

## THE DISTRIBUTION OF HEAVY METALS IN SEDIMENT OF JAKARTA BAY

Endang Rochyatun\* and A. Rozak

Research Centre for Oceanography, Indonesian Institute of Sciences

Jl. Pasir Putih 1, Ancol Timur, Jakarta 14430, Indonesia

*e-mail:* endang\_rochyatun@yahoo.co.id.

### ABSTRACT

A survey on heavy metal content in seawater and sediment was conducted in Jakarta Bay in May and October 2004. There is indication of significant presence of heavy metal in sediment. The contents of heavy metals in sediment at the western part of Jakarta Bay varied as follows: Pb = 10.67-35.19 ppm, Cd = 0.04-0.30 ppm, Cu = 7.41-74.70 ppm, Zn = 76.99-497.53 ppm and Ni = 4.58-18.75 ppm. At the central part of Jakarta Bay, they varied as Pb = 6.69-64.44 ppm, Cd = 0.01-0.442 ppm, Cu = 1.19-40.60 ppm, Zn = 53.87-275.68 ppm and Ni = 4.09-11.88 ppm and at the eastern of Jakarta Bay, Pb content varied between 3.64 and 43.97 ppm, Cd = <0.001-0.320 ppm, Cu = 0.82-36.47 ppm, Zn = 78.27-230.68 ppm and Ni = 4.58-11.02 ppm. The concentration of Pb in May and of Cu in October 2004 were found higher near the coast and decreases towards the open sea, which is commonly found in front of estuary such Angke and Cengkareng Drain. The concentration of Cd in Jakarta Bay was constant at all stations and does not show any correlation with the distance of station and estuary. Heavy metals content in sediment was high in Jakarta Bay.

**Keywords:** Heavy metals, Pollution, Sediment, Jakarta Bay.

### INTRODUCTION

Heavy metals are natural constituent of marine environment and in general these metals are in very low concentrations. Some of heavy metals appear to be biological essential, but in high concentrations these heavy metals would be toxic to marine organisms. Certain heavy metals find their way into estuaries as pollutants along with industrial and domestic wastes and also as the results of mining activities and erosion. This waste will affect fast or slow to marine resources. In sea water, heavy metals are found in low concentration, ranging from  $10^{-5}$  to  $10^{-2}$  ppm. In natural condition, the heavy metals are needed by organisms for growing and developing their lives (Phillips, 1980).

The presence of heavy metals in seawater can come from any sources, such as mining activity, housing and industrial waste (Connel and Miller, 1995). Heavy metal compound is often used in the industry, as well as for main material, additional material or catalyst. Beside as toxic, the heavy metals will also be accumulated in the sediment

and organisms through the process of gravity, bio-concentration, bio-accumulation and bio-magnification by the organisms.

Contamination of aquatic systems by heavy metals and other pollutants creates problems in society because the environment is often used as receptacle for waste products generated in economy. Stock pollutants such as heavy metals are not broken down and persist in environment. Metal concentration in surface water can fluctuate by several orders of magnitude over short time intervals depending on the conditions. The concentration in sediment does fluctuate to the same degree as in surface waters. Thus sediment of aquatic system is usually studied when studying the quality of a water system.

The objective of the observation was to determine the concentration and distribution of heavy metals in the sediment of Jakarta Bay.

### MATERIAL AND METHOD

This survey was carried out in the Jakarta Bay in May and October 2004. The sediments were

