Ilmu Kelautan. Maret 2004. Vol. 9 (I) : 431-36 *ISSN 0853 - 7291*

Concentration of Heavy Metals in Molluscs and Sediment from Sei Jang Estuary

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Abstrak

*Analisis konsentrasi logam berat Pb, Cu dan Zn dalam jaringan lunak moluska (*Geloina *sp dan* Calliostoma *sp) dan sedimen dari perairan muara Sei Jang Riau Indonesia telah dilakukan. Pada umumnya konsentrasi logam tersebut dalam jaringan lunak moluska lebih tinggi dari konsentrasi dalam sedimen, kecuali logam Pb dalam* Geloina *sp yang relatif lebih rendah dibanding dalam sedimen.* Geloina *sp mengakumulasi logam Zn lebih dari tiga kali lipat dari konsentrasi dalam sedimen, sedangkan* Calliostoma *sp mengakumulasi logam Cu lebih dari empatbelas kali lipat konsentrasi logam tersebut dalam sedimen. Peningkatan konsentrasi logam berat lebih terlihat jelas di sekitar kawasan bekas penambangan bauksit, galangan kapal dan di kawasan aktivitas penduduk. Akumulasi logam didapatkan lebih tinggi dalam jaringan lunak moluska yang berukuran lebih besar dimana hal ini mengindikasikan bahwa ukuran merupakan faktor penting dalam akumulasi logam berat oleh moluska. Indeks Akumulatif menunjukkan bahwa akumulasi logam tertinggi oleh moluska terjadi di kawasan bekas penambangan bauksit dan* Geloina *sp lebih baik dijadikan sebagai indikator untuk logam Zn sedangkan untuk logam Cu dan Pb lebih baik digunakan* Calliostoma *sp.*

Kata kunci : *logam berat, sedimen, moluska, indeks akumulatif*

Abstract

*Concentrations of lead, copper and zinc were measured in molluscs (*Geloina *sp and* Calliostoma *sp) and sediment samples collected from Sei Jang estuary Riau Indonesia. Concentrations of those metals in molluscs were higher than in sediments, except for lead in* Geloina *sp which was slightly lower than sediments.* Geloina *sp accumulates zinc more than threefold of the concentration in sediment, whilst* Calliostoma *sp accumulates copper more than fourteen-fold of the sediment concentrations. Elevated concentrations of heavy metals in an ex-bauxite mining area, dockyard and anthropogenic activities were found. Accumulation of metals in molluscs varied between sizes where larger size accumulated more metals than smaller size indicating that size is an important consideration for metal accumulation. Average accumulative indices indicated that highest metals accumulation by molluscs occurred in the area of an ex-bauxite mining activities. These indices also suggested that* Geloina *sp was better to be used as indicator organism for zinc, whilst* Calliostoma *sp was considered to be suitable indicator organisms for the accumulation of copper and lead.*

Key words : *heavy metals, sediment, mollusc, Accumulative index*

Introduction

Bintan is one of the islands in Riau Archipelago that has been developing for industrial and tourisms sector and these activities could contribute local marine environment impacts especially on the area receiving its wastes such as Sei Jang Estuary. Several activities such as anthropogenic, bauxite mining, fiber boat construction and shipping transportation have long been operated in these areas which eventually discharge organic and an-organic pollutants including heavy metals to the estuary.

Heavy metals discharge from industrial and anthropogenic effluents or from atmospheric deposition may be rapidly removed from the water column and transported to bottom sediment and associated organisms (Fung and Lo, 1997). Consequently, metal concentrations in sediment and organisms are often several orders of magnitude higher than those in ambient seawater (Ismail and Ramli, 1997).

Accumulation of heavy metals in marine invertebrates may be affected by environmental conditions, age, size and feeding rate (Phillips, 1990). Several previous studies have shown that animal size is an important independent variable influencing metal levels in marine molluscs (Boyden, 1977, Riget *et.al.*, 1996, Mouneyrac *et al.*, 1998). This short period of study aims to provide a background data on the

Diterima / Received : 07-01-2004
Disetujui / Accepted : 18-02-2004

concentration of heavy metals in sediment and molluscs in Sei Jang Estuary Riau Archipelago.

