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Original Paper

CONTENT OF HEAVY METALS (Cr, Cu, Pb, and Zn) IN MACROZOOBENTHOS AT JAKARTA BAY

Noverita Dian Takarina* and Andrio Adiwibowo

Department of Biology, Faculty of Mathematics and Natural Sciences, University of Indonesia, Depok, 1642, Indonesia

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ABSTRACT

Trace metal contamination of marine environments can be determined by measuring trace metal concentration in sediments, water or biota. Biomonitor organisms have the advantages over other measurements that they concentrate the portion of metals that are in a biologically available form, and this portion which is usually of interest when assessments is being made of trace metal contamination. Correspondingly, whole tissue trace metal concentrations of 4 metals in common Jakarta Bay benthic species (polychaetes, molluscs, crustaceans) from contaminated locations were measured. The mean concentration for Cu was 17.5 ± 21.8 µg g^{-1} dw in polychaetes, 11.9 ± 8.8 µg g^{-1} dw in molluscs, and 12.2 ± 5.5 µg g^{-1} dw in crustaceans. The mean concentration for Cr was 172.8 ± 262.5 µg g^{-1} dw in polychaetes, 31.8 ± 62.8 µg g^{-1} dw in molluscs, and 28.5 ± 29.0 µg g^{-1} dw in crustaceans. The mean concentration for Zn was 152.4 ± 76.4 µg g^{-1} dw in polychaetes, 132.0 ± 106.3 µg g^{-1} dw in molluscs, and 515.8 ± 503.5 µg g^{-1} dw in crustaceans. The mean concentration for Pb was 6.3 ± 13.6 µg g^{-1} dw in polychaetes and was 2.0 ± 4.5 µg g^{-1} dw in molluscs. The study provides significant contribution to confirm the content of heavy metal in each common benthic species inhabits coastal Jakarta Bay.

Keyword : Heavy metal; Macrozoobenthos; Jakarta bay

Correspondence : +62-811101630 ; email : takarinanoverita@hotmail.com

INTRODUCTION

Aquatic contaminations by heavy metal is very harmful since these elements are not degradable in the environment and may accumulate in living organisms. Furthermore, the ability of aquatic and marine organisms to accumulate metals has been documented (Agbozu *et al.*, 2007, Ali and Fishar, 2005). Polychaetes, molluscs, and crustaceans are often the common and dominant infaunal macroinvertebrate groups in marine sediments, both with regards to abundance and biomass. They are found in a wide range of habitats and can be suitable biomonitors of trace metals contamination in environment as a large number of species are infaunal obligate deposit feeders and inadvertently ingest sediment during foraging (Baker & Yousef , Bu Olayan & Thomas, 2005, Olomukoro & Azubuike, 2009, Poulton *et al.*, 1995). Polychaetes, molluscs, and crustaceans are also abundant in both contaminated and uncontaminated habitats and tolerant to contamination.

Jakarta Bay is threatened marine ecosystems because number of rivers from lands are flowing to this area. Along the waterways, land uses are dominated by anthropogenic activities, for instance industry and housing. As a consequence, the river systems receive numerous influx, include heavy metals.

Currently, there is a paucity of data reporting the whole trace metal contaminations of common macrozoobenthos. Therefore, the objective of this research was to compare predominant trace metal levels in the major and minor common macrozoobenthos among 8 rivermouths at Jakarta Bay.

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MATERIALS AND METHODS

Study Area

Jakarta Bay is located between longitude of 106°42'45" E and latitude of 6°13'10" S in Java Island, Indonesia. Most of the bay's area has a depth ranging between 5 to 30 meters. Eight sampling stations were chosen to reflect anthropogenic activities and land uses at 8 river mouths in Jakarta Bay. They were Dadap, Kamal, Cengkareng Drain, Angke, Ciliwung, Sunter, Cakung, and Bekasi, respectively. (**Fig. 1**). Each river mouth has different types of land use, they were agriculture, domestic, and industry.

Field Sampling

In August 2009, macrozoobenthos samples were collected from sediments of 8 river mouths. In each location, sediments collected from bottom by using *Peterson Grab.* Samples from fields then preserved and stored in cooler box and freezer at 4 °C. For identification purposes, sediments were sieved by using USA Standard Testing Sieves sizing 4 mm, 2.36 mm, 1.70 mm, 1.18 mm and 600 µm. Organisms retained in sieves were identified under binocular microscope.

