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Trace Metal Concentrations in Shrimp and Fish Collected from Gresik Coastal Waters, Indonesia

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ABSTRACT: A survey for the presence of metals in various aquatic animals was conducted in 2001 and 2002 along the Gresik coast of Indonesia. The results showed that levels of almost all metals measured were lower than those recorded in aquatic animals from other regions of the world. Only levels of copper and zinc were comparable those in other reports. Levels of metals in the tissue in all the samples collected were within the range acceptable for consumption.

KEYWORDS: metals, aquatic animals, accumulation, Gresik coastal waters, Indonesia.

INTRODUCTION

Heavy metals enter coastal waters from various sources. Rock and soils directly exposed to surface water are usually the largest natural source. Another major source is anthropogenic input, such as that from fossil fuel combustion, mining, smelting and solid waste incineration [1].

Problems associated with metal contamination were first highlighted in industrially advanced countries because of their larger industrial discharges, and because of incidents of mercury and cadmium toxicity in Japan and Sweden. Minamata disease in Japan caused the death of many people from intake of fish contaminated with toxic levels of mercury [2]. Similarly, the devastating effects of cadmium on animals were amply demonstrated by itai-itai disease in humans [3]. Several studies have revealed that cadmium is also dangerous to aquatic organisms and can be bioaccumulated in food chains [4, 5].

Gresik is one of the big industrial cities in Indonesia. The coastal waters near Gresik, Indonesia receive wastewater discharged from industrial facilities in the region. The zone has been under constant urban pressure during the last fifteen years due to industrial development. The potential industries that might contribute to levels of metals in the coastal waters are a superphosphate plant, an asphalt plant, a coal-fired electric power plant, a natural gas processing plant, metal smelters, refineries, etc. Although these waters are harvested for edible organisms by local fishermen, to our knowledge there have been no studies on the level of metals in harvested products.

The purpose of this study was to document the concentration of metals in the tissues of shrimp and fish from Gresik coastal waters and to discuss the implications of such contamination in terms of public health.

METHODS

Five species of fishes, ponyfish (*Leiognathus equlus*), anchovy (*Coilia dusumieri*), milk fish (*Chanos chanos*), mullet (*Mugil vaigiensis*) and sea catfish (*Arius leptonotacanthus*), and one species of shrimp (*Penaeus merguensis*) were chosen as samples for metal analyses. The selection of species for metal analyses was based on general abundance in the area, similarity in size and potential to be consumed by local fishermen. The animals were collected by local fishermen using gillnets in Gresik coastal waters between June 2001 and June 2002 (Fig. 1).

For fish species consumed in entirety (e.g., anchovies and ponyfish), whole body samples were homogenized and prepared for metal detection. For other fish and shrimp, only edible flesh was used for metal detection. Before filleting, external water from each individual sample was absorbed using tissue papers. The flesh was then pooled, weighed to the nearest 0.1 g on an analytical balance and minced by knife before addition to a known amount of double de-ionized water for homogenization in a multi-speed blender. The anchovies and ponyfish were handled in the same manner. Each pooled sample was divided into between two to six sub-samples depending on the quantity. The sub-samples were placed separately into