Materials and Methods

Samples of surface sediment and molluscs (*Geloina* sp and *Calliostoma* sp) were collected from three sampling stations in the Sei Jang Estuary (Figure 1). Station 1 represents shipping transportation lane and fiber boat construction area; station 2 represents populated area and station 3 represents an area of ex-bauxite mining activities. Nine samples of *Geloina* sp of different size (35 - 68 mm) and *Calliostoma* sp (56 - 95 mm) as well as samples of surface sediment were collected from each sampling location, placed in labeled plastic bags and then stored at 10°C until analysis for metal concentration. Water quality parameters at each sampling station were also measured during high tide. In the laboratory, sediments were air-dried, molluscs were defrosted, and the soft tissues were extracted from shells and washed to remove external contamination. Samples were then digested in a mixture of concentrated nitric and perchloric acids (4 : 1 v/v). The sediment was digested by similar procedures as described by Ismail and Ramli (1997). The digest solutions were then made up to 50 ml volume with doubled distilled water. Heavy metal concentration analysis was carried out using Atomic Absorption Spectrophotometer Perkin Elmer 3110 in Marine Chemistry Laboratory Faculty of Fisheries and Marine Sciences University of Riau.

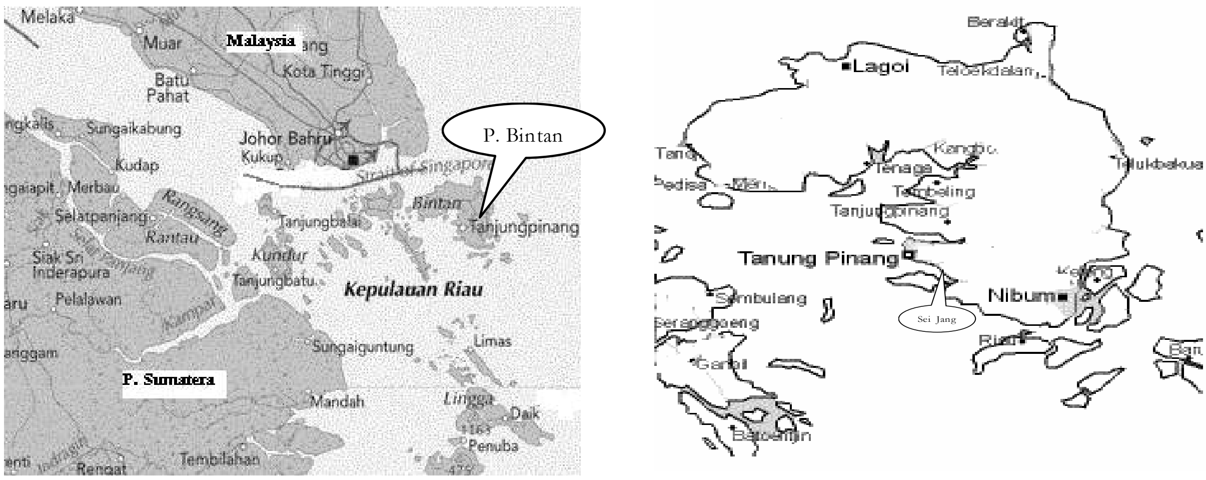

Figure 1. Map of Bintan Island and sampling location at Sei Jang

Results and Discussion

Water quality parameters

Some water quality parameters could affect metal concentration in aquatic environment. According to Vernberg *et al.* (*In* Hutagalung, 1991) salinity, alkalinity, temperature, pH, and the presence of other compounds could affect the absorption rate of metal. They also stated that combination of temperature and salinity would affect heavy metal accumulation in aquatic environment. Water quality parameters measured in Sei Jang Estuary (Table 1) were not significantly different and still in the range of tolerable limits for the survival of marine organisms.