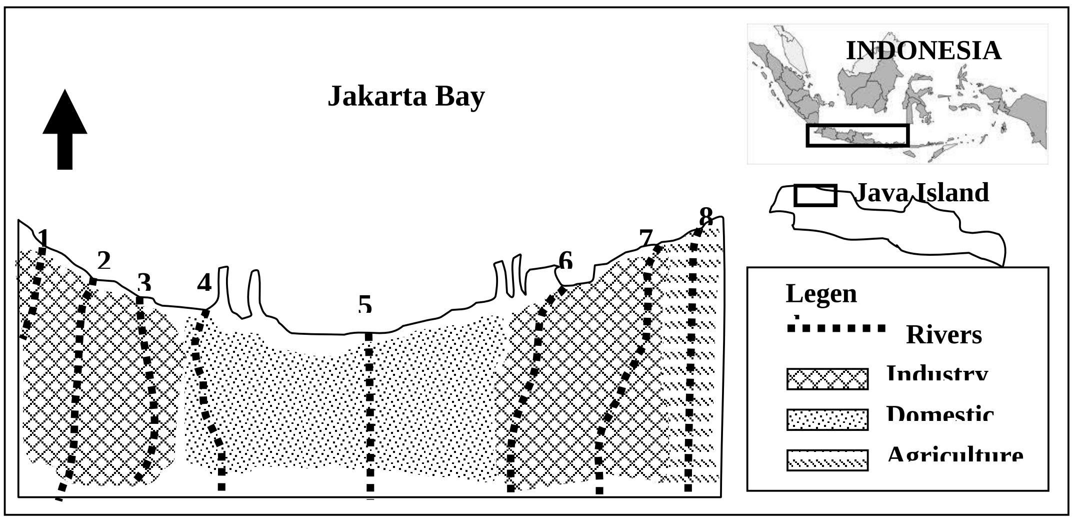

Fig 1. Map of Jakarta bay showing 8 sampling stations, rivers, and land uses (1 : Dadap, 2 : Kamal 3 : Cengkareng Drain, 4 : Angke, 5 : Ciliwung, 6 : Sunter, 7 : Cakung, and 8 : Bekasi)

Procedures

The samples were then preserved by 70% alcohol and dried for 2-3 hours at 105 °C. Dry samples destructed by 4 ml HNO_3 and 2 ml $HClO_4$ solutions. The sample was heated by using hot plate for 1-2 hours (until the solution volume shrank to 1-3 ml). Then double distilled water were added as much as 1-2 ml and cooled at room temperature. Samples were chilled and filtered using Whatman filter paper No. 40, and the filtrate was collected in a test tube. Then, the filtrate was added with double distilled water and made up to 7 ml. Furthermore, a test tube containing the sample solution was mixed, and then was vortexed. Samples were then ready for the heavy metals content (Cu, Cr, Pb and Zn) analysis by Atomic Absorption Spectrophotometry using Shimadzu model AA-6300. The digestion and analytical procedures were checked by analysis of DORM Certified Reference Material (CRM) for dogfish muscle with known concentration for heavy metals. The CRM values for Cu, Cr, Pb, and Zn were 107.35 µg g^{-1} dw, 105 µg g^{-1} dw, 99.93 µg g^{-1} dw, and 101.23 µg g^{-1} dw, respectively.

RESULTS AND DISCUSSION

Benthic Organisms. Table 1. shows the distribution of benthic organisms in Jakarta Bay. The family Polychaeta Spionidae was found in 5 river mouths, families Mollusc Arcidae,

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Mytilidae and Tellinidae were found in 2 river mouths, and family Crustacea Balanidae was found in 2 river mouths.

Polychaetes Trace Metal Concentrations

Whole tissue total trace metal concentrations of the Polychaete individuals are presented in **Table 2**. Chromium followed by zinc whole tissue concentrations was the highest among Spionids. Trace metal levels were observed in the sequence Cr > Zn > Cu > Pb. It was observed that Cr was higher than other metals. Furthermore, the Cr concentration from Sunter (348.4 ± 489.9 µg g^{-1} dw) was higher than other rivermouths. Compared to other sites, land uses around Sunter were dominated by industrialized areas. A comparison of Cr for industrial site with those of non-industializ\u0065d areas indicated Cr inputs from several industries, for instance tanneries and smelteries. Jordao *et al.,* (1997) reported that chromium contamination was positively correlated with tannery discharges into rivers.