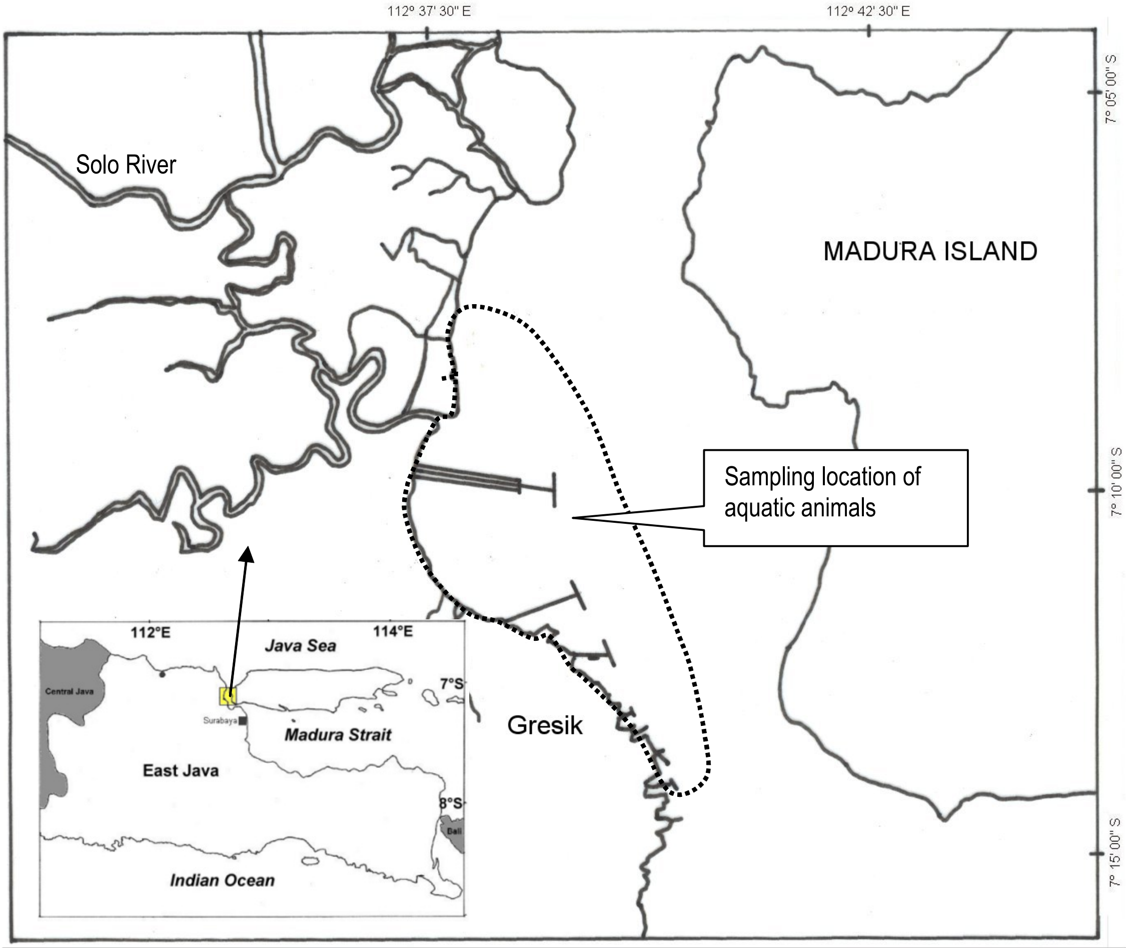

Fig 1. Sampling location of aquatic animals.

special flasks, weighed and frozen at –20°C for a period not less than 8 hours. The frozen samples were then placed under vacuum on a freeze-dryer unit (Labconco) until they were completely dried. Dried samples of approximately 1 g each were digested in 20 ml of HNO_3 (ultrapur, Merck) using a Microwave Digester (Ethos D) for approximately 25 minutes. Digests are filtered through Whatman no 4 paper and then made up to 50 ml with double de-ionized water. Metal concentrations in the digests were determined by inductively-coupled plasma emission spectroscopy (Thermo Jarrell Ash Type: IRIS Advantage). The accuracy of the analytical procedure was monitored by analyses of dogfish muscle reference materials, DORM-2, certified for metals by the National Research Council of Canada. The standard reference material digests were found to conform (94 - 108 %) with the documented values for certified trace metal concentrations (Table 1).

Results and Discussion

Dry weight trace metal concentrations recorded from different species are summarized in Table 2. Measurement for lead (Pb) and selenium (Se) of all samples were always below the detection limit of 0.001 mg/kg dry weight. We noted that all animals caught in 2001 and 2002 contained Cu and Zn levels higher than the level of other metals (As, Cd, Cr, Ni, and Pb) in the same animals. Our findings also showed that the concentrations of Zn and Cr in whole bodies of animals collected in June 2001 were relatively higher than those

Table 1. Results of the analyses of reference materials (DORM-2).