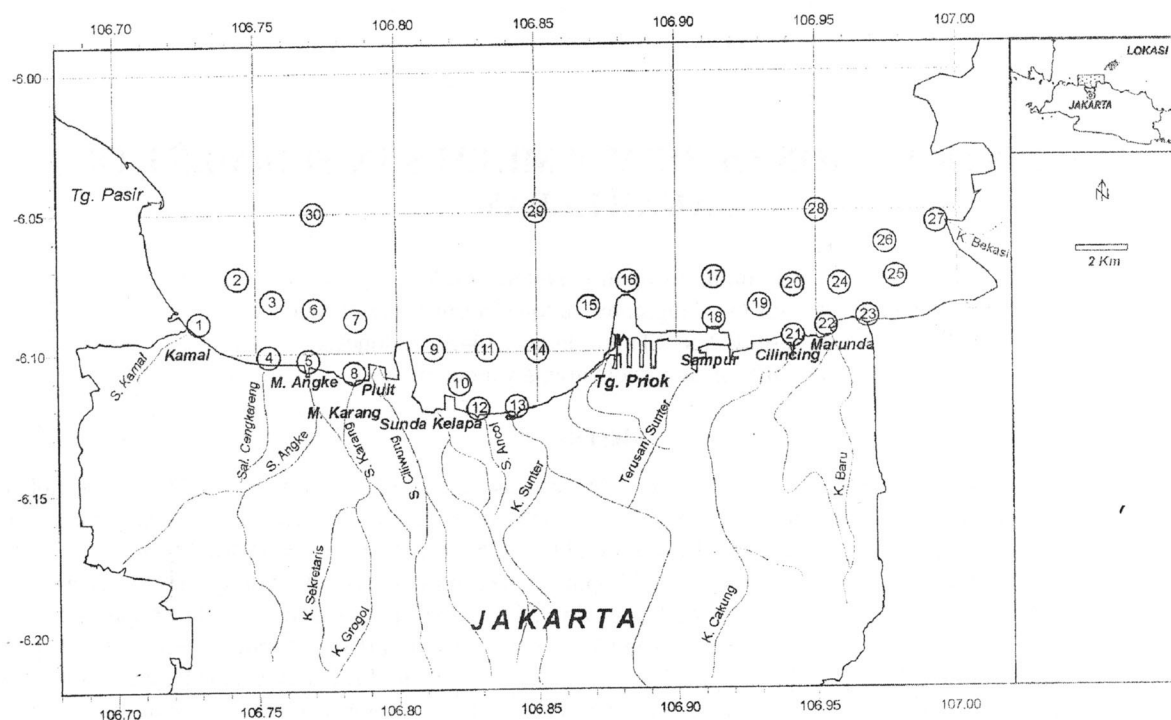


Figure 1. Map of sampling location, Jakarta Bay 2004

sampled using a Grab at surface layer, and were taken at stations which divided into 3 regions, such as in western part with 8 stations (St. 1, 2, 3, 4, 5, 6, 8, and 30), in central part with 11 stations (St 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 and 29) and in eastern part with 9 stations (St 19, 20, 22, 23, 24, 25, 26, 27 and 28).

Sediment samples were then transferred into acid-cleaned polyethylene vials. All samples were placed in clean bench at temperature 4°C and kept in a dark condition when their transport to laboratory for analysis (Batley and Gardner, 1977). To analyze Pb, Cd, Cu, Zn and Ni in sediment, samples were transferred into Teflon beaker, oven-dried at 105°C for 24 hours, rinsed with DDDW to remove soluble self from samples, then oven-dried again. Five grams of homogenate samples was transferred into 100 ml Teflon beaker and digested with HNO<sub>3</sub>, HCl<sup>-1</sup> and Aqua regia (Loring and Rantala, 1977). Then, all samples were dried on a hotplate at the maximum temperature of 60°C for 8 hours. After that, the continuous of decantation and then the concentration were measured. The accuracy of the present analysis was evaluated by analyzing the BCSS-1 certified references material at the time samples was being analyzed (Waldichuk, 1974). The results were in good agreement with recommended values.

The concentrations of pollutants heavy metals (Pb, Cd, Cu, Zn, and Ni) in all samples were determined by air-acetylene flame AAS SpectraAA plus Varian.

## RESULTS

### Western Part

The results of heavy metal analysis in sediment are presented in Figures 2, 3, 4, and 5. The results show that in May, the heavy metals sediment in the western part were high of Zn concentration. The concentration of Zn in sediment was 115.71-256.85 ppm, while Cu 7.41-72.27 ppm, Ni 4.81-15.78 ppm, Pb 11.05-35.19 ppm, and Cd 0.04-0.30 ppm. In October 2004, the concentration of heavy metal was as follow, Zn 76.99-497.53 ppm, Cu 14.50-74.70 ppm, Ni 4.58-18.75 ppm, Pb 10.67-32.27 ppm and Cd 0.075-0.291 ppm. Therefore, the concentration of metals Zn in sediment in May and October 2004 was always high, and Cd was very low (Fig. 2). The concentration of heavy metal in sediment in the western part generally was high at stations 1, 3, 5 and 7. These stations were located in front of the estuary such as Angke, Kamal, Karang and Cengkareng Drain (Fig. 1). The concentration of heavy metal in sediment was