Toxic heavy metal contaminations in those marine organisms have been recorded since metals concentration in macrozoobenthos in some locations have exceeded the safety standard issued by The Indonesian Food & Drugs Standards. For instance, Cu in Muara Cakung was 46.7 ± 33.3 µg g^{-1} dw, Pb in Angke, Sunter, and Cakung were 5.4 ± 4.4 µg g^{-1} dw, 20.9 µg g^{-1} dw, and 5.6 ± 2.4 µg g^{-1} dw, respectively. Furthermore, Zn in Angke, Ciliwung, Sunter, Cakung, and Bekasi were 140.1 ± 55.4 µg g^{-1} dw, 118.0 ±128.4 µg g^{-1} dw,135.9 ± 59.7 µg g^{-1} dw, 240.9 ±17.7 µg g^{-1} dw, and 127.1 ± 48.1 µg g^{-1} dw. Besides Cr, it was observed that Zn levels were also high. Metal bioaccumulation of those metals related to the feeding strategies and physiologies adapted to the habitat. According to Lichtenegger, *et al.,* (2003), some polychaeta worms exhibit high levels of Zinc in their jaws, whereas other accumulate Cu. Animals depend on calcification to harden certain tissues, in particular, fangs, teeth, and mandible.

Table 1. Distribution of macrozoobenthos in Jakarta bay

Benthic Organisms	River mouth Stations							
	1	2	3	4	5	6	7	8
Polychaeta								
Fam. Spionidae	-	+ (131)	+ (44)	+ (97)	+ (43)	-	-	+ (5)
Mollusc								
Fam. Arcidae	-	+ (3)	-	-	-	-	-	-
Fam. Tellinidae	-	-	-	-	-	-	-	+ (1)
Fam. Mytilidae	-	-	-	-	+ (1)	-	-	-
Crustacea								
Fam. Balanidae	+(1)	-	-	-	+ (1)	-	-	-

Numbers in parentheses indicate numbers of individuals collected
1 : Cengkareng Drain, 2 : Angke, 3 : Ciliwung, 4 : Sunter, 5 : Cakung, 6 : Dadap, 7 : Kamal, 8 : Bekasi

Table 2. Mean whole tissue trace metal concentrations in Jakarta bay polychaetes µg g^{-1} dw

Metals	River mouth Stations					Pooled data
	Angke [d]	Ciliwung [d]	Sunter [i]	Cakung [i]	Bekasi [a]	
Cu	13.0 ± 8.4	14.0 ± 17.5	7.3 ± 8.3	46.7 ± 33.3*	6.4 ± 11.1	17.5 ± 21.8
Cr	59.2 ± 16.3	78.3 ± 36.5	348.4 ± 489.9	255.4 ±374.1	122.9 ± 87.9	172.8 ± 262.5
Pb	5.4 ± 4.4*	NA	20.9*	5.6 ± 2.4*	NA	6.3 ± 13.6
Zn	140.1 ± 55.4*	118.0 ±128.4*	135.9 ± 59.7*	240.9 ±17.7*	127.1 ± 48.1*	152.4 ± 76.4

*Metal contents have exceeded the Indonesian Food & Drugs Standards (µg g^{-1} dw) Cu : 20, Pb : 2, Zn : 100 Land use : a : agriculture, d : domestic, i : industry, NA : not available

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Molluscs Trace Metal Concentrations.

Data only available for Angke, Bekasi, and Cakung because no molluscs were found in other sites. In molluscs, trace metal levels were observed in the sequence Zn > Cr > Cu > Pb. Molluscs from Bekasi contained metals that have exceeded the safety standard issued by The Indonesian Food & Drugs Standards, in particular, Cu was 24.7 µg g^{-1} dw and Zn was 317.4 µg g^{-1} dw (**Table 3**). Similar to polychaetes, in molluscs, Zn was higher compared to other metals. Zn is required to harden fangs, teeth, and mandible. Eventhough land uses in Bekasi were mainly agriculture, yet, still have high Zn values (317.4 µg g^{-1} dw) and followed by Cr (143.8 µg g^{-1} dw**)**. Taboada-Castro *et al.*, (1998) reported that manures may contain and release Zn, thus contaminates waterways surrounding agricultural area.

