean values of 18 readings in ppm.

metals, cadmium, lead, zinc, and mercury in small coastal water fishes in West Peninsular Malaysia. Reports of this nature should provide valuable information to the government for controlling industrial and chemical pollution by setting appropriate standards for regulating the dumping of wastes into the environment.

TABLE 4 - Concentrations of lead, cadmium, zinc, and mercury with body weight of fish[a].

Body weight range (g)	No. of samples	Concentrations in ppm (wet weight)			
		Lead	Cadmium	Zinc	Mercury
20-40	35	0.30±0.19	0.04±0.02	3.7±2.5	0.09±0.03
41-80	40	0.29±0.16	0.04±0.02	3.8±2.5	0.08±0.03
81-160	22	0.21±0.12	0.03±0.02	3.9±2.6	0.08±0.04
161-360	8	0.17±0.11	0.04±0.01	3.5±2.8	0.09±0.06
361-720	3	0.08±0.04	0.02±0.01	2.2±1.1	0.10±0.03
Total samples:	108				

[a] Mean values and standard deviation.

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