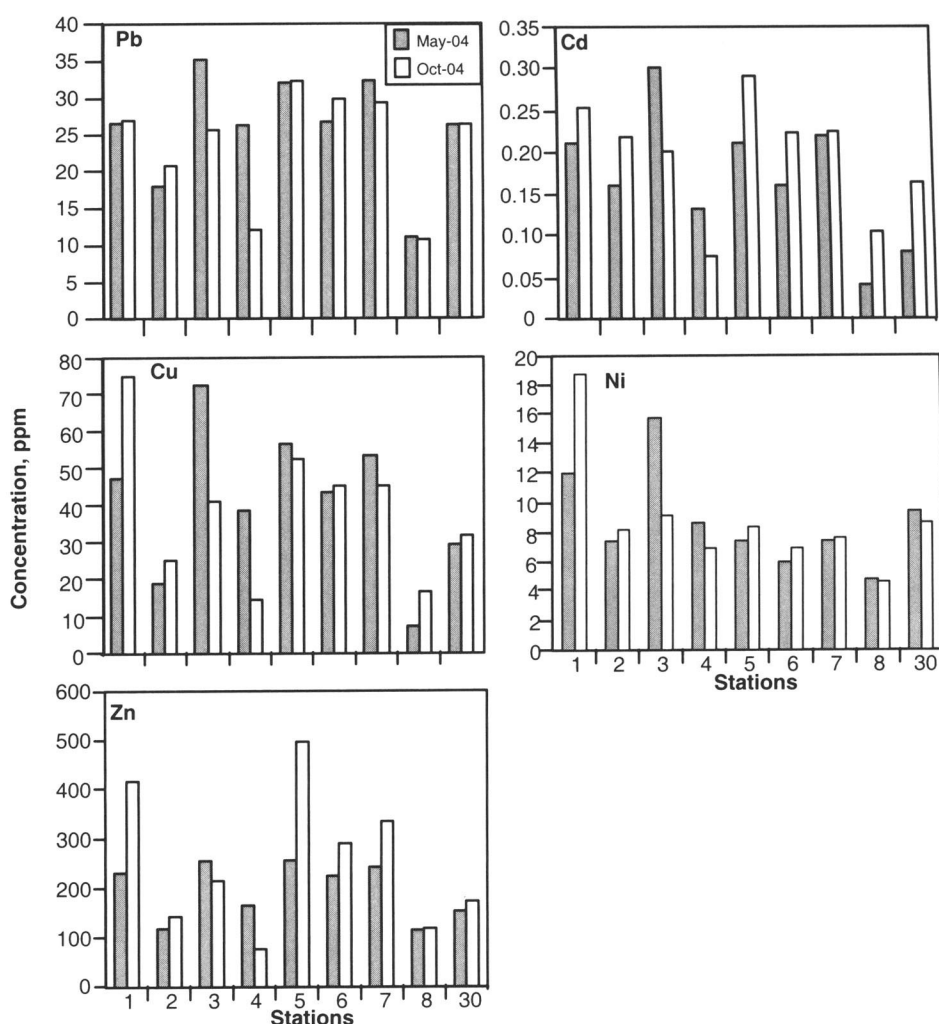


Figure 2. Heavy Metals in the western part of Jakarta Bay

low at stations 2, 4 and 8 (Fig. 2 and 5a). The high concentration of heavy metals at station 1, 3 and 5 were possibly due to the pollutant caused by activities on land. Sediments taken from these stations were black chromatic and smell. The sediment has composition in the form of mud, having pore - small pore of absorbing big, so that heavy metal rate which obtained is big enough. Results of perception indicated that heavy metal rate of sediment in western part in May 2004 lower than this in October 2004 (Fig. 5a).