Table 1. Average water quality parameters in Sei Jang Estuary

Station	Water quality parameters			
	Temperature (°C)	Salinity (‰)	pH	DO (ppm)
1	28.5	32.0	6.7	6.70
2	29.0	33.0	6.9	6.80
3	29.0	32.0	6.9	6.50
Average	28.83	32.3	6.8	6.67

Heavy metal concentration in sediment and molluscs

The result shows that the average heavy metal concentration in *Geloina* sp were 3.34 µg/g

(1.50 – 4.75 µg/g) for Pb, 5.58 µg/g (2.88 – 9.78 µg/g) for Cu and 39.58 µg/g (20.55 – 64.18 µg/g) for Zn. Concentration of Pb, Cu and Zn in *Calliostoma* sp were 5.14 µg/g (3.40 – 7.00 µg/g), 32.02 µg/g (18.84 – 40.36 µg/g) and 29.44 µg/g (14.64 – 61.11 µg/g); whilst in sediment were 4.48 µg/g (2.7 – 5.60 µg/g), 2.78 µg/g (1.53 – 5.29 µg/g) and 14.32 µg/g (7.38 – 31.68 µg/g) for Pb, Cu and Zn respectively (Table 2). Concentrations of Pb, Cu and Zn in *Geloina* sp and *Calliostoma* sp in the present study were slightly higher than concentrations in *G. coaxan* in Sei Pakning as reported by Febrizal (1995), *G. coaxan* in Meral (Efriyeldi and Amin, 2000, *Strombus canarium* in Busung, Bintan (Nurrachmi and Amin, 2000).

Table 2. Average concentration of heavy metals in sediment and molluscs from Sei Jang Estuary

Station	Metal concentration (µg/g)								
	Geloina sp			*Calliostoma* sp			Sediment		
	Pb	Cu	Zn	Pb	Cu	Zn	Pb	Cu	Zn
1	3.86	5.97	20.28	5.43	34.29	23.14	5.17	3.68	13.20
2	3.42	7.33	41.91	5.17	32.63	19.24	4.17	2.45	12.23
3	2.74	3.45	56.54	4.83	29.13	45.64	4.10	2.22	17.54
Average	3.34	5.58	39.57	5.14	32.02	29.44	4.48	2.78	14.32

The highest concentration of Zn was found in station 3 as can be seen in Fig. 2; whilst in contrast, Pb and Cu were lowest in this station and the highest was in station 1 (except for Cu in *Geloina* sp). Highest Pb concentration found in station 1 in all samples was attributed to the activities of shipping transportation and effluents from nearby fiber boat construction factory. High concentration of these metals in station 2 was probably related to anthropogenic activities where most of the population concentrated in the coastal area of this station. In station 3 high concentration of Zn was presumably related to past activities of an old bauxite mining which has already terminated its operation in 1998, however some mining activities further upland of this station were still in operation.

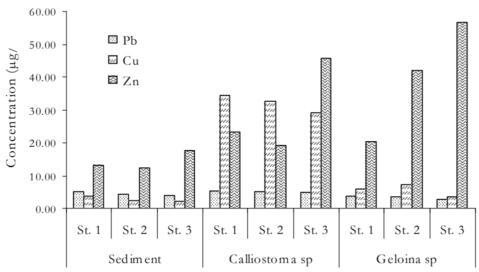

Figure 2. Average concentration of heavy metals in *Geloina* sp, *Calliostoma* sp and sediment from Sei Jang Estuary

Heavy metals concentrations increased with increasing size of molluscs. Concentration of Pb in small size of *Geloina* sp was 2.25 µg/g, Cu 4.60 µg/g and Zn 20.55 µg/g; medium size were Pb 3.40 µg/g, Cu 4.68 µg/g and Zn 47.48 µg/g and large size were Pb 4.33 µg/g, Cu 7.47 µg/g and Zn 50.69 µg/g. *Calliostoma* sp also shown similar trend in its metal concentration as for *Geloina* sp where smaller organism accumulate less metals compared to larger ones (Table 3 and Fig. 3).

Table 3. Average concentrations of heavy metals in *Geloina* sp and *Calliostoma* sp from Sei Jang Estuary according to their size

Geloina sp				*Calliostoma* sp			
Size (mm)	Concentration (µg/g)			Size (mm)	Concentration (µg/g)		
	Pb	Cu	Zn		Pb	Cu	Zn
35 - 38	2.25	4.60	20.55	56 - 60	3.67	25.28	19.00
40 - 51	3.40	4.68	47.48	70 - 74	5.83	31.72	22.04
60 - 68	4.33	7.47	50.69	90 - 95	5.93	39.05	47.27

Previous studies on molluscs also showed similar results (Pringgenies and Hartati, 1995; Febrizal, 1995; Ismail and Ramli, 1997; Amin *et al*. 2000, Amin, 2002). The results of this study also showed that Pb and Zn concentration in *Geloina* sp as well as Pb and Cu in *Calliostoma* sp exceeded the permissible level for human consumption set by WHO *in* Hutagalung (1991).