Table 3. Mean whole tissue trace metal concentrations in Jakarta bay molluscs µg g^{-1} dw

Metals	Rivermouth Stations					Pooled data
	Angke [d]	Ciliwung [d]	Sunter [i]	Cakung [i]	Bekasi[a]	
Cu	11.6 ± 1.8	NA	NA	NA	24.7*	11.9 ± 8.8
Cr	5.1 ± 6.2	NA	NA	NA	143.8	31.8 ± 62.8
Pb	BDL	NA	NA	NA	10.2	2.0 ± 4.5
Zn	90.2 ± 31.4	NA	NA	72.4	317.4*	132.0 ± 106.3

*Metal contents have exceeded the Indonesian food and drugs standards (µg g^{-1} dw) Cu : 20, Pb : 2, Zn : 100 Land use : a : agriculture, d : domestic, i : industry, BDl : below detection limit, NA : not available

Crustaceans Trace Metal Concentrations

In crustaceans, trace metal levels were observed in the sequence Zn > Cr > Cu. Furthermore, crustaceans from C. Drain and Cakung were contaminated by Zn and not safe for health (**Table 4**). Those observed metal content variations are related to the ability of some marine crustaceans to regulate internal concentrations of metals. High level of zinc compared to other metals because hepatopancreas seems to act as a store when excess zinc is absorbed from food (Bryan, 1968, Khrisnamurthi and Nair, 1999). However, low level of Cu because crustaceans have ability to regulate total body level of particular metal (White and Rainbow, 1982). Furthermore, excessive Cr can be stored in exoskeleton and thus, will be released during molting (Bergey and Weis, 2007). Crustacean was the only macrozoobenthos that can be found in industrialized areas in C. Drain. The presence of crustacean, indeed, confirmed metal levels in that site. It was observed that Zn (871.8 µg g^{-1} dw) was the highest metal followed by Cr (49 µg g^{-1} dw). Smelteries, electroplating industries combined with tanneries along C. Drain are the major sources of those metals.

Table 4. Mean whole tissue trace metal concentrations in Jakarta bay crustaceans µg g^{-1} dw

Metals	Rivermouth Stations					Pooled data
	C.Drain [i]	Ciliwung [d]	Sunter [i]	Cakung [i]	Bekasi[a]	
Cu	16	NA	NA	8.3	NA	12.2 ± 5.5
Cr	49	NA	NA	7.9	NA	28.5 ± 29.0
Pb	BDL	NA	NA	BDL	NA	NA
Zn	871.8*	NA	NA	159.8*	NA	515.8 ± 503.5

*Metal contents have exceeded The Indonesian Food & Drugs Standards (µg g^{-1} dw) Cu : 20, Pb : 2, Zn : 100
Land use : a : agriculture, d : domestic, i : industry, BDl : below detection limit, NA : not available

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Environmental Health

From the environmental health point of view, this research inform and confirm that marine organism in particular location are not suitable for human consumption. Since some of molluscs species (*Anadara* sp.) are consumed directly, thus metal contents on molluscs need to be concerned. Molluscs originated from Bekasi were positively contaminated by Cu, Pb, Zn and can posses serious threat to human. However, Molluscs originated from Cakung and Angke were still safe. Even Polychaetes and some of the Crustaceans were not consumed directly, however these organisms can transfer metals from their body through food chain if consumed by fishes and birds. Large marine organisms especially the Polychaeta predators inhabit Angke, Sunter, and Cakung pose serious threats because of accumulation of Pb and Zn in Polychaetes.

Conclusions

The present study revealed the significance of trace metal contents in each common benthic species inhabits Jakarta Bay. Among macrozoobenthos, concentrations of Zn and Cr were consistent and higher than Cu and Pb. High level of Cr related to the anthropogenic activities, for instance tanneries. Furthermore, high level of Zn related to the bioaccumulation in macrozoobenthos body. Validation of metal levels in benthic can be applied as bioindicator to metal pollution and enable to develop low cost and environmental-friendly monitoring systems in order to take precautionary measures. Furthermore, there is a paucity of data reporting benthic biodiversity. Thus, in the future, the study will continue to investigate the impact of metal accumulation on the numbers of species with their population measured in Shannon-Wiener Index.

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