### Central Part

The heavy metals concentrations in sediment in the Central part were relatively high. In May 2004, the concentration of Zn was as follow, 53.87-233.32 ppm, Cu 1.19- 40.60 ppm, Ni 4.09 -9.63 ppm, Pb 6.69 -64.44 ppm, and Cd 0.01-0.25 ppm

(May 2004). In October 2004, the concentration was as follows, Zn 68.82-275.68 ppm, Pb 9.03-53.00 ppm, Cu 9.24-40.41 ppm, Ni 5.28-11.88 ppm, and Cd 0.052-0.442 ppm. Similar to the western part, the concentration of metal Zn in sediment in the central part was also high, and Cd was very low (Fig. 3). The concentration of heavy metals at stations 15, 16 and 17 generally was high. These stations are in front of Sunter estuary and Tanjung Priok Port. While the concentration of heavy metal in sediment in the central part was low at stations 13 and 29 (Fig. 3). The concentration of heavy metal was high in station 15, 16 and 17, due to harbour activities which is yoke lego before stopping into Tanjung Priok Port and Sampur (Fig. 1).

Current velocity in the location was relatively weak (only influenced by ebb), therefore

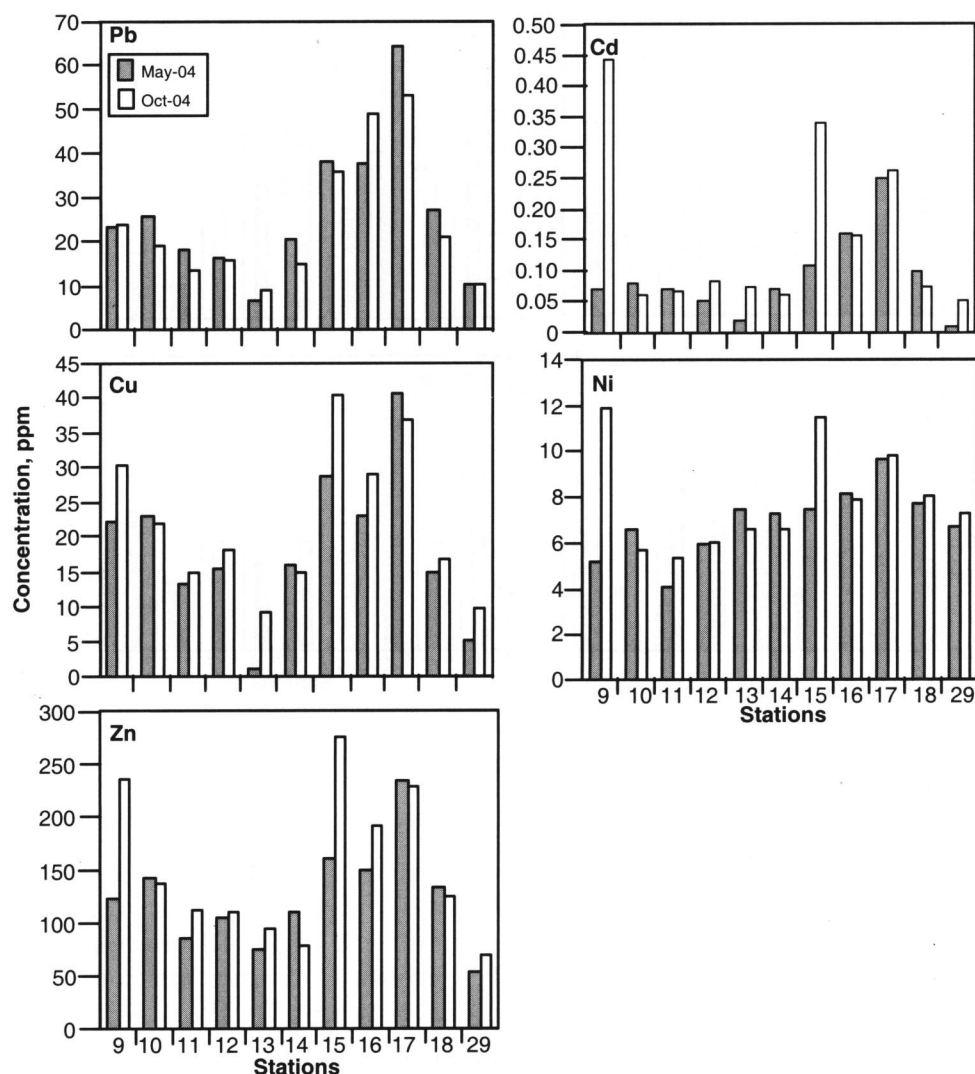


Figure 3. Heavy metals in the central part of Jakarta Bay

precipitation process of heavy metals to territorial water base was progressively quick. A period of water move out and in to the ports of Tanjung Priok Harbor and Sempur was much more slow, so this situation support strongly the precipitation process of heavy metal. The Sediments have their composition as muddy, having pore-small pore of absorpsi big, so that heavy metal rate which obtained was quite big. From the precipitation results was indicated that heavy metal rate in sediment in central part in May 2004 lower than this in October 2004 (Fig. 5b). The high concentration of heavy metals from the stations of the central region were thought to be due to pollutant from industry and domestic waste.