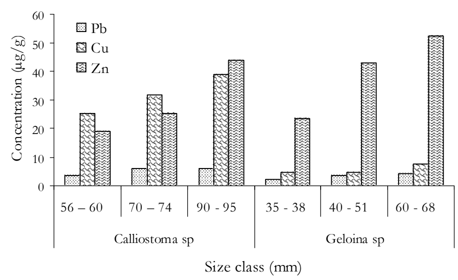

Figure 3. Average concentration of heavy metals in *Geloina* sp and *Calliostoma* sp from Sei Jang Estuary according to their size

Correlation between heavy metal concentrations with size of molluscs

Simple linear regression analysis indicates positive correlation between heavy metals concentration in soft tissue and size of *Geloina* sp with Y = 0.0350 + 0.0677 X (r = 0.7031) for Pb; Y = -0.6872 + 0.1284 X (r = 0.6184) for Cu and Y = -7.5333 + 0.9647 X (r =

0.8501) for Zn. Similar results found for *Calliostoma* sp with Y = 0.7408 + 0.0612 X (r = 0.7256) for Pb; Y = 0.7583 + 0.4269 X (r = 0.8484) for Cu and Y = -26.486 + 0.7638 X (r = 0.8391) for Zn (Figure 4). Significant positive relationships between size and metal concentrations in molluscs had been previously reported (Amin, 2002, Bilos *et al*., 1998; Amiard, 1986; Boyden, 1974; 1977).