Reference Material	Assigned Values (mg/kg dry weight)	Measured Value(Mean ± SD) (mg/kg dry weight)(n = 2)
Arsenic	18	17.34 ± 0.18
Cadmium	0.043	0.046 ± 0.01
Chromium	34.7	32.66 ± 0.21
Copper	2.34	2.52 ± 0.03
Nickel	19.4	18.95 ± 0.04
Lead	0.065	0.062 ± 0.01
Zinc	25.6	24.61 ± 0.42
Selenium	1.4	1.35 ± 0.02

Table 2. Metal concentrations measured in tissue samples (mg/kg dry weight) of animals caught from Gresik coastal waters between June 2001 and June 2002.

Species	Arsenic		Copper		Zinc		Cadmium		Nickel		Chromium	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Shrimp	2.33 ± 0.04	1.23 ± 0.21	19.5 ±2.0	28.9 ± 3.1	36.6 ± 3.1	30.3 ± 2.6	0.05 ± 0.03	0.01 ± 0.00	0.05 ± 0.02	0.01 ± 0.00	0.17 ± 0.02	0.22 ± 0.06
Ponyfish	1.70 ± 0.26	UN	6.71 ± 0.22	7.68 ± 1.09	64.27 ± 2.10	28.31 ± 2.94	0.03 ± 0.01	0.01 ± 0.00	0.13 ± 0.02	0.05 ± 0.04	0.17 ± 0.01	0.28 ± 0.00
Anchovy	0.77 ± 0.03	UN	7.1 ± 1.1	6.88 ± 0.43	34.00 ± 0.69	68.40 ± 2.14	UN	UN	0.29 ± 0.04	0.08 ± 0.04	UN	1.10 ± 0.18
Milkfish	0.44 ± 0.10	UN	7.09 ± 0.95	7.98 ± 0.94	22.72 ± 1.27	19.90 ± 0.14	0.01 ± 0.00	UN	0.48 ± 0.09	UN	UN	0.24 ± 0.08
Mullet	0.82 ± 0.17	UN	3.52 ± 0.33	5.23 ± 0.27	17.61 ± 0.92	24.8 ± 1.8	UN	UN	0.58 ± 0.05	UN	UN	UN
Catfish	1.56 ± 0.04	UN	5.86 ± 0.27	10.02 ± 0.35	15.53 ± 0.84	50.6 ± 2.0	UN	UN	0.21 ± 0.03	UN	UN	0.24 ± 0.08
Acceptable Limits	4[+)] (Australia[16])		80 (UK[15,8])		200 (UK[15,8])		8 (Hong Kong[15,8]) 0.4 (European Regulation 466/2001/EC[9])		2 (IRPTC[17])		4 (Hong Kong[15,8])	

UN = below the detection limit; [+)] inorganic arsenic, this study measured total arsenic; IRPTC = International Register of Potentially Toxic Chemicals, Geneva.

recorded in muscle tissues. In June 2002, concentrations of Ni, Zn, and Cr in whole body samples were higher than those in flesh samples.

Our results for higher concentrations of copper and zinc than other metals (As, Cd, Cr, Ni, and Pb) in both fish and shrimp were similar to findings previously recorded for crustaceans [6,7,2] and fish [8,9] from other waters of the world. The higher copper levels recorded in shrimp (*Penaeus merguensis*) when compared to fish was presumably influenced by the copper normally contained in the respiratory pigment of crustaceans. Both copper and zinc are essential elements and their concentrations are usually regulated in marine fishes [10] and crustaceans [11,4,12].

The levels of almost all the metals measured in this study are relatively lower than those recorded in aquatic animals from other regions of the world. Only levels of zinc and copper were comparable to those reported elsewhere [2,6,7,8,9].

Variation in metal concentration among the samples could have been dependent on such factors as size categories, ecological nich, trophic levels, or metabolic requirements. For example, bottom-dwelling and demersal species are known to have higher concentrations than more pelagic species, possibly due to greater exposure to contaminated sediments [13,8].

The potential toxicological impacts of contaminated seafoods can be evaluated on the basis of concentrations in whole body and flesh samples. Concentrations of trace elements can be 200 – 400% greater in organs and other tissues than in muscle [10,14]. This can explain the higher concentrations we recorded in homogenized whole body samples for metals like Zn and Cr.

The Government of Indonesia has no standards for maximum limits of metals in the muscle tissue of marine biota. However, using standards from other countries and organizations (Table 2) most of the animals caught from Gresik coastal waters contained trace metals within acceptable ranges for consumption.

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