#### Eastern Part

The result of heavy metals in sediment in eastern part was higher in Zn concentration than others. In May 2004, the concentration of Zn was 78.27-230.68 ppm, Cu 0.82-36.47 ppm, Ni 8.09-11.02 ppm, Pb 3.64-34.26 ppm and Cd is <0.001-0.32 ppm. In October 2004, the concentration of Zn 88.81-192.36 ppm, Pb 5.57-43.97 ppm, Cu 8.68-33.21 ppm, Ni 4.58-10.53 ppm, and in Cd 0.022-0.120 ppm. Similar to the condition in western and central parts, Zn in sediment in May and October 2004 in the eastern part of Jakarta Bay was also high and Cd was low (Fig. 4). The concentration of heavy metals was high at stations 19, 20, 24 and 27. These stations were found in front the estuaries of Cilincing, Marunda and Bekasi (Fig.

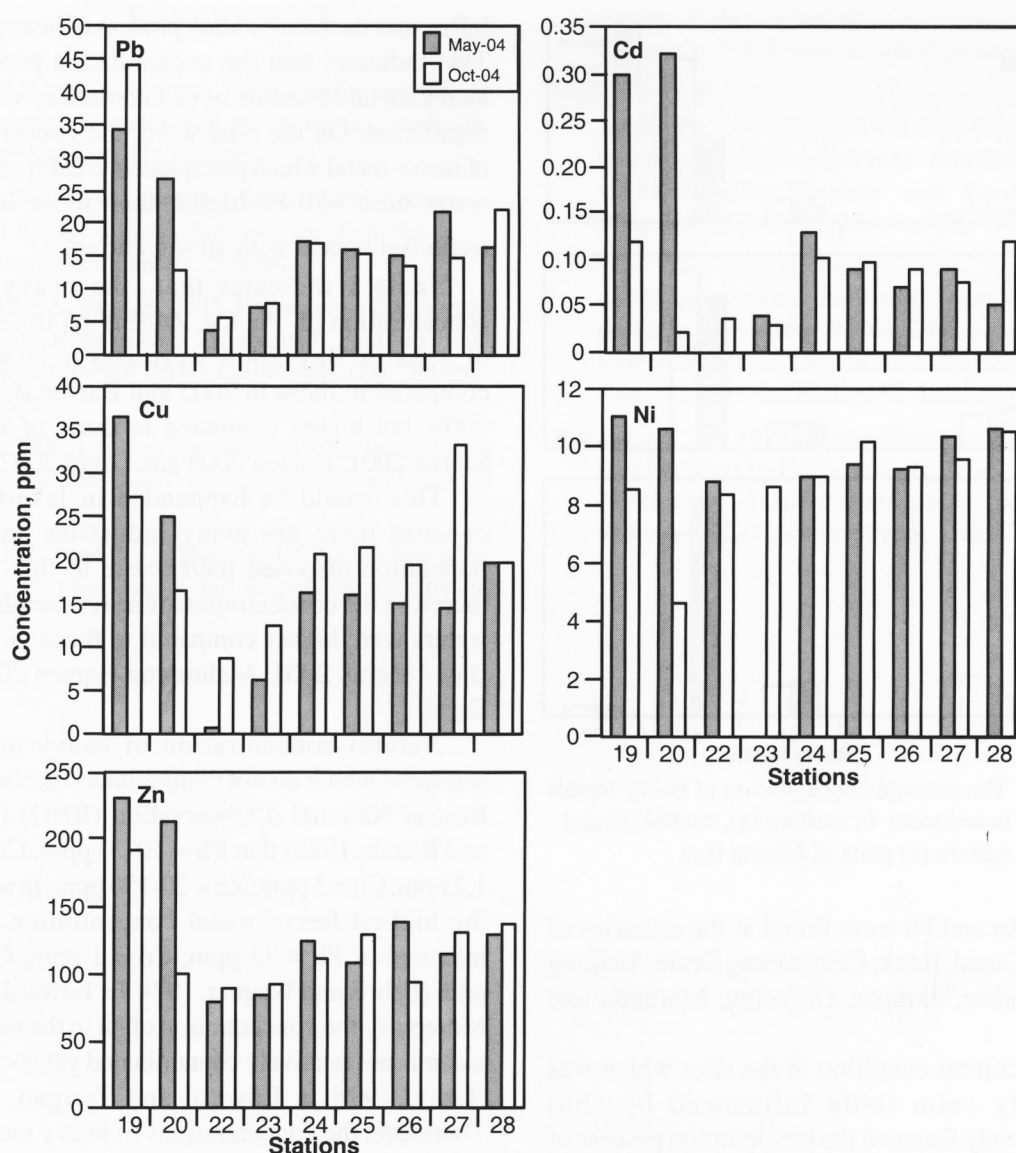


Figure 4. Heavy metals in the eastern part of Jakarta Bay

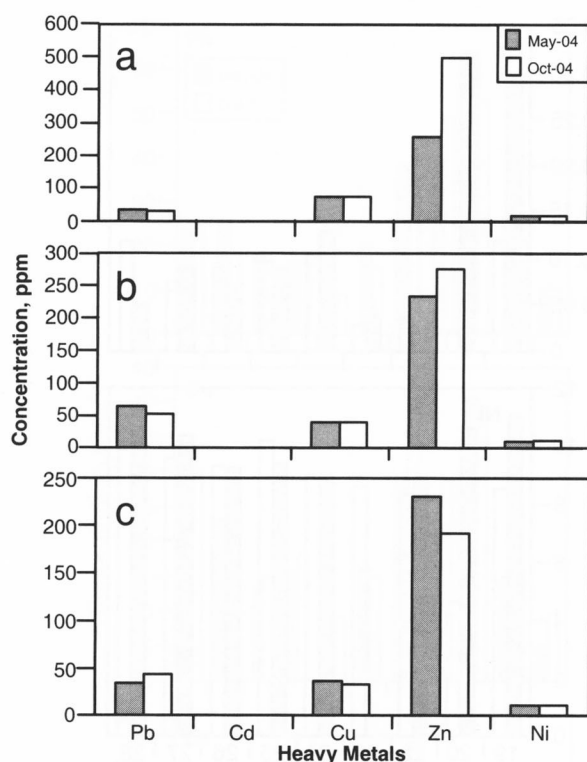
1). The high concentration of stations 19, 20, 24 and 27 were probably caused by the urban pollutant from the Jakarta Metropolitan City. The result of perception indicate that heavy metal rate in sediment of central part in May 2004 lower than this one in October 2004 (Fig. 5c). The high concentration of heavy metals from these stations were possibly due to pollutant from industry and domestic waste.

## DISCUSSION

The concentration of heavy metal (Pb, Cu, Zn and of Ni) of Jakarta Bay were detected highly in general, except Cu. The high concentration was

generally found at estuaries i.e. Angke, Kamal, Rock, Cengkareng Drain, Tanjung Priok Harbor, Sampur, Cilincing, Marunda and Bekasi.

The high concentration of heavy metals in Jakarta Bay is caused by the ship and harbour activities which anchor before coming enter the port. At Rock estuary, Angke estuary, Cengkareng Drain and surrounding area, the ships do not only anchor but also load and unload goods manner. Besides shipping and harbour activities, there are two important factors caused the high concentration of heavy metal in sediment of Jakarta Bay i.e. human activities and the condition of territorial environmental water. This conclusion is relied on the fact that the high concentration of



**Figure 5.** The average concentration of heavy metals in sediment in western (a), central (b) and eastern (c) parts of Jakarta Bay.

Pb, Cu, Zn and Ni were found at the estuaries of Angke, Kamal, Rock, Cengkareng Drain, Tanjung Priok Harbor, Sampur, Cilincing, Marunda and Bekasi.

The current condition at the sites which was relatively calm (only influenced by ebb) progressively fastened the precipitation process of heavy metal to the territorial water base. A period of water flow to sea off Jakarta Bay as a semi territorial water was much weak, and this condition

influences the precipitation process of heavy metal. This indicates that the accumulation process of heavy metal in sediment of Jakarta Bay was very significant. On the other word, the concentration of heavy metal which precipitated to calm territorial water base will be higher than those in other territorial waters with strong current.