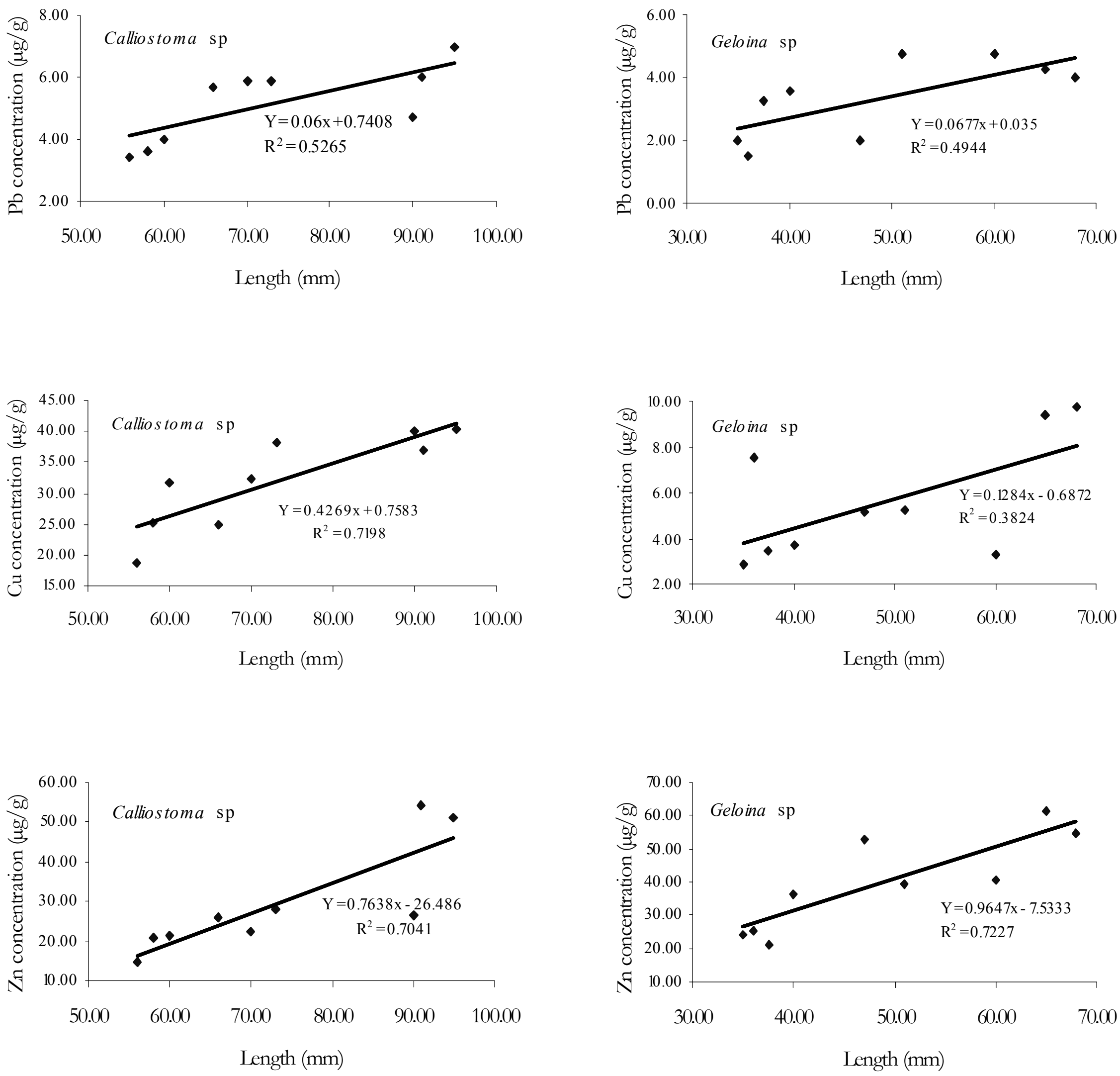

Figure 4. Correlation between Pb, Cu and Zn concentration in *Calliostoma* sp and *Geloina* sp with their size

Correlation between heavy metal concentration in sediment and molluscs

Weak negative correlations between heavy metal concentrations in sediment and mollusc were found for lead and copper both in *Calliostoma* sp and *Geloina* sp. On the other hand although they were also not significant zinc concentration in sediment showed positive correlation with its concentration in mollusc (Fig. 5).

The accumulative index (AI), which is the ratio of the heavy metal concentration in the molluscs compared to the concentrations in sediment, was examined (Table 4). Ratios greater than 1.00 indicated that the concentration of heavy metals was higher in the molluscs than that in sediment, while ratios less than 1.00 indicated that concentration of heavy metals in sediment was higher than that in molluscs. Accumulative indices between species were also compared. These values could be used to indicate which species had the highest rate of bioaccumulation for each metal.

Table 4. Accumulative indices (AI) for *Geloina* sp and *Calliostoma* sp from Sei Jang Estuary

Station	*Geloina sp*			*Calliostoma sp*		
	Pb	Cu	Zn	Pb	Cu	Zn
1	0.75	1.62	1.54	1.05	9.32	1.75
2	0.82	2.99	3.43	1.24	13.32	1.57
3	0.67	1.55	3.22	1.18	13.12	2.60
Average	0.75	2.05	2.73	1.16	11.92	1.97

Table 4 shows that highest AI in general were found in station 2 both for *Geloina* sp and *Calliostoma* sp with exception to Zn for *Calliostoma* sp at station 3. *Geloina* sp had highest AI for Zn and lowest for Pb whilst *Calliostoma* sp had highest AI for Cu and lowest for Pb. Average accumulative indices indicated that *Calliostoma* sp was better to be used as indicator for Cu accumulation whilst *Geloina* sp for Zn.

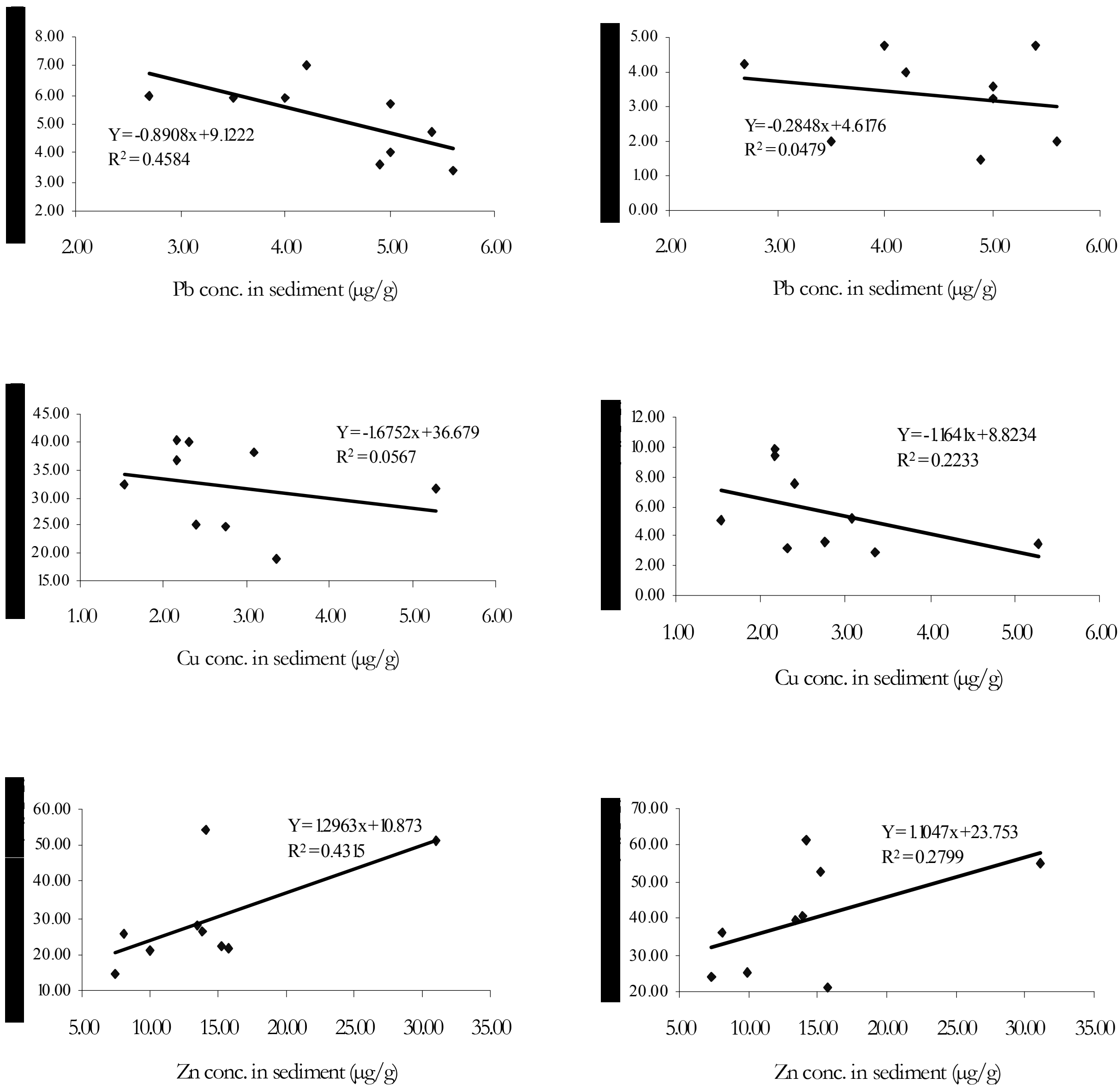

Figure 5. Correlation between Pb, Cu and Zn concentration in sediment and *Geloina* sp (right) and between sediment and *Calliostoma* sp (left)

Conclusion

Heavy metals concentrations found at the station nearby an ex-bauxite mining area, dockyard or fiber boat construction factory and anthropogenic activities were higher than in station relatively un-impacted from those activities. Concentrations of Zn in all samples were found to be the highest in the nearby an ex-bauxite mining area whilst Pb and Cu (except Cu for *Geloina* sp) were highest in stations closed to shipping transportation lane. The present results also showed that the larger size of *Geloina* sp and *Calliostoma* sp accumulated higher concentrations of Pb, Cu and Zn. Accumulative indices were higher in *Calliostoma* sp than in *Geloina* sp which indicated that *Calliostoma* sp was better to be used as indicator organism for Pb and Cu accumulation whilst *Geloina* sp for Zn.

Acknowledgement

The author wishes to thank Mr. R. Hermawan and R. Efendi for their excellent assistance in the collection of molluscs and sediment from Sei Jang in Bintan Island.

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