Table 1 indicates that the heavy metal concentration of Pb, Cu, Zn and Ni in sediment of Jakarta Bay 2004 were lower in general compared to those in 2003 and Banten (Ciujung) 2003, but higher compared to those of Banten-Merak 2001, Banten 2004 and Digul 2002.

This could be happened in Jakarta Bay, because there are many industries and high population disposed their waste to this waters, therefore the concentration of heavy metals in this waters were higher compared to those of Banten Bay - Merak 2001, Malimping-Banten 2004 and Digul.

Natural concentration of heavy metal in sediment which do not contaminated according to Réseau National d'Observation (RNO) (Thayib and Razak, 1981) that Pb = 10-70 ppm, Cd = 0,1-1,2 ppm, Cu = 5 ppm, Zn = 20-150 ppm. In addition, the highest heavy metal concentration can be tolerated of Pb = 33 ppm, Cd = 1 ppm, Cu = 30 ppm (Febris and Wagner, 1974 in Edward, 2006). Moreover, the concentration of Ni in the territorial water is not relatively contaminated yet is <16 ppm (Gray, 1996 in Edward and Tarigan, 2005). Therefore, the concentrations of heavy metal (Pb, Cd, Cu, Zn and Ni) in sediment of Jakarta Bay were high. The high concentrations are due to the pollutant from industry and domestic waste.

**Table 1.** The comparison of heavy metal rate (Pb, Cd, Zn, Ni and of Cu) ppm, in sediment in the territorial water of Jakarta Bay with those of other territorial waters in Indonesia.

Unsur	Location					
	Teluk Jakarta 2004	Teluk Jakarta 2003	Banten Bay-Merak 2001	Malimping, Banten 2004*	Digul 2002	Banten Bay-Ciujung 2003
Pb	3,64-53,00	0,25-77,42	1,91-11,81	2,25-25,800	2,61-14,07	0,25-77,42
Cd	<0,001-40,60	<0,001-0,44	<0,001-0,2	<0,001-0,519	0,01'-0,16	<0,001-0,44
Cu	0,82-74,70	0,79-193,75	2,23-6,65	0,85-16,421	1,02-10,69	0,79-193,75
Zn	53,87-497,53	71,13-533,59	13,33-55,09	5,83-82,145	15,48-140,47	71,13-533,59
Ni	4,09-18,75	0,42-128,47	2,11-6,09	0,74-12,979		0,42-128,47
Concentration in ug/g, heavy run dry						



## REFERENCES

- Batley, G. E., and D. Gardner. 1977. Sampling and storage of natural water for trace metal analysis. *Water Research* 11: 745-756.
- Connel, W. D., and Gregory, J. Miller. 1995. *Kimia and Ekotoksikologi Pencemaran*. Penerbit Universitas Indonesia: 520 hal.
- Edward dan S. Tarigan. 2005. Pemantauan Kandungan Logam Berat dalam sediment di Perairan Selat Makasar. *Jurnal Teknik Lingkungan ITB*, Oktober, 241-255.
- Edward. 2006. Laporan Pemantauan Rona Lingkungan Perairan Teluk Kao P. Halmahera, Maluku Utara, 78 hal.
- Loring, D.H., and R.T.T. Rantala. 1977. Geochemical analysis of sediment and suspended particulated matter. *Fisheries and Marine Service Technical Report* No. 700. Environmental Canada: 1-58.
- Philips, J. D. H. 1980. Proposal for monitoring studies on the contamination of the East Seas by trace metals and organochlorines. *South China Sea Fisheries Development and Coordinating programme* FAO-UNEP, Manila, May 1980. 1-35.
- Thayib, S.S., dan H. Razak 1981. Pengamatan kandungan bakteri indikator, logam berat dan pestisida di Perairan Pantai Teluk Ambon, Teluk Banten dan Teluk Jakarta. *Prosiding Seminar dan Kongres Nasional Biologi VI*, Surabaya: 196-217.
- Waldichuck, M. 1974. Some Biological Concern in Heavy Metals Pollution. In. *Pollution and Physiology of Marine Organism*. Verberg & Venberg (Ed.) Academic Press, London.